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Department of Economic History

PhD Thesis

Institutions, Geography and Market Power: the Political Economy of Rubber in the Brazilian Amazon, c.1870-1910

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

ABSTRACT

The thesis applies a political economy approach to the study of how institutions and geography explain the development of a commodity chain. Focusing on the Brazilian Amazon from 1870 to 1910, the analysis develops a new theoretical framework constructed by combining standard trade models with institutions and economic geography. There are two levels of analysis: interactions among, and within, different nodes of the commodity chain. A quantitative-driven analysis from macroeconomic data supports inferences from microeconomic behaviour. The thesis provides new information on rubber prices and exports, trader ledgers, estate accounts, newspapers, travellers accounts, and official documents.

The research develops a demand- and supply-side analysis of the history of rubber, from tappers to manufacturers. It features the main rubber manufacturing countries, Britain and the USA, and shows how competition prevailed along the chain, translating into a struggle for rubber supply. Rubber was not a homogeneous product. Due to a combination of quantity and quality, the Brazilian Amazon possessed significant market power, market power that shaped the rubber chain. In this light, the thesis investigates how the Brazilian rubber supply chain was organised and how agents profited from its monopolistic position. It also shows that taxation increased the regional welfare and allowed the government to support two related activities: telegraphs and shipping.

The thesis proves that violence and coercion were not necessary features of rubber production, as argued by much of the literature. Through a game-theoretic approach, the thesis demonstrates conditions under which production could have occurred without exploitation. In a context of high price-inelasticity of demand and rising prices, production was driven by market forces. Inelasticity of demand was indeed one of the main features of the rubber boom. It shaped production, bargaining power between different nodes of the chain and competition within them, defining the distribution of profits along the rubber chain.

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NOTE ON CURRENCY

From 1822 to 1942, Brazilian currency was denominated in *milréis* (or *mil-réis*), expressed as 1$000. One thousand *milréis* were known as *conto de réis* (or simply *conto*), expressed as 1:000$000. Therefore, the currency was not subdivided centesimally as most of other international currencies at the time but rather into millesimals.[1]

NOTE ON SPELLING

Because of changes in orthography, there were several different spellings for the same word in Portuguese. I maintained the original spellings in citations and names and used modern spellings in the text.

NOTE ON AMAZONIAN POLITICAL ORGANISATION

For the purposes of the thesis, the Brazilian Amazon is roughly comprised of the current Brazilian states of Pará, Amapá, Amazonas, Roraima and Acre. During the rubber boom (1870-1910) these administrative units were organised into two larger ones: Amazonas (including Roraima) and Pará (including Amapá). These two administrative units were called Provinces under the Empire (1822-1889) and States afterwards. Acre was not part of Brazil until 1903 when it was incorporated as a Federal Territory. See map below for current political organization of the Brazilian Republic where shaded areas represent the Amazon Region.

Source: elaborated by me.

[1] See Abreu and Lago (2001). I would like to thank Marcelo Abreu and Luiz Aranha Corrêa do Lago for revising this paragraph.

INTRODUCTION

In the eighteenth century, the so-called Industrial Revolution began to change the Western World: beginning in England, it engendered an unprecedented social and economic transformation. At the heart of this transformation was the increase in productivity generated by the substitution of machines for human labour. It is difficult to summarise the several technical improvements that jointly explain the Industrial Revolution. However, the steam engine is undoubtedly paradigmatic. The usage of steam engines pushed the demand for coal whose supply, in turn, was increased by the (atmospheric) steam engine. More and cheaper coal further created a spur to the iron industry, another raw material of steam engines. Therefore, a virtuous cycle crystallised and, with it, the possibilities for application of steam engines seemed endless. This was particularly true in the textile industry where subsequent improvements in machinery pointed to an ever increasing productivity. The processing of textiles (as well as of several other manufactures) demanded a greater amount of chemical substances and, at the same time, the increasing in productivity meant that the market had to expand accordingly. Again, steam engines were instrumental: transport improvements (notably railways and steamships) caused a decline in transportation costs and consequently the market potential increased. An expansion of trade ensued connecting more and more areas around the globe, a process that was strengthened by declining tariffs, gold standard, higher capital mobility, migration and improvements in communication. However, only after Britain's move towards free trade with the repeal of the Corn Laws (1846) and the Navigation Acts (1849) and the laying of submarine telegraphic cables across the English Channel (1851) did this cycle generated a true and enduring global trade boom: economic interconnectedness created a virtuous cycle in which falling transport costs, by shrinking economic distances, opened new areas to trade and to movement of people and, conversely, the increase in trade (and in migration) provided economies of scale that pushed transportation costs down. Conversely, the trade boom meant that industrial techniques were spreading from England to Continental Europe and a few other overseas areas.

Rubber encapsulates this globalisation process brought about by the Industrial Revolution. This raw material is the cause and consequence of the Industrial Revolution. On the one hand, rubber partly explains the Industrial Revolution insofar as more efficient steam engines would hardly have been devised without rubber seals. Improved long-distance communication would not have developed without rubber being applied for wire cladding, especially in submarine telegraphy. Some areas would have never thrived as markets for manufactures without the economic development and wealth brought about by rubber production. On the other hand, rubber is definitely a consequence of the Industrial Revolution as it is the result of developments in chemistry: only after a solution had been found to chemically stabilise this raw material, crude rubber became impervious to the weather, greatly expanding its industrial applications. Improvements in communication and shipping connected the producing areas with the main markets and the influx of people and capital boosted rubber production.

Developments in rubber trade have certainly mimicked the evolution of trade worldwide. Initially, the main rubber producing region, the Brazilian Amazon, was as far from Europe and the USA as it was from the Brazilian capital, Rio de Janeiro. This meant trade was a very costly, if not prohibitive, enterprise. However, due to developments in transportation, especially after the advent of steamships, distances (measured in terms of travel time) shrank by one-third and freight prices fell significantly as a proportion of the price of rubber. Communication between the Amazon and the rest of the world became more reliable and faster after the submarine telegraphic network was expanded up to Manaus city, located some 1,000 miles upriver, in the middle of the Amazon forest.

For the Brazilian Amazon, rubber production was fostered by forces that pushed the region towards integration into a wider economic domain. Initial demographic, geographic and economic conditions suggested that it was very unlikely that the region would have developed on its own, without an external impulse. Despite occupying over a third of South America its population amounted to only some 200,000 souls in 1850, less than 3% of Brazilian population (See Appendix). This population was completely isolated as their only connection with the rest of the country was by coastal shipping. Institutionally, the region stood closed to navigation of foreign flags and there was no regular steamship line connecting the port of Belém to other major ports in Brazil. Moreover, initially the region had very little to offer and thus no economic dynamism.

Rubber changed this state of affairs. From the 1860s onwards, rubber exports from Pará rapidly exploded and this raw material became the second most important article of trade for Brazil, ranking just below coffee. According to official statistics (see Appendix), rubber exports were more than 16% of total Brazilian exports at the turn of the century and a quarter of total exports in 1910. Due to this rubber trade, despite high mortality rates, population increased six-fold from 1850 to 1910 whereas real income per capita increased 4-fold in the same period (see Appendix). As will be shown in this thesis, steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported even further the development of (steam) navigation and the telegraphic system. Communication and steam navigation generated some integration, and the consequent movement of people (and other factors of production) and flow of information, created the conditions for further development of the rubber boom by supporting a virtuous cycle that completely changed the economic, political and social structures of the Brazilian Amazon.

These transformations were shaped by the pre-existing, but ever-evolving, institutional setting: even though the rubber economy can be seen as an inter-dependent microcosm in the world economy, its evolution was peculiar in several ways due to institutions. Societies have different technological (e.g. geographical location, useful knowledge, capital stock, etc.) and non-technological (law and enforcement methods, ways of allocating property rights, levels of corruption, and trust) features.[2] These non-technological features are generally called institutions which are understood here as the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction. They reduce uncertainty by providing structure to everyday life, defining and limiting the set of choices of individuals. Macroeconomically, they affect decisions about work, saving, investment, innovation, production and exchange and as

[2] Greif (2006, p. 5).

such have a significant impact on economic outcomes.[3] This is especially true when the social and economic structures experience a sudden change due to exogenous and endogenous factors as it was the case of the Brazilian Amazon. Indeed, the decline in rubber production was even faster than its meteoric rise: from 1910 onwards Southeast Asian rubber plantations displaced Brazilian wild producers from the market. The Brazilian Amazon lost its near monopolistic position that it had held since the 1870s.

Geography was another important aspect of the rubber boom in the Brazilian Amazon. Rubber production was originally confined to the region around Belém. Due to the density of the Amazon Forest and the sheer size of the territory, rivers were the main arteries for transportation. The development of rubber production thus followed the contours of the Amazon River and its main tributaries. It spread westwards in the direction of Manaus located some 1,000 miles upriver. In 1870, Manaus was only a small village whose growth would depend entirely on rubber production. The city eventually became the second most important rubber hub, rivalling Belém's long-established position in the rubber trade. Even though the rivers provided access to nearly all areas of the Brazilian Amazon (See Figure I.1 below)[4], production expanded mostly southwards due to the availability of *hevea brasiliensis* trees. As Chapter 3 will show, this tree provided the best rubber grade and tappers were continuously looking for *hevea* growing areas. In this search, Brazilian production would eventually cross national borders towards the Acre region which, until 1903, was *de jure* part of Bolivia. The region would be ultimately annexed into the Brazilian Federation as a consequence of the rubber boom.

[3] North (1990).
[4] Not all rivers were entirely navigable though. Sometimes they were too shallow for large vessels or they just had downfalls and rapids. However, even still, most of them were accessible by canoes.

Figure I.1: Main Occurrence of Hevea Brasiliensis Trees in the Brazilian Amazon

Source: Elaborated by me. Shade areas indicate main areas of occurrence of *hevea brasiliensis* trees within the Brazilian Amazon. The map is indicative only and do not intend to show precise areas of hevea concentration.

Rubber trees were seldom found in large concentrations, and 'rubber estates' generally spanned a large area.[5] The area was usually accessible by a river and production was extremely labour-intensive. Rubber extraction technique varied according to the type of tree. In the case of trees from the *hevea* genus, predominantly found in the Brazilian Amazon (in the shaded area in Figure I.1 above), the rubber tapper normally worked in two trails, each one on an alternate day to allow the trees to recover. The tapper would normally make two rounds. During the first, in the very early morning (around 3-4 am), he made some wounds in the tree with a small machete, fixing a cup to the tree an inch below the incision for the milky juice to flow into it. Then in the second

[5] Over time large rubber estates became more and more common. However, especially in the older producing areas closer to Belém, several small rubber estates continued to produce rubber throughout the rubber boom. See Weinstein (1983, pp. 170-180).

round, the latex was collected from the cups, poured into a bucket and carried back to his hut. He then ignited a buyon with a fire fuelled by palm nuts from whose top opening the smoke would normally come through. When the buyon attained a certain specific degree of heat, the tapper took up the bucket with the milk and removed it to the *defumador* which was a small room used for smoking the rubber, completely closed so that the wind could not interfere with the operation of curing. Curing, in turn, consisted in pouring the milk into a mould and then turning it round over the opening at the top of the buyon until the milk dried. The same operation was repeated until the milk was exhausted or the ball of solid rubber attained the desired size (normally not exceeding 50 lb.).[6]

H. Brasiliensis was the type of *hevea* mostly sought. It registered three varieties, namely: black, white and red. From the black hevea the finest rubber was prepared and its best quality was classified as 'Fina Hard Pará' whilst its lower grade was denominated as 'Entre Fina'. The rubber produced from the white hevea was designated locally as weak, of which the best grades were called 'Fraca Fina'. Crude rubber production methods hardly changed over the period 1870-1910.[7] The production entailed a very harsh life, and the death toll was very high indeed. According to Woodroffe,

> *"(...) the seringueiro* [rubber tapper] *can only work during the summer or dry months, and this is precisely when the forests are unhealthy, and during this period the mortality among the seringueiros is enormous, due, among others, to the following causes:*
>
> *(1) Paludic fevers and other diseases which have their origin in the damp heat and rotting vegetation.*
>
> *(2) Beri-Beri, consumption, and diseases caused by chills acquired while working in the swampy seringals, through eating unhealthy food, the lack of hygienic air, and the insanitary surroundings generally.*

[6] Woodroffe (1916, pp. 41-44).
[7] Akers (1912, pp. 3-4).

(3) Chest diseases owing to the damp and aggravated by the inhalation of the dense smoke by which the rubber is cured.

(4) The presence of decaying vegetable and animal matter in the water which the seringueiro uses for his cooking and drinking purposes.

(5) The weakened and impoverished state of his system owing to bad food and want of attention to even the most elementary laws of hygiene, and a variety of diseases peculiar to individuals."[8]

This development of the rubber boom in the Amazon is shrouded by myths and legends that reflect the high profits accrued in a region that was considered by most, a pre-capitalist society. In this context, Manaus Opera House is paradigmatic: the building is a monument to rubber bonanza. Inaugurated in December 1896, it is still preserved in its original style: eclectic and neo-classic architecture built with materials and a labour force brought from Europe. In Belém, the main rubber hub, another sumptuous theatre had been built from rubber proceeds some years earlier, the Theatro da Paz (Theatre of Peace). During the rubber boom, it was said that Manaus diamond consumption per capita was the largest in the world, men walked with canes topped in gold and silver, children went to school in Paris or Lausanne and almost 2,500 inhabitants took first-class tickets to Europe every year. Houses were decorated in Parisien style where "pre-dinner drinks were usually sipped from silver champagne goblets set on Carrara marble-topped tables with bases of solid gold".[9] In addition, it was also said that Havana cigars were lit with bank notes of 500 *milréis* (equivalent to 20 pounds at the 1900 exchange rate) and that every toothache was treated in Europe.[10] Exaggeration or not, these descriptions of the rubber boom reflect the rapid wealth that flowed to the region from 1870 to 1910, capturing the imagination of many people around the world and fuelling immigration. Droughts in northeast Brazil contributed for the push of immigrants, especially *cearenses*

[8] Woodroffe (1916, pp. 99-100).
[9] Collier (1968, p. 22).
[10] Prado and Capelato (1975, p. 300).

(from Ceará State), who worked as rubber tappers but stories about the Amazon black gold, as rubber was nicknamed, also attracted foreign fortune seekers.

The whole story was not so bright though as there were several accusations of labour exploitation in Brazil and elsewhere. The most infamous case of labour exploitation was unveiled by Sir Roger Casement who brought to light the atrocities commited by the Abir Co. in the Belgium Congo. According to Casement,

> *"A careful investigation of the conditions of native life around the Lake* [Mantumba] *confirmed the truth of the statements made to me – that the great decrease in population, the dirty and ill-kept towns, and the complete absence of goats, sheeps or fowls – once very plentiful in this country – were to be attributed above all else to the continued effort made during many years to compel the natives to work india-rubber. Large bodies of native troops have been quartered in the district, and the punitive measures undertaken to this end had endured a considerable period. During the course of these operations there had been much loss of life, accompanied, I fear, by a somewhat mutilation of the dead, as proof that the soldiers had done their duty".* [11]

The Abir Co. had been incorporated in 1892, being granted exclusive rights to exploit all the products in a given area of the Belgium Congo for thirty years. Rubber was the chief product exported by the company and the people of the area were to collect wild rubber for the company in lieu of paying taxes to the State. Collection was enforced by giving the company rights of police. In return, Abir Co. gave the State half the shares and agreed to recruit soldiers and workers for the State.[12] The company was very successful in exploiting its concession and by 1900, Abir dividends, duties and taxes accounted for

[11] *Correspondence and Report from His Majesty's Consul at Boma respecting the Administration of the Independent State of the Congo. No. 1 (Africa: Congo: Correspondence, pp. 247-248).*
[12] Harms (1975, p. 78).

10% of overall Belgium State revenues and three years later, the company alone exported nearly a thousand tons of rubber.[13]

Congo's atrocities would haunt rubber companies ever since. Casement himself would be at the centre of another furry of scandals relating to abuses in crude rubber production, this time in the Putumayo region. The Putumayo region is located at the borders of Colombia, Peru and Brazil, where the institutional frontier remained in dispute. Although atrocities against Putumayan Indians had been denounced by Colombian, Ecuadorian, Peruvian and US officials[14], the case only aroused public attention thanks to E. Hardenburg, who gathered evidence while in Peru. The 'civilised' public was then told that Indians were constantly beaten, enslaved, mutilated, tortured and slaughtered in order to placate Julio Cezar Arana's greed for rubber.[15] Arana was one of the largest rubber producers in the world who had reorganised his company in London as the Peruvian Amazon Co. (PAC) in 1907[16]. His alleged control of the Putumayo region was the result of the closure of entire rivers to navigation that created *de facto* private police control over large traces of land. Since the company was a British concern and involved crimes committed by and against colonial nationals (mainly Barbadians), the British Foreign Office decided to verify the claims. Due to his previous work on the Congo, Casement, who was by then Consul-General in Rio de Janeiro, was summoned to proceed to the Putumayo region and gather evidence on these supposed atrocities. His conclusions were mainly based on the direct testimony of Barbados men in the PAC's service. Casement claimed that,

> *"There was, moreover, the evidence of our own eyes and senses, for the Indians almost everywhere bore evidence of being flogged, in many*

[13] Harms (1975, p. 81).
[14] Stanfield (1998, pp. 133-138).
[15] Hardenburg (1913). His tales were actually published in a series of articles at the *Truth* in 1909 and only some years later transformed into a book. The cited book contains an account of the Putumayo region as well as translations from Peruvian newspapers at Iquitos and statements of Peruvians that allegedly confirm the atrocities. Additionally, in order to provide further evidence to his allegations, the book reprints Casement's report.
[16] Chapter 3 provides more detail on Arana's businesses. Furthermore, the Appendix shows some data for his English concern, the Peruvian Amazon Co.

cases of being brutally flogged, and the marks of the lash were not confined to men nor adults. Women, and even little children, were more than once found, their limbs scarred with weals left by the thong of twisted tapir-hide, which is the chief implement used for coercing and terrorising the native population of the region traversed.

The crimes charged against many men now in the employ of the Peruvian Amazon Company are of the most atrocious kind, including murder, violation, and constant flogging.

The condition of things revealed is entirely disgraceful, and fully warrants the worst charges brought against the agents of the Peruvian Amazon Company and its methods of administration in the Putumayo."[17]

There are indications that Casement's Report may have been somewhat biased[18] and the report neglects Indian traditions.[19] The full analysis of the Putumayo scandal is outside the scope of this thesis though and there is an extensive literature dealing with it.[20] What is more relevant for the thesis is to understand how violence in the Putumayo was assumed to apply to rubber production everywhere, including Brazil. For instance, the idea that the violence perpetrated in the Putumayo was necessarily found in other areas of the Amazon was indeed stated in another report of the British Foreign Office:

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[17] *Correspondence relating to the treatment of British Colonial subjects and native Indians employed in the collection of rubber in the Putumayo District, including Sir Roger Casement's Report. (Miscellaneous Papers n. 8, 1912: Putumayo, p. 2).*

[18] Despite the fact that Joseph Froude Woodroffe had been employed by the PAC during the period in which these crimes were supposedly committed, he made no mention to them in his 1914 book. The most 'outrage' violence that appeared in his book relates to an account of a rubber tapper who told him he had been eunuchised by Indians. See Woodroffe (1914, p. 58). See also Stanfield (1998, pp. 131-178).

[19] According to Stanfield (1998), Some of the abuses Casement portrays are just a reflection of customary behave of native peoples there. Also, Casement takes Barbadian's reports at face value as if he had pre-decided the source of wrongdoing. As usual by then, he shows prejudice against Peruvians (and other South American nationalities there).

[20] For instance, see Hardenburg (1913), Collier (1968), Stanfield (1998), Serier (2000), and Lagos (2005). See also Peruvian Rubber and International Politics, *American Review of Reviews*, 1912.

"But in the course of Inquiry your Committee have been impressed with the fact that ill-treatment of the Indians is not confined to the Putumayo. It appears, rather, that the Putumayo case is but a shockingly bad instance of conditions of treatment that are liable to be found over a wide area in South America. No doubt there are special features peculiar to the Putumayo problem, such as the dispute over the territorial sovereignty, which would not occur elsewhere. But the spirit of the 'conquistador' appears to be at work on other rivers. (...) It may be hoped that these depths of brutality are unparaleled elsewhere. But your Committee regret that they are unable to regard the ill-treatment of the Indians, of which the Putumayo case is an abominable instance, as an isolated phenomenon."[21]

Although the report makes no direct mention to Brazil, it speculates that similar violence may have been practiced there. British Diplomatic and Consular Reports do not show any evidence that violence was widespread in Brazil though. True, British diplomats had complained about mortality rates among rubber tappers, but the blame was invariably imposed on the Nature. For instance, in 1908 Roger Casement had decried about the lack of education and sanitary conditions in the Brazilian Amazon making him to ask himself: "(...) it may be questioned whether the universal subjection of this population to the spell of rubber production is altogether good for the people or the future of their country"[22]. Some criticism surfaced later on as expressed by Consul G.B. Mitchell in 1914:

"Travellers arriving from the Acre report the acutest distress among the seringueiros [rubber tappers] *of the territory. Many of those in the remoter parts are described as absolutely starving, and deaths from*

[21] *Report and Special Report from the Committee on Putumayo, together with the Proceedings of the Committee, Minutes of Evidence and Appendices. Ordered by the House of Commons, 5th June 1913.*
[22] *Brazil. Report for the Year 1907 and previous years on the trade of the consular district of Pará. N. 4111 (Annual Series), p. 22.*

starvation have already been denounced. This is largely due to the impoverished condition of the rubber merchants, estate owners, and aviadors [intermediaries], *who have been unable to furnish the usual supplies".*[23]

When this report was written, a final blow to Brazilian Amazon rubber production had long been laid as its production had been displaced by East-Asian plantation rubber after 1910. As rubber prices had plummeted and the region was facing an unprecedented crisis, Consul Mitchell's criticisms were directed to starvation, apparently caused by the general state of crisis. If such event were common during the boom years, these reports from the Acre region might not have captured his attention in 1913 only. British Consular Reports for the Brazilian Amazon have never claimed that violence was the typical way of enforcing rubber production. Nonetheless, the literature on the Brazilian rubber boom evolved around the topic of exploitation. A very recent work summarises this idea:

"Those considered lazy were corrected, first through debt and diplomacy, later, as huge sums of money flowed unchecked, through intimidation, beatings, enslavement, and torture".[24]

However, physical punishment seldom appears in contemporary descriptions. For instance, Yungjohann's accounts of his experience as a rubber tapper do not contain a single episode in which he suffered physical punishment. Perhaps this is due to the fact that he was a successful tapper otherwise his accounts would have never reached us. The only instance in which he refers to physical punishment in the area refers to Indians being enslaved by Peruvians[25] and punishment for theft[26]. Furthermore, when he decided to leave the area, he did not face any physical threat even though in the end he was

[23] *Brazil. Report for the Years 1910-12 and part of 1913 on the trade Pará. N. 5262 (Annual Series), p. 15.*
[24] Jackson (2008, p. 114).
[25] Yungjohann (1989, p. 50).
[26] Yungjohann (1989, p. 73).

amicably persuaded to stay for another season.[27] In one occasion, rubber agents unsuccessfully tried to cheat him but, according to his accounts, he relied on other tappers to prevent it from happening.[28]

Therefore, despite some claims of cruelty, contemporary accounts only stressed the extreme <u>economic</u> exploitation of rubber tappers and denounced the credit channel as exploitative. For instance, in 1854 Sebastião do Rego Barros, president of Pará Province, stated that

> *"(...)*
>
> *this difference* [he referred to the trade balance surplus, highlighting that imports had doubled whereas exports had quadrupled from 1851-52 to 1853-54] *is the result of higher consumption of imported goods, the extremely high price of rubber and, consequently, the employment of almost every men into rubber extraction and production which impels us to buy first necessity goods, which we had produced once, from other Provinces. This is certainly bad since the high profits of rubber industry, which absorbs and annihilates every other industry, do not lead to wealth distribution and establishment of small properties with their advantages and stability but rather to wealth accumulation in the hands of a few, mainly foreigners. <u>This scenario results in poverty for the mass population who abandoned their homes, small stores and maybe families in order to devote themselves to an uncertain and harsh life in which profits evaporates rapidly</u>."*[29]

Another president of Pará Province, Francisco Carlos de Araújo Brusque, echoed Barros's view in 1862:

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[27] Yungjohann (1989, pp. 74-75).
[28] Yungjohann (1989, pp. 77-78).
[29] *Barros, S. R. "Falla que o exm. snr. conselheiro Sebastião do Rego Barros, prezidente desta provincia, dirigiu á Assemblea Legislativa provincial na abertura da mesma Assemblea no dia 15 de agosto de 1854." edited by Pará: Typ. da Aurora Paraense, 1854, pp. 9-10 (underlined by me).*

"[Rubber industry] *is the most important element of our actual wealth, but this should not be mistaken, it is wealth for a few since it pours misfortune and poverty into the heart of those employed in its extraction and production.*

(...)

On these remote areas, and over marshy terrains, where hevea grows, <u>rubber tappers will construct their huts where they will live many months under deadly influences, without the necessary resources for a proper subsistence and generally fatigued</u>.

(...)

The men who work [in the rubber industry] *are represented as inert quantities, or figures at the end of a column that can be summed up, as if the mankind were a company where the worker plays the role of a machine where everything can be represented as profits or losses, forgetting that those quantities are persons and the arithmetic figures are lives; morality of human beings guided by God to the same destiny to which we aspire."*[30]

Rego Barros' and Araújo Brusque's complaints were made very early in the Rubber boom and they most certainly voiced the fear and opposition against rubber production stemming from part of the old Amazonian elite who based their wealth in agriculture, cattle or other traditional activity of the region. The opposition eventually fade as most of the old elite were integrated into rubber production or profited indirectly from it. However, the organisation of crude rubber production in the Brazilian Amazon continued to be denounced. For instance, Euclides da Cunha stated that

[30] *Brusque, F. C. A. "Relatorio apresentado á Assembléa Legislativa da provincia do Pará na primeira sessão da XIII legislatura pelo exm.o senr. presidente da provincia, dr. Francisco Carlos de Araujo Brusque em 1.o de setembro de 1862." edited by Pará: Typ. de Frederico Carlos Rhossard, 1862, pp. 47-48 (underlined by me).*

"(...)

the men, once having walked through the two doors that lead to the diabolic paradise of rubber estates, give away their best inherent qualities and kill themselves instantaneously. They laugh with that formidable irony. It is indeed at the exuberant landscapes of heveas and catilloas where the most criminal labour organisation that could be imagined by the most revolting selfishness awaits him. In fact, the rubber tapper (...) performs an abnormal task: he is a man who works for enslaving himself."[31]

Euclides da Cunha certainly wanted to capture the attention of his readers and he may then have exaggerated what he actually witnessed in the Brazilian Amazon. Nonetheless, whatever agenda these contemporaries may have had, it is very unlikely that they all made up their stories. Economic exploitation did happen but violence was not as typical as it is sometimes claimed. For instance Akers stated that,

"(...)

For the many thousands of labourers annually brought to the rubber properties, a certain percentage remain permanently on the estates, partly because they find themselves heavily in debt to their employer, and frequently for the lack of funds to pay for a return passage to their homes. As a general rule the men are well treated so far as personal relations between master and man are concerned, and the fact that they are charged abnormally high prices for the provisions and merchandise they purchase from the estate store carries very little weight with them, provided they are allowed to obtain what they desire without any restriction of credit."[32]

[31] Santos (1980, p. 167), originally from Euclides da Cunha.
[32] Akers (1912, pp. 54-55), underlined by me.

Price differential between goods in the rubber estate and in the main cities were the main instruments used by the literature to show economic exploitation.[33] Moreover, the debate about the economic exploitation of rubber tappers was extended to other links in the rubber chain, creating the view of an exploitative channel in which the export houses, sitting at the top of the chain, were absorbing most of the profits from rubber production. The credit channel (called *aviamento*) was criticised by contemporaries such as Woodroffe. For him, the aviamento credit system entailed exploitation at each layer of the rubber chain,

> *"(...)*
> *nearly the whole of the Amazon seringals* [rubber estates] *are mortgaged to commercial houses in Manáos, Pará, and the smaller towns, the proprietor relying upon the mortgages for his merchandise and, as a rule, binding them down to deliver to him alone. The whole organisation reminds me one of the saying that the biggest fishes eat the bigger ones, who in their turn, prey on the little ones, whilst these, the little fish, eat mud."*[34]

British Consuls also denounced the aviamento credit chain, as Mr. Cheetham did in 1909:

> *"(...)*
> *The whole of this valuable trade is gathered in the first place by a handful of illiterate, untrained men who, taking their lives in their hands, enter the vast uncultivated wilderness of the upper Amazon and on behalf of distant aviadores* [intermediaries] *and nominal forest owners, tap the trees and*

[33] See for instance Santos (1980, pp. 166-171).
[34] Woodroffe (1916, p. 48).

smoke the rubber that later figures as the second asset in Brazilian commercial and financial prosperity.

Deprived of her rubber, Brazil would lose one-third of her purchasing capacity.

Yet, although the source of so large a part of her national income, Brazil as a whole does nothing for her rubber producers, and these, in equal disregard of great responsibilities, do little or nothing for their rubber trees."[35]

Contemporary descriptions such as these could be tediously repeated. What is important is to understand how these descriptions shaped the way researchers later perceived the rubber boom. Some authors indeed followed this exploitative line of argument to construct a Marxist/Dependentist view of the rubber boom in the Brazilian Amazon.[36] Their views can be summarised in the following way. Debt-peonage, bondage, semi-serfdom or indenture system was at the heart of rubber production in the Brazilian Amazon since it developed as the commonest outcome of migration to the Amazon. The underlying idea was that in order to move, the labourer indebt himself and, once having arrived at the rubber estate, was exploited. In a Marxist perspective, rubber labourers were generally described as comprised of a mass of dehumanised and defenceless men who were exploited by cruel and greedy capitalists due to the latter's monopoly over the means of production (rubber fields and tools). In turn, rubber estate owners were also usually taken as having power to enforce the so-called 'Rules of the Rubber Fields' which dictated that fugitive labourers would be returned to their original rubber fields. Since the labourer was inside the forest and worked alone, escape was normally a difficult enterprise since there were not many alternatives left. If the conditions prevailing in the forest were not sufficient to entice labourers to work, rubber estate owners could resort to physical punishment, or so the literature argued.

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[35] *Brazil. Report for the Year 1908 on the Trade of Brazil. N. 4358 (Annual Series), pp. 24-25.*

[36] Ferreira Reis (1953), Prado and Capelato (1975), Santos (1980) and Bunker (1985).

Violence was at least assumed as a latent threat that shaped labour relations during the Brazilian rubber boom, creating a Marxist account of the rubber boom. Because land was supposedly free, labour had to be controlled or coerced. This Marxist account of the rubber boom was extended to the other links of the rubber chain providing the basis of a dependentist view of rubber production in the Brazilian Amazon. The credit channel was organised in a vertical way, in which every node was exploiting the node immediately beneath it. In this view, rubber production was the outcome of several successive exploitative relations along the rubber chain in which most of the surplus was drained by [foreign] export houses. Monopoly of capital was the mechanism that provided the rationale for such exploitative system.

Weinstein offers probably the first revisionist account of the debt-peonage system.[37] She argued that rubber tapper's resistance rather than coercion conditioned the nature and durability of social relations.[38] Weinstein argued that at least in downriver rubber estates 'the Rules of the Rubber Fields' were a dead letter. First, the extracted rubber was, by law and all practically, the property of the rubber tapper and not of the estate owner who held the land and the trees and then there was no monopoly over the means of production.[39] Secondly, the high cost of monitoring the rubber tapper strictly limited the degree to which the rubber estate owner could effectively control their workers and curb illicit rubber sales. A durable alliance was thereby formed between rubber tappers and rubber estate owners, based on interlocking self-interest – the rubber estate owner's need to control the exchange and the tapper's preference for autonomy – that

[37] Weinstein (1983) and (1986).

[38] Weinstein's revision is in line with the literature on slave economic rationality which argues that even slaves had some room for manoeuvre and used resistance as a means of enforcing their bargain power. In this regard, amongst others, see Genovese (1976) and Barzel (1977) for analysis on US slaves, Blanchard (1992) for Peru and Toplin (1969) for an analysis of slavery in São Paulo (Brazil). Moreover, Engerman (1992) provides a very broad view of the implications of differing forms of property rights in people.

[39] Weinstein seemed to be very influenced by Akers (1912) account of the rubber boom. In regard to Weinstein's assumption of relatively labour freedom, Akers (1912, p. 55) says that

> *"So long as a collector delivers a fair weight of rubber during the month, there is practically no interference with his mode of life, and he can and does, take holidays whenever he is so inclined, without asking the consent of the employer".*

Such depiction of the freedom of the rubber tapper is confirmed by Yungjohann (1989) accounts.

effectively frustrated local and foreign pressures for rationalising rubber extraction and trade.[40]

Bentes, in turn, advances that the rubber estate owners commanded the process of rubber production and owned the best and most profitable rubber fields but work relations were not defined by indebtedness. From the accounts of a rubber estate located in the Acre region, she shows that the estate owners used several different incentives such as bonuses, discounts and gratifications to ensure production and not necessarily violence.[41]

Another revisionist approach is that of Barham and Coomes who aimed at conforming labour relation system into the Institutional framework. Even though they deny Weinstein's assumption that rubber tappers necessarily preferred autonomy, they support her main findings while offering some new evidence. Their main contribution lies upon the role of risk[42] by arguing that labour arrangements depended upon the following factors: endowments, motivations and alternative opportunities open to rubber workers (which will ultimately define opportunity costs), the property relations under which they worked, and the type of rubber collected. Distinct labour arrangements were associated particularly with the type of rubber extracted and on *hevea* estates, the scarcity of labour and market features of risk and transaction costs provided strong incentives for rubber tappers and

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[40] Such opinion had actually been voiced by Akers (1912). Indeed, Weinstein work seem to be too much influenced by Akers' accounts of the rubber boom. Several of her main qualifications of the literature can be found in Akers. For instance, Akers (1912, p. 76) states that rubber tappers prized their independence. At page 56, Akers discusses the idea similar to Weinstein's assumption of durable alliance:

> *"Once the allotment of estradas* [trails connecting several rubber trees inside the forest] *is made, the collector becomes a temporary partner with the owners; for he is paid by a percentage of the rubber collected, and this is fixed in most districts at one-half the rubber collected."*

On page 57, he discusses monitoring:

> *"Supervision of the work of collectors in the estradas and in the preparation of the rubber is delegated to fiscales, or foremen. As a general rule these men perform their duties in a most incompetent and perfunctory manner, and it is the exception to find a man who is willing to make any real effort to protect the interests of his employer"* (p. 57)

[41] Bentes (1999, pp. 143-180).

[42] It is true that Weinstein (1983) also highlighted the role of risk, but this was of a secondary importance to explain the durable alliance between tappers and estate owners.

rubber estate owners to develop a durable relationship. For rubber estate owners, stable tappers would tap *heveas* with greater care (increasing future productivity of *hevea* trees) and would be a source of diminishing transaction costs (monitoring and recruitment costs would fall)[43]. Tappers, in turn, would also seek a stable relationship in order to guarantee access to more productive trails and as a way of obtaining some form of insurance against the risk of the environment.

Therefore, Barham and Coomes rely on transaction costs to account for the establishment of a durable relationship between tappers and rubber estate owners in lieu of Weinstein's assumption of tappers' preference for autonomy. Moreover, for Barham and Coomes, high premia over foodstuffs (see Chapter 6) could be explained by the high risk involved in the enterprise and should be regarded as normal remuneration of capital due to high risks entailed by rubber gathering.

The aim of the thesis is exactly to further deconstruct these Marxist/Dependentist views about the rubber boom in the Brazilian Amazon (as well as analyse some of the few revisionist ones) through an analysis that encompasses the whole rubber chain: from producers to consumers. The thesis analyses the conditions under which production could have been enforced without violence. It will also show that these conditions were more prevalent than previously assumed by the literature, as it is argued here that the role of inelasticity of demand had been so far completely neglected. Yet it is central to understand the rubber chain. Under high inelasticity of demand, all factors could have been properly remunerated and production could be enforced via market institutions. Moreover, high inelasticity of demand is in itself a reflection that the Marxist/Dependentist view was wrong: developments in crude rubber production were actually driving and shaping the manufacturing node, rather than the other way around. Finally, inelastic demand allowed the government to heavily tax rubber exports, increasing the Amazonian welfare without causing immiserising growth. A significant surplus was being retained by the government who redistributed it back to the region in form of subsidies and public

[43] Barham and Coomes (1996, p. 62) also accounted for less moral hazard problems and higher personal security for the rubber estate owner.

goods. The thesis combines qualitative and quantitative evidence under a new theoretical framework that asks whether a better explanation can be provided by examining how institutions and geography influenced the development of the rubber chain in the Brazilian Amazon from 1870 to 1910. By doing so, some theoretical contributions will additionally be made, especially in regard to the comodity chain framework.

Even though the thesis analyses the entire rubber chain, it does not follow the so-called Global Commodity Chain approach (GCC). Thus, Chapter 1 explains that the GCC approach is an extension of Wallerstein's word-system theory and as such it assumes that trade is embedded in, instead of being determined by the optimising behaviour of rational economic agents. Under the GCC, the global market is an uneven playing field, underscored by the existing hierarchy between core and periphery areas that translates into a pre-defined relation of power between nodes of the chain located in these two areas. As some subsequent works had done, the thesis rejects the centre-periphery assumption of the GCC and by consequence it also rejects the world-system theory altogether: here, the historical context shapes and influences the evolution of the commodity chain. Furthermore, the thesis uses an innovative game theoretical framework to analyse power relations between nodes of the chain which are further constrained by institutions. Finally, quantitative exercises complement the theoretical and historical aspects of the analysis.

The next chapters follow the organisation of the rubber chain and the methodology developed in Chapter 1. Chapter 2 deals with the manufacturing side, emphasising how production of rubber manufactures took place in an environment of great scarcity of crude rubber. Chapter 3 analyses the rubber trade, spanning the largest crude rubber producing areas in the world from 1870 to 1910: the idea is to survey the rubber trade in conjunction with investment and finance. Chapter 4 looks in more depth at the main crude rubber supplier, the Brazilian Amazon, which was responsible for around 60% of world supply in this period. The chapter provides a game theoretical framework that improves the understanding of the interactions between the main nodes of the rubber chain by highlighting the role of agents' horizon of planning, reward from cheating, expected income from an alternative employment and the implicit and explicit prices paid for rubber produced. This chapter thus shows that production could have been enforced without necessarily resorting to punishment or debt-peonage, a clear contradiction to the Marxist/Dependentist literature. However, in order to fully understand crude rubber production in the Brazilian Amazon, it is imperative to understand the role of the government. Chapter 5 then analyses the impact of government intervention in the market, showing that, contrary to contemporaries and to the subsequent literature, government intervention was positive for the Amazon region although not positive for everyone involved in the rubber trade. However, domestic losers could have been compensated and the government would still have generated a welfare gain for the region and a profit for itself. Actually, it could have even doubled the actual welfare gain it generated from 1870 to 1910, had it increased the export tariff up to the optimum level. True, part of the rubber proceedings were already being reinvested back into the Amazonian economy in the form of subsides to strategic sectors. The main recipients of state aid were probably the shipping companies which performed an important task in the Amazonian economy: given the natural environment and the size of the region, production had to be channelled through the Amazon River. Speed and reliability were fundamental to ensure production and profits: backed by the government, steamships rapidly displaced canoes from the rubber trade. Information was also crucial providing incentives for the development of a telegraphic network. These two communication systems and their relationship are analysed in Chapter 6, showing how important they were for the development of the rubber boom in the Brazilian Amazon. Finally, conclusions are provided and some speculations advanced. The idea is not only to point to future research on the Amazonian rubber boom but also to understand how this case study helps us understand a broader picture: globalisation and trade in the *belle-époque*.

Since the thesis spans a long period (1870-1910) and several different places, it required comprehensive and extensive sources of qualitative and quantitative materials that were gathered in several libraries: London School of Economics Library, British Library, University of London Library, Guildhall Library, Bank of England Library, Public Record Office at Kew and UCL library, Porthcurno Telegraph Museum, Brazilian National

Library, *Ministério da Fazenda* Library (in Rio de Janeiro), PUC-Rio Library, Pará Public Archives and Arthur Vianna Library. Qualitatively, there are several manuscripts that referred mostly to companies that operated in the Amazon region. From these data it was possible to obtain valuable information about their businesses in Pará, Amazonas (States/Provinces) and Acre Territory. From their activities, it was also possible to validate (or not) any inferences about the state of affairs in the rubber trade as their operations were invariably connected with rubber or at least indirectly influenced by it. Electoral registers are also a very useful resource as they generally recorded the name of the voter, his address, occupation and annual income. With this information in hand it would have been possible to track changes in income and in the wage level. However, it was not possible to find a comprehensive set of voting lists (only two lists for Bragança city) and thus they were only used in a qualitatively way. Real income of a rubber tapper was then compared to the income declared by a urban worker in these voting lists.

Official publications were another important source of information. Speeches, Communications, Annual State and Provincial Reports as well as Extraordinary Reports are all available online at the 'Brazilian Government Document Digitalization Project'. There are reports for both Amazonas and Pará (States/Provinces) as well as for the Federal government and its several ministries. These reports were complemented with several others found in Belém and Rio de Janeiro, produced by the myriad of secretariats of the Governments of Pará and Amazonas. Altogether they give a sense of the state of affairs of the government besides possessing valuable information on social conditions, the organisation of the rubber trade, companies operating in the area, relationship with foreign companies and individuals, relationship with the Central Government, and etc. British Consular reports (for Pará, Amazonas, Maranhão and Rio de Janeiro) were also instrumental as, on top of statistics for the region, they further provided to a certain extent a view from the outside.

Pictures of the region during the rubber boom were also found in several albums that were published by the government, firms or individuals from 1870 to 1910. They show boats and their description, rubber estates and their labourers, Belém, Manaus and several other smaller cities, commercial establishments, etc. This iconographic set is extremely important for historians of the region but it also provides the economic historian a more concrete sense of the economic and social transformations embodied in the rubber boom. This sense is either validated or qualified by travellers' accounts too. Indeed, numerous books were published as a consequence of travels to the region. True, most of these accounts envisaged self-promotion and thus researchers need be very cautious in using them. Finally, it is important to mention the most recent literature on the history of the Amazon and on the economic history of rubber manufacturing in the USA and Europe. They often offer the starting point for the researcher and a sense of what still needs to be improved or complemented.

Quantitatively, it was necessary to estimate crude rubber demand and supply equations as well as welfare effects of tariffs which required data for prices and quantities of several crude rubber suppliers and the taxation levied upon the rubber trade in the Brazilian Amazon. Regional data on population, fiscal revenues, GDP, exports, imports, etc. was also required. Entirely new series for several of these variables were constructed, reconstructed or completed. Official regional statistical publications, *annuaires*[44] as well as national statistics and some databases compiled by other researchers or institutions were the starting point. Their figures were reviewed and checked against foreign statistics on rubber trade, travellers' accounts information and against the Annual Reports of the States/Provinces and data from the central government. For the purpose of this thesis, the rubber trade was actually reconstructed from scratch, out of data from the main importing countries (USA and Britain but also France) which are deemed more reliable than statistics generated by the Brazilian government. The thesis contains an Appendix that makes available most of the data produced or organised for the thesis. It also presents the econometric model used in Chapters 2 and 5.

Putting all these materials together and making sense of them represented the very first challenge of the thesis. From these materials and from the theoretical framework

[44] Actually only a few of them were produced during the rubber boom. In spite of the fact that they were called serial publications, only one or two statistical publications were in the end produced.

presented in Chapter 1, it will be possible to build a coherent and accurate account for the question of how institutions and geography influenced the development of the rubber chain in the Brazilian Amazon from 1870 to 1910. The thesis thus turns to this question in the following chapters.

1. Commodities and Trade

1.1 - Introduction

Standard trade theory gives two complementary explanations for patterns of trade whose predictions are based on general equilibrium analysis. Whereas the Ricardian model suggests that technological differences account for trade specialisation (and hence to a specific trade pattern), the Hecksher-Ohlin model focuses on endowments. However, these two models neglect other important features of trade. They did not formally model intertemporal decisions, tastes are assumed equal across countries, the size of the economies do not matter and geography only enters indirectly into the models. Some of these features need be relaxed and incorporated into a partial equilibrium framework that would be more suitable for the analysis of commodity chains. In this regard, the present chapter builds a theoretical framework to analyse rubber production and trade and its impacts on the demand and supply side. The departure point is the Ricardian and Hecksher-Ohlin models. The new framework will incorporate into these models investment, finance, or other relations between parties to trade. While some of the features of this new theoretical framework are derived from Wallerstein's world-system theory and Gereffi's Global Commodity Chain (GCC) approach, the thesis rejects their methodological foundations. Neoclassical economic reasoning and modern standard trade theory models are assumed throughout and the thesis follows what is called here 'the commodity chain approach' (in contrast with the GCC approach). It adds a more detailed discussion of the role of institutions and geography in the organisation and development of the chain combining it all with a more quantitative-driven analysis (that gives macroeconomic support to the analysis at the micro level). Based on this modified commodity chain approach, the thesis is organised according to interactions among the main nodes of the rubber chain and its ultimate goal is to investigate how institutions and geography can explain the development of the rubber chain in the Brazilian Amazon from 1870 to 1910 and, by so doing, some contributions to Institutional Economics are additionally made.

The chapter is organised in seven sections, including this introduction. Section 1.2 briefly describes some very basic trade models that highlight the main determinants of patterns of trade. It also shows the conditions for immiserising growth: even in simple trade models, growth might generate a worsening of national welfare. Section 1.3, in turn, shows how the Global Commodity Chain (GCC) approach departs from general trade theories to establish that patterns of trade are defined by political-economy forces based on the World-Systems theory, an extension of the dependency theory. Under this context, the GCC approach is shown to be a-historical and polarised, implying a specific power relation between core and peripheral areas. Section 1.4 examines how the GCC framework had been adapted to study commodities within a more detailed historical context, giving rise to the commodity chain approach. However, it is argued that this approach still lacks a more thorough grounding in Institutional Economics as well as a more quantitative background. As it is shown in Section 1.5, this is exactly what the present thesis does: it provides a general framework in which institutions, geography and econometrics are integrated into the analysis, generating new and powerful insights about the rubber chain. It further shows how the thesis is organised and how this approach generates a thread along the whole dissertation: the thesis organisation follows the interactions between nodes of the chain. Section 1.6 gives an inside look into one of the main contributions of the thesis, namely, institutions theory and geography. The section explains how this theory is applied into the specific context of the Brazilian Amazon. Finally, Section 1.7 concludes.

1.2 – Standard Trade Theory, Immiserising Growth and Geography[45]

In the most basic Ricardian trade model, the world is comprised of two countries, Home and Foreign. In autarky these countries produce two goods (wine and cloth) using a single factor of production (labour measured in hours of work). Since resources are limited, there are limits to what can be produced and the production trade-off may be summarised

[45] Unless otherwise specified this section is based on Krugman and Obstfeld (2006), Dixit and Norman (1980) and Obstfeld and Rogoff (1996).

by a production possibility frontier. The opportunity cost of, say, producing 1 additional unit of wine in terms of units of cloth is equal to the absolute value of the slope of the production possibility frontier. The production possibility frontier, however, only defines the different mixes of goods the economy can produce but in order to determine what the economy will actually produce it is necessary to look at prices, more specifically at relative prices. Let P_c and P_w be the prices of cloth and wine, respectively. If it takes a_{LC} person-hours to produce one unit of cloth (constant returns in the production), the value of what a worker can produce in an hour is equal to $\frac{P_C}{a_{LC}}$. Wages in the cloth sector will then be higher if $\frac{P_C}{P_W} > \frac{a_{LC}}{a_{LW}}$, and since everyone will prefer to work in the industry that offers the highest wage rate, the economy will specialise in cloth if $\frac{P_C}{P_W} > \frac{a_{LC}}{a_{LW}}$ and in wine if $\frac{P_C}{P_W} < \frac{a_{LC}}{a_{LW}}$. Only when $\frac{P_C}{P_W} = \frac{a_{LC}}{a_{LW}}$ will both goods be produced.

Therefore, in general terms, even under autarky, countries should specialise in the production of a certain good if the relative price of this good is higher than its opportunity cost: in the absence of trade, the relative price of one unit of cloth to one unit of wine would be determined by the relative unit labour requirements: $\frac{a_{LC}}{a_{LW}}$. Countries would then tend to specialise in the production of the good they have a comparative advantage, measured as productivity of one good over the other in the two countries. Nonetheless, if trade is allowed, countries would specialise in the production of goods for which they possess relative comparative advantage. For instance, if due to technology differences $\frac{a_{LC}}{a_{LW}} > \frac{a^*_{LC}}{a^*_{LW}}$ (where the superscript asterisk defines that they were measured to Foreign), the ratio of the labour required to produce one unit of cloth to that required to produce one unit of wine is higher in Home than in Foreign, Home is relatively more productive in the production of wine. Note that this conclusion was reached from comparative advantage that was measured not in absolute terms but in relative terms.

Remember that in the absence of trade, the relative price of one unit of cloth to one unit of wine would be determined by the relative unit labour requirements: $\frac{a_{LC}}{a_{LW}}$ for Home and $\frac{a^*_{LC}}{a^*_{LW}}$ for Foreign. If trade is allowed, the price will no longer be determined by domestic considerations only but rather by the interaction of domestic and foreign markets (under a general equilibrium framework): the relative price of goods after trade would be located between the pre-trade levels of Home and Foreign. In this context, the gains from trade are quite obvious since trade will allow the countries to specialise in the good they are relatively more productive thereby increasing the total amount of goods produced. Consequently, a higher consumption (ensuring a higher utility level if there is no satiation) is attained. According to Ricardo,

> *"It is quite important to the happiness of mankind, that our enjoyments should be increased by the better distribution of labour, by each country producing those commodities for which by its situation, its climate, and its other natural or artificial advantages, it is adapted, and by their exchanging them for the commodities of other countries, as that they should be augmented by a rise in the rate of profits."*[46]

Therefore, trade is carried out due to the existence of different costs in autarky and, in the Ricardian framework, such differences are explained by technology. The results are quite intuitive but hard to generalise: once we leave the two-good case, it is not possible to establish a detailed predictive relationship stating that if the relative price of a traded good exceeds the relative price of that good in autarky, then that good will be exported by the country in question. All one can hope is to find a correlation between the pattern of

[46] Ricardo (1951, p. 132).

trade and differences in autarky prices. The model is also very simple and several of its assumptions can be relaxed, leading to more interesting results. However, even the simplest Ricardian trade model provides an explanation for patterns of trade and since technology is certainly a possible determinant of it, the thesis will explore further the implications of technology to trade.

Another possible explanation for patterns of trade relates to difference in endowments, such as the model known as Hecksher-Ohlin. In order to see how different endowments lead to certain patterns of trade, it is assumed now that Home and Foreign possess the same technology and that consumers in both countries have equal tastes (formally, identical homothetic preferences are assumed). In sum, both countries are identical but in their endowments. In order to generate such endowment differences, it is necessary to assume that countries still produce two goods (cloth and wine) for which they now use two inputs: land (measured in acres) and labour (measured in hours). We further assume that the ratio of labour to land used in the production of cloth is higher than the ratio of labour to land in the production of wine, or simply: $\frac{a_{LC}}{a_{TC}} > \frac{a_{LW}}{a_{TW}} \Rightarrow \frac{a_{LC}}{a_{LW}} > \frac{a_{TC}}{a_{TW}}$, where a_{LC} still indicates how many hours are necessary to produce one unit of cloth, and now a_{TC}, a_{LW} and a_{TW} represent acres of land used in the production of one unit of cloth, hours of labour used to produce one unit of wine and acres of land used to produce one unit of wine, respectively. What this expression tells is that cloth is labour intensive whereas wine is land intensive. Since resources continue to be limited, the production possibility frontier still summarises the limits of production. Ruling out corner outcomes, the economy will now produce at the point that maximises the value of production given the price it faces (or, formally, the point on the production possibility frontier that is tangent to the isovalue line whose slope is defined by the relative prices).

This simple Hecksher-Ohlin model is capable of establishing a relationship between relative factor abundance and pre-trade relative output prices, which will shape the pattern of commerce once trade is allowed. Remember that trade arise as a consequence of differences in autarky prices. This relationship is verified in three steps.

First, it is possible to show that from the specification of the model, the country with the highest relative price of labour will also have the highest relative price of cloth (because cloth is labour intensive). The same holds for land: the country with the highest relative price of land will also have the highest relative price of wine (which is land-intensive). There is then a one-to-one relationship between product prices and factor prices. Secondly, it is also possible to show that there is a one-to-one relationship between factor supplies (quantities) and output quantities: countries will tend to produce more goods that are more relatively intensive in the factor that is relatively more abundant domestically. These first two steps validate the factor abundance hypothesis: the factor which is relatively more abundant will be relatively cheaper, and then the good which uses this factor relatively more intensively in its production will be relatively cheaper as well. The factor abundance hypothesis is particularly important for the thesis and its implications for the pattern of rubber trade will be explored in detail. Finally, if aggregate demand can be derived from homothetic tastes, an increased relative factor supply ratio will therefore result in lower relative price of output. For instance, it follows that as cloth is labour intensive, an increased supply of labour would lead to increased production of cloth, and reduced production of wine (Rybczynski Theorem).

One interesting feature of the Hecksher-Ohlin model is the possibility of immiserising growth[47]. Let's assume an increase in the endowment of the abundant factor. This would have two effects: 1) since the national income rises, demand for both goods will increase (if both goods are normal); 2) domestic production of the good intensive in the abundant factor increases, whilst domestic production of the other goods goes down (Rybczynski Theorem). Therefore, production of the exported good increases and production of the imported good decreases. Increased supply of exports combined with increased demand for imports should normally result in less favourable terms of trade and there is no reason to expect *a priori* that the utility loss caused by less favourable trading terms to be smaller then the direct utility gain of a more abundant factor endowment.

[47] I need to thank prof. Jeffrey Williamson for suggesting me to look at immiserising growth in the Brazilian Amazon context.

Consequently, immiserising growth is a theoretical possibility which is more likely to happen in overspecialised, monoproducing countries (or regions) as it was the case of the Brazilian Amazon from 1870 to 1910. This follows from the fact that the region was a big player in the world rubber market: increases in the Amazonian rubber production could negatively affect the price of its exports which, *ceteris paribus*, may worsen its terms of trade. Therefore, it is necessary to analyse if there were signs of immiserising growth in the Brazilian Amazon during the rubber boom.

Immiserising growth may be generated from other sources as well. For instance, immiserising growth might occur in the traditional two-country and two-good trade model due to the worsening of terms of trade even in the presence of elastic foreign-offer curve.[48] Additionally, if neutral technical progress occurs in a protected industry, immiserising growth is also a possibility. Technical progress increases the efficiency and therefore potential output per head, but it also shifts resources towards the industry in which progress occurs. Thus, if the additional cost of excess protection outweights the increase in production per head, growth might generate a loss in national welfare.[49] According to Bhagwati, the possibility of immiserising growth is increased if: 1) the ratio of domestic production of the imported good to imports of this very same commodity is small; 2) the constant-utility demand-elasticity for the importable good with respect to its own price, is small; 3) the elasticity in supply of the importable good when production shifts along the production possibility curve in response to a change in its price, is small. Note that neither of these conditions nor any combination of them is a sufficient condition for immiserising growth and the possibility of immiserising growth arises when, with all these conditions fulfilled, either or both of the conditions below are satisfied:

1. the offer of the rest-of-the-world is inelastic (in the extreme, it would imply that growing country's exports are giffen goods abroad)

[48] Bhagwati, Panagariya and Srinivasan (1998, p. 369).
[49] Johnson (1967, p. 153).

2. growth actually reduces the domestic production of importable good at constant relative commodity prices.[50]

As in the Ricardian Model, it is difficult to generalise the results of this simple two-good x two-country x two-factor Hecksher-Ohlin Model. First, it is possible that the number of goods and factors may differ requiring sometimes information from the demand side as the supply side of the economy is insufficient to determine the quantities actually produced. Secondly, if countries can choose their best input-mix (or if technology allows different coefficients of use of resources), a factor intensity reversal may occur: for instance, for a certain relative price of land and labour it is possible that the technology used by the country will turn cloth into a land intensive good.

Factor intensity reversals may change the pattern of trade but they are usually unlikely to happen. Theoretically then, in the two-good x two-country x two-factor Hecksher-Ohlin model, patterns of trade will hardly change, engendering a geographical dimension for trade as endowments are often geographically specific. Yet, in the Ricardian model, specialisation leads to a certain geographical pattern of trade too but, in the case of the Hecksher-Ohlin model, one of the inputs may be immobile, making the consequent pattern of trade more inflexible. Therefore, for the purposes of the thesis, the [Brazilian] rubber supply resembles more a Hecksher-Ohlin model insofar as crude rubber depends on the quantity and quality of the existent rubber trees [in the Amazon forest]. These rubber trees, in turn, were geographically specific: as the thesis will show, although they could be found in nearly all continents, crude rubber quality differed significantly, depending on the tree from which it was produced and the dexterity of the rubber tapper. Moreover, initial attempts to transplant rubber trees failed and thus until 1910 (when rubber supply from Asian plantations inundated the market), rubber trees were, for all purposes, an immobile factor.

Therefore, physical geography [of the Amazon Forest] underlies [Brazilian] rubber supply. The location of the trees, measured by their distance to a river and/or a village and

[50] Bhagwati (1958, p. 205).

their density in a given area, invariably played a decisive role in determining the location of crude rubber production. First-nature geographical factors (the physical terrain) will thus influence production not only because they may represent natural impediments to production but also because they influence its costs. Therefore, the spatial distribution of crude rubber production is also shaped by second-nature geography, i.e., the spatial interaction between economic agents.[51] The thesis analyses in depth the impact of first- and second-nature geographical factors on the rubber chain, and it is important to note that second-nature geographical effects are more flexible than first-nature ones. In this context, economic distance and remoteness are a recurrent theme in the thesis, determining the spatial organisation of the rubber supply chain. Moreover, economic distances and costs of production shape the interaction between supply and demand.

In order to analyse the demand side, an additional feature needs be included in the model: economies of scale. The possibility of increasing returns to scale turn the first-nature geographical effects less important and issues such as the size of industrial plants and proximity to markets arise. There may also be agglomeration effects: manufacturing firms will locate their activities based on proximity to markets. This was true for the rubber shoe and boots industry which agglomerated around Boston (close to the main US cities), but also for the tyre manufacturers which agglomerated in Akron (close to Detroit where the carmaker companies were). The consequent agglomeration effects will generate spillovers and external economies of scale that will further reinforce the spatial agglomeration of rubber manufacturing firms on these sites.[52] Yet, access to inputs will still be important as cheap clean water and energy will be instrumental to manufacturing.

In sum, the Ricardian and Hecksher-Ohlin models presented here give two complementary explanations for patterns of trade and their predictions are always based on general equilibrium analysis. Whereas the Ricardian model suggests that technological differences account for trade specialisation (and hence to a particular trade pattern), the Hecksher-Ohlin model focuses on endowments. Even though only weak correlations

[51] Overman, Redding and Venables (2001) and Crafts and Venables (2003).
[52] Krugman (1991) and Krugman and Venables (1995) and Overman, Redding and Venables (2001).

between autarky prices and the pattern of trade can be sketched from less parsimonious and hence more realistic versions of these models, they both summarise the main mechanisms that drive trade: differences in technologies and in endowments. In terms of gains from trade, the Ricardian model offers a very positive view as trade benefits everyone in the economy. In the Hecksher-Ohlin model, in turn, there are typically losers and winners from trade: owners of a country's abundant factors gain from trade whereas those owners of scarce factors lose. Nonetheless, after trade it is possible to find an equilibrium that is Pareto-superior so long as the winners compensate the losers: there is thus a one-to-one relationship between relative prices and national welfare as an improvement in a country's terms of trade increases its welfare. Both models for trade pattern will be analysed in the thesis and, additionally, the possibility of immiserising growth will be explored as well.

However, these two models neglect other important features of trade. They did not formally model intertemporal decisions, even though different goods consumed in different periods of time may be regarded as different goods. Furthermore, these models assume that tastes did not differ in the two countries, a very unrealistic assumption in some cases. The truth is that difference in tastes does not generate any interesting result in terms of economic modelling as the observation that, *ceteris paribus*, a country will import goods for which domestic consumers have stronger preferences than foreign ones is rather trivial. With imperfect competition and product diversity, however, consumer tastes may have an important effect on trade. Incorporating into the models the size of the economies also generates interesting results as the possibility of immiserising growth reveals. Moreover, even though both models generate a certain geographical pattern of trade, geography only enters indirectly via costs to trade. Even though the rubber supply may still fit well into these models, the rubber demand requires a more detailed specification of spatial economics. Due to internal and external economies of scale, there are agglomeration effects that shape the organisation of the rubber demand. Therefore, the analysis of the rubber chain still needs a more suitable model that incorporates some of these features not dealt with by neoclassical trade models.

1.3 – Global Commodity Chain Approach

Standard trade theories usually consider trade in isolation from investment, finance, or other relations between parties to trade. In turn, the Global Commodity Chain (GCC) approach has a different departure point and does not explain trade patterns as derived from different technology or endowments. The GCC addresses questions about what products countries do (and should) import and export in relation to complex institutions. Moreover, instead of deriving trade patterns from optimizing behaviour of rational economic agents, for GCC, trade is taken as embedded in, and to a considerable extent as determined by, specific (but changing) institutional structures.[53] GCC is ultimately the development of the world-system theory at the micro level. It is thus imperative to discuss the main features of this theory before analysing the Global Commodity Chain approach. Even though the GCC approach will be in the end rejected, some of its features will still be present in the thesis, making it necessary to analyse GCC's theoretical foundations in detail before a more suitable framework can be constructed.

A social-system is a self-contained unit of analysis as the dynamics of its development is mainly internal. Only small autonomous subsistence economies and world-systems can be considered as actual social systems. According to Wallerstein, a world-system is thus "a social system, one that has boundaries, structures, member groups, rules of legitimation, and coherence".[54] In history, there have only existed two types of world-systems: world-empires, in which there is a single political system over the whole area, and world-economies in which such political system does not exist. According to Wallerstein, it is exactly the absence of a single political system that allows capitalism to operate within an arena larger than any political entity can actually control, giving capitalists room for manoeuvre that is structurally based.

Geographical factors such as transport and communication define the borders of this world-system, inside which an extensive division of labour develops. This division of

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[53] Raikes, Jensen and Ponte (2000, p. 394).
[54] Wallerstein (1976, p. 347).

labour is geographical and arises not only from ecological factors as it is also a function of the social organisation of work: following a Marxist framework, it magnifies and legitimises the ability of some groups within the system to exploit others. As a consequence, a clear-cut division between core-states and peripheral areas arises. Whereas core-states are those where a strong state machinery and a national culture are created to ensure the coherence of the world-system and to justify disparities that have arisen within the world-system, peripheral areas are those where the indigenous states are weak, ranging from non-existence (e.g. colonial situation) to one with a low degree of autonomy (such as neo-colonial situation). Core-states are thus understood as those that possessed sovereignty *vis-à-vis* other states which additionally are strong before any particular social group within the state. There are also semiperipheral areas which are in between the core and the periphery: some of those areas had been either a core-state of a given world-economy or a peripheral area that was promoted as a result of changing geopolitics of an expanding world-economy. It is possible to infer then that for Wallerstein, state structures are relatively strong in the core-areas and relatively weak in the periphery.[55]

The aforementioned division of labour entails a hierarchy of occupational tasks in which core-states concentrate higher levels of skill and capital. Since a capitalist world-economy essentially rewards accumulated capital (including human capital) at a higher rate than raw labour, the system is prone to self-maintenance and to increasing disparity. Moreover, the absence of a central political entity makes it very difficult to employ counteracting measures to remedy this maldistribution of rewards. This maldistribution of rewards, in turn, does not necessarily generate the seeds of internal discontentment and dissolution since with the expansion of the system (especially through technological developments) ever new areas are being absorbed. This process of development in the periphery (and in the semiperiphery) then masks the inequality of rewards.[56]

Wallerstein's framework is based essentially on the nation-state and consequently individual workers, entrepreneurs, industries and firms are either neglected in his analysis

[55] Wallerstein (1976).
[56] Wallerstein (1976).

or assigned a secondary role. As these players influence the functioning of the world-system, it was necessary to integrate them into the Wallersteinian framework. That is exactly one of the initial objectives of the global commodity chain (GCC) literature: according to its proponents, by tracing the network of commodity chains, it is possible to track the underlying division and integration of labour processes and thus monitor the constant development and transformation of the world-economy's production system.[57] In this context, a commodity chain is understood as a "network of labour and production processes whose end result is a finished commodity"[58]. For analytical purposes, the chain is assumed to be comprised of several nodes or "boxes" that correspond to quite specific production processes. The boundaries of a given box are taken as socially constructed and locally integrated, highlighting the social embeddedness of economic organisation. Therefore, a box may be redefined, reconstructed, consolidated or subdivided based on technical or social organisational changes.

In short, a "GCC consists of a set of interorganisational networks clustered around one commodity or product, linking households, enterprises, and states to one another within the world-economy"[59]. At the macro level, all these networks are constituents of the world-system in which an extensive division of labour exists along geographic lines. This division of labour is understood as being usually triggered by a globalisation process of production and trade.[60] For analytical purposes, such globalisation process may be subdivided into three different phases: a) investment-based globalisation (1950-1970) when the multinational spread of transnational corporations accelerated in a growing number of manufacturing and raw material industries; b) trade-based globalisation (1970-1995) was based on the rapid and diversified industrialisation of a wide range of developing nations, changing the centre of gravity for many manufacturing industries; c) digital globalisation (1995 to date) when an information revolution developed as a consequence of the rapid spread of connectivity, impacting on business strategies.

[57] Hopkins and Wallerstein (1994, p. 17).
[58] Hopkins and Wallerstein (1986, p. 159).
[59] Gereffi, Korzeniewicz and Korzeniewicz (1994, p. 2).
[60] Gereffi, Humphrey and Sturgeon (2005, pp. 78-79).

The result of this ongoing globalisation process is the emergence of a worldwide manufacturing system in which production capacity is dispersed to an unprecedented number of developing as well as industrialised countries. This globalisation pattern implies a degree of functional integration between and control over internationally dispersed activities that span over core, semiperipheral and peripheral areas[61]. This international dispersion of activities, in turn, follows a hierarchy whose rationale is given by the world-system theory: a relatively greater share of wealth accrues to core-like nodes than to peripheral ones, underscoring the fact that, by construction, the periphery produces raw materials whereas the core produces industrial products. Even though this is too simple and might not be true for all commodity chains, it should be true for the world-economy as a whole.

Therefore, hierarchy among countries at the macro-level (periphery versus core areas in the world-system theory) translates into a relation of power among nodes along a commodity chain at the micro level (GCC). Power here is defined as the ability to coordinate and control transnational production systems, which can be structured and categorised in two different ways: as producer-driven or buyer-driven. On the one hand, "producer-driven commodity chains are those industries in which transnational corporations or other large integrated industrial enterprises play the central role in controlling the production system (including its backward and forward linkages)"[62]. The distinctive feature of the producer-driven commodity chain is the degree of control exercised by the headquarters of transnational corporations. On the other hand, "buyer-driven commodity chains refer to those industries in which large retailers, brand-name merchandisers, and trading companies play the pivotal role in setting up decentralised production networks in a variety of exporting countries, typically located in the Third World"[63].

Ultimately, under the GCC framework, power assures that the most profitable nodes will be located in the core areas. According to Hopkins and Wallerstein, monopoly

[61] Gereffi (1994, pp. 95-96).
[62] Gereffi (1994, p. 97).
[63] Gereffi (1994, p. 97).

and competition are key to understand the distribution of wealth among the nodes in a commodity chain (and in aggregate, for the world-system as a whole). Competitive pressures are less pronounced in core nodes as enterprises and states in core areas gain competitive edge through innovations that transfer competitive pressures to peripheral areas of the world economy[64]. As it will become clear later, the degree of competition will continue to be useful in the new approach of this thesis, being examined in detail for each and every node of the rubber chain.

Even though commodity chain analyses are usually a-historic, competitive pressures change over time following a Shumpeterian notion of competition. For Hopkins and Wallerstein, concentration and decentralisation (or shifts in the zonal location of nodes) are associated with cyclical rhythms of the world economy: during A-periods (upswings) vertical integration and geographical concentration of boxes of a chain are induced as a consequence of reduction of transaction costs, whereas during B-periods (downswings) a geographical dispersal of chain's boxes happens in order to ensure reduction in labour costs by subcontracting.[65]

In sum, the underlying idea of the Global Commodity Chain framework is that by describing and analysing a commodity chain, it is possible to show how social relations shape production, distribution, and consumption in a given industry or sector. Even though theoretically it could be applied to all commodity chains (maybe requiring sometimes some adaptations), GCC has mainly been applied to industrial chains such as apparel[66], semi-conductors[67], automobiles[68] and footwear[69] despite some attempts to apply it to other areas such as services[70], fresh fruit and vegetables[71] and illegal commodities[72]. Therefore, the rubber chain has been so far left out. However, it will be argued here that the GCC approach does not provide a suitable framework to analyse the rubber chain and

[64] Hopkins and Wallerstein (1994, p. 18).
[65] Hopkins and Wallerstein (1994, pp. 19-20).
[66] Gereffi (1999).
[67] Henderson (1989).
[68] Doner (1991).
[69] Schmitz (1999).
[70] Rabach and Kim (1994).
[71] Reynolds (1994).
[72] Wilson and Zambrano (1994).

thus an alternative theory/model needs to be found or developed. That is exactly the goal of the following sections.

1.4 – Global Commodity Chains: a Critique

As shown above, standard trade models are based on optimising behaviour of rational agents. In these models, the possibility of trade usually increases the total welfare but it is impossible to generalise this result. It is certainly true for the basic two-country x one-factor Ricardian model. However, even in the most basic formulation of the Hecksher-Ohlin model, trade does not benefit everyone: there are losers and winners. It is usually possible to achieve a Pareto-superior equilibrium but it was shown that immiserising growth remained a theoretical possibility.

The Global Commodity Chain approach is a development of the world-system theory at the micro level. As such, it is an extension of the dependency theory. Instead of the Prebischian notion of dependency being created from increasingly unequal terms of trade[73], in the world-system the global market is a uneven playing field, underscored by the existing hierarchy between core and periphery areas that translates into a relation of power between nodes of the commodity chain located in these two areas. Proponents of the GCC approach have seldom appropriately defined the concept of 'power'. It is certainly the equivalent of the hierarchy existent at the macro level but its underlying rationale is usually lacking. For Hopkins and Wallerstein, core areas derive power over peripheral (and semiperipheral) areas out of the development and possession of more advanced technologies and consequently by high degrees of market power whereas, for Gereffi, power involves the ability to out-source lower value-added activities and to retain or incorporate those with higher value-added.[74] As noted by Raikes *at al.*, under the GCC approach, power is usually regarded in an 'all or nothing' terms: it usually disregards degrees of power along the chain and assumes a polar structure in which one node of the

[73] See for instance Love (1980). See also Prebisch (1959).
[74] Hopkins and Wallerstein (1994) and Gereffi (1994).

chain is taken as dominant.[75] This is a critical and important point that the thesis will develop further.

As mentioned above, the GCC approach was usually applied to industrial chains and largely ignored the historical/cyclical context. Both the historical and cyclical contexts are embedded. On the one hand, the historical context is actually provided by the world-system theory that describes how capitalism evolved within the world-system. On the other hand, cycles are explained by a Schumpeterian notion of development. There have been some efforts to construct the global commodity chain analysis with a more detailed historical context. The most concerted effort in this direction is certainly the book edited by Topik, Marichal and Frank.[76] The editors criticised the global commodity chain approach, adapting it to the analysis of (non-industrial) commodities in a long-run historical perspective. The central idea is still to focus on commodity chains rather than on countries or continents even though the commodities were chosen on a geographical basis, namely Latin America. Since economic activity transcends national borders, it cannot be adequately analysed within the limits of political administrations and borders. As in the case of GCC, waves of globalisation provides the rationale for the commodity chain approach as countries cannot be understood in isolation or autarky. The contribution of Topik *et al.* to the commodity chain literature is that the historical context is not embedded in but rather analysed in conjunction with the development of the commodity chain. Here the term commodity chain will be used to make a distinction from the Global Commodity Chain approach. In short, production decisions are assumed to be based on the international dynamics of a commodity chain, not simply on the autonomous plans of a national government. As will be discussed in the next section, these assumptions seem more valid for the analysis of the rubber chain as well.

Topik *et al.* also depart from the GCC approach by not assuming a necessary centre-periphery relationship. In the GCC approach, the location of production and the distribution of returns in the commodity trade are usually defined by the centre-periphery

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[75] Raikes, Jensen and Ponte (2000, p. 402).
[76] Topik, Marichal and Frank (2006).

relationship. In a commodity chain, the notion that European players constituted the metropolis while Latin American countries/regions were peripheral or semiperipheral is explicitly rejected. Each commodity is assumed to follow its own logic following a much wider set of conditions: core economies sometimes export primary commodities to one another; peripheral economies sometimes import primary commodities from the core; depending on the complexity of the chain, there may be several steps in the production, warehousing, shipping, and marketing of a commodity – all of which make it necessary to pay attention to what happens to commodities at each stage in the chain.[77]

Commodities are evaluated and analysed on a case-by-case basis with no relationship or power structure imposed *ad hoc*. In the GCC approach, power is loosely defined and usually lacks the establishment of degrees of power between nodes of the chain. Topik *et al.* does not formally model the concept of power either even though they see the analysis of the interactions and relative power of different positions on a commodity chain as one of their main contributions. Global trade is taken as heterogeneous and the international markets as far from uniform or consistent.[78] Markets are not assumed to be natural laws that impose themselves onto humans but rather as human constructs that are determined by social and political values and institutions.

Due to the different historical context and to the rejection of the centre-periphery approach, the analysis of strategies of global firms, which is the cornerstone of the GCC approach, is no longer so useful and Topik *et al.* develop a more integrated approach in which the role of other participants is analysed in production, processing, and marketing of commodities. In sum, their edited book examines, from the commodity chain's viewpoint, the interaction of supply and demand which determines the development and cycles of the major export commodities without disregarding the social and political consequences on both ends of the chain.

Topik *et al.* examine the chains in raw materials (silver, henequen, and rubber), in intermediary inputs (cochineal, indigo, and fertilisers) and in stimulants that were

[77] Topik, Marichal and Frank (2006, p. 14).
[78] Topik, Marichal and Frank (2006, p. 11).

consumed in social events (cocoa, cocaine, coffee, sugar and tobacco). For the purpose of this thesis, the most interesting commodity chain is certainly that of rubber, where Frank and Musacchio analyse for the first time the entire rubber chain, "from trees to tires"[79]. These authors reject the centre-periphery approach as their analysis is more centred at standard trade theory. They explicitly assume that factor shares and geographical conditions largely determined the location of production and additionally that risks and rewards tended to be distributed in competitive markets. Moreover, States and pressure groups played an important role in deciding the location and relations of production. For Frank and Musacchio, actors were rational but operated within limited information and uncertainty. From their analysis, several points can be raised. Brazil was not a usual peripheral or semiperipheral country insofar as developments in the Brazilian supply chain influenced and limited the room for manoeuvre in the rubber manufacturing sector. One indication that this was the case is the fact that the rates of profit along the chain moved in synchronisation due to competition forces (that were present in every link of chain). Brazilian producers, in turn, adapted to circumstances and acted optimally given their limited access to labour and capital.

Clarence-Smith had analysed one of the commodity chains included in Topik *et al.*: cocoa. He was interested in examining, from the commodity chain's viewpoint, why cocoa cultivation seems to have failed to generate economic take-off[80]. On the supply side, he highlights that cocoa provided few backward linkages and limited forward linkages but the actual economic impact of cocoa was very disappointing. Even though there were more chocolate factories in tropical countries before 1914 than it is usually appreciated, forward linkages remained quite limited. Yet, exports of cocoa still provided the producing countries with an important source of foreign revenues which was nonetheless usually squandered by governments. Governments indeed seem to have played a pivotal negative role in the development of cocoa cultivation by restricting immigration, discouraging savings, failing to protect the forest, allowing cartels, etc. Moreover, cocoa

[79] Frank and Musacchio (2006).
[80] Clarence-Smith (2000).

cultivation engendered a voracious appetite for virgin forest whose destruction undermined the long-run viability of the enterprise. Even planting cocoa in lands previously used for other crops usually proved unsuccessful.

On the demand side, Clarence-Smith analyses the history of consumption of cocoa (and chocolate). Western markets rapidly became the main consumers of the product that was usually processed by small workshops that produced finished chocolate, cocoa butter and cocoa powder. Large Western companies became more prevalent only after 1850s but before 1914, despite some cartelisation and collusion attempts, the market remained quite competitive due to low barriers to entry. On the intermediaries side (traders and shippers), Clarence-Smith acknowledges that information is still poor, requiring some further research. In sum, this author analyses all the links of the cocoa chain in an integrated way, unveiling the facts that jointly explained why cocoa failed to produce economic take-off in the producing regions that span Latin America, initially, and Africa and Asia after 1880s.

Another interesting application of the concept of commodity chain is the paper by Ian Hunter[81] who analyses the meat and dairy (butter and cheese) industries in New Zealand, having the meat and dairy industries in Latin America as counterpoints. His analysis is complemented by the application of the concept of networks. For Hunter, whereas chains are characteristically linear, network relations that hold the chain together may be better understood as multidimensional or multilayered. He departs then from the dichotomy of producer-driven and buyer-driven chains which assumes a central role for big and internationalised firms that organised and control a vertical chain: in different cultures and societies, institutional arrangements and societal norms engender different forms of commercial activity, support different labour processes, and inspire different managerial responses. In Hunter's variant of the commodity chain, control or power over the chain is not a critical factor: the pursuit of economic opportunity is. In some contexts, this pursuit is more easily accomplished by the formation of networks built around an entrepreneur (or groups of entrepreneurs). In conclusion, Hunter states that innovation

[81] Hunter (2005).

fostered by entrepreneurial networks had a direct impact on the size and structure of New Zealand's economy, particularly in the case of two export staples: frozen meat and dairy industries.

In short, even though there are just a few contributions in the commodity chain approach, its proponents tend to reject the centre-periphery assumption of GCC. By doing so, they typically reject the world-system theory altogether replacing it with more neoclassical economic reasoning and modern standard trade theory models. A construction of a more detailed and integrated historical context becomes thus a requirement as it ceases to be embedded in and becomes commodity-specific. In this context, the evolution of the commodity chain over time now interacts with this more general and specific historical background. In the commodity chain approach, institutions are sometimes used in the analysis to limit the agent's room for manoeuvre but a more detailed and thorough discussion of institutional theory and spatial economics within the commodity chain approach is still lacking. Moreover, as in the GCC approach, very few quantitative studies have emerged within the commodity chain literature.

1.5 – Thesis Approach: Bringing Institutions and Geography to the Fore

The thesis follows the commodity chain approach as described above. However, it adds a more detailed discussion of the role of institutions and spatial economics in the organisation and development of the chain. This new framework further embodies a more quantitative-driven analysis that gives macroeconomic support to the analysis at the micro level. Thus the thesis innovates on theoretical grounds: it builds a new theoretical framework to investigate how institutions and geography can explain the development of the rubber chain in the Brazilian Amazon from 1870 to 1910.

But what is exactly the rubber chain? The rubber chain is the outcome of several interconnected activities that result in final products that are made primarily of crude rubber. These final products could be of several kinds: rubber shoes, machine belts, tyres, hoses, waterproofed clothes, railwagon buffers, submarine [telegraphic] cables, steam engine seals, surgical products, and so forth. The rubber manufacturing industry is very diversified, a sheer consequence of how versatile this raw product really was. One of the main characteristics of rubber was its tensile elasticity, a characteristic that very few other products could match, making for a very low degree of substitutability. Crude rubber was in this sense a unique material.

Crude rubber was itself a product of human ingenuity too. As the thesis will show, crude rubber was the result of a very rudimentary process first developed by Native Americans who transformed the latex (sap) of some specific trees into waterproofed clothes and bouncing balls for leisure games. The process was hardly perfected from 1870 to 1910 and consequently crude rubber experienced no significant technological change in its production. In contrast, rubber manufacturing did so. The development of the 'vulcanisation' process was certainly a watershed for the rubber industry insofar as it allowed the mechanisation of production and created two geographically separate nodes of the rubber chain: 1) crude rubber supply where the latex of rubber trees was processed and transformed into crude rubber and; 2) crude rubber demand where crude rubber was being processed and transformed into manufactured rubber products. Between these two nodes, several other ones developed as there was very little vertical integration in the chain, even in the final years of the rubber boom period (1870-1910).

Figure 1.1 shows the main nodes of the chain, which is depicted in the horizontal format in order to avoid imposing any *ad hoc* relation of power or hierarchy between them. On the left side, there are rubber manufacturers (such as Macintosh, Dunlop and Firestone, to name a few) and rubber traders (agents who imported crude rubber from the producing countries). Sometimes a rubber agent (or broker) made the bridge between these two agents, either by advising the rubber manufacturer about the best rubber grades to buy or by finding possible buyers to a certain rubber trader. The rubber trader relied on information coming from producing areas and on a close relationship with the shipping companies.

In the crude rubber producing country/region there were several nodes, each responsible for a different stage of rubber production or transportation.[82] As the thesis will show, the rubber export house was the commercial establishment that sold crude rubber to buyers located in the main consuming regions, usually United States, Britain, France, Belgium and Germany. The rubber trade was their main business but these trading houses invariably exported other Amazonian products too (e.g. Brazil nuts). They were often foreign owned and their economic position depended on connections with the consuming countries and a close relationship with shipping companies. In the Brazilian Amazon, there were also import houses who imported products to be sold in the local markets and to rubber intermediaries. Rubber intermediaries, in turn, bought several products from import houses and sold them to the myriad of rubber estates located miles away from the main cities in exchange for their crude rubber. They either possessed their own ships or relied on a close relationship with a domestic shipping company. Finally, the rubber estate owner bought goods from the intermediary that were either consumed in the rubber estate or advanced to rubber labourers in exchange for the crude rubber they produced. Crude rubber was produced by rubber tappers and channelled through the rubber chain to the export houses from which it would reach the rubber traders and finally the rubber manufacturing companies.

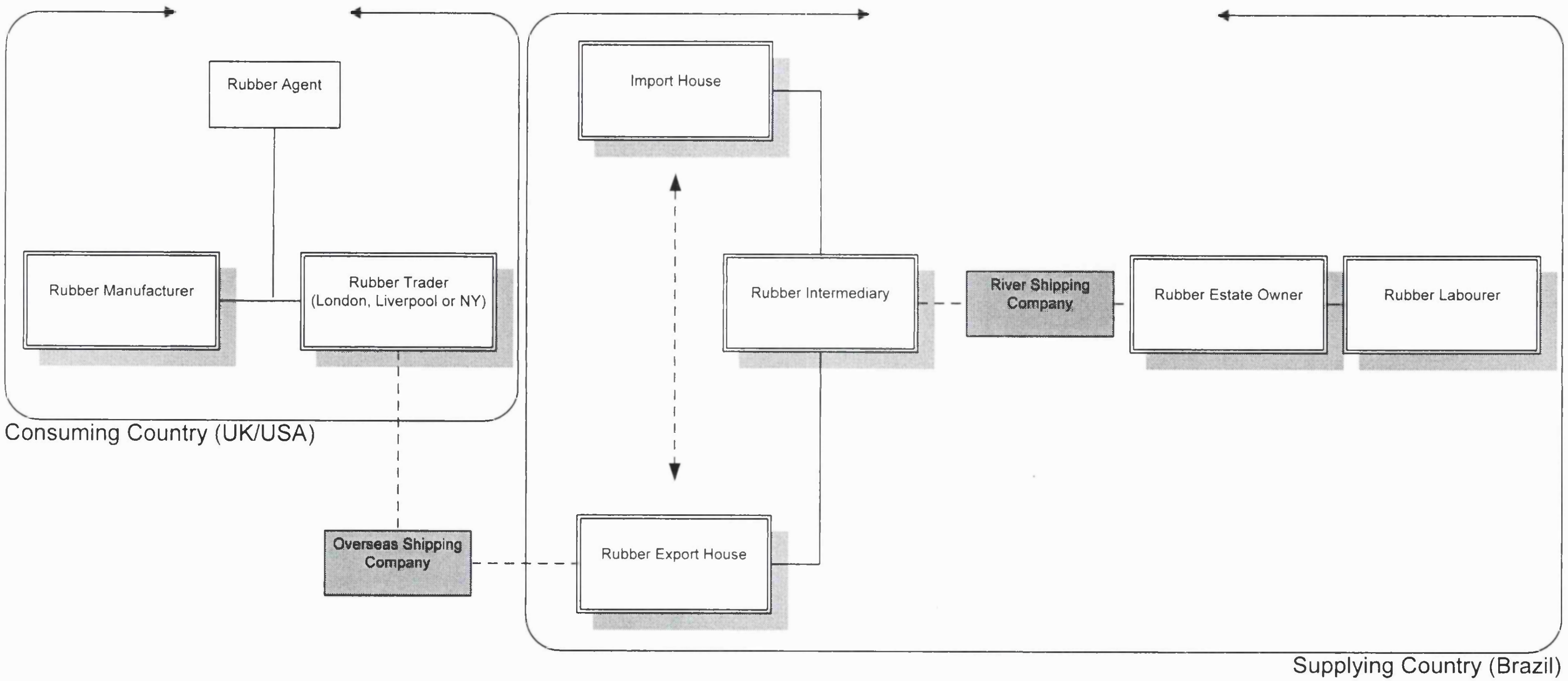
The distinction of the activities of these nodes was sometimes blurred but Figure 1.1 provides a stylised overview of the rubber chain. The thesis follows this stylised organisation. Chapter 2 discusses the demand side, i.e., the US and British rubber manufacturing industries. Chapter 3 deals with the interactions between demand and supply. It analyses the rubber trade, spanning all major crude rubber producing areas and its two main buyers: the USA and Britain. Chapter 4 examines the Brazilian Amazon crude rubber supply chain. Chapter 5 analyses the role of the government and its impact on the rubber chain whereas Chapter 6 finally examines domestic and overseas transport and communication networks (shaded nodes in Figure 1.1). However, the analysis is not linear

[82] A stylised configuration of the rubber chain in the Brazilian Amazon is presented here. Other producing regions possessed quite different organisation, usually following their own institutions and geography.

as it investigates two different dimensions altogether. In the first dimension, the thesis analyses the interaction among agents within a certain node of the chain whereas in the second one the interactions between nodes of chain are explored.[83] The section briefly explains the main content of both the within- and between-analyses found in the next chapters.

[83] It is not intended to cover fully every node of the rubber chain but rather to give an illustration of the complexity of the several processes and stages involved in the chain and which were considered of particular importance.

Figure 1.1 – Rubber Chain



Source: Elaborated by me, following a stylised version of the rubber chain.

In the 'within-analysis', the thesis deals mainly with competition issues. In this regard, Chapter 2 analyses the location of rubber manufacturing companies and their interaction. Initially, proximity to crude rubber production was essential for the viability of the enterprise but a technological breakthrough (the 'vulcanisation' process) made it possible to concentrate rubber manufacturing in factories closer to consuming markets. Ricardian and Heckcher-Ohlin models determine why production of finished rubber products moved geographically from, say, the Brazilian Amazon to the USA and Britain. A technological development allowed the exploitation of economies of scale in rubber manufacturing due to specialisation based on endowments. Since the Brazilian Amazon possessed a huge concentration of rubber trees whereas the USA and Britain possessed none, it was rational for the Brazilian Amazon to specialise in the production of the good (crude rubber) that was intensive in the abundant factor (rubber trees). Yet, Ricardian and Hecksher-Ohlin models do not help understand the subsequent evolution of the rubber manufacturing industry and why manufacturing companies located where they did. Especially in the USA, economies of scale increased the optimal size of the rubber manufacturing plants that tended to concentrate now closer to consuming markets. Spatial economies started to matter: external economies of scale and spillover effects created agglomeration economies that ultimately shaped the organisation of the rubber manufacturing industry and explained their expansion to Akron, Ohio. Formal institutions, notably patent legislation, further influenced and shaped the market structure of the rubber manufacturing industry: indeed, patents enforced a process of amalgamations in the USA and Britain even though the rubber manufacturing industry remained quite competitive on both sides of the Atlantic (in contrast with the GCC approach).

Chapter 3 complements this analysis by exploring competition between several crude rubber sources. It is shown that investments in crude rubber production before 1910 (focusing on sources other than plantations) defined production and quality of the raw product Britain and the USA were acquiring. The chapter further explains that Brazilian leading position was established due to a combination of quantity and quality of the product (endowments). Therefore, first-nature geographical factors played a decisive role but institutions such as cultural and political ties created a path-dependence structure of the trade with all other crude rubber sources apart from Brazil. There was limited competition between Brazilian crude rubber and other sources. Brazilian crude rubber exporters may be regarded as market leaders to a certain extent. Moreover, the chapter shows that among the crude rubber exporters, there was a high degree of concentration leading to oligopolisation of the business: competition was limited but cartelisation attempts failed.

Chapter 4 further examines the economic relations on the Brazilian crude rubber supply chain. The chapter shows the degree of concentration among the rubber intermediaries. It is shown that the intermediary market was less concentrated than that of the rubber exporters, meaning that competition was definitely fiercer in this node of the chain. Among rubber estate owners, competition was also prevalent but they enjoyed a certain amount of market power due to the monopoly of land rights: indeed, according to Bentes, at the end of the rubber boom there were no good lands available to rubber exploitation any longer.[84] As will be shown here, labour was also a scarce factor of production meaning that despite the constant and increasing influx of people to the region, labourers theoretically enjoyed a good bargain position (at least initially).

Lastly, Chapter 6 shows the degree of concentration in transport and communication. In this chapter, second-nature geographical aspects are analysed in depth showing how much closer the Brazilian Amazon got from 1870 to 1910 in terms of travel time, travel cost, speed of news and cost of sending messages (mail and telegraphs). The conclusion is that all of these markets were oligopolised. Whereas in the internal navigation, the Amazon Steam Navigation Co. dominated the market, in the overseas business, the Booth Line exercised a high degree of oligopoly control. In communication, there was initially only one (submarine) telegraph company that at the end of the period had to compete against the government land telegraph. Mails were usually a prerogative of the State.

[84] Bentes (1999, pp. 143-180).

In sum, within all nodes of the rubber chain, there were clear signs of oligopolisation. However, the thesis shows that the leading companies at each node of the chain were not always able to fully exercise their oligopoly power over another node. It is possible to show it by examining the second dimension of the rubber chain: the relationship between nodes of the rubber chain. This analysis is carried out through a simple game that highlights the main incentives of the players involved at each node of the rubber chain. Moreover, institutions are examined too as they provided limits to agents' interactions.

In the 'between-analysis', the thesis is mainly concerned with relationship between agents located in different nodes of the rubber chain. In this regard, Chapter 2 presents a quantitative exercise that shows how hungry for crude rubber traders located in the consuming countries (USA and Britain) were. Competition at the manufacturing level resounded along the rubber chain, translating into a struggle for securing a steady and reliable source of crude rubber, the main input in the industry. Due to its scarcity, crude rubber was very expensive and access to resources thus became strategic to determine (or influence) profitability at the manufacturing level, turning the manufacturing node very different from the ideal GCC/'Wallersteinian' core-node type.

Chapter 3 shows that, differently from standard trade theory, crude rubber trade needs to be examined in conjunction with investment and finance. The chapter surveys investments made in crude rubber production on a regional basis. It also explains the links between crude rubber importers in the USA and Britain and crude rubber exporters in the supplying countries, focusing on the main supplier: Brazil. Since the literature has argued that the bulk of the British and American investment in rubber production was channelled through (foreign) rubber export houses, the Chapter also provides a case study of the relationship between one Brazilian/Portuguese rubber export house and one British rubber buyer. Even though results are difficult to generalise, the case study provides new insights that challenge long accepted facts about the international trade on rubber.

Chapter 4 complements the previous two chapters by examining the economic relationship within the Brazilian crude rubber supply chain. Unlike the GCC approach, no pre-defined power relationship is assumed between the nodes of the rubber chain and bargain power becomes not only defined by its fundamentals but also constrained by Institutions. This chapter develops one of the main theoretical contributions of the thesis, notably, an explicit evaluation of power between nodes of the commodity chain. It does so by defining a game that summarises the main incentives of agents involved in the transactions between any two nodes of the chain. The chapter partly refutes the existent literature on the rubber boom: the rubber chain is much more intricate and the relations of power do not necessarily follow a vertical one in which every forward node is able to exploit the node immediately beneath it (as the GCC approach usually assumes). True, rubber exporters might still have been better positioned to extract monopoly rents due to their knowledge of the rubber market and the degree of oligopolisation of their activities. Yet, looking at the whole chain together, it is possible to conclude that rubber production is even easily self-enforced under a scenario of constant production expansion and of high inelasticity of demand, like the one that prevailed from 1870 to 1910 in the Brazilian Amazon. Under this scenario, all factors of production could have been properly remunerated.

Chapter 5 examines the impact of government interventions in the crude rubber market. States (and thus governments) create, mould or destroy institutions. Governments are not taken as central or pivotal, being just another agent that influences the developments along the rubber chain. However, in the rubber chain the government was able to extract monopoly profits through taxation even under a perfect competition market. The departure point of the present chapter is the fact that rubber exporters in Brazil faced an inelastic demand (as is shown in Chapter 2) which allowed the government to capture monopoly profits even under a perfect competitive market. Chapter 5 thus supports Frank and Musacchio's view that there was no economic imperialism in the Amazon as the rubber chain does not fit into the model of peripherality of raw material and centrality of manufacture. This traditional formulation is at the heart of the GCC approach and it suggests that production in the periphery (Brazil) should have developed in tandem with impulses emanating from the industrial core (USA and Europe). That pattern would ensure that profits in the periphery would either be held down (so as to maximise profits at the industrial core) or be high in order to ensure profitability from investments flowing from the industrial core. It is not surprising that for a quite long period, given the high inelasticity of demand for Brazilian rubber, manufacturers in the core economies were tied to developments occurring within the Brazilian Amazon, diametrically contrary to the traditional assumption of economic imperialism and to that embedded in the GCC approach.

From taxation, the Amazonian governments accumulated considerable wealth that was partly redistributed back in form of public goods. These funds were instrumental to develop two supporting activities, telegraphs and steamships, whose impacts onto the rubber chain are analysed in Chapter 6. Interestingly, rubber had fostered the development of submarine telegraphs for gutta-percha (a kind of low quality rubber, extracted from a tree that grows in Southeast Asia) was used to insulate submarine copper cables. On the other hand, rubber was also important in the improvement of the efficiency of steam engines insofar as this raw material was sometimes used as seals. Steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported even further the development of (steam) navigation and the telegraph. The rubber boom demanded better communication and transport systems and the consequent increased intensity in the flow of people and merchandises provided these systems with economies of scale that ensured their ulterior development. The spread of news and the improvement in the transport system also provided the region with the scarcest factor of production, labour[85]. Furthermore, the advent of steamship navigation in the Amazon region displaced the canoes, releasing even more labourers to work in the rubber industry. Thus communication and (steam) navigation overcame first-nature geographical hurdles and generated some integration. The consequent move of people (and other factors of production) and flow of information, in turn, created the conditions for further development of the rubber boom by supporting a virtuous cycle. In sum, without rubber, steamships might have been even more costly to operate, and the submarine telegraphic system may

[85] As shown in Chapter 4, the Brazilian rubber supply was very inelastic to this factor of production.

have never developed. Analogously, without steamships and telegraphic communication, the rubber boom might have never taken place.

Therefore, the analysis of the rubber chain proceeds in a non-linear way. There are two dimensions of analysis that are both explored in every chapter. In the 'within-analysis' the thesis examines the relationship among agents located in the same node of the rubber chain. The main instrument of analysis is competition. However, institutions and geography shape the way competition evolves. In the 'between-analysis', the thesis explores interactions between agents located at different nodes of the rubber chain. This dimension of analysis relies on game theory, institutions and geography. Institution Economics and geography are indeed the main features of the thesis. It is then necessary to understand how it is incorporated into the analysis. The next section provides an inside look on how they are incorporated into the thesis.

1.6 – Inside Look at Institutions and Geography

Like in the GCC framework, the departure point of the analysis of the thesis is the focus on a product (rubber) but with special attention to its development in the main producer region: the Brazilian Amazon. Therefore, the thesis is geographically specific. According to standard trade theory though, this focus on a single commodity is not unwarranted as the theory proclaims that trade should be analysed under a general equilibrium framework. By focusing on one sector (or one commodity), there might be a chance of missing the connections and interactions with other sectors of the world economy that might be crucial in understanding the commodity chain in certain contexts. However, abstracting from the real world and reducing the reality are key procedures to understand economic phenomena and it is exactly the researcher's task to simplify the reality to its most basic components that help explain economic phenomena without losing the connection with that same reality.

The theoretical framework here looks at two different dimensions: between nodes of the chain and within nodes of the chain. As in standard trade models, patterns of trade are initially explained by technology and endowments. However, even though technology and endowments explain the *likely* pattern of trade, Institution Economics and Economic Geography are applied to examine the *actual* pattern of trade that emerged. Therefore, trade is not considered in isolation from geography, investment, finance, or other relations between parties to trade and thus it is not assumed to be carried out in a free environment but rather in an environment that is constrained by institutions: cheating, asymmetry of information, enforcement of contracts are all analysed in conjunction with market forces. A careful and detailed analysis of institutions within the commodity chain framework is exactly one of the main contributions of the thesis. These institutions permeate the whole chain from one end to another and are usually applied to analyse the environment in which agents take decisions about production, consumption, etc.: institutions constrain the interactions among agents, ultimately defining the market structure in a given geographical space. As in the Wallersteinian framework, competition and monopolistic forces are key to analyse the interactions between nodes of the chain but the thesis further examines the interactions within the nodes of the chain in which economic costs and geography are important factors as well. Like the Wallersteinian notion of the limits of his world-system being determined by the transport costs, the scope of the rubber chain here is also influenced by economic costs and geography.

In this context, agents are assumed to behave as rational individuals that pursue their own individualistic goals summarised by their utility functions. However, agents act under incomplete information and uncertainty even though the assumed model of economic behaviour continues to be more connected to the formalist view. On the one hand, the proponents of the formalist view claim that embeddedness was not greater than the low level found in modern societies, allowing the use of neoclassical economic concepts and tools for the analysis of pre-capitalist societies[86]. On the other hand, the proponents of the 'substantivist school' argue that economic behaviour was heavily embedded in social relations in pre-capitalist societies but became much more

[86] Granovetter (1992). This author's approach suggests that the level of embeddedness of economic behaviour is lower in non capitalist societies than is claimed by sustantivists and it has changed less with modernisation than they believe. Granovetter (1992) also argues that this level has always been and continues to be more substantial than is allowed for by formalists.

autonomous with modernisation. It is thus argued here that since actors in the Brazilian Amazon registered profit motivation it does justify a more formalist approach in which decisions can be atomised: the majority of the agents here was comprised by foreigners who went to the region in a quest for profit. Furthermore, even if this region is taken as a pre-capitalist society, there seems to be evidence that economic concepts can be applied to explain individual behaviour in pre-capitalist societies.[87]

The adoption of the formalist approach does not mean that economic theory will be used upon the assumption of purely neoclassical economics. There were many market-failures [88] that were partially overcome by the creation of certain institutions (not necessarily efficient ones) opening room for some extra-economic behaviour. Therefore, these atomised individual decisions are constrained by institutions (formal or informal ones) that are understood as the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction. They reduce uncertainty by providing structure to everyday life, defining and limiting the set of choices of individuals.[89]

These institutions are not *ad hoc* but rather the result of an historical evolution of interactions among agents. Therefore, the thesis also rejects the historical context of the world-system theory, assuming instead that each commodity has its own history, its own evolution and its own geography. As in the commodity chain literature, by rejecting the historical context of the world-system theory, the thesis needs also to reject the necessary centre-periphery relationship: the Brazilian Amazon is not assumed to be peripheral. However, unlike the commodity chain approach, the notion of power is formally defined and analysed by applying game theory. This game theoretical framework has the additional advantage of providing a myriad of possible outcomes for market interactions instead of simplifying it to one single homogeneous solution (chains are not necessarily polarised anymore).

[87] See Law (1992) and Ogilvie (2001).
[88] For a summary of new institutionalism see Bates (1995). This author discusses market failures and how they are sometimes overcome by institutions.
[89] North (1990, pp. 3-4).

Power between nodes of the chain is understood as bargaining power between transacting agents in a world constrained by formal and informal institutions. The formalisation and modelling of power structure is certainly one of the most innovative theoretical developments of the thesis. In the several games analysed here, individual maximisation of utility does not necessarily generate the best possible social outcome, meaning that bad Nash-equilibria are usually present. True, cooperation among players may lead to a Pareto-superior equilibrium which is nevertheless seldom a self-enforcing solution. Cooperation may only arise naturally if there are a <u>small number of players</u>, the play is <u>repeated</u> and players possess <u>complete information</u> about the other players' past performances.[90]

First, some forms of exchange involve and require the interactions among several players. Secondly, since the game is never repeated *ad infinitum* (as agents do not survive forever), a cooperative solution (like the 'tit-for-tat') is seldom a stable equilibrium. Thirdly, actors frequently must act on incomplete information and process the information that they receive through mental constructs that can result in persistently inefficient paths. Preferences are not stable, actors do not possess true models and the information feedback is insufficient[91]: when information is incomplete, principal and agent will not form equal expectations, opening room for deceit.

Deceit may be avoided through second-party or third-party punishment/retaliation. One obvious way to do it is through collective action, i.e., by forming an alliance among players to punish any deviant behaviour. According to Greif contract enforcement can also be achieved through a variety of other instruments: morality, personal trust and the legal system[92]. First, if there is any preference for being honest (which overcomes profit motives) the agent would live up with the terms of the agreement even in the case where cheating could be profitable, provided that the agent could signal to the principal that they would not cheat under any circumstances. Secondly, in a repeated game, playing some

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[90] North (1990).
[91] North (1990).
[92] Lovejoy and Richardson (1997) show an example of how culture/region-specific institutions can enforce contracts, strengthening Bates (1995) assertion that there are limits to policy prescription from new institutionalism analysis. Lovejoy and Richardson (1997) show how important was the pawn institution as a way of enforcement.

tit-for-tat strategy, agents might form personal trust diminishing the costs of monitoring. However, it does not seem economically rational for the agents to do so since they would be giving up bargain power in exchange for nothing (unless the minimisation of monitoring cost[93] allowed production and everyone was thus better off). Lastly, although the legal system is not strictly necessary for enforcing informal contracts[94], it may be used to punish and/or ostracise deviant players.

The proposed methodology is thus based on the commodity chain literature and analyses the rubber chain under a partial equilibrium approach. Even though the focus is on a commodity (rubber), the thesis unveils the economic and social impacts on a specific region, the Brazilian Amazon that from 1870 to 1910 accounted for around 60% of the overall supply of that commodity (see Appendix). Neoclassical analysis provides the basic framework that points out the *likely* outcomes of the forces at play that, once combined with Institutional Economics and Economic Geography, explains the *actual* outcomes of the interactions among atomised agents who maximise their own utility function independently. The resultant effect on the macro level is further quantified and investigated by econometric analysis. This interaction between qualitative and quantitative evidences represents one step further in the analysis of commodities in general, and commodity chains in particular.

1.7 – Final Remarks

Basic trade models suggest at least two determinants for patterns of trade: technology and endowments. In terms of gains from trade, the Ricardian model offered a very positive view as trade benefits everyone in the economy. In the Hecksher-Ohlin model, in turn, there are typically losers and winners from trade: owners of a country's abundant factors gain from trade whereas those owners of scarce factors lose. Even

[93] According to North (1990), because it is costly to measure the valued attributes fully, the opportunity for wealth capture by devoting resources to acquiring more information is ever present. It is measurement plus the costliness of enforcement that together determine the costs of transacting.
[94] See Greif (1996).

though it is still possible to find a Pareto-superior equilibrium, this basic model shows the theoretical possibility of immiserising growth.

These standard trade theories usually consider trade in isolation from investment, finance, or other relations between parties to trade. The Global Commodity Chain (GCC) approach, in turn, has a different departure point and instead of explaining trade patterns as derived from different technology or endowments, the approach addresses questions about what products countries do (and should) import and export in relation to complex institutions. Moreover, instead of deriving trade patterns from optimizing behaviour of rational economic agents, for GCC, trade is taken as embedded in, and to a considerable extent as determined by specific (but changing) institutional structures. The Global Commodity Chain approach is a development of the world-system theory at the micro level and, as such, it is an extension of the dependency theory. Instead of the Prebischian notion of dependency being created from increasingly unequal terms of trade, in the world-system theory, the global market is a uneven playing field, underscored by the existing hierarchy between core and periphery areas that translates into a relation of power between nodes of the commodity chain located in these two areas.

The proponents of the commodity chain approach, in turn, reject the centre-periphery assumption of GCC. By doing so, they typically reject the world-system theory altogether replacing it with more neoclassical economic reasoning and modern standard trade theory models. A construction of a more detailed and integrated historical context becomes thus a requirement as it ceases to be embedded in and becomes commodity-specific. In this context, the evolution of the commodity chain over time now interacts with this more general and specific historical background. In the commodity chain approach, institutions are sometimes used in the analysis to limit the agent's room for manoeuvre but a more detailed and thorough discussion of institutional theory within the commodity chain approach is still lacking. Moreover, as in the GCC approach, very few quantitative studies have so far emerged.

The thesis follows the commodity chain approach but adds a more detailed discussion of the role of institutions and geography in the organisation and development of the chain combining it all with a more quantitative-driven analysis (that gives macroeconomic support to the analysis at the micro level). The analysis becomes two-dimensional and hence non-linear: it analyses the interactions between nodes of the rubber chain as well as interactions within the nodes of the chain. Based on this modified commodity chain approach, the thesis is organised according to the main nodes of the rubber chain and its ultimate goal is to investigate how institutions can explain the birth and development of the rubber chain in the Brazilian Amazon from 1870 to 1910 and, by so doing, some contributions to Institutional Economics are additionally made. Neoclassical analysis provides the basic framework that points out the *likely* outcomes of the forces at play that, once combined with Institutional Economics and Economic Geography, explains the *actual* outcomes of the interactions among atomised agents who maximise their own utility function independently. The resultant effect on the macro level is further quantified and investigated by econometric analysis.

2. Demand for Crude Rubber: from early history to 1910

2.1 – Introduction

As explained in Chapter 1, the thesis follows a modified commodity chain approach in which institutions and geography are brought to the fore. Institutions are assumed to permeate the whole chain, shaping and influencing interactions among and within the nodes of the rubber chain. Under this perspective, the present chapter aims to analyse the first node of the chain, namely the rubber manufacturing industry. It then provides a succinct history of the industrialisation of rubber, focusing on two countries: the United States and Britain. It is shown that formal and informal institutions defined the degree of competition (within-analysis) that prevailed in rubber manufacturing, making the industry somewhat different from the GCC/Wallersteinian model. Secondly, the chapter shows that competition emanated along the rubber chain translating into a struggle for crude rubber supplies (between-analysis). Therefore, institutions in the form of relations between parties to trade and the role of finance and investment enhance the understanding of the actual pattern of rubber trade that emerged, complementing the prescriptions of standard trade models. Quantitatively, it is further shown here that this struggle for rubber supplies, in turn, would have allowed the main crude rubber supplier, the Brazilian Amazon, to extract monopoly rents from consumers, moving the rubber chain further away from the Wallersteinian model. This quantitative exercise is entirely based on new data on US and British rubber trade, combined with information obtained from Brazilian sources.

The chapter is organised into 7 sections, including this introduction. Section 2.2 presents the history of the rubber industry until the discovery of the vulcanisation process and its consequent application in rubber manufacturing. Section 2.3 and 2.4 then surveys the evolution of the rubber industry in Britain and in the USA, respectively, showing that despite some cartelisation attempts, competition prevailed on both sides of the Atlantic. Section 2.5 explains how this competition at the manufacturing level resounded along the rubber chain, translating into competition for crude rubber sources whereas Section 2.6

computes elasticities of demand that validates this assumption. Finally, Section 2.7 concludes the chapter.

2.2 – Early Rubber History until 1850s

Even though pieces of rubber containing 1.92% of sulphur were found in the lignite deposits of Germany dating from the Eocene period (B.C. 58.8 to 33.7 million of years), the modern history of this raw material is more intrinsically connected with the discovery of the Americas. The presence of latex-yielding trees in Mexico, Central America and notably in the Amazon basin led to the application of this milky-fluid by American civilisations, as noted by early European explorers including Columbus (on his second voyage in 1493-6), Pietro Martire d'Anguiera (1530), Gonzalo Fernandez de Oviedo (1535), Antonio Herrera Tordesillas (1601) and F. J. de Torquemada (1615). Most of these accounts portrayed a (rubber) ball game similar to today's football, but also religious ceremonies in which rubber was used as tribute. The utilisation of rubber for waterproofing was early recognised, but the product still remained as a simple curiosity.[95] Charles Marie de la Condamine[96] and François Fresnau's[97] accounts directed more attention to rubber but no immediate industrial development followed. In the eighteenth century they described the process of crude rubber production, the types of trees from which latex was obtained and some possible applications of the material. They nonetheless inspired two other

[95] Jones (1952, pp. 1-2) and Rogers (1952, pp. 40-41).

[96] According to Charles Marie de la Condamine (1778, pp. 76-77) :

> *"The wax so-called cahuchu (pronounced cahout-chou) in the surroundings of Quito, close to the sea, is also very common on the banks of the Maragnon river and has the same usages. If fresh, one can mould it to any shape; it is impervious to the rain; above all, it is its elasticity that is most remarkable. One can make it into strong bottles, boots or hollow bowls that become flat if pressed and regain its original form as soon as the pressure is released. The Portuguese from Para were taught by the Omaguas how to transform it into pumps or syringes that do not require piston: they look like hollow pears with a cavity on one end where a cannula is introduced. If filled with water, and pressing until full, they will function as ordinary syringes. This device is very common amongst (the) Omaguas."* (my translation from French)

[97] Moreover, Fresnau's memorandum of 1747 (transcribed in Jones, 1952, pp. 21) states:

> *"Uses of the Different milky saps of which I have spoken: With these spread on linen one could make tarpaulins, sleeves for pumps, divers' suits, waterbottles, bags for biscuits, etc., without fear that this material would impart a bad smell, but all these things can only be made on the spot where the trees grow, as the saps lose their fluidity very soon, especially the Şereingue (sic) sap".*

Frenchmen, François Herrissent and Pierre Macquer to make the first attempts to employ rubber in Europe by chemically dissolving the product. From their work, and of other French scientists, the first breakthrough was reached: the utilisation of turpentine and pure ether as solvents for rubber.[98] On the other side of the Channel, experiments were also being carried out by Winch, Samuel Peal, Henry Johnson and J. Clark among others, all of whom devised a different chemical mixture for dissolving rubber. In parallel, a patent for preparation of rubber varnish was registered in the United States by J. F. Hummel.[99]

The dissolution of rubber and its consequent industrial manipulation led to several rubber factories being founded in the USA and in Europe (see Figure 2.1 below). Probably the first rubber company was founded in St. Denis, near Paris in 1803. Eight years later, J. N. Reithoffer opened a rubber factory in Vienna for the manufacture of elastic goods. In England, the first rubber concern was founded by Thomas Hancock in 1820 for working rubber and cutting strips to insert into garters and waistbands. Three years later, his future partner, Charles Macintosh founded Chas. Macintosh & Co. in Manchester whose main initial production was waterproofed fabric. In 1828, the first German rubber manufacture was founded at Finsterwalde near Berlin for the production of rubber thread and woven elastic. In the same year, Jan van Geuns started a company in Haarlem, Netherlands, for the confection of surgical specialities of soft rubber. In 1830, a rubber manufacturing company named H. Kirkstein was established in St. Petersburg, Russia, to make footwear whereas three years later the first American rubber manufacture was founded: Roxbury India Rubber Factory for the manufacture of rubber cloth and leather.[100] As can be seen from Figure 2.1, some other rubber concerns were founded in the 1830s in the USA, Britain and France.

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98 Woodruff (1958, p. 2).
99 Jones (1952, pp.10-11).
100 Rogers (1952, pp.40-48).

Figure 2.1: Early Rubber Manufacturing Concerns, 1800-1840

Company Name or Entrepreneur's Name	City	Country	Year of Incorporation
n.a.	St. Denis	France	1803
J. N. Reithoffer	Vienna	Austria	1811
Thomas Hancock	London	Britain	1820
Chas. Machintosh & Co.	Manchester	Britain	1823
Rattier and Guibal	n.a.	France	1828
François Fonrobert	Finsterwalde	Germany	1828
Jan Van Geuns	Haarlem	Netherlands	1828
H. Kirkstein	St. Petersburg	Russia	1830
Barbier & Daubrée	Clermont Ferrand	France	1832
Roxbury India Rubber Factory (later Goodyear Manufacturing Co. and thence Boston Belting Co.)	Roxbury	USA	1833
David Moseley & Sons, Ltd.	Chorlton-on-Medlock	Britain	1833
Eagle Rubber Co.	Easton	USA	1835
P. B. Cow & Co., Ltd.	London	Britain	1836
London Caoutchouc Co. (later Wm. Warne & Co., Ltd.)	London	Britain	1837

Source: elaborated from Rogers (1952, pp. 40-48). Note: n.a. = not available.

Rubber manufacturing companies appeared in several countries, but by 1830s, they started to be more and more concentrated in Britain and in the USA (even though France was also an important early rubber manufacturer). However, despite the establishment of these various manufacturing concerns there still remained technological hurdles for rubber manufacturing. The main issue hampering further industrialisation and commercialisation of rubber was not only its industrial manipulation but especially the fact that the product became rigid and inflexible in cold weather and it softened and decomposed under the sun or in hot weather. This problem was particularly important in a place like Northeast USA where extreme variations in temperature are recorded during the year and where customers were probably more deeply dissatisfied with rubber manufactures.

In parallel to this process of rubber industrialisation in Europe and in the USA, North-American interests started to establish themselves at the future centre of worldwide crude rubber supply: Belém city at the mouth of the Amazon River in Pará region, Brazil. However, their initial commercial interest referred more to indigenous rubber shoe trade, set by New England traders who worked a shipping route linking Northeast US to the Brazilian coast, and Buenos Aires, in Argentina. That trade emerged after a ship captain named Benjamin Upton brought a pair of shoes to Salem, Massachusetts. Thomas Crane Wales somehow took notice of this new product and by 1825 he imported 500 pairs of rubber shoes from Belém, which were readily sold in the local market. Other traders followed suit and rubber shoe imports quickly rose, fostered by the transfer of some technical knowledge to native producers in Brazil. US traders indeed established commercial *entrepôts* (usually run by family members of New England traders) in Belém which allowed them to instruct local rubber tappers on what they wanted and how to imprint a certain brand on the footwear. Proximity to production (geography) also permitted a more readily perception of supply variables, rendering responses to demand changes easier.[101]

Brazilian rubber shoes were praised for their quality and durability: the indigenous rubber men were taken as experts at their business.[102] Belém producers possessed 'Ricardian' comparative advantage in rubber shoe production. Their comparative advantage in rubber shoe production was strengthened by technological impediments (long time of travel, faulty preparation of the raw material, etc.) to crude rubber trade: it usually got damaged during the travel becoming useless for industrial purposes or requiring higher costs of manipulation. Higher quality and commercial ties should thus explain the increase in rubber shoe trade until mid 1840s (see Figure 2.2 below), even in the context of a civil war that disrupted trade in Belém from 1835 to 1840.[103] Indeed, in 1837-8 (in the middle of the civil uprising) 212,500 pairs of shoes were exported from Pará and from 1841 to 1846 420,000 pairs of shoes were exported on average per year. However, from 1846 onwards the rubber shoe trade from Pará started to wither away until 1854, when orders ceased to come through.

[101] Coslovsky (2005, pp. 11-29).
[102] Coslovsky (2005, pp. 12-13).
[103] It must also be noted that there was some technological impediments (long time of travel, preparation of the material, etc.) to crude rubber trade: the material usually got damaged during the travel becoming useless for industrial purposes.

Figure 2.2: Exports of Rubber Shoes from Pará to Selected Countries (in pairs) 1836-1856

	1836-1841		1841-1846		1846-1851		1851-1856	
	n. of pairs	%	n. of pairs	%	n. of pairs	%	n. of pairs	%
USA	894,320	87.4%	1,722,918	82.1%	1,187,893	82.7%	81,400	44.6%
Germany	50,224	4.9%	151,359	7.2%	82,447	5.7%	37,135	20.4%
France	25,229	2.5%	114,455	5.5%	66,330	4.6%	600	0.3%
Britain	18,877	1.8%	61,188	2.9%	39,639	2.8%	8,354	4.6%
Portugal	16,096	1.6%	25,000	1.2%	56,565	3.9%	51,904	28.4%
Others	18,651	1.8%	24,843	1.2%	2,770	0.2%	3,078	1.7%
Total	1,023,397	100.0%	2,099,763	100.0%	1,435,644	100.0%	182,471	100.0%

Source: computed from Hancock (1857, pp. 158-165).

As it can be further inferred from Figure 2.2 above, US traders clearly dominated the rubber shoe trade with Pará, accounting for more than 80% of total Pará rubber shoe exports until the 1850s (note that England was never a large consumer of native rubber shoes even compared to countries such as Germany and France). However, by 1850s, two things were undermining the native rubber shoe trade. First, the boot and shoe industry in Massachusetts was experiencing an organisational change from the 'Domestic Stage' to the 'Factory Stage'. In the 1850s, there was a sharp increase in demand for boots and shoes following the Californian and Australian gold discoveries which brought about immense orders with big profits, pushing to its very limits of production the boot and shoe organisation. [104] Large economies of scale rendered mechanisation profitable, especially after 1860 with the introduction of the McKay sole sewing machine and the Goodyear Welt machine in 1875.[105] Secondly, the discovery of the vulcanisation process by Charles Goodyear in 1839 improved the quality of US and European rubber products which became impervious to the weather, making the centralisation of production viable through the exploitation of large economies of scale. There was then a structural break in the rubber industry that shifted relative comparative advantage in manufactured rubber towards the USA and Britain. By increasing the quality of rubber products, the vulcanisation process undermined the quality advantage Brazilian shoes had had, explaining the sharp decrease in rubber shoe imports in the 1850s. This specialisation of

[104] Hazard (1913, pp. 244-262).
[105] Roe (1913, pp. 938-940). See also Coslovsky (2005, pp. 36-45).

rubber manufacturing closer to consuming markets shaped the rubber chain: manufacturing ceased to be concentrated geographically closer to rubber trees in the Brazilian Amazon. The Brazilian Amazon then became a producer of crude rubber whereas the USA and Britain specialised in rubber manufacturing. In order to understand this transition and its consequences, it is important to examine this technological breakthrough first and then consider if technology was country-specific. Once the rubber market strucuture in the USA and Britain is analysed, it will be possible to evaluate the demand for crude rubber, i.e., the relationship between rubber manufacturing and the other nodes of the rubber chain.

What is the vulcanisation process and how was it achieved? The perfection of industrial manipulation of rubber relates to technological breakthroughs in the USA and in Britain. Whereas in Britain rubber developments are associated with Thomas Hancock and Charles Macintosh's experiments, in the United States, the name of Charles Goodyear stands out. Hancock began his experiments with rubber as early as 1819 which led to the registration of several patents connected to mechanical apparatuses to treat the product. The most famous of these machines was the 'masticator' or 'pickle', comprised of two hollow wooden cylinders armed with teeth in which initially a hand-driven spiked roll was turned. The pickle welded together scraps of rubber into a homogeneous dough which could be applied to manufacture. Macintosh, in turn, (re-)discovered about 1820 the use of coal tar oil as a cheap solvent for rubber.[106] Therefore, the process of dissolving rubber by the Macintosh process was perfected by treating the material mechanically through Hancock's pickle machine, making cheap and financially viable the manipulation of rubber. By the end of the 1830s, there had been a consolidation of the Hancock-Macintosh forces with certain textile interests around Manchester, trading under the name of Chas. Macintosh & Co.

US industrial developments went along other lines. US industries did not adopt Hancock's pickle machine, the method chosen was to compress crude rubber between wooden or iron cylinders. For instance, in 1836 Edwin Marcus Chaffee (original member

[106] Woodruff (1958, pp.1-5).

of Roxbury India Rubber Company) developed a 'calender' or coating machine, comprised of steam heated rolls that allowed for the grinding and mixing of the rubber either without the use of solvents or with their limited use. Even though the absence of solvents would diminish the odour, it did not solve the primary problem that rubber hardened under cold temperatures and softened/melted in hot weather. This would be solved three years later with the discovery of the vulcanisation process by Charles Goodyear. Goodyear became interested in rubber in 1832 and his experiments continued until his death in 1860. His first patent was registered in 1837 for an 'acid gas process' which he believed had solved the basic problem of rubber industrialisation and manipulation. However, its commercialisation was a failure and only after he started to apply sulphur to rubber in his experiments (following suggestion by Nathaniel Hayward, from Eagle Rubber Co., who sold rights of his 'solarisation process' to Goodyear), would Goodyear make the final breakthrough: applying high temperature to a compound of sulphur, lead and rubber. Rubber would then achieve a new (vulcanised) state whereby it would be impervious to weather conditions.[107]

From then on, rubber manufacture technology was defined by a six-step industrial process: cleansing, grinding, softening, mixing, calendering and lastly vulcanising. First, rubber balls were cut into pieces and any foreign matter was extracted. The rubber pieces were then inserted into a water-filled barrel fitted with rotating and fixed knives that would tear apart the rubber and separate it out from impurities. Secondly, the cleansed material was plasticised by grinding and compressing it against two rolling heated cylinders. Next, softeners (such as camphene) were added and the rubber was placed into the mixer where the chemicals (vulcanising agents) were incorporated. For articles built from sheets of rubber the next step would then be the calendering: rubber would be compressed against rotating cylinders so close to each other that the crude rubber would be transformed into rubber sheets. Lastly, rubber was placed into a steam-heated chamber until it achieved its vulcanised state – a state that could only be determined by an experienced worker.[108] Crude rubber manufacturing became much more capital and

[107] Woodruff (1958, pp. 6-10), Lunn (1952, pp. 31-37) and Goodyear (1855).
[108] Woodruff (1958, pp. 21-23).

technology intensive and the skills necessary for production were not the same as the ones American Natives possessed, partly explaining why rubber manufacturing moved geographically. Economies of scale increased the benefits of larger industrial plants that, due to costs, needed be located closer to consuming markets.

However, even though technically rubber could now be industrialised, the USA was still suffering from the crisis of 1837. Heavily in debt, Goodyear looked to England and in 1842 empowered Stephen Moulton to dispose of his formula for £50,000. Stephen Moulton carried with him the first samples of vulcanised rubber which were presented to Hancock and Brockedon (Hancock's partner). However, the negotiation came to naught and Moulton went back without the money Goodyear needed so much. Moreover, from the vulcanised rubber pieces shown to Hancock, it was possible to discover the vulcanisation process and indeed Hancock registered his formula in Britain in November 1843, two months before Goodyear belatedly applied for his English patent.[109] Therefore, in the mid-1840s, the consolidation of the vulcanisation process started and with it the applications of rubber greatly expanded.

Figure 2.3: Exports of Crude Rubber from Pará to Selected Countries (in lbs.) 1836-1856

	1836-1841		1841-1846		1846-1851		1851-1856	
	in pounds	%	in pounds	%	in pounds	%	in pounds	%
USA	235,476	14.0%	974,765	47.5%	4,956,447	59.6%	11,683,325	52.9%
Germany	87,322	5.2%	136,428	6.6%	192,688	2.3%	418,069	1.9%
France	303,776	18.1%	314,836	15.3%	740,777	8.9%	795,860	3.6%
Britain	650,793	38.7%	485,847	23.7%	2,364,348	28.4%	8,195,542	37.1%
Portugal	326,308	19.4%	51,226	2.5%	21,344	0.3%	36,055	0.2%
Others	77,757	4.6%	90,547	4.4%	41,952	0.5%	951,690	4.3%
Total	1,681,432	100.0%	2,053,649	100.0%	8,317,556	100.0%	22,080,541	100.0%

Source: computed from Hancock (1857, pp. 158-165).

From Figure 2.3 above, it can be seen that exports of crude rubber from Pará increased steadily throughout the period and that the US and Britain clearly took a lead as main importers: altogether they accounted for 90% of total Pará rubber exports in the

[109] Woodruff (1958, pp. 10-14) and Hancock (1857).

early 1850s. Note that the growth of crude rubber trade increased even faster when rubber shoe exports started to wither away.

In sum, proximity to latex-yielding trees and the dexterity of indigenous inhabitants of Pará combined with technical expertise and capital advanced by New England shoe-makers gave rise to a thriving rubber shoe trade which from 1836 to 1856 entailed the export of nearly 5,000,000 pairs of rubber shoes (of which nearly 4,000,000 exported to the USA alone) from one of the least developed regions of Brazil. However, the general demand for boots and shoes increased markedly due to Californian and Australian gold discoveries in the 1850s, generating more economies of scale that could only be explored through mechanisation. The discovery of the vulcanisation process in 1839 undermined the superior quality of Brazilian rubber shoes and made possible centralisation of production in factories. Moreover, with the vulcanisation process, the applications of rubber greatly expanded giving rise to a thriving flow of crude rubber from non-industrialised countries to industrial ones, with the US and Britain taking the lead.

At first glance, the vulcanisation process then allowed rubber production to behave along the lines of the GCC/Wallersteinian framework. Core-states (here USA and Britain) concentrated higher levels of skill and capital. However, as explained in Chapter 1, the thesis does not assign any pre-defined notion of power among different nodes of the rubber chain and there is no assumption that any node was necessarily regarded as core. Furthermore, the development of the rubber trade also follows the Hecksher-Ohlin trade model as Brazil became an exporter of crude rubber and importer of rubber manufactures: indeed Brazil was relatively abundant in crude rubber but relatively scarce in capital for rubber manufacturing concerns (especially because the dexterity of native producers ceased to be too relevant after the discovery of the vulcanisation process). Conversely, the USA and Britain deepened their industrial position in rubber manufacturing[110], a process that was influenced and shaped by formal (especially patents) and informal institutions that developed in relatively the same way in both countries. As in the GCC

[110] Tariffs might have also played a role in withering rubber shoes trade from Pará. See Coslovsky (2005).

approach, it is important to understand the resultant market structure as monopoly and competition are considered key to understand the distribution of wealth among the nodes of a chain. Hence the next sections explore the evolution of the British manufacturing industry and later contrast it with its US counterpart. Once the resulting market structure in both countries is understood, it will be possible to analyse the demand for crude rubber, i.e., the relationship between rubber manufacturing and the other nodes of the rubber chain.

2.3 – British Rubber Manufacturing Industry, 1860s-1910

As can be seen in Figure 2.4, several rubber companies were incorporated in Britain from the late 1840s to the 1860s, evincing the technical success of the vulcanisation process with more and more applications being developed for crude rubber (the list is not intended to be extensive though). The most important companies founded in this period were probably G. Spencer, Moulton & Co. (1848), The India Gutta Percha, and Telegraph Co. Ltd. (1852) and the North British Rubber Co., Ltd. (1855). Even though Moulton never became a large company in the rubber industry, remaining very much specialised, there are quite a lot of academic works about the company that shed light into the rubber manufacturing industry as a whole.[111] The India Gutta Percha and Telegraph Co.[112] remained very specialised too but its ramifications into submarine telegraphic communication turned this company into an important player in the rubber industry.[113] Finally, as will be discussed in more detail later in this chapter, the North British Rubber Co. was an important competitor of both Chas. Macintosh & Co. and Dunlop (after the turn of the century). However, the viability of most of these early rubber companies was attached to patented vulcanisation rights owned by Chas. Macintosh & Co. Formal

[111] See, for instance, Woodruff (1951), Woodruff (1953), Woodruff (1958) and Payne (1961).

[112] The Company was merged in 1865 with Glass, Elliot & Co. (see Figure 2.4) to form the Telegraph and Construction Maintenance Co., or simply Telcon. This was the first company to be involved in every stage of cable making, from insulating the core to laying it. See Lawford and Nicholson (1950, pp. 9-64).

[113] It is the same group (especially John Pender) behind the Eastern Telegraph Co. See Chapter 6 for details on submarine telegraphic communication.

institutions became then key to understand the evolution of British rubber manufacturing and how competition developed among the main firms.

Figure 2.4: British Rubber Concerns, 1840s-1870

Company Name	Year of Incorporation
J. G. Ingram, Ltd.	1847
G. Spencer, Moulton & Co., Ltd.	1848
J. Mandleberg & Co., Ltd.	1850
C. E. Heinke & Co., Ltd.	1852
The India Rubber, Gutta Percha, and Telegraph Works Co., Ltd.	1852
Glass, Elliot & Co.	1854
North British Rubber Co., Ltd.	1855
The Leyland and Birmingham Rubber Co., Ltd.	1862
J. Frankenstein & Sons	1868
J. G. Franklin & Sons, Ltd.	1870
Northern Rubber Co. Ltd.	1870

Source: elaborated from Rogers (1952, p. 42) and Lawford and Nicholson (1950).

Due to patents, by the 1860s, Chas. Macintosh & Co. enjoyed a competitive edge (and rents) in the British market but its leading position and property rights did not remain uncontested for long. In 1849, Stephen Moulton began to manufacture rubber under his own patent that prescribed lead sulphate instead of sulphur as the vulcanising agent.[114] Moulton's patent was a result of his early association with the brothers William, John and Emory Rider, manufacturers of rubber goods in Harlem, NY. Their vulcanisation formula was discovered in Rider's factory by an American chemist, James Thomas, and registered in England where they initially intended to sell it. This is another example of how technology was spread from one side of the Atlantic to the other. However, Stephen Moulton had other plans and decided to set production in Bradford-on-Avon for which he counted on technical knowledge from the Americans.[115]

Once Chas. Macintosh & Co. had enforced Hancock's patent in England (and Wales) through litigation against Goodyear, the Manchester company channelled its

[114] Woodruff (1953, pp. 41-42).
[115] Woodruff (1958).

energies against Moulton & Co. under the plea that Moulton's patent was also an infringement of Hancock's. The court decided in Macintosh & Co.'s favour but its victory was only partial: Moulton & Co. was granted a restrictive license under which to continue operations the company had to pay £600 per year. Nonetheless, even though Macintosh was henceforth forced to share the market with Moulton & Co., Moulton's venture did not challenge Macintosh's market position. The Bradford company specialised in high quality rubber mechanicals[116] instead of producing a wide range of rubber products as Macintosh did. In fact, more important competitors arose from Scotland and overseas instead.

Despite its victory against Goodyear (and, by consequence, against all American licensed rubber manufacture companies) in the English courts, Macintosh was never able to keep American products (produced under Goodyear license) at bay. Moreover, the English monopoly of the vulcanisation process was not fully secured as a group of American investors used a breach of the law to establish a rubber factory in Scotland. Hancock's patent was registered in England before the Patent Law Amendment Act of 1852, and it was not automatically extended to the rest of Britain. In Scotland, it was Hancock (Chas. Macintosh & Co.) who belatedly applied to a patent as Goodyear's patent preceded Hancock's by 3 months.[117]

In 1856, Norris & Co., a footwear concern, was established in Edinburgh as a Goodyear licensee. A year later the venture was reincorporated as North British Rubber Co. with an authorised capital of US$491,000 (or £100,000) increased to US$1.9 million (or £350,000) in 1888[118]. Like Chas. Macintosh & Co., British Rubber Co. also diversified into a wide range of rubber products such as belting, hose and other mechanical goods, giving a spurt to sales. The move to tyre production proved later even more profitable and in 1898, tyres accounted for 38% of sales.[119]

Chas. Macintosh & Co. responded to the entry of North British Rubber Co. and to foreign competition by cutting prices below costs, causing lower standards and profits in

[116] The company was very specialised in rubber mechanicals such as rubber buffers or springs for train wagons which led to its later association with the House of Spencer. See Payne (1961).
[117] Woodruff (1958, p. 143).
[118] Figures were converted from sterling pounds into US dollars using exchange rate series provided in the Appendix.
[119] French (1988, pp. 396-403).

the British rubber manufacturing. Paradoxically though, increased competition and general uncertainty about the supply of crude rubber coupled with price warfare compelled the British rubber industry towards collusion. Yet the problem with issuing uniform price lists was that the quality of rubber goods differed immensely. Additionally, cartelisation could not control foreign competition. With overt support of the India Rubber Journal[120], the first Rubber Manufacturers Association of Great Britain was created, based in Manchester but the Association was handicapped as some important firms decided not to join: for example, Wm Warne & Co., North British Rubber Co., Spencer Moulton & Co., and The Silvertown Co.[121]

Macintosh would not continue indefinitely as the main rubber manufacturer in Britain, being surpassed by Dunlop which would become in 1930 the eighth largest British company in terms of estimated market value. This firm's initial growth rested on John Boyd Dunlop's 1889 patent of the pneumatic tyre principle. This patent was nonetheless invalidated three years later after the re-discovery of Robert William Thompson's much earlier patent of the pneumatic tyre in 1845. Were it not for the purchase of other important patents, such as the Welch and Bartlett ones (the last one bought from North British Rubber Co. for £200,000) concerned with methods of attaching pneumatic tyres to bicycle rims, Dunlop's company might not have survived. Indeed, the company's expansion was laid upon possession of patented technology that the company tried to protect abroad through international ventures in France, Germany, Russia, Canada, United States, Japan and Australia.[122]

As with Macintosh some years earlier, formal institutions (namely, patent rights) explain Dunlop success. However, whereas Macintosh's patents related to an industrial process for rubber manipulation, Dunlop's referred to a specific product, the pneumatic tyre, and methods of applying it to cars and bicycles. Apart from Dunlop and Moulton & Co., British rubber companies were usually highly diversified, producing a wide range of

[120] *India Rubber Journal*, 13th May 1898.
[121] *India Rubber World*, 1st May 1900.
[122] Tariffs were also decisive in defining Dunlop's international strategy. See Jones (1984, pp.35-41).

rubber products as North British Rubber Co. and Chas. Macintosh & Co. did. However, with the re-discovery of the pneumatic principle, these companies lost market share to Dunlop which specialised in the most rapidly increasing niche of the industry, rubber tyres. According to the UK Census of Production, in 1907 rubber tyres accounted for 31.8% of overall sales in the industry that stood at US$43.3 million (equivalent to £8.9 million) in 1907 and US$62.3 million (or £12.8 million) in 1912.[123] Dunlop was the company that benefited the most from this structural change, becoming the biggest rubber concern in Britain employing around 4,000 people in 1913[124] out of a total employment in the rubber industry of 31,900 in 1912[125]. In turn, North British Rubber Co. had around 3,500 employees in 1908[126] against a total employment in the rubber industry of 24,039 in 1907.[127] In capitalisation terms, in 1905 Dunlop ranked 16th among British industrial companies with a total capital of US$21.4 million (or £4.4 million), dwarfing North British which was capitalised at US$1.8 million (or £360,000).

In sum, a formal institution, patent legislation, was at the heart of the development of the British rubber industry. Initially, Macintosh used patents to enforce a domestic monopoly, with some success. The company was able to prevent American competition for a while, at the same time that it cashed in with its licensees. However, North British Rubber Co. and Moulton & Co. were a thorn in the side of Macintosh in a context of increasing foreign competition with ever new players in the market. On top of that, following the re-discovery of the pneumatic principle, rubber tyres were applied to bicycles and later to motorcars, changing completely the composition of rubber manufactures.

Remember that, apart from Dunlop and Moulton & Co., British rubber companies were usually highly diversified, producing a wide range of products. Thus due to more specialisation in the most rapidly growing niche of the rubber industry, Dunlop profited from the change in the demand for rubber manufactures that became more and more

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[123] UK Censuses of Production (1907) and (1912).
[124] Shaw (1983, p. 53).
[125] UK Census of Production (1912).
[126] Shaw (1983, p. 53).
[127] UK Census of Production (1907). For the sake of comparison, according to Censuses for England and Wales (1861) and Scotland (1861) , in that year there were only 1,840 rubber workers in Britain.

concentrated on tyres. Despite Dunlop's leadership, the rubber manufacture market remained quite competitive, though not as much as it was during the price war of the 1860s. In that sense, the British rubber industry does not follow so closely the characteristics of a Wallersteinian core-node as initially thought. Even though patents (formal institution) enforced monopoly/oligopoly, competition continued to be prevalent: despite the existence of big players (such as Dunlop, Macintosh and North British Rubber Co.) cartelisation was always unsuccessful as it was not possible either to curtail foreign competition or to assure a price list in such a heterogeneous market.

2.4 – US Rubber Manufacturing Industry, 1860s-1910

As in Britain, amalgamation and collusion in the rubber industry was shaped by formal institutions, right from the start. As mentioned before, Goodyear was responsible for the emergence of the US rubber industry as new industries appeared as Goodyear's licensees. In late 1840s, the first voluntary association of rubber industries was born as Goodyear Associates and Licensees when six firms (Goodyear's Metallic Rubber Shoe Co., L. Candee & Co., Newark India Rubber Co., Ford and Company, Hayward Rubber Co. and Oderdonk and Letson) agreed to pay into a common fund – to be used for prosecution of infringers of the patent – a royalty of three US cents a pair on all sellable footwear manufactured under Goodyear license. This sum was additional to the royalty of one-half cent a pair paid directly to Goodyear. These firms also agreed on minimum and maximum discounts, and further agreed to meet annually to decide on prices. From 1852, a tighter control was established with production quotas being assigned to members of the agreement.[128]

Between 1865 and 1892 several other agreements were pursued in order to increase profits by maintaining high prices through production limits (or the consolidation of companies). In 1882, B.F.Goodrich proposed to several rubber companies the formation of a single central company which would absorb sixty-makers of rubber goods, including B.F.Goodrich. The idea did not last long, but was revived in 1886 when a pool

[128] Babcock (1966, pp. 21-22).

for mechanical goods (including industrial belting) was formed [129], resulting in the incorporation of the Central Rubber Co., a Rhode Island Corporation. However, dissent among stockholders led to court actions and the dissolution of the company in 1892. In parallel to this agreement in the mechanical goods, other collusion was attempted among boot and shoe companies which nonetheless did not materialise until 1889 when 10 out of 14 rubber boot and shoe companies formed the Rubber Boot and Shoe Manufacturers' Association aiming at securing high prices.[130]

Apart from protection of property rights, the driving forces behind collusion and amalgamation were usually competition and the swings in the price of crude rubber. After the Sherman Antitrust Act (1890) the US Federal Government started to intervene in those overt collusion agreements, but further concerted action in the rubber industry still ensued, notably as consequence of the efforts of Charles R. Flint who organised and prepared the incorporation of the United States Rubber Co. (USRC) on March 29th, 1892. By the end of that year nine companies merged (see Figure 2.5 below). In 1893, USRC gained control of Goodyear's India Rubber Glove Manufacturing Co., Woonsocket Rubber Co. (and its subsidiary Marvel Rubber Co.), the Lawrence Felting Plant and Colchester Rubber Co. The next major purchase was that of the Boston Rubber Shoe Co. in 1898 which means that by mid-1890s there were only two rubber footwear companies outside USRC's control. Yet, by the end of the decade, competitors were emerging to challenge USRC market dominance. These companies were all incorporated by former managers, directors or presidents of some of the companies amalgamated into the USRC.[131]

[129] Blackford and Kerr (1996, p. 26).
[130] Babcock (1966, p. 24).
[131] Babcock (1966, pp. 26-40).

Figure 2.5: Rubber Footwear Concerns Amalgamated into USRC before 1900

Year of Incorporation	Name of the Company	Year of Amalgamation into USRC
1845	Goodyear Metallic Rubber Shoe Co.	1892
1847	Goodyear's India Rubber Glove Manufacturing Co.	1893
1850	New Brunswick Rubber Co.	1892
1852	The L. Candee and Co.	1892
1853	Boston Rubber Shoe Co.	1898
1861	Meyer Rubber Co.	1892
1864	National India Rubber Co.	1892
1867	Woonsocket Rubber Co.	1893
1877	New Jersey Rubber Shoe Co.	1892
1878	American Rubber Co.	1892
1878	Boston Rubber Co.	1892
1881	Para Rubber Shoe Co.	1892
1888	Colchester Rubber Co.	1893
1888	Brookhaven Rubber Co.	1892
1890	Lycoming Rubber Co.	1892
1896	Hood Rubber Co.	1898

Source: elaborated from Babcock (1966, pp. 26-50).

In 1898, Charles R. Flint was again active in amalgamations in the rubber industry, orchestrating the incorporation of the Rubber Goods Manufacturing Co. (RGMC) on January 26th, 1899. Members of the syndicate subscribed US$ 5 million (of which US$ 3 million in cash)[132] to be invested in properties of manufacturers of rubber goods and allied products other than boots and shoes. By February 1893, the RGMC had acquired 99.8% the capital stock of the Mechanical Rubber Co., 75% of the stock of Morgan and Wright and the entire stock of the following companies: Peerless Rubber Manufacturing Co., Akron India Rubber Co., Sawyer Belting Co., Hartford Rubber Works Co., Indianapolis Rubber Co., Sandy Hook Reclaiming Works, Mechanical Fabric Co., American Dunlop Tire Co., Single Tube A and B Co. and Peoria Rubber and Manufacturing Co.[133]

In 1905, the most important agglomeration in the rubber industry took place when the United States Rubber Co. bought the Rubber Goods Manufacturing Company, thereby becoming the largest firm in the industry as of 1907 (see Figure 2.6 below) its net sales reached nearly US$ 40 million (£8.2 million). USRC sales dwarfed all other major rubber

[132] £1,028,000 and £616,780, respectively. See appendix for data on exchange rates.
[133] Babcock (1966, pp. 44-47).

companies and its profits were twice as large as B.F.Goodrich's and twenty times that of Firestone.

Figure 2.6: Financial Performance of Major US Rubber Manufacturers, 1907 (in £)

	Net Sales	Net Profits	Net Income as a Percentage of Net Sales
U.S. Rubber	8,172,016	944,444	11.6%
B.F.Goodrich	2,660,503	478,166	18.0%
Goodyear	450,617	n.a.	n.a.
Firestone	345,885	44,092	12.7%

Source: elaborated from Blackford and Kerr (1996, p. 43). Converted into pounds sterling using series presented in the Appendix.

The second major company in the industry by 1907 was B.F.Goodrich with net sales of US$ 13 million (£2.7 million) or just 32.6% of U.S. Rubber Co.'s. B.F. Goodrich was the first rubber company west of the Appalachians, beginning operations in February 1871 in Akron, Ohio. Numerous factors accounted for the establishment of the company in that site, which would later become the rubber capital of the United States: for example, availability of clean water (essential in the cleansing process), good transportation facilities (not only by canal but also by rail), cheap fuel from Ohio's coal mines and a relatively inexpensive labour supply.[134] B.F. Goodrich initial success also accounted for the spurt in rubber production in Ohio as other companies moved to the region. By 1904, there were another twenty-six rubber companies in Ohio; in 1909, 41. In 1905, Ohio had already established itself as the main rubber manufacturer in the USA and in 1914, the State accounted for 36.4% of overall US rubber manufacture production.[135] Even though Dunlop and North British also possessed large scale plants, there is no comparable agglomeration of rubber plants in Britain as the Akron rubber cluster in the USA.

Moreover, the relationship with car makers (that were agglomerating in the nearby Detroit area) granted the US tyre manufacturers advantage in the development of the new

[134] Blackford and Kerr (1996, p. 37).
[135] Barker (1940, pp. 17-21).

designs necessary for car tyres[136] and, for instance, by 1907, Goodyear dismissed British Dunlop's car tyre as unsatisfactory: standardisation of demand (and quality and technological improvements) emerged as a response to the needs of the motorcar industry.[137] As a consequence, whilst in Britain a wide variety of types and sizes for tyres would become the rule, in the United States motor manufacturers at any one time restricted their demands for tyres to a limited number of sizes and types.[138]

It must be mentioned that economies of agglomeration might have been present long before the motorcar industry. The rubber shoe and boot production had clustered in New England, especially around Boston, as an extension of the traditional shoe and boot industry.[139] This might have accounted for the early high productivity of the US rubber industry. With the tyre making industry, these economies of scale and agglomeration simply intensified, facilitating the formation of cartels or any other restrictive agreements.

Like the USRC, B.F.Goodrich was involved in several agreements to restrict competition. As mentioned earlier, the company was at the heart of consolidations of the mechanical rubber goods, even though it did not join the Rubber Goods Manufacturing Co. agreement until later. By mid-1890s, B.F.Goodrich tried another arrangement, this time to limit competition in the bicycle tyre market, and form a pool to control the price of crude rubber. These efforts were not successful, though they resulted in the formation of the Rubber Tyre Association which lasted two years only because one third of the companies in the market decided not to join.

In the late 1890s and early 1900s,

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[136] French (1987, p. 70).
[137] French (1987, p. 70, footnote 21).
[138] Donnithorne (1958, p. 53).
[139] The Appendix shows my own computation of productivity in the US and British rubber industries. Due to data availability it is only possible to compare productivity in the 1900s. The data shows a significant productivity gap of 2:1 favouring the USA. Since early productivity was relatively high in the USA, it is possible to speculate that this gap may have existed as early as 1860s, contradicting Woodruff's (1955) claims. His computation is quite misleading as he proxies productivity by crude rubber consumption divided by the number of workers. The data shown in the Appendix relates more to the idea of productivity as being defined by quantity of production divided by the number of people employed in the industry. Woodruff's productivity is measuring technology differences rather than productivity.

"(...) *the company* [B.F.Goodrich] *joined with others, including Goodyear, in an effort to limit competition by purchasing from the Single Tube Automobile and Tire Company the right to manufacture automobile tires under the Tillighast patents. Companies not so licensed were excluded from making certain types of tires. Similarly, in 1903 Goodrich joined the Rubber Goods Manufacturing Company and several others in setting up the Clincher Tire Association. This body tried to limit competition by acquiring patents that gave its members the sole right to make clincher automobile tires. It also set production quotas and prices. Goodyear was given a very small allocation and Firestone was excluded altogether".*[140]

As the quote above shows, B.F.Goodrich was indeed involved with various agreements that tried to curtail competition but, as several previous ones, these efforts failed or were at best short lived. It was very difficult to cartelise such a heterogeneous market. Moreover, these agreements invariably gave incentives for outside firms to innovate thereby overcoming the limits of the cartel. This indeed happened in the case of the Clincher Tire Association mentioned above. The cartel backfired as the outsiders, Goodyear and Firestone, developed a "straight-side" tyre that was much easier for motorists to replace. Because of this development, Firestone was granted its first orders from Ford and emerged as one of the biggest companies in the rubber industry.[141] Goodyear and Firestone companies were very much specialised in tyre production, and because of the increasing demand for rubber tyres, as a consequence of the development of the motorcar industry, they rapidly increased their market shares in detriment of B.F.Goodrich and The United States Rubber Co. that remained very much diversified. Both companies were latecomers: the Goodyear Tire and Rubber Co. was founded in 1898 by F. A. Seiberling (former financier of B.F.Goodrich), H. Manton, and D. E. Hill[142] whereas the Firestone Tire and Rubber Co. was only established in 1900, by H. S.

[140] Blackford and Kerr (1996, p. 34).
[141] Blackford and Kerr (1996, p. 34).
[142] Rogers (1952, p. 45).

Firestone and other investors, initially based on an invention by James A. Sweinhart of a tyre that could be easily fastened to the rim.[143] By 1907, these two rubber concerns were still small compared to US Rubber Co. and B.F.Goodrich, but with further development of the motorcar industry they would soon catch up. Goodyear would eventually become the biggest rubber company in the USA.

Even though in the USA cartelisation of the industry seems to have been more successful (a bit closer to the Wallersteinian core-node ideal type if compared to its British counterpart), the four giant rubber corporations were not able completely to control the marked. Even the USRC, the largest company, accounted for less than 15% of the market by 1910. Therefore, competition was curtailed somewhat along the process of amalgamations in the industry but the market remained quite competitive. Competition indeed continued, despite agglomeration forces. Agglomeration economies in Akron were created by proximity to markets (especially, Detroit where the motorcar industry was also agglomerating) and to inputs (clean water, coal and labour). Spillover effects and the geographical proximity to carmakers gave a competitive edge to US rubber manufacturers, creating even more external economies of scale.

Even though the geographical proximity between several firms pertaining to a same segment of the rubber market facilitated cartelisation, as in Britain, patents were the main formal instrument used to limit competition.[144] However, this amalgamation process cannot be viewed solely as attempts to limit competition by greedy capitalists as it was also a natural adjustment of the industry in a period of rapid growth in a context of scarcity of the main input of the industry: crude rubber.

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[143] Firestone (1926, pp.46-55).

[144] Patents were also used to keep some foreign competitors out of the market. For instance, British Dunlop had trouble to re-enter the US market after having given in the rights to trade in the United States in tyres "for use on cycles and other vehicles", when they sold its American venture to its Canadian manager. After the Rubber Goods Manufacturing Co. secured a controlling interest in the (American) Dunlop Tyre Co. in 1899, British Dunlop was forbidden to trade under its own brand up to 1916 after a payment of US$95,320 (or £20,000) in royalties for the United States Rubber Co. (which by then owned the Rubber Goods Manufacturing Co.). See Jones (1984, pp.35-41).

2.5 – Impulses of Demand

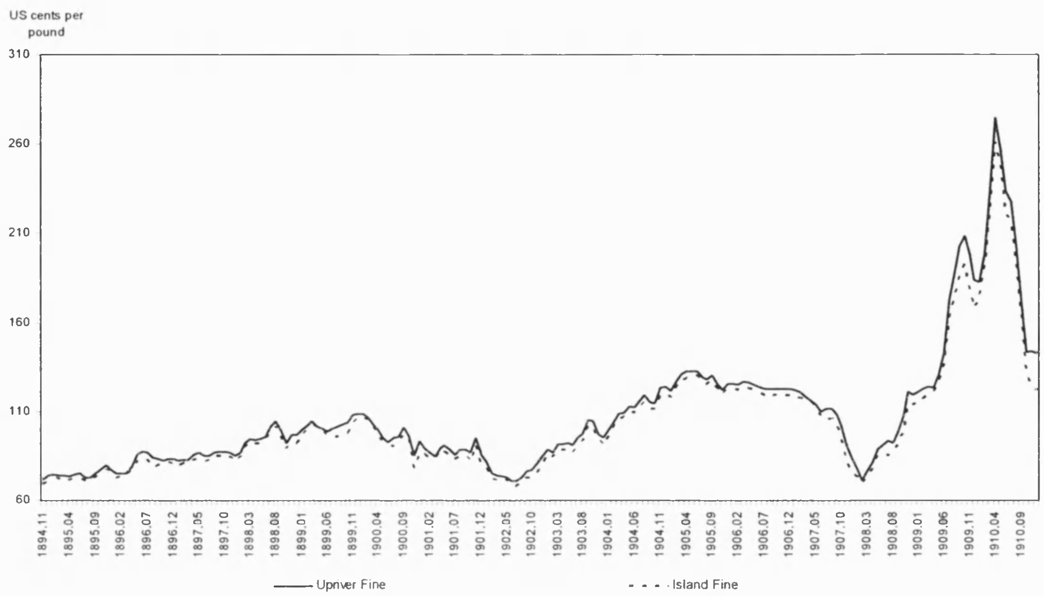
As argued in the previous sections, despite cartelisation efforts, competition prevailed on both sides of the Atlantic and as shown by international ventures (epitomised by Dunlop's attempts to establish itself in the USA), British and American rubber companies were definitely rivals. British and American exports of rubber manufactures soared with clear advantage to Britain since most of US rubber manufacture production was absorbed by the domestic market as a consequence of the deeper development of the motorcar industry in that country.

This rivalry among rubber companies (and between British and American rubber industries) emanated along the rubber chain, notably after the demand for bicycles and motorcars caused the demand for crude rubber to take an explosive trend. As explained in the previous section, the British and American rubber industries do not appear to have followed the Wallersteinian core node ideal type as competition continued to be prevalent and this section further shows that profitability does not follow the GCC prescriptions as swings in crude rubber price influenced profitability at the manufacturing level rather than the reverse. In order to understand why the rubber chain departs so much from the GCC, it is important to analyse the rubber trade in conjunction with investment and finance. Even though this will be carried out in more depth in the next chapter, it is shown here that access to a steady and reliable supply of rubber was the key to success in a context of rising crude rubber prices.

As can be inferred from Figure 2.7 below, the price of crude rubber showed an upward trend, especially from 1902 to 1910, despite an interruption in mid-1906, result of an attempt by a Brazilian export house to corner the rubber market in Belém, which nonetheless failed due to a recession in the USA. The price of crude rubber in 1910 simply reflected the fact that wild sources were inadequate to support an increasing demand for rubber, pushed by motorcars sales in the USA and abroad.

Figure 2.7: Monthly Price of two Varieties of Brazilian Crude Rubber in New York

(November 1894- December 1910)



Source: computed from several issues of the *India Rubber World*. The plotted line was computed as the average between minimum and maximum prices for 'Pará Upriver' and 'Island Fine' rubber grades as quoted in the New York market. 'Upriver Coarse', 'Island Coarse' and 'Cametá' grades (lower quality grades from the Brazilian Amazon) all showed the same basic trend in prices. See Appendix for further data on prices for different rubber grades.

As can be seen, the average price for 'upriver fine Pará' in 1905-1910 period was 1.54 times higher than in 1895-1899 and 2.35 times higher than 1875-1879. Hence, rubber manufacturers became increasingly concerned about crude rubber supply. The analysis of costs in the industry does suggest that rubber was the main cost component that could account for as much as 30% of the price of the final product.[145] Moreover, some industries set their prices based on the cost of rubber rather than on the scale of its activities:

> *"(...) for Moulton* [from Moulton Co., later Spencer, Moulton & Co.] *price was determined not so much by movement to and from a point of equilibrium in the scale of operations as by changes in the cost of raw*

[145] This can be observed by dividing the value of crude rubber consumption (proxied by imports minus exports) over the value of rubber manufacture production in a given year (taken from the Census of Manufactures or Census of Production).

materials; particularly movements in the crude rubber market that affected a great part of his total manufacturing costs. Over a period, and this point needs to be stressed, no other factor could so easily spell prosperity or disaster for the producer than changes in the value of his rubber stocks"[146]

As the quote above shows, changes in the price of crude rubber usually drove prices of rubber manufactures as it can be inferred from several letters exchanged by Moulton and Spencer regarding price adjustments. Moreover, Stephen Moulton always showed confidence that his price adjustments would be followed by the whole industry.[147]

Further evidence of how important crude rubber prices were in influencing the price for the whole chain derives from the fact that the profit levels along the rubber chain were strongly correlated and profits for tyre companies usually had a positive correlation with crude rubber prices.[148] The explanation for this counterintuitive result reinforces Moulton's perception in the quote above: rubber stocks held could cause disaster or could be a blessing for a rubber manufacturing company. Crude rubber was so scarce that a good position in this market could determine profits at the rubber manufacturing industry. This explains the US and British struggle for crude rubber supply. There was little horizontal integration along the rubber chain and then British and American rubber manufacturers would usually place orders to crude rubber traders at the beginning of the rubber tapping season. Therefore, there was usually a stable and long relationship between traders and rubber manufacturers and once the orders were placed, rubber traders would often directly advance funds to crude rubber producers (or buying in the spot market) in order to meet the demand. They would also speculate by buying more

[146] Woodruff (1953, p. 61), underlined by me.
[147] Woodruff (1953, p. 54).
[148] Frank and Musacchio (2006, pp. 288-289). B.F. Goodrich (1881-1910) and Firestone (1903-1910) do show a strong correlation between their profits and crude rubber price. So does Spencer & Co. from 1861 to 1890. However, the North British Rubber Co. (1857-1910) and Moulton & Co. (1855-1860) showed a negative correlation, suggesting that these two companies might have had more trouble passing through increases in the crude rubber price to the final consumer. Sources: a) for profits: French (1988), Woodruff (1958), Payne (1961), Blackford & Kerr (1996) and Lief (1951); b) for crude rubber prices: *US Trade and Navigation Reports* (several issues) and *UK Parliamentary Papers* (several issues).

rubber than that required by the forward contracts. In this context it was difficult for American rubber manufacturers to bypass British buyers (and vice-versa) even if they offered a higher price as most of the market was hidden under forward contracts and only a small proportion of trade occurred on spot markets: for example, according to a British crude rubber trader,

> *"(...) [t]otal imports (into Liverpool) for the last three months are 2,265 tons while the total sales only represent 562 tons, it is thus perfectly evident that large quantities of Rubber, especially Pará, must find its way to the manufacturers without coming on the open market, the result no doubt of forward contracts so that considerable quantities must have been forwarded from the store".*[149]

However, as England (London and Liverpool) established itself as the main rubber spot market, it is not surprising that, even still, American rubber manufacturers (and crude rubber traders) tried to bypass importers on several occasions under the assumption that they were suffering from speculation. For instance, in 1910, Bertram G. Work, president of B.F.Goodrich decried the "work of speculators in London in raising crude rubber prices"[150].

For a rubber trader, a good position in the crude rubber market was crucial to meet the forward contracts, whereas from the viewpoint of rubber manufacturers, it was crucial to ally themselves with an (or a pool of) influential (rubber) trade house(s). It was also important to forecast accurately the demand for rubber manufactures as additional marginal production would require going to spot markets where prices were usually very high due to the scarcity of the product. Since the American industry was the one expanding the most, US rubber manufacturers ended up resorting more to the spot markets, meaning that American rubber companies paid higher prices (especially at the margin) for a same quality of crude rubber. Moreover, in general the US rubber traders

[149] W. Wright & Co./SM, 20 March 1875, cited by Woodruff (1958, p. 52, footnote 4).
[150] Blackford and Kerr (1996, p. 56). See also Frank and Musacchio (2006).

were acquiring a lower average quality of crude rubber. Indeed, according to a British crude rubber trader:

> "[i]*t is a noticeable fact that the average price of crude rubber imported into the U.K. was higher than the average price of that exported (1889 for example 231s. cwt. against 209s.) which suggests that the British manufacturer normally retained the superior and exported inferior kinds*"[151]

Nonetheless, this was also a consequence of the fact that most of the trade entering Britain was actually under forward contracts that usually embodied a lower value for rubber trade in exchange for a steady, long-term relationship between the parties. If most of the British re-exports were spot sales against forward contract purchases in the importing market, it would be expected that prices should be higher in the re-export market regardless the quality of the product. If this was really the case, to account for lower prices in British re-exports of rubber, the quality of the product must have been very low indeed.[152]

As mentioned earlier, rubber traders sometimes made direct investments in rubber production, usually by advancing money to producers, shaping the connection between manufacturers and the other nodes of the rubber chain. Before 1910 the supply of crude rubber came mainly from wild sources, and British and American investments were mostly carried out through export houses, which provided capital for native rubber producers in exchange for their future production of rubber. Sometimes the export houses were simply

[151] Wright, Roberts & Co.'s Circular, 20 January 1871. Cited by Woodruff (1958, p. 49, footnote 1).
[152] According to the Appendix though, implicit prices for Brazilian crude rubber imported into the USA were considerably lower than reported for Britain (and France). Even though it could be argued that American buyers were more successfull in lowering prices due to market power, the text shows evidence in contrary. Moreover, as the thesis will further show, US buyers were more dependent on rubber (higher inelasticity of demand), they paid higher freights, and qualitative information from rubber manufacturers suggest that they were getting more low quality rubber. Another explanation for lower prices in the US data refers to the different role of US and British rubber exporters placed in Brazil. On the one hand, the former were mainly agents of US importing firms and then were probably exporting rubber at its cost price (with the profits being accrued by the headquarters). On the other hand, the latter had more freedom of manoeuvre and were exporting rubber at the highest possible price.

representatives of British and American rubber traders.[153] However, funds were also channelled through stock markets even before plantations came into place: there are examples of native wild rubber companies that were directly incorporated abroad, such as the Liberian Rubber Corporation, the Peruvian Rubber Co. and De Mello Brazilian Rubber Co., among others. These wild rubber producers went to London in search of capital, and the London Stock Exchange was preferred to its New York counterpart. By 1910, London had established itself as an international financial centre, trading securities from the whole world whereas New York traded almost exclusively in American stocks and bonds.[154] In regard to rubber, it is true that after several scandals due to speculation and fraud[155], rubber securities were banned from the London Stock Exchange in 1909 but investors continued to trade in rubber shares in an alternative market set up in Mincing Lane, London. In the USA, plantation companies seldom met

> *"(...) the strict requirements for listing on the New York Stock Exchange and promoters usually employed paid journalists and bold advertising to peddle their securities directly to unsophisticated investors – physicians, school teachers, clerks, waiters, laborers, widows and other susceptible women, and others with money to invest."*[156]

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[153] See, for instance, Weinstein (1983).

[154] Michie (1986, pp.184-185).

[155] There is ample evidence of speculation on rubber shares. First, the sheer amount of money channelled to rubber production in the 1900s is indicative of this process. The Appendix shows the paid-up capital of crude rubber producing companies in Africa, Americas and Asia. Secondly, the number of firms involved in the rubber trade also provides further evidence (see Appendix). Thirdly, there are several stories of frauds with rubber shares making Munro (1981, p. 267, underlined by me) affirm that in African rubber investments,

> *"[t]here were often uncertainties surrounding the assets of the business – for example, over the actual amount of tappable rubber available in the forest concession, or whether the company's monopoly rights could be defended,* de facto *as well as* de jure, *against competing elements. Against these operational risks were set the possibility of quicker and higher returns on capital than from plantations which might require several years of expensive development work. Consequently, companies to exploit natural rubber concessions were more susceptible to speculative financial pressures".*

Michie (1986, p. 184), Schell Jr. (1990, p. 225), Drabble (1973) and Drabble and Drake (1974) provide further information on rubber investments. See also The Rubber Producing Companies (1911) and The Rubber Share Handbook (1910).

[156] Schell Jr. (1990, p. 223).

Thus in the first decade of the 20th Century, there was speculation with rubber shares, fuelled by the increasing demand for crude rubber in the industrialised countries, notably in Britain and America, that drove prices upward. Several companies were formed or funds channelled directly to investments in crude rubber production all over the globe and indeed rubber was a globalised commodity *par excellence*: rubber yielding trees were found in all continents. However, as can be inferred from Figure 3.1 (further below), Brazil supplied around 60% and the rest of the Americas another c.10% of the market to both, the USA and Britain. The remaining 30% was supplied by Africa and 'Asia & Oceania' for Britain and by European re-exporters to the USA. This geography of the rubber trade will be explored in more detail in Chapter 3 and what is important to note here is just that competition for rubber sources was pushing prices up, forcing production to continue to expand to ever new areas too. Consequently, the investment in crude rubber production was soaring.

The geographical struggle for crude rubber supply meant that Britain and the USA had different access in terms of the quality of rubber they imported insofar as crude rubber was not a homogeneous commodity at all, registering huge differences in terms of quality and physical properties of the material (notably in terms of tensile elasticity). For instance, gutta-percha, a native tree from Malaya and the Dutch East Indies, was a non-elastic variety of rubber and owed its commercial use for insulation of (submarine) cables and for outer casing of golf balls. In turn, African rubber produced a decent quality of crude rubber, registering a good cost advantage in the production of buffers of railway carriages: buffers made out of lower quality rubber would seldom return to their original size once compressed. Finally, hevea trees, native of the Amazon forest, produced the best quality of rubber (the best tensile elasticity) and thus Amazonian crude rubber (especially from Brazil and Bolivia) were usually either applied to high value added products or mixed to lower grades in the confection of medium value added products. Therefore, the higher the quality of the crude rubber, the more applications it would have and of course, the higher the price: prices indeed reflected quality and there were several different grades of rubber in the market whose prices could vary by more than 3 times. [157]

During 40 years of rubber trade, from 1870 to 1910, at a first glance total rubber import figures suggest a draw in the struggle for crude rubber supply: whereas Britain imported on average 16,690,980 kilograms of crude rubber per year, the USA imported on average 16,504,344 kilograms of rubber per year.[158] However, the geography of trade differed significantly: most of the primary sources of US crude rubber imports were located in the Americas whereas Britain relied heavily on its colonies and on Brazil. But since US primary sources of crude rubber were insufficient to meet demand, it was very dependent on re-exporters, especially on Britain. From 1870 to 1910, British colonies supplied 20% of total crude rubber imports into the UK whereas Britain and its colonies supplied 18% of overall US crude rubber imports. Moreover, since most of the crude rubber trade was carried by British vessels, the role of British capital was even more decisive. In that regard, resource endowments suggest that Britain was in a better position. Not only did this country have more access to rubber sources but it might also have been able to influence price and quality in US rubber manufacturing industry (at least marginally).

Therefore, competition among British and American firms emanated along the rubber chain, translating into a battle for crude rubber resources. Investments were normally channelled through the London Stock Exchange to several different rubber producing countries (or colonies) all over the globe in order to create a flow of crude rubber to meet the demands of the American and British rubber industries. The dependence of these two industries to supplies of crude rubber might have been so great that the control of capital might not have been able to offset the control of crude rubber reserves by indigenous crude rubber producers before the advent of plantation in 1910, contradicting GCC's prescriptions: a high inelasticity of demand for crude rubber might have then ensued. However, the British rubber industry might have faced a lower inelasticity of demand in view of the fact that this country was importing more rubber than

[157] See Appendix for details on prices for different rubber grades.
[158] Computed from several issues (1870-1910) of UK Parliamentary Papers and US Trade and Navigation Reports of the Secretary of the Treasury. See Appendix for data on the rubber trade.

its industry needed and moreover part of the rubber was coming from its own colonies, over which London rubber traders might have possessed a higher degree of control. Here, the relations between parties in trade and the role of investment and finance (these roles will be explored further in the next chapter) help understand the actual trade pattern that defined the geography of trade *vis-à-vis* the likely trade pattern as predicted by standard trade theories.

Access to crude rubber sources was important but not sufficient to meet the needs of rubber manufaturing industries insofar as the quality of the rubber imported mattered. Depending on the industrial use, a higher or less quality was required and to achieve that desired quality level sometimes different grades of rubber were mixed.

2.6 – Elasticities of Demand

From previous sections, it is possible to infer that the rubber manufacturing industry in Britain and in the USA evolved in a relatively competitive environment and that its activities and profitability were directly dependent upon establishing a stable and reliable supply of crude rubber of some minimum quality. This competition at the manufacturing level emanated along the rubber chain and resulted in fierce competition for raw material. Given the nature of production until 1910, which was almost exclusively dependent on wild sources, this section investigates, from British and American trade balance data, how hungry for rubber these industrial centres were and what their strategies were to save on rubber. The data is all new and original, collected by the author from primary sources. British data was obtained from Parliamentary Papers whereas USA data came from the Foreign Commerce and Navigation of the United States. [159] It is shown that the USA was much more in need of a steady crude rubber supply than Britain, which might even have been able to extract monopoly rents from the USA due to its

[159] Import value and quantity was collected by country of origin from 1870 to 1910 for both the USA and Britain. Apart from Brazil, no other single country possessed significant market share throughout the period and only seldom a country exceeded 10% mark. Therefore, countries had to be aggregated in groups, notably in view that their territory often changed as consequence of colonial policies or simply independence or incorporation by another.

position in the market: Britain imported more than it needed and re-exported a sizeable fraction of its rubber stock, notably to the USA.

The methodology is based on estimations of elasticities of demand from the two main sources of rubber: Brazil and British Colonies (for the USA, the last category includes Britain). Together, they accounted for 76.2% of total crude rubber imports into the UK and 74.4% of total crude rubber imports into the USA between 1870 and 1910. It is very likely that Brazilian figures (BRZ) include some crude rubber produced in neighbouring countries such as Bolivia, Venezuela and Colombia since Belém city in Brazil developed as the main rubber hub in the region.[160] In the British dataset, 'British Colonies' (BRC) comprise 'Channel Islands', 'New South Wales', 'British West Indies', 'British East Indies', 'British India', 'Madras', 'Bombay & Scinde', 'India Singapore & Ceylon', Singapore & Eastern Straits', 'Ceylon', 'Federated Malay States', 'Borneo', 'Mauritius', 'Aden', 'Australasia', 'British West Coast Africa', 'British East Coast Africa', 'British South Africa', 'Natal', 'Zanzibar & Pemba', 'Gold Coast', 'Lagos', 'Nigeria', 'Sierra Leone', 'Gambia', 'Niger Protectorate' and finally 'Other British Possessions'. For the US data, BRC includes 'United Kingdom', 'British Honduras', 'Dominion of Canada', 'New Foundland', 'Labrador', 'Canada', 'British West Indies', 'British Guiana', 'British East Indies', 'British Australasia', 'British Africa' and 'Other British Possessions'.

There are several ways of computing these elasticities. One possible way would be to estimate demand and supply equations for the whole market jointly. However, in order to add up crude rubber supplies from several different parts of the world, that procedure would require the assumption that rubber was a homogenous commodity. In view of large quality differentials, this procedure does not seem to be satisfactory; especially in view that quality is an important feature of our story here. Moreover, the interaction between American and British demands would be lost. Another estimation

[160] Import data refer to Brazil as a whole. As Figure 3.4 shows, lower rubber grades were produced in other Brazilian regions as well. It was not possible to decompose British and US rubber imports by region of origin within Brazil. Even though the thesis is only concerned with the Amazon region, the aggregated results can and must be understood as being representative for the Amazon region as the other Brazilian regions produced very little in comparative terms. Moreover, since these regions produced lower quality rubber, in value, its proportion was even smaller. See Appendix for details.

procedure would be to calculate a separate demand and supply system for each crude rubber source but this procedure would treat each rubber source as a totally different commodity, leaving no room for complementarity or substitutability among the sources: it is true that crude rubber was not a homogenous product but, as argued earlier, different grades of crude rubber were substitutes to some extent and sometimes they could also be mixed to achieve some desired minimum quality.

The estimation procedure proposed here is based on an Almost Ideal Demand System (AIDS)[161] which provides a framework that is general enough to be used as a first-order approximation to any demand system (a more comprehensive discussion of the model is presented in the Appendix). Although it assumes that the supply for all rubber sources are perfectly elastic (which might be a strong assumption in some cases and will be relaxed along the rest of the thesis), this procedure provides a measure of the relationship between any given pair of crude rubber sources. From the estimation output, it is possible to see if rubber sources were complementary or substitute, or if they were normal or inferior goods, for example. Under this setting, equation 2.1 below is the specification to be estimated here, using data on import of rubber from Britain and the USA balance of trade statistics:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log \frac{x}{P} \tag{2.1}$$

where $\log P = \sum_k w_k \log p_k$ (2.2)

where w_i is the budget share of country i, α_i is the intercept, p_j is the implicit price for rubber from all sources j and x is the amount of money spent on rubber by country i. Lastly, P is the Stone's Price Index as defined in Equation 2.2, which is used because

[161] For a discussion about Almost Ideal Demand System, refer to the seminal article by Deaton and Muellbauer (1980). For applications of the model see Alston *et al.* (1990) and Alston *et al.* (1994). Finally, for economic historians, Irwin (2003) article is a good example of application of the model to the analysis of an historical case: cotton during the Antebellum USA.

implicit prices for rubber are collinear[162]: correlation between Brazilian and British Colonial rubber is 0.92 in the US sample and 0.95 in the British sample. Theoretically, homotheticity, homogeneity and symmetry should be imposed in the estimation to assure that the microeconomics behind the model will hold. Homotheticity would require that all β_i coefficients summed to zero whereas under homogeneity (of degree zero in prices) all γ_{ij} summed up should equal zero for each equation. Finally, homogeneity requires that $\gamma_{ij} = \gamma_{ji}$ for all i and j.

For instance, in Equation 2.1 for Brazilian rubber, we will be estimating the Brazilian market share (dependent variable) against the price of Brazilian rubber, the price of British Colonial rubber and a variable that capture overall physical demand of the market as it is defined as the total expenditure on crude rubber (total imports of crude rubber) divided by an average price of the raw product. Analogously, for British colonial rubber, the British Colonial share (dependent variable) will be estimated against the price of Brazilian rubber, the price of British Colonial rubber and a variable that capture overall physical demand of the market as it is defined as the total expenditure on crude rubber (total imports of crude rubber) divided by an average price of the raw product.

In fact, both equations (for Brazilian and British Colonial rubber) were estimated jointly by iterative SUR (Seemingly Unrelated Regression) techniques with only symmetry imposed and the results for the US and British data are presented in the Appendix. Symmetry was rejected only for US data (statistical tests for symmetry are presented in the Appendix), but it was still imposed to the system to avoid double elasticity of substitution between Brazil' and British Colonies' crude rubber sources. Tests for homogeneity in both systems suggested that it should be rejected under symmetry and

[162] Under high collinearity, small changes in data might produce wide swings in the parameter estimates which may have very high standard errors and low significance levels even in the case when they are jointly significant and the R^2 of regression is quite high. Furthermore, coefficients may present the "wrong" sign or implausible magnitudes. However, this does not seem to be the case here, as it will be clear later on, coefficients do show plausible magnitudes, expected sign and are quite robust. Moreover, collinearity increases the likelihood of Type II error, i.e, the likelihood of accepting the null hypothesis that a certain parameter is equal to zero increases. And, since this does not work in favour of the results here rather the contrary, it is possible in this case to simply disregard collinearity, especially because its correction would entail either dropping a variable or making the coefficients biased. Neither would help in the analysis: dropping a variable would embody losing information whilst biasing estimators would turn inferences from point estimators useless.

non-symmetry. Moreover, homotheticity was not imposed since the system here is equivalent to the one in which an extra equation for "all remaining countries" had been deleted whose β coefficient would be given by the adding-up restriction.[163]

For Britain, Adjusted-R^2 indicates a reasonably good fit in both equations: 0.45 in the equation for the Brazilian rubber demand and 0.30 in the equation for British Colonial rubber demand. For the USA, Adjusted-R^2 is lower in the Brazilian equation (0.20) but higher in the British Colonial equation (0.38). Durbin-Watson statistic suggests positive serial correlation in all equations from both systems possibly due to omission of price expectations or inflexibility in the short run, as a result of long run contracts between buyers and sellers. Even though the estimated coefficients remain unbiased and consistent, they are not efficient anymore. For both systems, Augmented Dickey-Fuller tests on residuals in level for each equation (not reported here) indicated that the null hypothesis that the residuals follow a unit root is always rejected.

Under AIDS, changes in real expenditure operate through the β_i coefficients: it is positive for a luxury good and negative for necessities. According to the estimates presented in the Appendix, Brazilian rubber is a luxury good for both the USA and Britain whereas British Colonial rubber is always a necessity (although not significant in the USA demand system). Yet, since their magnitudes are very close to zero, changes in the quantity of crude rubber consumed do not cause a significant change in terms of market share: for instance, whenever British consumption of rubber increased (income increased) there was only a more than proportional increase in Brazilian market share and a decrease in its Colonies' market share.

From the parameters of the AIDS equation is possible to retrieve the implied price-elasticities of demand as well as the elasticity of substitution among all rubber suppliers.

[163] In fact, to be strictly correct, the estimated equation should have included a price variable for "all remaining countries". However, the micro properties do not change and the system is equivalent to impose that the coefficients of these prices were equal to zero. All qualitative results are robust to specification changes and it was just chosen here the minimal specification required to support the hypothesis put forward here, i.e., that Britain could, at least partly, pass-through the price of rubber scarcity. Furthermore, it must be stressed that estimates are invariant to the equation deleted. See Barten (1969).

According to Alston *et. al.*[164], the compensated elasticity of demand for the *i*th good with respect to the *j*th price is defined as below:

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i} w_j \tag{2.3}$$

where δ_{ij} is the Kronecker delta that is equal to one if $i = j$ and zero otherwise. The standard error of the elasticity is given by γ_{ij} divided by w_i. The elasticity of substitution is also implicit in the AIDS estimated parameters and is defined as:

$$\sigma_{ij} = 1 + \frac{\gamma_{ij}}{(w_i w_j)} \tag{2.4}$$

where $i \neq j$, with an associated standard error calculated as the standard error of γ_{ij} divided by $w_i w_j$.

Figures 2.8 and 2.9 below show the implied price elasticities (on the diagonal, shaded cells) of US and British demand for Brazilian (BRZ) and British Colonies (BRC) rubber as well as their elasticity of substitution. Their associated t-ratios are shown below each estimate.

Figure 2.8: Implied Price Elasticities and Elasticity of Substitution of British demand for Rubber, 1870-1910

	Mkt Share	Beta	BRZ	BRC
BRZ	59.46%	0.07	-1.54	1.85
		3.99	-12.37	3.23
BRC	16.68%	-0.03		-0.92
		-1.77		-2.51

Source: computed from data presented in the Appendix.

164 Alston *et al.* (1994).

From Figure 2.9 above, it can be seen that British demand for Colonial rubber was more inelastic than for Brazilian rubber: -1.54 for BRZ against -0.92 for BRC. Even though both demands were relatively inelastic, Colonial rubber was more inelastic due to the prevalence of colonial interests over purely market forces. Thus a 1% increase in the price of Brazilian rubber would lead to a decrease of 1.59% of the British demand for Brazilian rubber. Analogously, a 1% increase in the price of Colonial rubber would cause a less than proportional decrease (0.92%) in the British demand for rubber from its own Colonies. Lastly, for British crude rubber buyers and traders, Brazilian and Colonial rubber were substitutes (elasticity of substitution was positive: +1.85).

Looking at all elasticities together, it can be inferred that in a context of rising prices of rubber (and in which prices are very collinear), British buyers decreased their demand from both sources but decreased Brazilian sources more than proportionally. Since Britain was importing more rubber than they needed, they could do it without affecting their manufacturing sector. The only change would be in terms of the quality of crude rubber they were consuming: they were importing less Brazilian rubber proportionally, which was considered on average as the best quality of crude rubber in the market (see Chapter 3).

Figure 2.9: Implied Price Elasticities and Elasticity of Substitution of US Demand for Rubber, 1870-1910

		Beta	BRZ	BRC
BRZ	57.64%	0.08	**-1.11**	-0.80
		5.06	**-13.26**	-2.26
BRC	17.52%	-0.02		**0.32**
		-1.44		**146**

Source: computed from data presented in the Appendix.

From Figure 2.9 above, it can be seen that US demand for Brazilian rubber was very inelastic: -1.11. Thus, an increase in the price of Brazilian rubber would cause a just proportional decrease in the quantity demanded by US crude rubber importers. Note that

US demand for Brazilian rubber was more inelastic than British demand for Brazilian rubber, -1.11 against -1.54, suggesting that US rubber manufacturers were in more need of Brazilian rubber than the British rubber manufacturers. As can be seen from Figure 2.9, US demand for Colonial rubber (which here includes Britain) is inelastic but positive suggesting that it was an inferior good: Americans would buy more British Colonial rubber if the price increased, probably because that would suggest that the quality would have improved. Thus, a 1% increase in the price of Colonial rubber would lead to a 0.32% increase in the demand for Colonial rubber. Lastly, for the US crude rubber importers, Brazilian and Colonial rubber were taken as complementary goods (elasticity of substitution was negative: -0.80).

Analysing all elasticities together it is possible to understand the US rubber industry strategy in a context of rising prices of crude rubber. Whenever crude rubber prices increased (remember: prices are highly collinear), the USA would decrease imports of that raw material from Brazil more than proportionally and increase the imports from British Colonial sources less than proportionally. Therefore, in a context of rising prices of crude rubber, both the USA and Britain would save on rubber to some extent, but Britain was in a better position: since that country was importing more rubber than its domestic market needed, if crude rubber prices increased, they could simply save on all rubber sources and sell even more (at higher price) to the USA. For the USA, there were clearly limits to save on rubber and the alternative was just to mix more low quality rubber from British Colonies with better quality rubber from Brazil, impacting over the overall level of quality of the raw product. In this context, it is easy to understand why the USA was more reliant on reclaimed rubber than Britain: reclaimed rubber was a compounding ingredient and would only compete with crude rubber at times of high crude rubber prices.[165] Thus, at the turn of the nineteenth century, the United States was the only country where reclaiming was of real importance, although small quantities were manufactured in Great Britain and on the Continent.[166]

[165] Barker (1940, p. 39).
[166] Essex (1952, pp.83-88).

In sum, the American and British rubber industries evolved in a relatively competitive environment. Given its scarcity, crude rubber supply proved to be the key variable to define profitability at the manufacturing level. Competition between rubber manufacturers translated into a struggle for crude rubber suppliers. Funds were channeled through the London Stock Exchange to several different parts of the globe but even though these investments registered a high correlation with trade flows, the control of the capital was not enough to alleviate the shortage of the main input in the industry, resulting in a high inelasticity of demand for crude rubber. However, since the British rubber industry was better positioned in the crude rubber market, its demand for crude rubber was more elastic compared to the USA. Furthermore, the quantitative results suggest that there was room for extraction of monopoly rents by Brazil, the main rubber producer.

2.7 – Final Remarks

The present chapter shows that at first proximity to rubber sources and the dexterity in the manipulation of rubber initially provided a 'Ricardian' comparative advantage to indigenous rubber manufacture. However, the discovery of the vulcanisation process (coped with the increase in the demand for rubber manufactures) undermined the superior quality of indigenous production and made possible the centralisation of rubber manufacture in factories: vulcanisation shifted comparative advantage in rubber manufacturing towards Britain and the USA. Therefore, from then on, the pattern of trade can mainly be understood as a result of Hecksher-Ohlin forces: Brazil specialised in the production of crude rubber due to the relative abundance of rubber trees in the Brazilian Amazon whereas Britain and the USA specialised in the production of rubber manufactures due to the relative abundance of capital, that became a requisite for larger rubber concerns. Therefore, from the 1860s onwards, Britain and the USA deepened their industrial position in rubber manufacturing with a similar technology being used on both sides of the Atlantic.

Even though standard trade theories help explain the geography of rubber trade (and by consequence the first node of the rubber chain, namely, the rubber manufacturing industry) there were other forces at play. For instance, economic geography forces explain agglomeration and location, notably in the US rubber manufacturing industry. In the within-analysis, the chapter shows that formal institutions, especially patent legislation, influenced and shaped the market structure of the rubber manufacturing industry: indeed, patents enforced a process of amalgamations in both countries even though the rubber industry remained quite competitive on both sides of the Atlantic. In the between-analysis, this competition at the manufacturing level resounded along the rubber chain, translating into a struggle for securing a steady and reliable source of crude rubber, the main input in the industry: competition within the manufacturing node influenced the interactions of agents located in different nodes. Here, the analysis of the rubber chain is enhanced by acknowledging that trade is not carried out under neoclassical assumptions: the relationship between parties to trade and the role of investment and finance is instrumental to understand the actual pattern of the rubber trade that emerged. Given its scarcity, that crude rubber was very expensive and access to resources thus became strategic to determine (or influence) profitability at the manufacturing level, turning the manufacturing node of the rubber chain very different from the ideal GCC/'Wallersteinian' core-node type. Yet, the British rubber industry was better positioned compared to its American counterpart: since British traders were importing more crude rubber than the British industry needed, they were able to pass through the burden of crude rubber scarcity to American buyers since the latter were unable to meet all their demand from primary sources. Furthermore, there was also scope for Brazilian crude rubber traders to extract monopoly rents especially from US buyers who registered a more inelastic demand for their product when compared to British demand for Brazilian crude rubber (-1.11 for the USA against -1.54 for the Britain). It is important then to analyse the organization of crude rubber supply in Brazil in order to understand how (if any) monopoly rents were generated. This would bring the rubber chain even further away from the GCC/Wallersteinian ideal chain type. That is exactly the objective of the next chapters.

3. World Rubber Supply: the US and British Struggle for Rubber

3.1 – Introduction

Before the Brazilian supply side can be fully analysed, it is important to investigate the main competing rubber producing regions in the world. Rubber could be found in nearly all Continents as the tensile elasticity of the material could be obtained from several types of trees, some of even different genus. However, the quality of the material (measured by its tensile elasticity) varied according to the type of tree which, in turn, demanded a different production technique. In the end, crude rubber quality depended on the rubber tree, the associated production method and the dexterity of the rubber tapper. Whereas the dexterity of the rubber tapper could be improved (at least to a certain extent), before the successful domestication of rubber trees in large scale (plantation), little could be done about geography and natural endowments: they were a given.

This geographical pattern of production was generated and/or supported by investment flows. Even though it is not possible to draw any causal relationship, investment and finance shaped the rubber trade in a way that it is not explored by simple standard trade models and, as shown in Chapter 2, the scarcity of crude rubber led to a struggle along the rubber chain to secure regular supply of the raw product: indeed, the rubber manufacturing industry needed to break the dependence upon an unreliable raw product that defined its prices and the ultimate level of manufacture. With this aim, this chapter shows that British and American investments, fuelled by their rubber manufacturing needs, poured into several different parts of the globe. The analysis is based on the same new trade data discussed in Chapter 2[167] but also on investment data from primary and secondary sources, that is, completely new dataset on rubber concerns organised in London and presented in the Appendix.

[167] Imports and re-exports of crude rubber into the USA and Britain by country of origin, covering the period 1870-1910. The sources for Britain came from the Parliamentary Papers (Annual Statements of Trade) which provide a full dataset on crude rubber trade broken down by country of origin from 1854 onwards. For the USA, a complete series on crude rubber trade was obtained from the Trade and Navigation Report of the Secretary of the Treasury for the years 1861-3 and 1869 onwards.

The underlying idea is to show all the main competing rubber producing regions around the world, underscoring the fact that their competition was somewhat limited by differences in the quality of the crude rubber produced which, in turn, depended on the type of tree available in the region. Here, economic geography plays a smaller role as second-nature geographical effects are of secondary importance: production is defined mainly by first-nature geographical aspects, i.e., endowments. In this vein, this chapter surveys the quality of production by analysing the trees available in every major rubber producing region and the technique employed to extract raw rubber. The Chapter thus shows that a combination of quantity and quality rendered the Brazilian Amazon a unique position as the major crude rubber producer, accounting for nearly 60% of the world supply.[168] This high market power in rubber (as computed and explained in Chapter 2), if exercised, would have generated monopolist (oligopolist) profits to rubber exporters placed in Brazil. Therefore, the Chapter also investigates if those conditions were really in force by analysing a case study: the relationship between a Brazilian/Portuguese export house (J.H.Andresen & Co.) and a British buyer (Schluter & Co.). Schluter's accounts are very rich, offering new insights on the rubber trade. It is really the first time that archival data (collected in London and in Brazil) is available to analyse the relationship between these two nodes of the rubber chain. If the relation of power really leaned towards independent rubber exporters in Brazil, the rubber chain would be even further from the ideal Wallersteinian chain type, requiring a more detailed investigation of the conditions of supply within the Brazilian Amazon, i.e., the relationship among the several nodes of the rubber chain located in the Brazilian Amazon. In sum, the chapter investigates competition within the rubber trade but also between players located in different nodes of the rubber chain.

Besides this introduction, the Chapter is organised into other 6 sections. Section 3.2 briefly shows the role of re-exporters as suppliers of rubber to the USA and Britain. Section 3.3 analyses the quality, quantity and organisation of rubber production in Asia and Africa (Oceania is included as well), stressing the role of colonies (especially to

[168] This figure actually refers to Brazil as a whole. See the Appendix for a discussion on the dataset.

Britain). British and American investments in rubber production are also surveyed and their returns analysed. Section 3.4 examines the struggle for American supplies, notably from Mexico, Central America and the Amazon region (excluding Brazil), emphasising the varying quality of rubber produced in each region. The main rubber producer is then finally analysed in Section 3.5, highlighting the superior quality and the sheer quantity of rubber produced in the Brazilian Amazon. Investments in rubber production and in adjacent sectors of the economy are also surveyed and analysed. The main conclusion is that capital was channelled mainly through (foreign) export houses placed in Belém and Manaus. The role of these export houses and their relationship with American and British buyers is thus finally examined in Section 3.6 through a case study: the relationship between the Brazilian/Portuguese export house J.H.Andresen & Co. and the British buyer, Edmund Schluter & Co. Even though this case cannot be directly generalised to the other players in the Brazilian Amazon, it sheds new light on the role of export houses in Brazil and their market power on world rubber market. Finally, Section 3.7 concludes the Chapter.

3.2 – Re-Exporters (mainly Europe)

The European Continent possessed no reserves of rubber trees[169] yet some countries played an important role in the market as re-exporters of crude rubber that came mainly from their colonies in Africa and Asia. From 1870 to 1910, re-exporters supplied 14.2% of the total crude rubber imported into Britain (see Figure 3.1 below), meaning an average annual value of 2,367,855 kilograms of crude rubber.[170] The USA was even more reliant on re-exporters of crude rubber: 27.6% of its crude rubber imports came from re-exporters of which more than a half was from Britain (see Figure 3.1 below).[171] Despite

[169] Actually, Turkey and Russia sometimes appear as crude rubber producers or re-exporters and it is not at all clear where their product is coming from. It is possible that they may have possessed some small reserves of crude rubber in their territory.
[170] For Britain, the list of re-exporters that appear in any one year in the UK Annual Statements of Trade (1870-1910) is the following: Hanse Towns, Russia, Holland, 'Channel Islands', Belgium, Turkey, United States, France, Portugal, Spain, Italy, Hamburg, Bremen and Germany.
[171] For the United States the list of re-exports in the US Trade and Navigation Reports to the Secretary of the Treasury (1870-190) is the following: Austria-Hungary, Spain, Belgium, Denmark, France, Germany, Italy, Netherlands, Portugal, Russia, Turkey and the United Kingdom.

the fact that Britain was competing for primary sources of crude rubber, as in the case of other commodities, a sizeable portion of its trade was carried out to be simply re-exported to other countries in Continental Europe and the USA. Therefore, even though the USA had a lead on rubber manufacturing (as seen in the Chapter 2), Britain secured more crude rubber supplies than the country actually needed, and with soaring prices, reflected by the expansion of US rubber manufacturing industry, British rubber traders could profit substantially. This position in the crude rubber market was probably achieved thanks to its colonies in Africa and Asia and its naval supremacy.[172] Although the USA was emerging as a naval power, port statistics in the main crude rubber producer, Brazil, suggest that most of the trade continued to be carried by British vessels, especially by the Booth Line, an English company that ran a regular service connecting the Brazilian and Peruvian Amazon to New York and Liverpool (see Chapter 6).

Figure 3.1 – Breakdown of Value of Crude Rubber Imported into Britain and the USA, 1850-1910

	Brazil		Americas		Africa		Asia + Oceania		Europe	
	Britain	USA	Britain	USA	Britain	USA	Britain	USA	Britain	USA
1850-1859	73.39%	n.a.	8.82%	n.a.	1.21%	n.a.	10.80%	n.a.	3.81%	n.a.
1860-1869	51.78%	n.a.	17.27%	n.a.	3.23%	n.a.	19.01%	n.a.	5.12%	n.a.
1870-1879	58.72%	51.56%	11.90%	33.05%	12.36%	0.85%	10.95%	3.02%	4.09%	11.28%
1880-1889	58.66%	58.00%	4.51%	19.20%	18.87%	1.38%	11.58%	1.68%	5.35%	19.69%
1890-1899	57.66%	63.92%	5.38%	6.47%	22.67%	0.30%	4.81%	0.94%	8.63%	28.37%
1900-1910	60.43%	54.30%	7.98%	8.82%	11.73%	0.01%	10.04%	1.52%	8.37%	35.36%

Source: computed from several issues of UK Parliamentary Papers and US Trade and Navigation Reports of the Secretary of the Treasury. Note: 'Americas' excludes Brazil.

3.3 – The Role of Colonies: Oceania, Asia and Africa

From 1870 to 1910, Oceania accounted for nearly zero percent of both British and American rubber supplies[173] whereas Asia accounted for almost 10% of overall crude

[172] It is important to note that, contrary to what Prado and Capelato (1975, p. 300) stated, the USA were the main importers of Brazilian rubber. They were right though when they said that Britain was an important centre for re-exports of rubber. As was clear from the previous chapter, the USA was consuming much more rubber than any other country in the world, including Britain.

[173] In the UK Annual Statements of Trade (Parliamentary Papers), I could only find two exporters of crude rubber into Britain located in Oceania: Australasia and 'New South Wales'. In turn, in the US Trade and Navigation Reports of the Secretary of the Treasury for the years 1870 to 1910 the only place in Oceania that ever appeared in the data was 'British Australasia'.

rubber imports into Britain[174] and 2.5% into the USA[175]. This can be seen in Figure 3.1 above, which shows a decade by decade breakdown of Asian market share in crude rubber imports into the USA and Britain. In absolute terms, the British leading position in the South-East Asian crude rubber market was even clearer: between 1870 and 1910, Britain imported on average 1,503,174 kilograms of crude rubber per year from the region against an equivalent amount of only 360,626 kilograms for the USA.[176]

In regard to Africa, the situation was not different: the region was responsible for a significant portion of the supply of rubber to Britain: 20.0% of its total crude imports.[177] In absolute terms, Africa generated an average annual influx of 3,345,954 kilograms of rubber from 1870 to 1910 into Britain. In contrast, the region accounted for only 0.5% of total rubber imported into the USA, with an average annual influx of only 88,198 kilograms of crude rubber on average. It is even more striking that, from 1900 to 1904, when consumption of crude rubber was skyrocketing, the USA did not import a single kilogram of rubber from that entire Continent.[178]

There are geographical and institutional aspects that explain the geography of crude rubber trade in Asia and Africa. As will be shown here, first-nature geography explain the location of crude rubber endowments: latex yielding trees were mainly found in tropical rain forests such as the Congo basin and in today's Indonesia. However, the types

[174] In the UK Annual Statements of Trade (1870-1910) there are several entries relating to Asian crude rubber imports into Britain: 'British East Indies', 'British India', Java, China, 'India, Singapore & Ceylon', 'Singapore & Eastern Straits Settlements', 'Federated Malay States', Borneo, St. Thomas, Aden, 'Bombay & Scinde', Ceylon and Madras. See Figure 3.2 for the geographical location of these places.

[175] According to US Trade and Navigation Reports of the Secretary of the Treasury (1870-1910), there are few less places located in Asia that exported crude rubber directly into the USA: China, 'British East Indies', 'Dutch East Indies', Hong Kong, Japan, Siam, Philippines and 'All Other Asia'.

[176] Computed from several issues (1870-1910) of the Annual Statements of Trade of the United Kingdom (Parliamentary Papers) and US Trade and Navigation Reports of the Secretary of the Treasury.

[177] There are several places in Africa that exported crude rubber in any one year to Britain: 'Western Coast Africa', 'German West Africa', 'German East Africa', 'British West Coast Africa', 'British East Coast Africa', 'East Coast Africa', Madagascar, China, 'British South Africa', Natal, Mauritius, 'Zanzibar & Pemba', 'Gold Coast (incl. Lagos)', Nigeria, 'Sierra Leone', Gambia, 'Niger Protectorate', 'French West Africa', 'French Somaliland', 'Portuguese West Africa' and 'Fernando Po'. See the Annual Statements of Trade of the United Kingdom (1870-1910) and Figure 3.3 for geographical location of these places.

[178] US Trade and Navigation Reports of the Secretary of the Treasury (1870-1910). There were a few less places exporting crude rubber from Africa into the USA, reflecting exactly the British (and other European powers) jurisdiction over the region. According to the data, there are only six different entries for African crude rubber imports: 'British Africa', 'Portuguese Africa', 'French Africa', Liberia, Madagascar and 'All Other Africa'.

(or genus) of trees found in these forests differed from one another, influencing the quality and defining the method of extraction of the crude rubber ultimately produced. Institutions (Colonial Power) further explain why Britain was much more successful in generating a crude rubber inflow from these three continents (Oceania, Asia and Africa) compared with the USA. British trade statistics show that, in Asia, the majority of rubber came from India and the Straits Settlements whereas, in Africa, the British Gold Coast was the main supplier: indeed, for about fifteen years, from 1890 to 1905, that colony was the forth biggest exporter of crude rubber in the world, ranking behind Brazil, the Congo Free State and Angola.[179] Regarding the USA, the country's limited rubber imports from these regions came mainly from the British East Indies and to a lesser extent from the Dutch East Indies.

Figure 3.2 – Map Showing Proximate Area of Crude Rubber Production in Asia

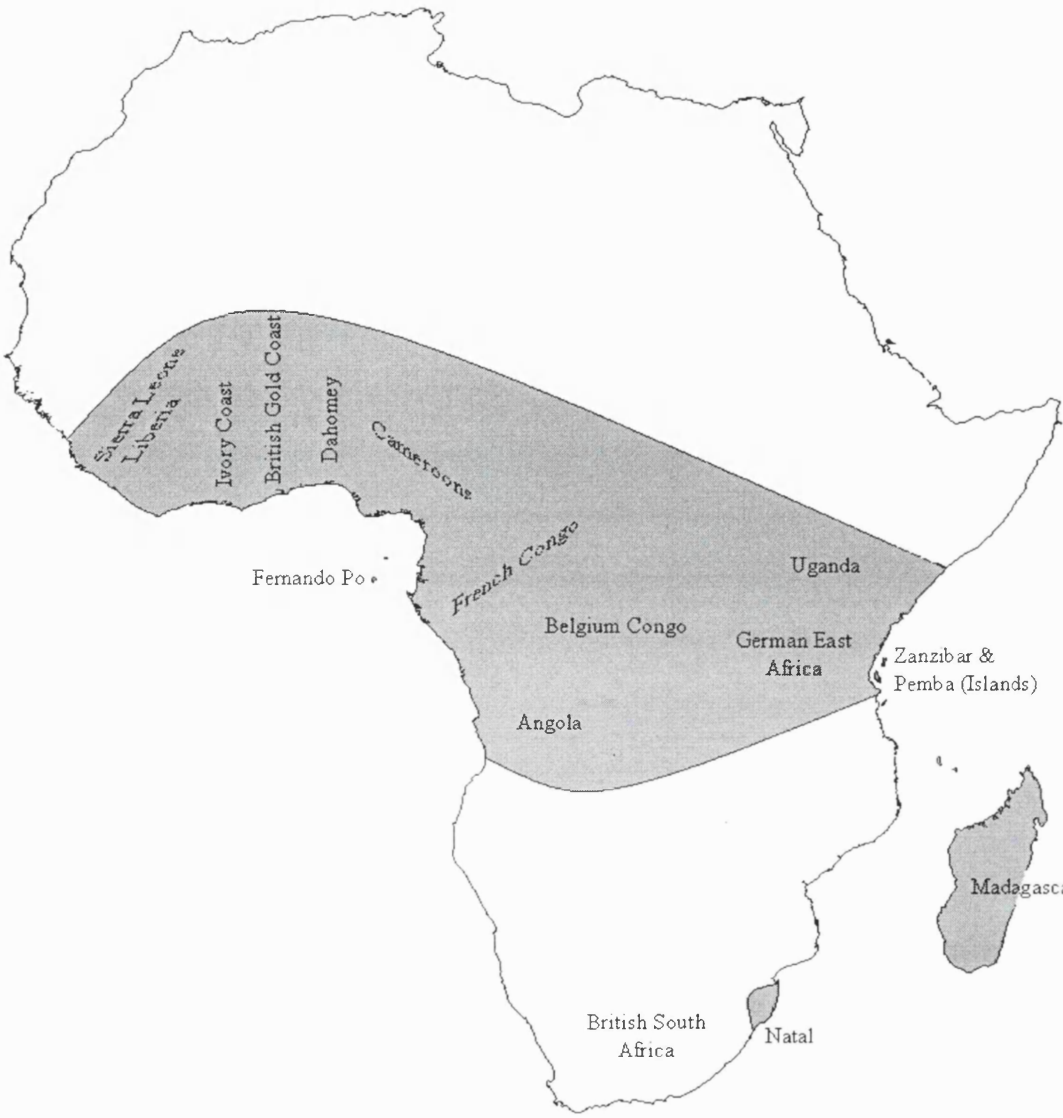
Source: elaborated by me. The map does not intend to show precise places where rubber production took place, but rather to give a proximate idea of the geography of production. I used modern day borders to reconstruct an approximate area of these colonies, protectorates or countries.

[179] Annual Statements of Trade, UK Parliamentary Papers (1870-1910).

In Asia, there were two main indigenous species of latex yielding trees: *Ficus elastica* and gutta-percha. *F. elastica* is native to Burma and Assam and even though most of the supply came from wild sources, the tree was also cultivated in small scale in India, Assam, the Malay Peninsula, Java and Sumatra (see Figure 3.2 above). Indeed, probably the oldest rubber plantation experiment in the world consists of *F. elastica* and was situated in West Java, set up by British Capital (Anglo-Java Plantation Co.) in 1872.[180] This plantation experiment was not extended but continued to produce into the interwar period. In turn, gutta-percha trees were found in the wild state in Malaya and in the Dutch East Indies. Since it was a non-elastic variety of rubber, it owed its commercial value to the use for insulation of submarine telegraphic cables and for outer casing of golf balls. Unlike *F. elastica*, gutta-percha trees cannot be tapped regularly and they were usually cut down with the latex being extracted after the felling (this also represents a very different method of latex extraction from Amazonian trees, as will be discussed later on in this chapter). Therefore, most of the indigenous trees were destroyed over time. Early plantation experiments with gutta-percha were abandoned for more remunerative crops and only a plantation set up by the Dutch government in 1885 lingered on, accounting for a sizeable percentage of the overall supply of gutta-percha.[181]

[180] Eaton (1952, p. 52).
[181] Eaton (1952, pp. 57-61).

Figure 3.3 – Map Showing Proximate Area of Crude Rubber Production in Africa



Source: elaborated by me. The map does not intend to show precise places where rubber production took place, but rather to give a proximate idea of the geography of production.

In Africa, the two main indigenous sources of crude rubber were the *Funtumia elastica* tree and the *Landolphia* vines. *Funtumia* was widely distributed in tropical Africa from Sierra Leone (west) to East Africa and in Belgium Congo, Liberia, Nigeria, Dahomey, Cameroons, French Congo, Uganda and French Ivory Coast (See Figure 3.3 above). *Landolphia* vines were mostly concentrated in tropical Africa and unlike *Funtumia*, they were not suitable for regular tapping, and the method of extraction invariably embodied the killing of the plant. There were also a number of shrubs or bushy plants of the genus

Landolphia, *Clitandra*, *Carpodinus* and *Cryptostegia* that were found mainly in tropical Africa, from which rubber was also extracted.[182] Therefore, as in Asia, rubber extraction techniques were exhausting the natural reserves of the region and plantation soon became the key issue.

Plantations were tried early in both Asia and Africa, usually set up by English capital, though some German and Dutch finance was also important. The most successful plantation experiments in Southeast Asia happened to be with *hevea brasiliensis* tree and they relied heavily upon capital raised in London. Indigenous to the Amazon region, the tree was not only the most resilient one, enduring three tapping seasons a year, but also the tree that produced the best rubber quality. The history of *hevea* plantations in Asia began in 1876, when Henry Wickham collected some 70,000 seeds in Pará region that were planted (only 2,600 germinated) in Kew Gardens, London, from where they were transplanted to Ceylon in 1876 to be distributed to other moist and hot regions around.[183] Even though plantation trees in the region seldom yielded as much latex as they did in wild state in Brazil, the organisation of production proved to be decisive. In 1877, the first trees were planted in Singapore and in the Federated Malay States, and during the 1890s and 1900s plantation took an explosive trend forcing all wild rubber producers out of the market, including Brazil (the main crude rubber producer) after 1910.[184] However, since rubber trees took at least 6 years to produce rubber (sometimes more than 10 years), before 1910 production from *hevea* plantations was still negligible and most rubber produced in Asia still came from wild sources instead.

In Africa, British investment and entrepreneurship was also instrumental for the development of the rubber trade, albeit plantations were less important. African merchants played an important role in the crude rubber trade at first but long-established British trading firms, mainly Alexander Miller Brothers and F. and A. Swanzy, came to dominate the market by the turn of the century: some price-fixing eventually occurred but coastal trading firms usually competed with each other for crude rubber supplies from the interior.

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[182] Eaton (1952, p. 51).
[183] Wickham (1908), Drabble (1973), Dean (1987) and Jackson (2008).
[184] Eaton (1952, pp. 52-55).

Since production usually damaged the rubber tree or vine, production moved geographically towards the thick forests in the Agni kingdoms of Sanwi and Indenie along the middle reaches of the Komoe River in the hinterland of the French Ivory Coast, by-passing French ports. Then the closure of this trade from French territories pushed rubber more into new supply sources in Asante. Usually, villagers collected rubber on credit advanced by British coastal traders or by middlemen.[185]

In West Coast of Africa, British colonial administrations were not willing to alienate forest blocs on the scale required by the companies and the three largest British African rubber concerns ended up operating outside British jurisdiction. In that region, the most ambitious rubber concern was the Liberian Rubber Corporation organised in 1905 whose board even included a nominee from the Dunlop Rubber Co. Although Dunlop had a contract with this African concern to purchase the entire output of the corporation for 10 years at market price less brokerage, the Liberian Rubber Corporation was a fiasco and went into bankruptcy already in 1910.[186] This failed attempt into crude rubber production by Dunlop made even more evident the lack of vertical integration in the rubber chain in the period from 1870 to 1910.

In East Africa, British investments also spread outside British jurisdiction with British capital ending up owning between one quarter and one third of the total rubber acreage of German East Africa, totalling £1.26 million.[187] In contrast to West Africa, British investments in East Africa were concentrated on plantation ventures of *ceará* (*manihot*) rubber trees that were initially set up by the Germans.[188] This tree was indigenous to north-east Brazil and was suitable to regular tapping, even though its quality and productivity did not match that of *hevea brasiliensis* tree and its main advantage lay in the fact that it could be tapped earlier than *hevea*: 2.5 years after planting instead of 5.0 years for *hevea*.

[185] Dumett (1971, pp.79-101).
[186] Munro (1981, p. 268-270).
[187] Munro (1983, p. 369).
[188] Monson (1993).

British capital also participated in concession areas in Congo. The infamous Abir Co. was initially incorporated as the Anglo-Belgian India Rubber and Exploration Company in 1892 although 6 years later, British capital was withdrawn following a reorganisation of the company that ultimately led to its increasing pressure over villagers to collect rubber. In 1900, Abir dividends, duties and taxes accounted for 10% of the total revenue of the Belgium State and three years later, the company alone exported nearly a thousand tons of rubber.[189] However, in the following year, the depletion of rubber was becoming apparent due to the destruction of rubber trees. Moreover, following a furry of scandals in Europe, led by Sir Roger Casement, unveiling the atrocities committed by Abir officials in the search for rubber[190], the company was reorganised again into the hands of King Leopold but the move proved to be a disaster for the State and a blessing for the company.[191]

From 1905 to 1910, 53 African rubber companies were incorporated in London, and in 1910 alone £4.4 million new capital was raised, a figure almost identical to the nominal British investment in rubber in the Dutch East Indies, or equivalent to 55% of nominal capital invested in plantations in Malaya in that same year. Although very significant, British investments in the region provided extremely poor commercial returns, with little dividends being paid and several failures being registered from 1910 onwards as a result of competition with Malayan rubber plantations.[192] Other reasons for failures stemmed from deficient managerial expertise and fraud, perpetrated by promoters who invariably published misleading reports exaggerating rubber production and future profits.[193]

Although direct investment in African rubber plantations proved to be a failure for entrepreneurs, they actually provided the expertise for the later successful development of Asian plantations. In the 1900s, crude rubber from Southeast Asian plantations achieved high prices almost at par with Brazilian wild *hevea* prices, generating high profitability for

[189] Harms (1975, pp. 73-81).
[190] Anstey (1971).
[191] Harms (1975, p. 87).
[192] Munro (1981, p. 266).
[193] Munro (1981, pp. 273-274).

plantation ventures in the region. In contrast with African ventures, Asian plantation companies paid huge dividends in the first years as, for instance, the Pataling Rubber Estates Syndicate, which paid 45% in 1908 and 325% in 1910. Interest quickly arouse for Malayan rubber shares in London, leading to the incorporation of 271 Malayan rubber concerns in London from 1904 to 1910, with a total authorised capital of £18.3 million and 521,000 acres planted.[194] The seeds for the demise of Brazilian rubber boom were already in place, and it was then just a matter of time until the Brazilian wild rubber production would be forced out of the market.

In sum, first-nature geographical aspects explain the location of latex yielding trees and consequently the location of crude rubber production which was concentrated in tropical areas, especially in the Congo Basin and in today's Indonesia. The pattern of trade was very much impacted by institutions as colonial power and jurisdiction played an important role in rubber trade flows. Foreign capital and entrepreneurship were also instrumental for rubber production. Moreover, the types and genus of latex yielding trees differed geographically, impacting the quality of crude rubber ultimately produced. Different trees, in turn, implied different methods of extraction as latex collection sometimes required the felling of trees forcing rubber reserves into exhaustion. Indeed, as several trees started to disappear, production initially moved geographically but there were obvious limits to increase production over time and soon plantation became an issue. There followed several attempts to domesticate different latex yielding trees that explain the later success of *hevea* plantations in South East Asia. Institutions fostered rubber plantations as governments were sometimes involved directly into plantation ventures (or just in distributing seeds).

3.4 – Americas (excluding Brazil)

As in Asia and Africa, first-nature geography and institutions also explained the pattern of crude rubber trade that emerged. First, rubber came mainly from the tropical

[194] Stillson (1971, pp. 589-594). Authorised capital cannot be translated into investments, since sometimes only part of it was actually issued. Moreover, debentures and loans should account for British investment in plantations as well. See also Drabble and Drake (1974).

parts of the Continent, especially the Amazon basin, Central America and parts of Mexico. The types of trees found in these three main areas differed among them as well as in comparison with Asian and African rubber trees. Therefore, the quality of rubber produced and the methods of latex extraction differed too. Proximity to the USA (second-nature geography) and political aspects (institutions) will turn the United States the main market for crude rubber from the Americas.

In Mexico and Central America, US interests clearly prevailed over British. While from 1870 to 1910 the region accounted for less than 1% of total imports of crude rubber into Britain[195], 6% (in terms of quantity) of American total crude rubber imports came from there.[196] In absolute terms, from 1870 to 1910 Britain imported on average 93,637 kilograms of crude rubber every year from Mexico and Central America compared to US imports of 1,292,561 kilograms p.a., or almost 14 times the British figure. In the Amazon region (excluding Brazil), the USA also held a leading position: the region accounted for 6.3% of all crude rubber imported into the USA, averaging 1,032,730 kilograms per year from 1870 to 1910. Britain imported just over a half of it, or an average of 553,895 kilograms of crude rubber per year during the same period (3.3% of its total crude rubber imports).[197]

In Mexico and Central America, the main US rubber source was the Central American States, with an increasing participation of Mexico though: from 1900 to 1910, Mexico accounted for 81.2% of total quantity of crude rubber imported by the USA from

[195] Reflecting the small significance of crude rubber imports from this region, only a few places in the Americas were ever reported in British trade statistics from 1870 to 1910: 'Central America', Ecuador, Chile, 'Nueva Granada', Guatemala, Nicaragua, Colombia, Venezuela, Peru, Haiti and Mexico.

[196] US crude rubber imports from the Americas came from everywhere in the Continent: 'British Honduras', Canada, 'Costa Rica', Guatemala, Honduras, Nicaragua, Panama, Salvador, Mexico, 'British West Indies', Cuba, 'Puerto Rico', 'Dutch West Indies', Haiti, 'Santo Domingo', 'Central American States', 'New Granada', Chile, Colombia, Ecuador, 'British Guiana', 'Dutch Guiana', 'French Guiana', Peru, Uruguay, Venezuela, 'Spanish West Indies', 'French West Indies' and 'All Other America'.

[197] Computed from several issues (1870-1910) of the Annual Statements of Trade of the United Kingdom (Parliamentary Papers) and US Trade and Navigation Reports of the Secretary of the Treasury.

that region. In the Amazon (excluding Brazil) the main rubber producing regions were the Putumayo and Acre, areas subject to territorial disputes.[198]

Proximity, and perhaps lower freight rates (second-nature geography), explains the US leading position in the region *vis-à-vis* Britain. This economic geography aspect was especially true for Mexico, which shared borders with the USA and whose dictator, Porfirio Díaz, courted US investments he believed would provide "all the fruits of annexation without any of the dangers". [199] Therefore, US investments in rubber plantations in Mexico were part of a broader wave of American investments in Mexico which usually led to land speculation. Most of the plantations were comprised of *Castilloa elastica* trees, a rubber yielding tree that is indigenous to Central America but that can also be found in the Andes and Amazon regions.[200] For the quality of the rubber produced from those trees, *Castilloa* plantation was a very promising investment notably in the context of the 'rubber famine' in the 1900s. However, although these trees could produce abundant latex per tapping[201], the tree could only be tapped once a year (twice if the tree was eight or more years old) against three times for the *hevea brasiliensis* tree (see Section 3.5 further below). [202] Moreover, native methods normally killed the tree, preventing a steady and enduring increase of production from wild sources.

US investments in *Castilloa* plantations in Mexico might have amounted to US$ 50 million (£10.3 million) by 1908 and US$ 75 million (£15.4 million) by 1913[203] while, as shown in the Appendix, in 1911 British investments in Mexican rubber ventures amounted to a mere £1.3 million (nominal capital). However, most of the investment was speculative or redirected for other uses than plantation, contributing for the general discredit of rubber ventures that prevented their floating into the London Stock Exchange from 1909 onwards. Moreover, in spite of these massive investments in *Castilloa* plantations, wild guayule sources (a low-growing shrub) accounted for the bulk of rubber exported from Mexico

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[198] Computed from several issues (1870-1910) of the Annual Statements of Trade of the United Kingdom (Parliamentary Papers) and US Trade and Navigation Reports of the Secretary of the Treasury.
[199] Schell Jr. (1990, p. 219).
[200] Schell Jr. (1990, pp. 217-222).
[201] Cook (1937, p. 406).
[202] Schell Jr. (1990, p. 234).
[203] Schell Jr. (1990, p. 238). Figures converted into £, using series presented in the Appendix.

throughout the period: for instance, in the 1908-09 fiscal year total Mexican rubber exports totalled US$ 11,393,807 (£2.3 million) of which US$ 10,702,839 (£2.2 million) referred to wild Guayule sources, or 94%.[204] Therefore, even though the USA were able to secure a very important flow of rubber from Mexico and Central America, the country seemed to have paid dearly since most of the investments made rarely bore fruits.

In turn, in the Amazon region (excluding Brazil), the rubber boom was certainly an extension of what was happening in the main rubber producing country, Brazil, even though it possessed a dynamism of its own: declining rents from traditional exports helped the development of the boom. Most of the Amazonian rubber reserves came from *castilloa* trees (with the exception of Bolivian sources that were predominantly comprised of *hevea* trees) and their rubber showed relatively good quality and was well regarded in the rubber market. Figure 3.4 below gives an overview of the area where latex yielding trees could be found in the region: it overlapped with the Amazon rainforest, consequently spanning several countries or colonies.

[204] Schell Jr. (1990, p. 235).

Figure 3.4 – Map Showing Proximate Area of Crude Rubber Production in South America

Source: elaborated by me. The map does not intend to show precise places where rubber production took place, but rather to give a proximate idea of the geography of production. The Figure shows modern day territories but during the rubber boom period (1870-1910) borders were not at all settled, changing for instance significantly in the Acre region (between Brazil and Bolivia). Borders are here merely indicative as they were extremely fragile and permeable.

In Bolivia, rubber collection gained commercial viability after the exploration of the Lower Beni River by the American Edwin R. Heath who confirmed that the Beni flowed into the Madeira in 1880. Even though there were several falls on the Madeira river, merchandises (notably rubber) could henceforth flow from the Bolivian *Oriente* to Manaus, Belém and thence to Europe and the USA. The *Oriente* was abundant in *heveas*, especially in the section adjacent to the unsettled borders with Brazil, precisely where the two largest Bolivian rubber producers would arise: António Vacas Diez and Nicolás Suárez. António Vacas Diez had established a number of rubber producing units in the region as early as 1876 and could then take profit from his strategic position in the main waterway to the Atlantic. However, by 1890s Vacas Diez was seriously undercapitalised and went to Europe in search of funds, meeting success in both Paris and London. On 1st February 1897 the Orton (Bolivia) Rubber Co., Ltd was officially registered in London. Vacas Diez died just 4 months afterwards and, due to high indebtedness, the company was passed in its entirety to Casa Suárez, which happened to be its chief creditor. Nicolás Suárez established himself in the Bolivian *Oriente* in 1881 and soon founded a strategic position in the area as well. Like Vacas Diez, Nicolás Suárez also turned to England in order to capitalise and with the help of his eldest brother, who was the Bolivian-Council General in London, they launched F. Suárez & Co. This close connection with Britain would mean that the entirety of the production of Suárez House would be shipped to this country throughout the period under analysis here.[205] As shown in the Appendix, by 1911 there were four Bolivian ventures registered in London: the Anglo-Bolivian Rubber Estates Ltd., the Galvez Rubber Estates Ltd., La Martona Rubber Estates Ltd. and the Zongo Rubber Estate, Ltd. Altogether, they had an authorised capital of £650,000 of which only £343,188 were issued.

However, American capital had also been pervasive in the region but at first it concentrated in colonisation and transport enterprises and thus American capital was only indirectly connected to rubber production in the Amazon. The National Bolivian Navigation Company was chartered and granted to the American Colonel Church on 27th August

[205] Fifer (1970, pp.120-133).

1868 but since it met immediate Brazilian opposition, the colonel would not find too much success in his enterprise even though he would later be a prominent figure in other ventures in the region, especially on the Brazilian side of the border. Another American venture was the Colonisation and Commercial Company of Bolivia, founded on 25th January 1870 in California aiming at attracting settlers to upper Acre region. That venture did not meet success and was later dispersed with the change in the Bolivian presidency.

Even in colonisation enterprises, British capital was rivalling American investments in the region. Francisco Javier Brabo organised an enterprise in London that proposed to introduce one hundred thousand colonialists into the Bolivian East within ten years, construct railroads across the Chaco, establish arsenals in the Beni River and maintain armed steamers on the Mamore River. Another colonisation enterprise, known as the Bolivian Syndicate, was also organised in London in 1901 but counted with American directors (including a cousin of the US president Theodore Roosevelt) and capital: it had an authorised capital of £5 million and was granted a thirty-year lease of the Acre territory. The Syndicate was authorised to administer Upper Acre, to collect taxes, to establish police, sanitation, and other public services, and to construct railways, wharves and other communication facilities. The incorporation of this company arose fierce Brazilian opposition who feared the region could become a new Africa in which chartered companies opened the way for future foreign power control. The disputed region ended up in Brazilian hands after occupation by Brazilian forces, payment of indenisation to Bolivia (£2 million) and the buy-out of the Syndicate by the Brazilian government for £110,000.[206]

Rubber exploitation in Peru, Colombia and Ecuador also took place in a region where borders were unsettled and the jurisdiction of the territory was under dispute. Fuelled by the development of the crude rubber trade, aggressive westward expansion by Brazil reached the Putumayo region which was claimed by Peru, Colombia and Ecuador. The region offered both liabilities and opportunities but the development of the rubber trade heightened the economic value of the region. Counting initially with guano resources (1840s-1870s), Peru pushed forward its jurisdiction over the disputed territory and

[206] Tambs (1966, pp. 254-273).

transformed Iquitos into a thriving crude rubber hub in Northwest Amazon through infrastructure investments: the government was an 'institutional builder' by its role in supporting the construction of docks, trade regulation, definition of property rights, private steamboat navigation and subvention of a shipping line connecting Iquitos to Liverpool, managed by Booth Co., an English concern (see Chapter 6 for details). Political will and the geographic and strategic position of Iquitos would be decisive to curb Colombian and Ecuadorian interests in the region. The Colombians were more diligent, establishing a colonisation policy in the region but they lacked political stability and resources to beat the Peruvians, even though they would in the end secure the upper reaches of the Putumayo and Caquetá. Ecuador lacked both financial resources and political will to succeed, insofar as the economy was more directed to the Pacific coast where a thriving cocoa trade was developing. Ecuadorians looked with pride to their Amazonian region but they failed to assure their *de facto* possession against their neighbours.[207]

Rubber production in the Putumayo region came chiefly from *castilloa* trees which, even though they could be exploited throughout the year (*castilloa* trees were not confined to flooded areas as *heveas* were), the tree was usually damaged during the tapping due to a lethal fungi. Therefore, rubber collectors usually cut down the tree and extracted the whole latex which could amount to 90 kilograms compared to just some 3 kilos a tapped *hevea* could produce in one year. It is true that *hevea* rubber commanded a higher price but rubber collectors in the Putumayo area could profit immensely from the sheer quantity of *caucho* they produced.[208] Even though *caucho* production, as rubber produced from *castilloa* was known, was more itinerant than *hevea* rubber production, some companies or rubber producing units developed in the region. In fact, the Putumayo became mostly known for the large rubber producing units which not unusually entailed the closure of an entire river to navigation and where Indians (which supplied most of the labour force in the region) were enticed to work. It is true that sometimes they were lured for axes, machetes, firearms, etc. and they freely set themselves to work for rubber producers, but the

[207] Stanfield (1998, pp. 63-87).
[208] Stanfield (1998, pp.23-25).

relationship led to abuses and violence in order to subject them to a regime of work that they were not willing to, just to placate the greed of rubber producers. The Putumayo scandal, unveiled in 1910 by Sir Roger Casement (the same person who unveiled the Congo atrocities) following a series of articles based on W. E. Hardenburg's accounts, would bring Julio Cezar Arana's name to the fore. Some years before, in 1907 at the height of the rubber boom, Arana registered his company in London as The Peruvian Amazon Company (PAC), with an authorised capital of £1,000,000[209] and a claimed area of 12,000 square miles (see Appendix). Julio Cezar Arana became infamous because of the Putumayo scandal, but he was not the only one and the region saw the emergence of other rubber barons such as Rafael Reyes, Benjamín Larraniaga, Crisóstomo Hernández and Isaiah Fermín Fitzcarrald. Despite the size of Arana's venture, there were only a handful of rubber companies registered in London that operated in the Putumayo area and most of the foreign capital was channelled to production through several foreign trading houses placed in Iquitos, such as Wesche and Co. which transacted business and financial deals with firms in New York city to the tune of US$10,000 (around £2,050) by mid-1890s.[210]

In sum, in the Americas (excluding Brazil) first-nature geography explained the location of crude rubber production which concentrated close to reserves of latex yielding trees that, in turn, happened to be located in the tropical areas of the American Continent, notably in the Amazon region, Central America and parts of Mexico. *Castilloa* trees were abundantly found in both Central America and in the Amazon region whereas *guayule* trees were found primarily in Central America and Mexico. *Hevea* trees, in turn, were only found in the Brazilian and Bolivian Amazon. As in Asia and Africa, different trees required different production techniques: *guayule* production invariably entailed the felling of the tree but *castilloas* and *heveas* could be tapped regularly. However, production from *castilloa* trees often involved the killing of the tree due to lethal fungi.

209 See Collier (1968), Serier (2000) and Lagos (2005).
210 Stanfield (1998, p. 92). Value converted in £ using series presented in the Appendix.

Second-nature geography and institutions shaped crude rubber production and trade. Given the rubber endowments, production was either defined by domestic jurisdiction which fostered, protected or corrupted production or by foreign relations as the political attachment between Mexico and the USA demonstrates. Proximity (and freights) may have helped determine the pattern of crude rubber trade that emerged, possibly biasing it towards the USA.

3.5 – The Brazilian Rubber Supply

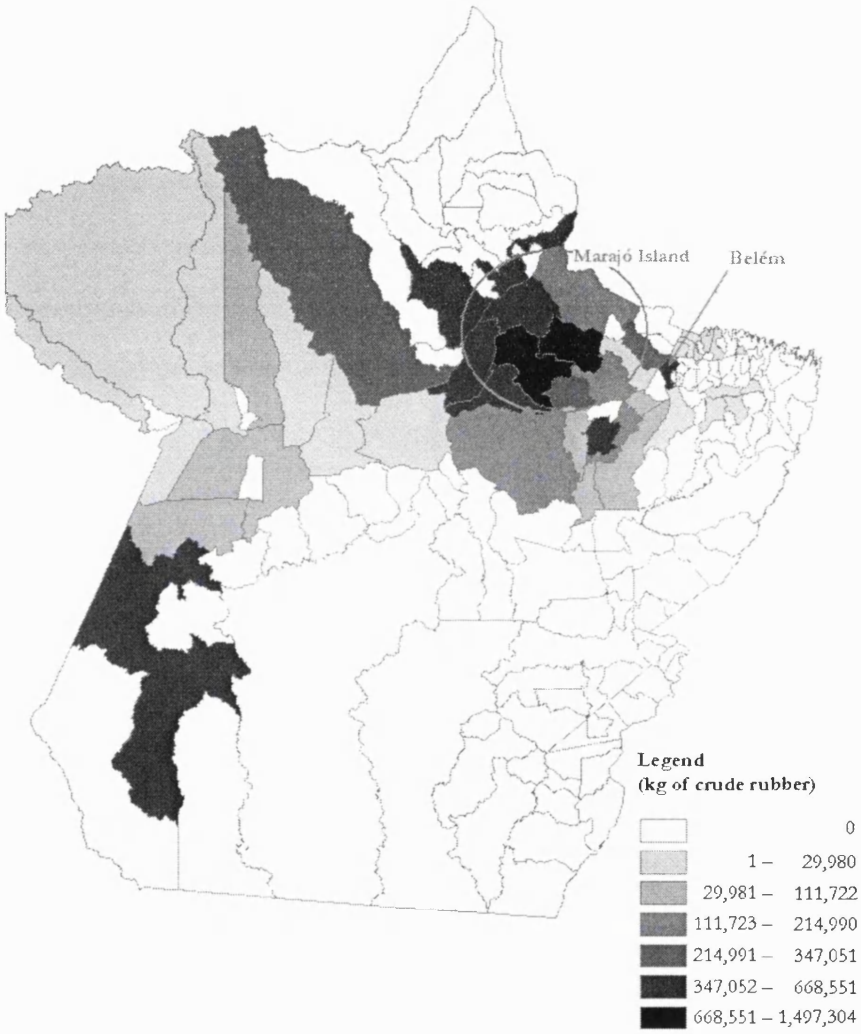
The *hevea* tree underlies the rubber boom in the Brazilian Amazon. As explained in the introduction, the tree is indigenous to the region south of the Amazon River. As explained in the Introduction, historically, production started in the region around Belém (located at the mouth of the Amazon River) and followed the course of the Amazon River towards the city of Manaus located at the confluence between Amazon and Negro rivers. Production also spread along the main tributaries of the Amazon, especially south and westwards towards Acre region in search for *hevea* trees. These trees were seldom found in large concentrations, usually being spread over a large territory. The Amazon region comprises around half the Brazilian territory but the rainforest is even larger surpassing the Brazilian jurisdiction further into Bolivian, Colombian, Venezuelan, Peruvian, Ecuadorian, English, French and Dutch territories in South America. However, despite the rubber trees being geographically spread out, the difficulty in accessing the hinterland caused production to remain mainly confined to the areas close to the major river gateways. Production was then shaped by first-nature geography.

Figure 3.5 below shows exactly how crude rubber production became concentrated along the Amazon river and its main tributaries.[211] The Figure shows the geographic dispersion of crude rubber production by cities/municipalities in the State of Pará in 1897-1898[212]. It is possible to see that there was very little production in the

[211] I am indebted with Leonardo Monastério for helping me producing this map.
[212] *British Diplomatic and Consular Reports, n. 2140 [Annual Series], Brazil: Report for the Year 1897 on the Trade of Para and District, 1898.*

hinterlands[213] and that the majority of crude rubber production was still taking place around the city of Belém and in Marajó Island.

Figure 3.5: Geography of Crude Rubber Production in the Brazilian States of Pará and Amapá, 1897-1898



Source: Rubber Production by Cities, *British Diplomatic and Consular Reports, n. 2140 [Annual Series], Brazil: Report for the Year 1897 on the Trade of Para and District, 1898.* Note: I first found the geographical coordinates (latitudes and longitudes) of the cities or villages where production took place in 1897-8. Luckily, the cities/villages retained their old names and thus I was able to find their geographical coordinates from data gathered at the Instituto Brasileiro de Geografia e Estatistica (IBGE) website (http://www.ibge.gov.br). I then matched their actual location with the political-administrative organisation of Pará State into municipalities as of 1998.

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[213] However, it is possible that production was taking place further inland and just being channelled through the cities listed in the Report above.

Compared to other trees, with the right technique, *heveas* could endure tapping for several years without losing much productivity. *Hevea* trees were the basis of Brazilian influence in the rubber trade: due to a combination of quantity and quality, the Brazilian Amazon assumed a leading position in the world crude rubber trade. From 1870 to 1910, Brazil supplied on average 7,600,995 kilograms of crude rubber per year to Britain and 9,095,951 kilograms per year to the USA, accounting then for 45.5% of total crude rubber imports into Britain and 55.1% into the USA. Brazil was then the biggest producer of rubber throughout the period, until plantations in Southeast Asia forced its crude rubber production out of the market. In terms of value, Brazilian market share was even higher, due to the presence of the *hevea brasiliensis* tree which, as argued above, provided the best quality of the product, especially in terms of tensile elasticity.[214]

As elsewhere, American and British capital was instrumental for the development of the rubber boom in the Brazilian Amazon. Some rubber concerns were incorporated in Britain such as The Amazonas Rubber Estates Ltd. (1895, £300,000 of authorised capital), The Pará Island Rubber Estates Ltd (1910, £125,000 of authorised capital), De Mello Brazilian Rubber Co., Ltd (1906, £495,000 of authorised capital), Brazilian Rubber Trust, Ltd (reorganised as Islands Rubber Estates Ltd. in 1907 with an authorized capital of £37,500), Amazonia Rubber and Trading Co., Ltd. (£25,000 of authorized capital) and The Rubber Estates of Pará Ltd. (1898, £350,000 of authorized capital).[215] As shown in the Appendix, in 1911 there were still 12 'Brazilian' rubber concerns registered in London of which half were operating in the Brazilian Amazon. These six Amazonian companies had a total claimed area of 401,228 acres and authorized capital of £860,000 (the paid-up capital, in turn, amounted to £797,466).

Furthermore, British and American capital had interests in several utility companies in the Brazilian Amazon, supporting the rubber boom indirectly. In Britain, the following concerns (among others) were incorporated: Cia. de Gas do Pará (1866,

[214] Computed from several issues (1870-1910) of the *Annual Statements of Trade of the United Kingdom (Parliamentary Papers) and US Trade* and *Navigation Reports of the Secretary of the Treasury*. Again, note that figures refer to Brazil as a whole. Rubber was also produced in Ceará, Bahia and Mato-Grosso Provinces/States. See Appendix for details.
[215] The list is not intended to be extensive yet and it was compiled from *London Stock Exchange – Tea, Coffee & Rubber – Commercial Report – several years.*

£250,000 of authorised capital), The Amazon Steam Navigation Co., Ltd (1872, £850,000 of authorised capital in 1876), The Pará Central Sugar Factory (1885), The Manaos Trading Co. (1885), The Amazon Telegraph Co., Ltd (1895, £250,000 of authorised capital), Manaos Harbour Ltd (1902, £500,000 of authorised capital), Pará Electric, Railways and Lighting Co. (1905, £700,000 of authorised capital), Pará Telephone Co. (1909, £62,000 of authorised capital), The Manaos Tramways and Light Co Ltd (1909, £300,000 of authorised capital) and Municipality of Pará Improvement Ltd (1910, £400,000 of authorised capital). Additionally, some Amazonian companies were also incorporated in the USA, among others: Madeira and Mamore Railway Co. (1870 but reincorporated in 1907 with an authorised capital of US$11 million or £2.3 million), The Pará Transportation and Trading Co. (1888, US$7 million of authorised capital equivalent to £1.4 million) and Port of Para Co. (1906, US$32.5 million or £6.7 million).[216]

The City of London played a more important role as intermediary of funds to the Brazilian Amazon than Wall Street even though the Americans imported slightly more crude rubber from Brazil than the British. As the world financial centre, London was able to counterbalance the leading position the Americans had enjoyed during the rubber shoe trade (see Chapter 2). American interests clearly established themselves in the region first and that is why the USA led the international pressure over the free navigation of the Amazon in the 1850s, notably after their attempts to establish a steamship line between Pará and the USA was barred by the Brazilian authorities.[217] However, in the end, even shipping lines came to be dominated by English capital (as will be shown in Chapter 6).

Another form of direct investment refers to loans contracted abroad.[218] After the proclamation of the Republic in 1889, states and municipalities were entitled to contract loans abroad and thus at the beginning of the twentieth century six major loans were

[216] Santos (1980, pp.134-135) and *London Stock Exchange – Tea, Coffee & Rubber – Commercial Report – several years*. Values were converted from US dollars to British pounds using exchange rate series presented in the Appendix. There were additionally some Belgium and French investments such as La Brésilienne (Brussels, 1898), Cie. d'Enterprises Electriques de Pará (Brussels, 1899), Compagnie Général des Caoutchoucs (Paris, 1905) and Compagnie Agricole et Commercial du Bas Amazone (Paris, 1907). See Santos (1980, pp. 135-136) and Coelho (1982, p. 25, Table 1).
[217] See Ferreira Reis (1965, pp.60-85).
[218] I need to thank prof. Marcelo de Paiva Abreu for giving me valuable information about the loans.

negotiated in England and one in France (see Figure 3.6 below). As it can be seen from Figure 3.6 below, the State of Pará contracted three loans with Seligman Brothers (London) totalling £2,300,000. The interest rate paid was around 5% but the initial face value discount decreased over time indicating a higher credit rating as a consequence of the improvement in the revenues of the State which in turn depended on the booming rubber trade.[219] The same improvement in the credit rating can be observed from the loans contracted by the Municipality of Belém: the interest rate was usually the same as for the State of Pará, i.e. 5%, with the initial face value discount decreasing over time.[220] In total, the loans contracted by the Municipality of Belém totalled £1,600,000. Despite the more modest amount, the Municipality of Manaus also contracted a loan in the City, with the Bank of London and South America, amounting £350,000. The interest rate was also 5% and the initial discount over face value was 9%.

Figure 3.6 – Amazonian Loans Contracted Abroad

	Issued in	Year	Nominal Value (£)	Interest (%)	Type	Maturity (years)
State of Pará	London	1901	1,450,000	5.0%	69	50
Municipality of Belém	London	1905	1,000,000	5.0%	86	n/a
Municipality of Belém	London	1906	600,000	5.0%	95	50
Manaus City	London	1906	350,000	5.5%	91	29
State of Amazonas	Paris	1906	3,327,249	5.0%	n/a	n/a
State of Pará	London	1907	650,000	5.0%	87	37
State of Pará	London	1910	200,000	6.0%	90	6

Source: computed from Bouças (1955) and Santos (1980).

As the main crude rubber producer and due to the quality of its production, international capital flowed into the region in several different ways: direct investments in rubber production, investments in public works and in companies operating in the region and loans to the Amazonian states and municipalities. However, the bulk of direct investment in rubber production was probably channelled through the export houses which very early secured a foothold in the rubber trade: the literature has indeed

[219] It may also reflect path dependence: after each successive loan, the underwriter and the lenders possessed more information about the track record of the borrower.
[220] Note that the interest rate and the initial discount over the face value also depended on the guarantees given. For a description of guarantees given, see Santos (1980).

advanced that most of the capital employed in the production of rubber in the Brazilian Amazon was ultimately supplied by these foreign export houses.[221]

Active foreign participation in the Amazonian trade can probably be dated from the 1850s when two foreign export houses appeared in Belém (and would both later become among of the largest in the region): Denis Crouan & Co., French cocoa traders, and Singlehurst, Brocklehurst & Co., a British concern that later would also organise the transatlantic Red Cross Line (see Chapter 6 for details about shipping).[222] With the development of the rubber boom, some other export houses fought for a position in the trade but throughout most of the rubber boom, a few export houses dominated the rubber export trade in both Manaus and Belém. For instance, as in Figure 3.7 below, during the 1899-1900 fiscal year, the top three export houses in Pará accounted for 72.9% of all rubber exported from Belém and 53.0% from Manaus. Concentration was in fact even higher since several Manaus export houses were simply agents or branches of Belém export houses which moved part of their operations upriver as a consequence of taxation incentives: in 1878 the State of Amazonas (where Manaus lays) decided to divert part of the trade towards its jurisdiction by levying a lower duty for rubber exported directly from Manaus in comparison with rubber channelled through Belém. When in 1885 the tax gap widened to 5 percentage points, most export houses and intermediary (*aviador*) houses were forced to move part of their operations to Manaus in order to profit from the lower tariff.[223]

[221] See Santos (1980) and Weinstein (1983). From 1870 to 1910, despite Brazilian leadership in the crude rubber market, there were only a few Brazilian rubber companies incorporated in London compared to many more operating in other regions (see Appendix). This seems indicative that money was channelled to the region in different ways, possibly, through export houses as suggested by the literature.
[222] Weinstein (1983, p. 62).
[223] Weinstein (1983, pp. 195-196).

Figure 3.7 – List of Exporters of Rubber from Pará and Manaus during the Year 1899-1900

From Belém (in kg)	USA	%	Europe	%	Total	%
Cmok, Prusse & Co.	2,081	20.7%	3,367	39.1%	5,448	29.2%
Adelbert H. Alden	3,032	30.1%	1,182	13.7%	4,214	22.6%
Frank da Costa & Co.	2,302	22.9%	1,651	19.2%	3,953	21.2%
The Sears Pará Rubber Co.	1,908	19.0%	-	0.0%	1,908	10.2%
Rud. Zeitz	250	2.5%	895	10.4%	1,145	6.1%
Denis Crouan & Co.	107	1.1%	349	4.1%	456	2.4%
R. Suárez & Co.	-	0.0%	334	3.9%	334	1.8%
Mello & Co.	-	0.0%	227	2.6%	227	1.2%
H. A. Astlett	187	1.9%	16	0.2%	203	1.1%
Henry Airlie & Co.	105	1.0%	71	0.8%	176	0.9%
Kanthack & Co.	32	0.3%	101	1.2%	133	0.7%
Comptoir Colonial Français	-	0.0%	132	1.5%	132	0.7%
B.A.Antunes & Co.	-	0.0%	101	1.2%	101	0.5%
Sundry Exporters	61	0.6%	184	2.1%	245	1.3%
Total	**10,065**	**100.0%**	**8,610**	**100.0%**	**18,676**	**100.0%**
From Manaus (in kg)	USA	%	Europe	%	Total	%
Prusse, Dusendschon & Co.	773	32.1%	1,090	18.8%	1,863	22.7%
Witt & Co.	825	34.2%	506	8.7%	1,331	16.2%
Marius & Levy	11	0.5%	1,144	19.7%	1,155	14.1%
Rud. Zeitz	89	3.7%	400	6.9%	489	6.0%
Adelbert Alden	356	14.8%	49	0.8%	405	4.9%
Comptoir Colonial Français	4	0.2%	337	5.8%	341	4.2%
J.H.Andresen	22	0.9%	276	4.8%	298	3.6%
Brocklehurst & Co.	112	4.6%	138	2.4%	250	3.0%
Kahn Pollack & Co.	-	0.0%	193	3.3%	193	2.4%
Luiz Schill & Co.	-	0.0%	144	2.5%	144	1.8%
Mello & Co.	4	0.2%	125	2.2%	129	1.6%
J.A. de Freitas & Co.	26	1.1%	77	1.3%	103	1.3%
Moray and Aguiar	-	0.0%	119	2.1%	119	1.4%
Sundry Exporters	187	7.8%	255	4.4%	442	5.4%
Iquitos Merchants	-	0.0%	944	16.3%	944	11.5%
Total	**2,409**	**100.0%**	**5,797**	**100.0%**	**8,207**	**100.0%**
Grand Total	12,474		14,407		26,883	

Source: Adapted from *UK Diplomatic and Consular Reports, n. 2580, Annual Series, Brazil, Report for the Year 1900 on the trade of Para and District, p. 23.*

Looking at the names of the companies in Figure 3.7 above, it is clear that some export houses operated in both cities. That was obviously the case of the German exporter, Rudolph Zeitz; the French Company, *Comptoir Colonial Français*; the American export house, Adelbert H. Alden; and etc. However, some other branches were more difficult to identify as, for instance, Witt & Co. (Manaus) was related to Frank da Costa & Co. (Belém) and Prusse Dusendschon & Co. (Manaus) to Cmok, Prusse & Co. (Belém). The rubber export trade was indeed concentrated in the hands of a few firms, indicating a low degree of competition within the rubber trade node of the chain.

Following the Global Commodity Chain approach, it is useful to see the degree of competition in every link of the chain. It is very difficult though to analyse how competitive the rubber export trade was, as it is hard to follow a given company's track record over time because export houses frequently changed their names. For instance, until 1910, the house of Ernesto Schramm became Pusinelli, Prusse & Co., then Cmok, Schrader & Co., and finally Schrader Gruner & Co. Therefore, even though the names of the leading export houses changed over time and even though several restructuring of these companies occurred, the control of the export trade remained mostly in the same hands during the rubber boom. Indeed, looking at the ranking of top exporters of rubber from Manaus in 1910 it can be inferred that they were basically the same as in 1899-1900: 1st) Dusendschon, Zarges & Co. (the reminiscent of Prusse, Dusendschon & Co.): 6,536,080 kilograms of rubber exported; 2nd) Adelbert H. Alden: 2,880,490 kilograms and; 3rd) Scholz & Co. (which seems to the successor of Marius & Levy[224]): 2,715,130 kilograms. In total, these three companies handled 77.2% of the total quantity of rubber exported from Manaus. Therefore, Barham and Coomes' claim that "(...) frequent entry and exit of export houses during the rubber boom are consistent with an actively competitive industry"[225] does not find support from the data. It is true that some firms disappeared, as happened to the *Comptoir Colonial Français*, but at the top the companies were usually only changing their names, with the rubber trade remaining in the same hands throughout most of the period. Moreover, different export houses have different goals, as some acted as agents for rubber manufacturers whereas others were simply brokers.[226] The degree of competition in the rubber trade seems then to be much smaller than in rubber manufacturing but does it necessarily mean that the rubber traders were actually the core node in the rubber chain?

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[224] This assumption is mostly speculative and based on accounts from Schluter & Co., importers of rubber in London. See next section for details.
[225] Barham and Coomes (1996, pp. 32-35).
[226] Accodring to the Confidential Letter of Hulne Cheeltham to Sir Edward Grey (Petrópolis, 14th March 1909),

> *"The American Export houses are in more direct relations with the manufacturers, and act rather as agents, while the German and French houses are in the position of brokers, who, by withholding supply and other manipulations, produce artificial prices and otherwise disturb the market."*

Export houses provided most of the capital for rubber production in the Amazon Valley. However, a handful of companies managed to possess a high market share of the rubber export trade that remained virtually unchanged over time. The nature of their business was simply to buy rubber at the lowest prices possible from the intermediaries, called *aviadores* (even though some export houses were also *aviadores* in their own right), and sell at the highest prices possible to importers mostly in Britain and in the United States. In general, these export houses acted as agents for rubber buying firms placed in New York and Liverpool, although a few functioned independently (such as J. Marques). For instance, Ernesto Schramm represented Heilbut, Symons & Co. of Liverpool whereas La-Roque da Costa & Co. (and Frank da Costa & Co.) represented another American buyer.[227] Moreover, Sears & Co. was founded in 1882 as a subsidiary of the renown and ubiquitous W. R. Grace & Co. besides having also initially represented Charles R. Flint & Co., the architect of mergers in the US rubber manufacturing industry (see Chapter 2 for details). His plans were to devise a pool of rubber buyers to increase their bargain position in the rubber trade. Finally, Adelbert H. Alden represented the homonymous American firm.

What was the degree of freedom these export houses had? Were they merely agents of rubber importing firms placed in New York and Liverpool for which they received a fee for their services? Were they able to speculate? What was the bargain position they had in their interactions with the rubber buyers? Those are very difficult questions to address in a definitive way but, based on new accounting data collected by the author from British and Brazilian sources, next section tries to shed some light on some of these issues by analysing a case study: the relationship between J.H. Andresen, a Portuguese rubber export house of Manaus and Schluter & Co. traders of rubber coffee and tea, placed in London but with branches in Liverpool, New York, Hamburg and in several other cities in Europe. If some light can be shed on these issues, it will be possible to draw the

[227] Although partly Brazilian funded, the behaviour of that company differed in no significant way from foreign export houses. See Weinstein (1983).

power relation between rubber traders in rubber consuming countries versus rubber traders in rubber producing countries.

3.6 – Case Study: Edmund Schluter & Co. versus J. H. Andresen & Co.

Edmund Schluter & Co. were general merchants (particularly in coffee, rubber and tea) with trading links in France, Germany, Belgium, Sweden, Italy, Austria, the United States and Brazil. The business was founded in 1858 and was initially based at 35 Mincing Lane (1858-1859). In 1860, they moved to 24 Mark Lane where they remained throughout the rubber boom.[228] The company collection is comprised of ledgers, account sales, bills receivable, cash books, coffee purchase book, expenditure daybook, invoice book, and journals. However, only the ledgers and the cash books overlap with the rubber boom (1870-1910). The ledgers are divided into three handwritten notebooks: 1873-1886, 1887-1900, and 1901-1910.[229] They show more detailed information on the companies Balance Sheets than what was ultimately published and submitted to the London Stock Exchange. Whereas the publish Balance Sheets only showed consolidated accounts, the handwritten ledgers provide all information related to that account at the end of the year. The cash book only refer to the period 1904-1910 but provides even more detailed information. In every account, it is possible to see all operations credited/debited, even if it is the same operation repeated several times during the year. It further shows the date when these operations took place. Therefore, whilst the ledgers provide a snapshot of the financial situation of the company at the end of the year, the cash books provide information on all operations that happened within that same year.[230]

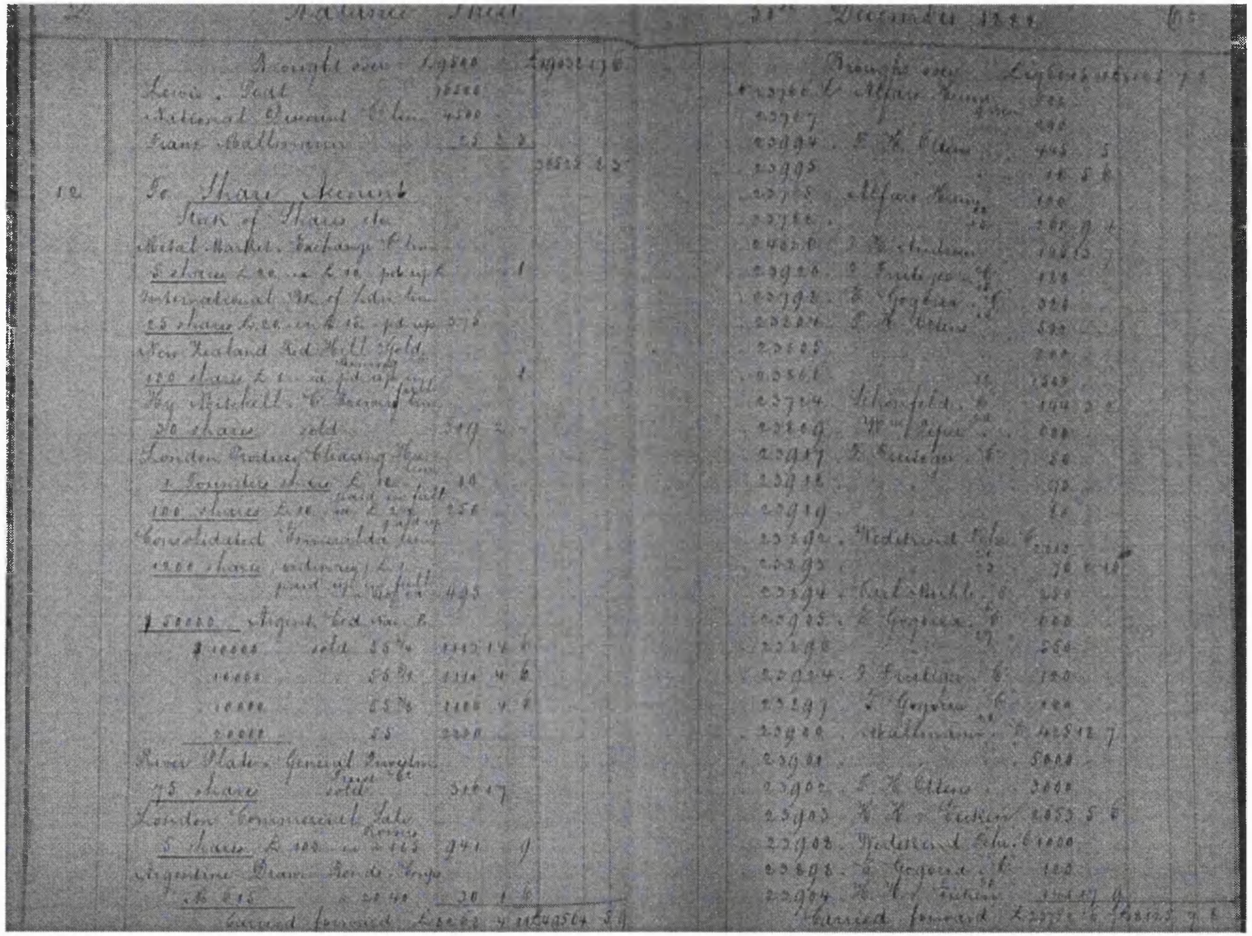
[228] Records of the company were donated to the Guildhall Library in 2005, catalogued and given free access to the public at the Manuscript Section. The surviving records used here refer to Ledgers/Balance Sheets (1873-1910) and Cash Books (1904-1910).
[229] They show information on Office Furniture, Reserve Account, Share Account, Sundry Charges Account, Insurance Account, Commission Account, Debtors, Cash Account, Interest Account, Exchange Account, Bills Payable, Merchandise Account, Rubber Account, Tea Account, Coffee Account, Account Sales, Loan Account, Creditors, Bills Receivable, Trade Expenses, Dockcharges Account, Freight Account, Postage and Telegrams, Billbrockerage, Coupons Account, Shipping Charges, Fire Insurance and Sundry Creditors.
[230] *Edmund Schluter & Co. Accounts. Ledgers/Balance Sheets (1873-1910) and Cash Book (1904-1910), Manuscript Section at Guildhall Library, catalogue reference: MS 35975-91.*

From the company's balance sheets, it is not possible to know where funding came from, but they provided some clues. Dividends were rarely paid (or at least they were not explicitly stated in the balance sheets) and when they did, they usually referred to someone from the Schluter's family or some other German investor[231]. The company seldom borrowed money and when it did, very small amounts were involved. It is possible that members of the Schluter family might have individually borrowed money and invested it in the company but, unfortunately, if those transactions ever existed, it was not possible to trace them. Small loans were sometimes given to individuals and companies but they were never significant either.

A significant amount of money was invested in stock shares of several companies. The composition of the company's portfolio changed substantially over time. In the 1870s, investments in shares were very limited and indicated a tendency to invest in Central Europe, notably in Hungary. In the 1880s, investment in English concerns started to abound in parallel with a shift of investments towards Asia and the River Plate.[232] Argentina would indeed become the biggest recipient of investments from the Company, especially after 1885 when Schluter & Co. started to buy Argentine government bonds. Figure 3.8 above shows a sample page of Schluter & Co.'s ledger in 1888. On the left hand side, it is possible to see some of the Argentine shares and bonds the company invested in: 'River Plate and General Investment', 'Argentine Drawn Bonds & Coupons' and 'Argentine Ced. Nacional B'. Indeed, from 1888, investments in Argentina became more diversified with the company holding shares in a railway, a water supply & drainage company and an investment trust. Investments elsewhere also became more diversified with an important stake on 2 copper companies besides investments in aluminium production, an ammunition company and banks.[233]

[231] The surnames suggest that they were usually of German origin.
[232] *Edmund Schluter & Co. Accounts. Ledgers/Balance Sheets (1873-1886), Manuscript Section at Guildhall Library, catalogue reference: MS 35975.*
[233] *Edmund Schluter & Co. Accounts. Ledgers/Balance Sheets (1888), Manuscript Section at Guildhall Library, catalogue reference: MS 35976.*

Figure 3.8 – Sample Page of Schluter & Co.'s Ledger, 31st December 1888



Source: Edmund Schluter & Co. Accounts. Ledgers/Balance Sheets (1888), Manuscript Section at Guildhall Library, catalogue reference: MS 35976.

In the 1890s, investments in Argentina continued to dominate in a context in which the portfolio of the Company substantially increased, comprising investments in several different sectors: tobacco, cotton, petroleum, railway, trading, sugar refining, sugar, banks, waterworks, etc. The portfolio further showed a broader geographical coverage: Portugal, Brazil, Argentina, Uruguay, Cuba, North America, Borneo, England, Germany, etc. After the turn of the century, the portfolio diminished in size and in composition with an increasing participation of government loans: besides Argentine bonds, Japanese and Brazilian bonds also appeared in the portfolio.[234] From the records of the company, it is difficult though to assess the profitability of these investments but it is possible to speculate that the reduction of the company's investments in the 1900s were a consequence of losses incurred in the 1890s when several holdings were written off (possibly due to the economic and credit crisis in Argentina).

From 1870s to 1910, in contrast to its investments, the company became more and more concentrated in the market of a very few products: coffee, rubber, tea and to a much lesser extent cocoa. Even though coffee was the main product traded by the company, this product will not be analysed here as the interest rests solely on the rubber trade (more specifically on the Brazilian rubber trade). Schluter & Co. distributed rubber to the European Continent and to the USA (sometimes rubber was also shipped directly to the final destination) and several rubber manufacturers figured among the clients of the company: Dunlop Rubber Co., Northern Rubber Co., Rubber Co. of Scotland, Russian-American India-Rubber Co., Spencer & Co., Clyde Rubber Co., Prager Gummi W. Fabr., Unity Rubber Co. Ltd., among others.[235]

Among the Brazilian suppliers of rubber to Schluter and Co. some were identified: Marius & Levy (after 1907, Schölz & Co), J. H. Andresen, S. Brocklehurst & Co., Mesquita & Co., Pará/Marajó Rubber Estates Co. and Araujo Rozas & Co. As mentioned elsewhere before, S. Brocklehurst & Co. organised one of the main shipping lines (Red Cross Line)

[234] *Edmund Schluter & Co. Accounts. Ledgers, Manuscript Section at Guildhall Library, catalogue reference: MS 35976.*
[235] *Edmund Schluter & Co. Accounts. Ledgers, Manuscript Section at Guildhall Library, catalogue reference: MS 35975-7.*

connecting Liverpool to the Brazilian Amazon besides being an exporter in its own right. Therefore, due to its two different operations, from the records of the company it is difficult to separate what was purely rubber trade and what was shipping[236]. Since Marius and Levy changed the name and their operations virtually vanished after the turn of the century and most of the other companies sold rubber to Schluter & Co. only sporadically, I decided to limit the analysis to the relationship between J. H. Andresen & Co. and the Schluter & Co.

As will be shown in Chapter 4, J. H. Andresen & Co. (or S/A Armazéns Andresen) was a Portuguese trade house placed in Manaus that handled several Amazonian commodities amongst which, of course, crude rubber. According to Figure 3.3 above, Andresen ranked in 7th among the top exporters of rubber from Manaus, a position established by its prominent role as a rubber intermediary (see Chapter 4). Andresen operations were usually channelled via Oporto that was connected to Manaus through its own transatlantic vessels.[237] Since there is no evidence that Schluter & Co. ever transacted any other commodity with J.H.Andresen & Co., it is likely that most the of the transactions between this company and Andresen referred to rubber despite the fact that Andresen was a big player in the market of Brazil nuts. Conversely, even though it is not possible to infer the amount of rubber traded between them, it seems that Schluter & Co. was only buying a portion of Andresen's trade and thus the relationship was not a monopsony.

Looking at the financial and commercial transactions between Schluter & Co. and J.H. Andresen & Co., it is possible to identify three major periods. First, during the 1890s, there are no surviving cash books of Schluter & Co. and thus the analysis was carried out only from ledgers (balance sheets). The problem with balance sheets is that they only show a snapshot of financial and commercial transactions of Schluter & Co. at the end of the year and, by consequence, all transactions that were initiated and completed within

[236] It is true that Schluter & Co. specified a separate account for shipping charges but it is not at all clear if the outstanding bills and debts of the S. Brocklehurst & Co. would refer to the rubber trade or to shipping charges. Anyway, only a few transactions with S. Brocklehurst & Co. were identified which would not be enough to make a full picture of the rubber trade as intended here.
[237] LeCointe (1922, p. 249).

the calendar year would not be registered in any way there. Before the 1890s, J.H.Andresen & Co. was rarely recorded making any inferences about this period very uncertain. In the 1890s, J.H.Andresen & Co. name consistently appeared in the balance sheets in form of Schluter's creditor or debtor or whenever there were any outstanding bills to be paid by Schluter.[238] In this period, Andresen was usually a net creditor of the company as it can be seen in the Figure 3.9 below.

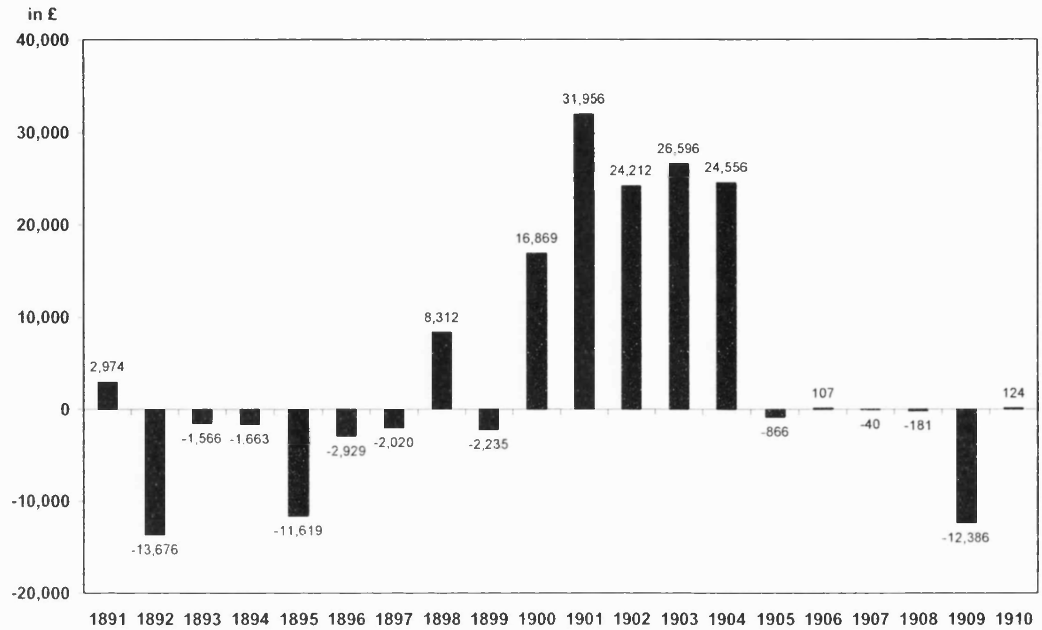
Secondly, in the first five years of the twentieth century (1900-1904), Andresen's net position turned into a huge debt with Schluter & Co. that was nonetheless offset by outstanding bills. Therefore, the data does not suggest in any way that J.H.Andresen & Co. ever became heavily indebted with Schluter & Co. Therefore, Andresen's net debtor position in these years only reflected the nature of the trade: rubber was sent, say, from Manaus to Liverpool and invoiced against Schluter & Co. in form of short term payable bills. If no other transactions were made, Andresen's debtor position would be cleared out after just a few months.[239]

In 1905 there is evidence of the only interest payment earned from J.H.Andresen amounting to £26 11s. Since there was no outstanding loan to Andresen in the Balance Sheet in 1905, I believe that the interest payment referred to a short term loan that was probably paid back during the same fiscal year. However, from that year onward, Schluter & Co.'s cash books suggest a change in the nature of the trade with Andresen: Andresen's net debtor position was henceforth always close to zero, payable bills virtually vanished from the balance sheets and the financial transactions between these two firms decreased drastically, especially after 1906.[240] This might have been the effect of the rubber valorisation attempt by a Brazilian export house.

[238] *Schluter & Co. Ledgers/Balance Sheets (1887-1900), Manuscript Section at Guildhall Library, catalogue reference: MS 35976.*
[239] *Schluter & Co. Ledgers/Balance Sheets (1900-1904), Manuscript Section at Guildhall Library, catalogue reference: MS 35977.*
[240] *Schluter & Co. Cash Book (1904-1910), Manuscript Section at Guildhall Library, catalogue reference: MS 35978.*

Figure 3.9 – J.H. Andresen's net debtor position against Schluter & Co., 1891-1910

(in current £)



Source: Schluter & Co. Ledgers/Balance Sheets (1891-1910) and Cash Book (1904-1910), Manuscript Section at Guildhall Library, catalogue reference: MS 35976-8. Note: positive figures refer to net debt of J.H.Andresen & Co. with Schluter & Co., whereas negative figures indicate that Schluter was in net debt with J.H.Andresen.

Why did Schluter & Co. substantially decrease the trade with Andresen after 1906? Did any other Amazonian firm take over Andresen's position? Schluter & Co.'s rubber account indicate that the Company continued to expand its rubber trade so that some other firm took indeed Andresen's position as the main supplier of rubber to Schluter. However, no other firm in the Amazon replaced Andresen as the trade was in fact shifted elsewhere, especially to Asia where rubber plantations were starting to invade the market. Therefore it seems that Schluter & Co. made a relatively early shift towards Asia[241], consistently diminishing the volume traded with J.H.Andresen & Co. In turn, the latter firm did not diminish its overseas trade and probably found another buyer for its exports. This change in the strategy can also be inferred from Schluter's investment portfolio. Despite the importance of the rubber trade for the company, until 1907 there was

[241] If this was a conscious decision it is impossible to know. It might very well be the case that J.H.Andresen & Co. decided to change its trade partner in Europe and not the opposite.

no direct investment in any rubber producing venture. As can be seen from Figure 3.10 below, from that year onwards, the company started to invest in several plantation companies usually located in South East Asia despite the large sum invested in guayule production in 1910.[242] According to the Appendix, Guayule Rubber Co. Ltd. was a company operating in Mexico from wild guayule rubber sources whose total authorised capital amounted to £400,000 (which was fully paid-up). Therefore, despite the huge investment in this company, Schluter & Co. had just over 1% of the venture. Additionally, there is no evidence that the company ever invested in any of its partners in the Brazilian rubber trade even though it is possible that a certain member of the Schluter family might have personally invested in, say, Andresen.

Figure 3.10 – Rubber Shares in Schluter & Co.'s Portfolio, 1873-1910 (in current £)

Year	N. of Shares	Name of the Company	£	s.	d.
1907	100	Bantong Selangor Rubber Estates	50	-	-
1908	100	Bantong Selangor Rubber Estates	87	10	-
	250	Ledbury Rubber Estates	93	15	-
1909	1,000	Anglo Malay Rubber Co. Ltd	800	-	-
	500	Chersoncor Estates Ltd.	125	-	-
	1,645	Batong Malaka Rubber Estates Ltd.	2	3	2
1910	1,000	Guayule Rubber Co. Ltd.	1,000	-	-
	3,000	Guayule Rubber Co. Ltd. (ordinary shares)	1,735	-	-
	3,080	Guayule Rubber Co. Ltd. (ordinary shares)	2,000	-	-
	200	Rubber Plantation Investment Trust	333	14	-
	200	Anglo Malay Rubber Co. Ltd	226	9	-
	500	Highlands Lowlands Para Rubber Co.	1,326	2	-

Source: Schluter & Co. Ledger/Balance Sheets (1907-1910), Manuscript Section at Guildhall Library, catalogue reference: MS 35977.

What does the analysis of Schluter & Co. accounts tell us? First, the relationship between Schluter and Andresen resembles a usual trade relationship in which both companies benefited. The accounts suggest indeed that no firm possessed any specific

[242] *Schluter & Co. Ledger/Balance Sheets (1901-1910), Manuscript Section at Guildhall Library, catalogue reference: MS 35977.*

market power over another: J.H.Andresen had probably other clients and Schluter & Co. had other suppliers. It is true that before 1905, J.H.Andresen was a major supplier of rubber to Schluter & Co., but this relationship changed over time following different market conditions. The advent of plantations (and maybe the 1906 crisis following the unsuccessful valorisation attempt by the Vianna trading house) caused Schluter's rubber trade to divert elsewhere but J.H.Andresen still found buyers for its exports. Secondly, the trade between Schluter and Andresen was not based on commissions: Schluter actually seemed to have bought the rubber from Andresen and sold it either directly to rubber manufacturers or to its own agents placed in several cities in Europe and in the USA. Thirdly, even though the relationship between Schluter and Andresen seemed to have followed market conditions, we should expect that the former firm might have enjoyed a privileged position due to its knowledge of supply of and demand for rubber. However, looking at its own accounts, Schluter & Co. generated very small margins in the rubber trade[243], which would indicate that if any of these two firms was benefiting at the expense of the other, that firm would be Andresen and not Schluter. Without Andresen's accounts it is impossible though to make any definitive conclusion about which link of the rubber chain profited the most in the rubber trade and to define, incontestably, the relations of power between rubber traders placed in rubber consuming and rubber producing countries.

Accounts of De Mello & Co.[244], a similar albeit a bit smaller *aviador*-cum-exporter, suggest that this firm was profiting quite a lot from the rubber trade. The balance sheet at 30th June 1907 shows that the firm earned £60,138 in profits. According to the report of directors, the company received 521 tons of rubber that were sold for £251,561 2s. 10d., or on average by 9s. 8d. per kg. The average price of rubber imported from Brazil into the UK (which includes freight rate and docking expenses) was 8s. 11d. (1906-1907) much lower than the price earned by De Mello & Co. That can either simply indicate that this

[243] From the records of the company, however, it is difficult to know exactly how the profit and loss on the rubber trade was calculated. The results suggest the perception of the company towards the rubber trade though.
[244] Guildhall Library, *Tea, Coffee & Rubber – 1906-1907, commercial report, catalogue number 978.*

company was selling higher quality rubber or that it possessed some market power, especially because the company was not exporting all its production as part of its rubber was sold to other exporters in Manaus: therefore, the average price earned by the company was higher than the average price paid by buyers in the UK even though the company was selling a significant part of its production in the domestic market. So, I do not think we should expect anything too dissimilar for J.H.Andresen and the company was probably very good positioned in the rubber market, being able to exploit its market power to a certain extent.

Generalisations from this case study are hard to draw as it is difficult to know how typical this relationship was. There is no other case study to compare and the results here should be regarded then as a first step towards a full understanding of the nature and conditions of the transatlantic rubber trade. Yet, J.H.Andresen might have enjoyed a quite substantial room for manoeuvre in the rubber market, contradicting, at first glance, the fact that export houses in Brazil were generally solely operating on behalf of buyers placed in Europe and in the USA. In order words, there is no evidence that rubber exporters placed in Brazil were not exploiting their market power or that they were facing monopsony power. Rubber manufacturers were to some extent in the hands of rubber traders, be they Brazilian, Portuguese, German, French or English. It is not at all clear which of them benefited the most, even though the analysis here suggests that were the ones placed in the rubber producing countries (especially in Brazil). This result certainly brings the rubber chain even further away from the ideal Wallersteinian chain type.

3.7 – Final Remarks

The first chapter of the thesis built a theoretical framework that is more suitable for the analysis of commodity chains, in general, and of the rubber chain, in particular. The underlying idea is that the analysis needs be non-linear as it is necessary to examine two different dimensions: interactions that take place between agents located in the same node of the chain and interactions between agents located in different nodes. In this vein, Chapter 2 analysed the first node of the chain, i.e., rubber manufacturing. First, competition among manufacturing firms in Britain and the USA was examined. The main conclusion was that there were several attempts to cartelisation that nonetheless failed. Secondly, it was shown that this competition at the manufacturing level emanated along the chain as evinced by the high inelasticity of demand for crude rubber. Under this scenario, it was speculated that it was possible for traders, located at the crude rubber producing countries/regions, to extract oligopolistic profits.

In the present chapter, the analysis of the relationship between one Brazilian/Portuguese rubber exporter and one British rubber buyer indicates that the relationship between them resembled a usual trade relationship in which both companies benefited. However, if any company exercised market power, it was probably the Brazilian/Portuguese export house. Generalisations from this case study are hard to draw as it is difficult to know how typical this relationship was but the Brazilian/Portuguese export house might have enjoyed some market power at the British buyer's expense, contradicting, at first glance, the fact that export houses in Brazil were generally solely operating on behalf of buyers placed in Europe and in the USA. There is no evidence that rubber exporters placed in Brazil were not exploiting their market power or that they were facing monopsony power. Rubber manufacturers were to some extent in the hands of rubber traders, be they Brazilian, Portuguese, Germans, French or English. This result certainly brings the rubber chain even further away from the ideal Wallersteinian chain type but it is still necessary to analyse the other nodes of the rubber chain to provide a full understanding of which nodes benefited the most from the rubber boom and that is exactly the aim of the next chapters in which the Brazilian rubber supply will be investigated in detail.

Competition between different sources of crude rubber was also examined here. It was argued that crude rubber production depended on endowments of latex yielding trees (first-nature geography) that happened to be located mostly in tropical areas. The main producing regions, however, possessed different types of rubber trees that required different methods of extraction and generated different qualities of crude rubber. Therefore, due to high heterogeneity, competition was somewhat limited as rubber grades were not at all completely substitutes to one another. In this context, the Brazilian Amazon emerged as the market leader due to a combination of quantity (thanks to the size of the Amazon forest) and quality (thanks to its *hevea* reserves).

Second-nature geographical factors and institutions also shaped the rubber chain. First, economic distance seems to explain why the USA was able to generate a higher crude rubber flow from the Americas compared to Britain. However, institutions played an important role too. Not only because of governments, jurisdiction and foreign relations (international politics and colonial power) as these factors were important on their own right but also because they determined economic distances by influencing freights and shipping (see Chapter 6 for an analysis of shipping and communication in the Brazilian Amazon). Thus, given its naval and colonial power, it is not surprising that Britain was able to generate a much higher crude rubber flow from Africa, Asia and Oceania, turning Britain into an important player in the crude rubber market as a re-exporter.

Furthermore, the Brazilian Amazon case suggests that Britain was indeed able to offset geographical distance with Brazil by creating several institutions. Brazil was not clearly within British or US sphere of influence. It was certainly on both, but neither of them succeeded in having a clear prominence over the other. The USA were the main consumer of Amazonian crude rubber but capital came chiefly from Britain. As will be shown in Chapter 6, shipping and communication were both organised by British (and Brazilian) interests, resulting that, despite geographical distances, economic distance was shorter between the Brazilian Amazon and London or Liverpool than between the Brazilian Amazon and New York. The Brazilian government was also instrumental in creating and/or supporting other institutions. The jurisdiction of the country (and the federal states) within the Amazon was instrumental to support rubber production. Subsidisation of shipping and communication also played a role (see Chapter 6). Government interventions in the crude rubber market, especially via taxation, changed incentives and shaped the actual pattern of production within the Brazilian Amazon (see Chapter 4 and 5). Therefore, in order to fully understand the rubber chain, it is necessary to move the analysis further into the supply chain of the main crude rubber producer, the Brazilian Amazon.

4. Brazilian Production Chain: a Re-Interepretation

4.1 – Introduction

The present Chapter unveils the interactions among economic agents along the rubber production chain within the Brazilian Amazon. Chapter 2 analysed the demand for rubber, highlighting the main economic forces behind it whereas Chapter 3 described the link between supply and demand, notably the investment channel. This Chapter then complements the previous two chapters by examining the economic relations along the supply chain within the main producer region: the Brazilian Amazon. Unlike in the GCC approach, here no pre-defined power relationship is assumed between the nodes of the rubber chain and bargain power becomes not only defined by its fundamentals but also constrained by institutions.

This chapter develops one of the main theoretical contributions of the thesis, notably, an explicit evaluation of power between nodes of the commodity chain. It does so by defining a game that summarises the main incentives of the agents involved in the transactions between any two nodes of the chain. The chapter concludes that different from the existent literature on the rubber boom, the rubber chain is much more intricate and the relations of power does not necessarily follow a vertical one in which every forward node is able to exploit the node immediately beneath it (as the GCC approach usually assumes). Rubber exporters might still have been better positioned to extract monopoly rents due to their knowledge of the rubber market and the degree of oligopolisation of their activities. Moreover, looking at the whole chain together, it will be possible to conclude that rubber production is even easily self-enforced under a scenario of constant production expansion and of high inelasticity of demand, just like the one that prevailed from 1870 to 1910. Under this scenario, all factors of production could have been properly remunerated.

The Chapter is divided into 6 sections, including this introduction. Section 4.2 presents the game theoretical framework that is used to explain the interactions between rubber tappers and estate owners. Section 4.3 shows how the Institutional theory changes the likely outcome of the game between tappers and estate owners. Section 4.4 then moves along the rubber chain and applies a similar game framework to analyse the other links in the production chain within the Brazilian Amazon. These interactions between the major players in the rubber supply chain shed new light on the Brazilian Rubber Boom, allowing, in Section 4.5, a re-interpretation and re-evaluation of previous works that were mainly concerned with the idea of labour exploitation. Finally, Section 4.6 concludes the Chapter.

4.2 – Estate Owners & Tappers: a Game Theoretic Approach

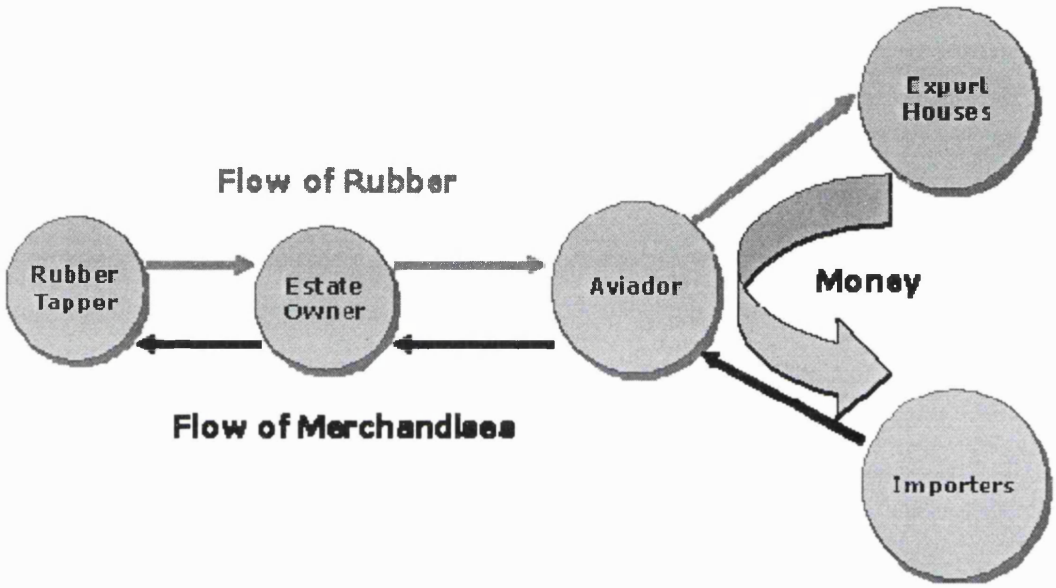
Until mid-eighteenth century metallic currency was barely used in Pará, and the bulk of transactions was carried out through exchanges of merchandises such as cotton. Only in 1749 was fiat money introduced, amounting ca. 55 contos de réis[245], and a hundred years later it was still of scarce utilisation due to slavery (which meant that many labour arrangements did not evolve into payment of wages) and geographical conditions (in more remote places people still preferred to exchange merchandises than to make transactions based on fiat money). Since colonial times, however, an informal credit channel had been evolving. The first economic activity of the region, the collection of *drogas do sertão*[246], relied heavily upon the exchange of merchandises: the gatherer received merchandises in exchange for the product collected in the Amazon Forest. This informal credit channel was called *aviamento* which means credit without money.[247]

Therefore, as explained in the introduction, according to the literature, *aviamento* turned to be the typical credit channel in the Amazon Region. During the rubber boom the *aviamento* was roughly organised into a horizontal channel (see Figure 4.1) in which the estate owner advanced the merchandises to the tapper in exchange for a promise to deliver a certain quantity of rubber. This merchandise was supposed to be the means of living that would allow him to concentrate solely on rubber extraction. The estate owner, in

[245] See 'Note on Currency' at the front of the thesis.
[246] 'Drogas do sertão' means, literally, drugs from the backlands and in the Amazonian context it meant commodities extracted from the Amazon Forest.
[247] Santos (1980, p. 157).

turn, was financed by an *aviador*, who was merely an intermediary who bought the merchandises from the export houses (or from importers with the money advanced by the export houses) which, as explained in Chapter 3, were the ultimate source of funding in that credit channel.

Figure 4.1 – *Aviamento* Credit Channel in the Amazon Region



Source: Elaborated by me, based on the main nodes of the rubber chain located within the Brazilian Amazon. This is illustrative only as the definition of nodes is much more intricate with an agent sometimes acting in several nodes of chain at the same time.

The credit channel encompassed all nodes of the rubber chain located within the Brazilian Amazon and was much more complex than what this 'Weberian' ideal credit chain suggests. It hides several other relationships between the economic agents involved in the rubber chain as the degree of verticalisation increased quite substantially over time, especially during the last decade of the rubber boom (1900-1910). First, several intermediaries possessed their own ships (see Figure 6.3 in Chapter 6) to transport rubber from the jungle to warehouses in Belém or Manaus. Secondly, these intermediaries invariably ended up possessing some rubber estates, either following a business plan or as a consequence of foreclosure of rubber estates for collection of debts from their clients.

Thirdly, some intermediaries also exported part of their rubber and could then be considered as export houses. Conversely, some export houses ventured into the intermediary market and also ended up renting or buying rubber estates.

As explained in the introduction, most of the literature on the Brazilian Rubber Boom adopted a Marxist approach as the authors invariably looked for evidences of exploitation. In this context, the rubber chain was generally drawn vertically, indicating a pre-existing and *ad-hoc* notion of power between nodes of the chain. The literature has thus assured some form of debt-peonage, bondage, semi-serfdom or indenture system as the outcome of migration to the Amazon. The underlying idea is that, in order to move, the labourer indebt himself and once having arrived at the rubber estate they were exploited. Rubber labourers were generally described as comprised of a mass of dehumanised and defenceless men who were exploited by cruel and greedy capitalists due to the latter's monopoly over the means of production (rubber trees and tools).[248] In turn, rubber estate owners were also usually taken as having power to enforce the so-called 'Rules of the Rubber Fields' which dictated that fugitive labourers should be returned to their original rubber fields. Since the labourer was inside the forest and worked alone, escape was normally a difficult enterprise since there were not many alternatives left. If the conditions prevailing in the forest were not sufficient to entice labourers to work, rubber estate owners could further resort to physical punishment.

In the particular case of the Brazilian Amazon, Weinstein offers probably the first revisionist literature on the debt-peonage system.[249] She argued that rubber tapper resistance rather than coercion conditioned the nature and durability of social relations. Weinstein argued that at least in downriver rubber estates 'the Rules of the Rubber Fields' were a dead letter. First, the extracted rubber was, by law and for all practical purposes, the property of the rubber tapper and not of the estate owner who held the land and the trees. So there was no monopoly over the means of production. Secondly, the high cost of monitoring the rubber tapper strictly limited the degree to which the rubber estate owner

[248] Barham and Coomes (1996, p. 16), Brusque (1862, pp. 47-48), Santos (1980, p. 167) and Barros (1854, pp. 9-10).
[249] Weinstein (1983) and (1986).

could effectively control their workers and curb illicit rubber sales. A durable alliance was thereby formed between rubber tappers and rubber estate owners, based on interlocking self-interest – the rubber estate owner's need to control the exchange and the tapper's preference for autonomy – that effectively frustrated local and foreign pressures for rationalising rubber extraction and trade.[250]

Bentes, in turn, advances that the rubber estate owners commanded the process of rubber production and owned the best and most profitable rubber fields but work relations were not defined by indebtedness. From the accounts of a rubber estate located in the Acre region, she shows that the estate owners used several different incentives such as bonuses, discounts and gratifications to ensure production and not necessarily violence.[251]

Another revisionist approach is that of Barham and Coomes who aimed at conforming the labour relation system into an Institutional framework. Even though they deny Weinstein's assumption that rubber tappers necessarily preferred autonomy, they support her main critics over contemporary accounts with some new evidences. Their main contribution lies on their analysis of the role of risk[252] by arguing that labour arrangements depended upon the following factors: endowments, motivations and alternative opportunities open to rubber workers (which will ultimately define opportunity costs), the property relations under which they worked, and the type of rubber collected. Distinct labour arrangements were associated particularly with the type of rubber extracted and on *hevea* estates, the scarcity of labour and market features of risk and transaction costs provided strong incentives for rubber tappers and rubber estate owners to develop a durable relationship. For rubber estate owners, stable tappers would tap *heveas* with greater care (increasing future productivity of *hevea* trees) and would be a

[250] Weinstein's revision is in line with the literature on slave economic rationality which argues that even slaves had some room for manoeuvre and used resistance as a means of enforcing their bargain power. In this regard, amongst others, see Genovese (1976) and Barzel (1977) for analysis on US slaves, Blanchard (1992) for Peru and Toplin (1969) for an analysis of slavery in São Paulo (Brazil). Moreover, Engerman (1992) provides a very broad view of the implications of differing forms of property rights in people.

[251] Bentes (1999, pp. 143-180).

[252] It is true that Weinstein (1983) also highlighted the role of risk, but this was of a secondary importance to explain the durable alliance between tappers and estate owners.

source of diminishing transaction costs as monitoring and recruitment costs would fall[253]. Tappers, in turn, would also seek a stable relationship in order to guarantee access to more productive *estradas* (trails) and as a way of obtaining some form of insurance against the risk of the environment. Hence, Barham and Coomes rely on transaction costs to account for the establishment of a durable relationship between tappers and rubber estate owners in lieu of Weinstein's assumption of tappers' preference for autonomy. Moreover, for Barham and Coomes, high premia over foodstuffs (see Chapter 6) could be explained by the high risk involved in the enterprise and should be regarded as normal remuneration of capital due to high risks entailed by rubber gathering.

Since there are diverging revisionist theories, the objective here is to develop a game theoretic approach that unveils the bargain position of rubber tappers and rubber estate owners. Distinct from the Global Commodity Chain approach, there will be no pre-defined power relation between nodes of the rubber chain: the bargain positions of transacting players located in different nodes define and shape the outcomes of the game. Once the game is specified and analysed, Institutions Theory will then be applied in order to see how the likely outcomes would change. Additionally, the revisionist literature will be analysed through this theoretical viewpoint which will ultimately improve the current knowledge of the *aviamento* credit chain during the rubber boom (that spam all the nodes of the rubber chain located within the Brazilian Amazon).

Northeasterners and, to a lesser extent, foreigners comprised the bulk of the immigrants who fostered the increase of the Brazilian Amazon population during the rubber boom and formed the workforce for the rubber industry, alongside Amerindians and *caboclos*. Nonetheless, the economic role that each one played was ultimately dependent upon their initial endowments. The most deprived workers were usually impelled to act as rubber tappers, normally renting a trail from the estate owner who was himself either a more affluent immigrant or a former rubber tapper who made profit from previous work in a rubber estate and then moved along the forest to establish a rubber

[253] Barham and Coomes (1996, p. 62) also accounted for less moral hazard problems and higher personal security for the rubber estate owner.

estate of his own.[254] It is argued here that labour arrangements between the tapper and the estate owner depended primarily upon their respective bargain position at the time of the 'contract agreement' which implied no pre-defined power relation. Note, however, that no formal contract was required and indeed much of the transactions in the Amazon region took place informally.

According to Woodroffe a labour arrangement between the tapper and the estate owner would be based on one of the following systems:

1. The rubber was delivered to the estate owner at fixed prices, calculated at a discount from the prices ruling at Pará or Manaus.
2. All rubber produced was sold to the estate owner, who made it a condition that he would pay in goods or cash, or send the rubber to the local market to be sold for account of the tapper, deducting from the net result of such sales the value of the rubber agreed upon as rent of the rubber trails.
3. The rubber was delivered to the estate owner, who sent it to the local market, having paid all freight and other charges, after having deducted for himself a percentage as commission and having paid the remaining of the net proceeds to the tapper.[255]

The basic problem of these contracts is to entice tappers to work at the minimum possible cost. In the first contract, there is risk-sharing, as the remuneration of both, estate owner and tapper, depend on the future price of rubber. They both suffer from lower market prices and profit from abnormally high ones. In the second contract, the risk is almost entirely borne by the tapper, as the estate owner's remuneration is mostly fixed. In thesis, tapper would profit alone from a abnormally high production whereas bad production would spell disaster only to the tapper (as long as production is at least enough to pay for the rents of the trails or as long as the tapper possesses some additional capital to pay for the rent). Finally, in the third contract, the risk is still entirely borne by the tapper but now profits are shared: there is an assymetrical payoff, favouring the estate owner.

[254] See Weisntein (1983).
[255] Woodroffe (1916, pp. 56-57).

What determines which contract would be adopted is exactly the bargaining power of each, estate owner and tapper, at the time of the agreement. It is possible to see this through a stylised game. Consider then an idealised typical chain of the *aviamento* credit system in which the **Rubber Estate Owner** (Principal) advanced D (usually in the form of merchandises) to the **Rubber Tapper** (Agent) in exchange for Q^* kilograms of rubber[256] and promised to pay P per any additional kilogram of rubber. Those merchandises were in fact the means of living that would allow the tapper to concentrate solely on rubber extraction. The tapper was furnished with the implements necessary for tapping and curing rubber as well as firearms, ammunition, foodstuffs and supplies such as flour, sugar, coffee, rice, lard, dried meat, beans, tobacco, salt, kerosene, soap, spirits, medicine, clothes and a few oddments.[257] The advance in kind was particularly important in the most remote regions since this should provide the tapper with means of living also during the off-season, which normally lasted more than 6 months (contingent to the rainy season)[258]. For purposes of simplification, it is assumed here that D is fully consumed by the rubber tapper during the year. It is also initially assumed that rubber tappers are homogeneous and if they play the game they make the maximum effort possible. These two assumptions will be relaxed later.

Assuming no difference in rubber quality[259], the production of the rubber tapper must result in either of the two outcomes, according to the game specified above:

1. The actual production (Q) is below that required by the principal, or $Q < Q^*$:

[256] Note that from Q^* and D it is possible to infer the implicit rubber price in the contract, i.e., $P^* = \frac{D}{Q^*}$. Moreover, note that P* might also incorporate an implicit interest rate over the initial capital advanced (D).
[257] Woodroffe (1916, p. 52).
[258] The rainy or flood season ranged from November to April or May. Depending upon the rain and the terrain, the working season would sometimes last from June to October, that is, only 4 months.
[259] According to Akers (1912, p.3), and as explained in Chapter 3, crude rubber varied according to the type of tree as well as with the dexterity of the rubber tapper. Even though some areas contained more *heveas* than others (and different types of *heveas*), and the extraction technique was not uniform, it is possible and still valid for the purposes of this game to assume that crude rubber was homogeneous, at least across different rubber tappers operating in a given rubber estate. On average, they would produce very similar grades of rubber as the trees in the area would not differ too much and best techniques could be more easily transmitted. In order to avoid issues stemming from differences in quality, it is possible to assume that Q^* and Q represent some weighted quantity of different rubber grades.

- Principal receives Q and earns QP_i, where P_i is the price by which the principal sells the rubber produced to the intermediary.
- Agent receives nothing and increases his indebtedness (I) by $(Q^* - Q)P^*$ where $P^* = \frac{D}{Q^*}$.

2. The actual production is equal to or higher than that required by the principal, or $Q \geq Q^*$:
   - Principal receives Q, earns QP_i and pays to the Agent $(Q - Q^*)P$.[260]
   - Agent receives $(Q - Q^*)P$ or decreases his previous indebtedness (I) by the same amount.

In the aforementioned game, if there is some degree of legal enforcement, the Agent will borrow from the Principal and produce rubber as long as their expectations over future production ($\bar{Q}$) are higher than Q^*, which is the threshold from which they start profiting. Moreover, profits should be at least higher than the wage they could earn in an alternative occupation (outside option). In order words, the game will be played so long as[261]:

$$D + (\bar{Q} - Q^*)P \geq \overline{W} \quad (4.1)$$

where $\overline{W}$ stands for the wage from an alternative employment, P is the price the estate owner promised to pay for any additional kg of rubber the tapper produces in excess of Q^*

[260] Ideally, $P^* \leq P \leq P_i$, where P^* is the price of rubber implicit in the contract, P is the price of rubber explicit in the contract for additional kg of rubber produced by the tapper and P_i is the "market" price for rubber, i.e., the price at which the estate owner sells its production to the intermediary.

[261] It is implicitly assumed that the agent is risk neutral. This assumption will be made for the other subsequent games later in this Chapter. If the agent is assumed risk averse the constraint would be given by:

$$U[D + (\bar{Q} - Q^*)P] \geq U[\overline{W}]$$

where $U(.)$ is the utility function of the agent, and $U'(.) > 0$ and $U''(.) < 0$. If the agent decides to produce rubber, his utility needs be at least as high as if he had taken his outside option.

and D refers to the initial consumption of the rubber tapper as a consequence of the advancement of merchandises at period zero.

This game is not played only once and then condition 4.1 above should be restated. Thus there would be production as long as the stream of expected income from rubber production discounted at the appropriate rate (r) is higher than the expected earnings from an alternative employment (also discounted by the appropriate rate). Or:

$$\sum_{j-1}^{J-1}\frac{\overline{D_j}}{(1+r_j)}+\sum_{j}^{J}\frac{(\overline{Q_j}-\overline{Q_j^*})\overline{P_j}}{(1+r_j)}\geq\sum_{j}^{J}\frac{\overline{W}_j}{(1+r_j)} \tag{4.2}$$

where all variables are defined as before. Just note that P became $\overline{P_j}$, i.e., now it refers to the expected price the estate owner will promise to pay for future additional kg of rubber the tapper produces.

Nonetheless, in the context of a wealth-maximising world, where there is no form of enforcement, the gains from cheating might exceed the gains from cooperative behaviour[262]. Indeed, in a world where no legal enforcement is possible, the above profit condition may not hold because the Agent could always runaway with D and produce nothing instead of investing that amount of money (or 'merchandises') into the production of rubber.

In a repeated game, there will be production as long as the reward from cheating is less than the stream of expected income discounted at the appropriate rate (r_j). Or:

$$\sum_{j-1}^{J-1}\frac{D_j}{(1+r_j)}+\sum_{j}^{J}\frac{(\overline{Q_j}-Q_j^*)\overline{P_j}}{(1+r_j)}\geq\sum_{j}^{J}\frac{\overline{W}_j}{(1+r_j)}+D_0-RC \tag{4.3}$$

[262] Note that the game applies a narrow definition of cheating. Here cheating is understood as running away with D without producing any rubber. In practice, there were several other ways through which the rubber tapper could cheat such as selling part of his production to an itinerant trader (*regatão*), increasing the weight of the rubber ball produced by adding alien substances such as rocks and sand, etc.

where all variables are defined as before and *RC* is the transport cost to run away from the rubber estate.

Notice that condition 4.3 is more stringent than condition 4.2. Now, the stream of expected profits from rubber production plus the current and future consumption of merchandises advanced by the estate owner must be higher than the stream of expected alternative income (ouside option) plus the net reward from cheating. That self-enforcing cooperative solution is then achieved when the game is repeated: if the game continues, it may be in the parties' interest to live up to the terms of agreement, because the gain from successive interactions might exceed the once-and-for-all reward from cheating.[263]

Much has been said about the agent's incentives in the aforementioned game, whereas little has been said about how the principal determines Q^* as well as the price they promise to pay for the additional amount of rubber (P). These issues will be dealt with later on in this Chapter but it is important to discuss some aspects of them here. The principal is the contract designer. His basic goal is to produce rubber at the lowest feasible cost. As explained in Chapter 3, production costs depend on the type of tree and on the dexterity of the rubber tapper. However, it also depends on the effort the tapper puts into rubber production. The principal may know the type of trees available in their estates or at least, it is possible to assume that they can survey their lands and determine it with some accuracy. However, the principal does not know how skilled the agent is (or may become). Therefore, there are two important features of rubber production: moral hazard and adverse selection. Moral hazard appears because effort is a non-observable variable whereas adverse selection is the result of the heterogeneity of rubber tappers.[264] It will be shown later, how these two features change the outcomes of the game.

In the contract, it is straightforward to see that Q^* is the quantity that once sold to the intermediary (or directly to the export house at the price P_i) provides the estate owner

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[263] It should be emphasized that it is implicit in the argument that cheating is costless. If there is cost of cheating (apart from transport cost of moving away from the rubber estate) the condition would be less binding.

[264] There is an extensive literature on contracts that shed light on moral hazard and adverse selection. For moral hazard, see Malcomson and Spinnewyn (1988), Rey and Slanie (1990), Chiappori *et al.* (1994) and Mas-Colell *et al.* (1995, pp. 477-488). On adverse selection, see Milgrom (1981) and Mas-Colell *et al.* (1995, pp. 436-476).

with the amount of money necessary for: a) covering the costs of production (including transport costs if applicable); b) cancelling their debts (due to the advancement of credit) and; c) remunerating their capital (especially the one invested in land) weighted by the risk involved in the enterprise. On top of moral hazard and adverse selection, there were at least three more sources of risk. First, product losses occurred due to rainy weather which spoiled the fine rubber latex, with shrinkage in transit of up to 16 percent,[265] and due to impurities introduced by nature or by the sly tapper through the mixture of sand, flour or *tabatinga* in order to increase rubber weight[266]. Secondly, attrition rates due to death, illness, and desertion, especially in the Upper Amazon appear to have been very high indeed. For instance, a report from U.S. Consul Kenneday at Belém mentioned that of 100 workers recruited and sent to the rubber fields, 75 would die, desert or leave because of illness.[267] Thirdly, the price the estate owner promises to pay for the rubber (i.e., P^*) would bear a directly link with the expected price of rubber: P^* would be the today's expected price of rubber for the day the rubber would be sold discounted by the risk of price variations. This risk cannot be neglected since the price of rubber registered wide variations which were magnified by exchange rate swings. Lastly, it should be emphasised that both Q^* and P would also be a function of transaction costs: the more searching, negotiating, monitoring, and enforcing required to transact an exchange (e.g., rubber for credit), the higher the transaction cost and, by consequence, the higher Q^* and P.[268]

4.3 – How does Institutions Change the Likely Outcomes of the Game?

The outcomes of the above mentioned game are summarised in Figure 4.2 below in the case condition 4.3 is satisfied (otherwise there would be no production). Note that this game is played in two steps: first the principal advances the merchandises to the

[265] Barham and Coomes (1996, p. 42). Pearson (1911, pp. 216-217) shows more detailed statistics for rubber shrinkage. According to his figures, certain rubber grades could lose as much as 35% of their weight. Shrinkage would occur by natural drying process *en route* or in store or by washing in the product to get rid of alien substances or carbon from the curing process.
[266] Pearson (1911, pp. 38-42).
[267] Barham and Coomes (1996, p. 46).
[268] Barham and Coomes (1996, p. 46).

agent (setting Q^* out of their expected rubber sale price and risks) who in turn decides whether or not to produce rubber. Whenever the income from rubber production is lower than the reward from cheating plus the alternative wage, the rubber tapper will cheat by running away with D and producing nothing. However, since players have complete information and are rational, they can accurately infer the likely response of any other player and if there is any incentive to cheat, the principal will decide not to play the game at first and production will just not occur (and of course neither will cheating!). Furthermore, whenever the principal believes that an agent is productive enough, the former will decide not to cheat either in order to keep them producing next year. This is especially true here since shortage of labour prevents the principal from easily hiring other agent to replace him.[269]

Figure 4.2 – Game Matrix under Neoclassical Assumptions

		Rubber Tappers	
		cheat	does not cheat
Rubber Estate Owners	cheat	no production	not likely to occur
	does not cheat	no production	**production**

Source: elaborated by me, based on the game specified in the text.

In the matrix above, it can be seen that, assuming rationality (which here is defined as profit maximising behaviour) and complete information, there are two possible outcomes: no production or production with no cheating. But are these two assumptions reasonable in the Brazilian Amazon context? As explained in Chapter 1, this question lies

[269] This is a very important assumption of this game, i.e., there is no pool of unemployed agents at the equilibrium wage (as, for instance, in Greif, 1996), because of a high shortage of labour which implies that the equilibrium wage is so abnormally high that everyone is employed. This is possible due to the inelasticity of demand as computed in Chapter 2 that allows the rubber price to accommodate high costs of production.

at the heart of the debate between substantivists and formalists. The proponents of the former argue that economic behaviour was heavily embedded in social relations in precapitalist societies but became much more autonomous with modernisation whilst the proponents of the latter claim that embeddedness was not greater than the low level found in modern societies, allowing the use of neoclassical economics concepts and tools for the analysis of precapitalist societies[270]. It is argued here that actors in the Brazilian Amazon registered profit motivation and then a more formalist approach shall be adopted.

Indeed, in the Brazilian Amazon context, the discussion about fundamental differences between capitalist and pre-capitalist societies and the underlying lack of profit maximisation motive is not applicable as shown by Bentes[271]. Moreover, the majority of the Brazilian Amazon labour force was comprised by foreigners who went to the region in a quest for profit. Even if this region is taken as a pre-capitalist society, there seems to be evidence pointing in the same direction of Law and Ogilvie, insofar as these studies highlight the importance of economic concepts in explaining individual behaviour in a pre-capitalist society.[272]

However, the adoption of the formalist approach does not mean that economic theory will be used upon the assumption of purely neoclassical economics. There were many market-failures[273] that were partially overcome by the creation of certain institutions (not necessarily efficient ones) opening room for some extra-economic behaviour[274]. As explained in Chapter 1, institutions (formal or informal ones) are the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction. They reduce uncertainty by providing structure to everyday life, defining and limiting the set of choices of individuals. The self-enforcing condition 4.3 states that wealth maximising individuals will usually cooperate with other players when there are a small

[270] Granovetter (1992). This author's approach suggests that the level of embeddedness of economic behaviour is lower in non capitalist societies than is claimed by sustantivists and it has changed less with modernisation than they believe. Granovetter (1992) also argues that this level has always been and continues to be more substantial than is allowed for by formalists.
[271] Bentes (1999).
[272] See Law (1992) and Ogilvie (2001).
[273] For a summary of new institutionalism see Bates (1995). This author discusses market failures and how they are sometimes overcome by institutions.
[274] The credit channel discussed in this article bears some resemblance with marketing boards in Africa. See Bates (1989).

number of players, the play is repeated and players possess complete information about the other players' past performances. Let's take a look at these three conditions.[275]

First, in terms of the game specified in the previous section, even though rubber estates normally covered a vast territory, rubber trees were scattered over the forest and thus a high concentration of rubber tappers in a given area was seldom required. **Secondly**, in the *estate owner/tapper* game it should be emphasised that the rubber tapper's horizon of planning, *J*, was usually small due to the high attrition rates and then the profitability of the enterprise needed be very high to ensure production (and increasingly higher since the game is not repeated indefinitely).

> "[t]*he mortality of the rubber districts of Brazil has always been large. It was reported for example, when the census of Purús river district was taken, that enough immigrants had gone there to make a population of 40,000 yet the figures showed 16,000 remaining. It is not probable that all or one-half of the 24,000 missing perished. Still a great many were victims to disease, as a rule brought on by their own lack of care.*" [276]

Mortality rates varied enormously depending on distance to medical facilities, animals in the jungle, mosquitoes (proximity to marsh or flooded lands), etc. Mortality rates in the main cities (especially in Belém and Manaus) were probably one of the lowest in the region.[277] The Amazonian governments certainly tried to depict the region as very healthy.[278] Propaganda served the purpose of attracting more labour to the region but indirectly it may have influenced the initial expected *J*: if propaganda was effective, rubber labourers arrived in the region with an expectation of living conditions that was far better than what they actually found, meaning that their initial *J* was somewhat higher too.

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[275] North (1990).
[276] Pearson (1911, p. 168). See also Akers (1912, p. 92) and Woodroffe (1914, pp. 99-100).
[277] *Annuario Estatístico, Estado do Pará 1902,, pp. 72-111.*
[278] See Caccavoni (1898, pp. 1; 108), Braga (1916, pp 21-22) and *L'État du Pará* (1897, p. 23).

Thirdly, actors frequently must act on incomplete information and process the information that they receive through mental constructs that can result in persistently inefficient paths. Preferences are not stable, actors do not possess true models and the information feedback is insufficient. [279]

But how can incomplete information alone change the outcome of the aforementioned game? First, when information is incomplete, principal and agent will not form equal expectations, opening **room for deceit**. Secondly, it is likely that many of the rubber tappers had no information about the alternative wages in the nearest villages/cities. It is true that labour was very scarce throughout the Amazon region and, consequently, wages were indeed very high especially on dry seasons when many people flooded from the cities into the forest to tap *heveas*. A document from Pará sugar cane producers of 1901 argued that wages were quoted from 4 *milréis* to 5 *milréis* per day whereas in Pernambuco (a State located in the Northeast), it ranged from 800 *réis* to 1 *milréis*, i.e., wages were roughly four to five times higher in Pará than in Pernambuco.[280] Likewise, "[i]*n the Brazilian Amazon, rural wage labourers would receive the equivalent of between US$ 24 (Lower Amazon) to US$ 40 (Upper Amazon) per month with rations. Such wages were competitive in the urban labor market (...)*".[281] However, since tapper's lives were confined into this narrow jungle environment, they might have been completely disconnected from urban centres and probably might have had no knowledge whatsoever about any alternative income: under these conditions, cheating (as defined in the game) may be ruled out as agents had no information about any available outside option.

In the case of incomplete information, there stands the issue of enforcement which can be achieved through second-party or third-party punishment/retaliation (note that when information is complete in the game above, there is no need for enforcement

[279] North (1990).
[280] Santos (1980, p. 113).
[281] Akers (1912, p. 18). Actually, data from the Ministry of Agriculture (1922) show that wages may have been even higher than that reported by Akers. In Pará State, the average daily wage ('*a seco*', i.e., without payment in kind) for an agricultural labourer in 1911 was 10$000 or US$ 3.26 whereas in Amazonas State it was 6$500 or simply US$ 2.12 a day. Assuming a 21 working day month (which is probably less than the usual agricultural weekly working load), the monthly wages in Pará and in Amazonas were US$ 68.50 and US$ 44.53, respectively. I need to thank Eustáquio Reis for providing me data on wages in Amazonas and Pará in 1911.

because the outcome of the game will rule out any opportunity for cheating). Indeed, as argued in the Introduction, punishment lies at the heart of the discussion about labour arrangements in the Brazilian Amazon and this explains the emergence of **semi-serfdom** labour arrangements in some areas. As mentioned earlier, the literature has tended to use a Marxist/Dependentist approach to argue that rubber tappers were exploited even through physical punishment: the control over the means of production meant that they could expropriate labour use-value, and rubber estate owners could resort to monitoring and physical punishment whenever there was room for deceit. However, according to the game developed here, if the tapper possessed some initial capital, there would be less room for exploitation and if the tapper knew about the prevailing wages elsewhere (which were high), no exploitation would ensue either.

Since one rubber estate would seldom transact with another, it is possible to set aside the discussion about segmentation of the labour market[282]: all transactions occurred within the rubber estate and the only transaction with the outside was that between the principal with the rubber buyer (which normally would exchange merchandises – to be reinvested in rubber production – and cash for rubber). The only instance in which segmentation might be important relates to the case when a cheating rubber tapper is hired in another rubber estate: since rubber estate owners desperately needed more labourers they would hire whoever wanted to tap rubber trees, provided that the incentives in the game made cheating irrational (or there was some other source of enforcement, as discussed below).

In fact, collective action between principals does not linger on here: shortage of labour would have made the incentives to break the agreement very high and, in order to work out, this collective action would have required the share of information among members (reputation then would have played a minor role in this game). Indeed, the so-called 'Rules of the Rubber Fields' which dictated that fugitive rubber tappers should be returned to their original rubber estate owner were usually a dead letter, just as claimed by

[282] See Greif (1996) for a discussion about segmentation.

Weinstein[283]. This informal alliance[284] amongst rubber estate owners to guarantee that no rubber tapper could leave the rubber estate before cancelling all his debts was difficult to sustain in a context of shortage of labour. Likewise, the crystallisation of any collective action among agents was also unlikely: they were scattered over a large territory turning mobilisation into a difficult enterprise.

According to Greif, contract enforcement can also be achieved through a variety of other instruments: morality, personal trust and the legal system[285]. The first instrument can change the outcome of our game in a very straightforward way: if there is any preference for being honest (which overcomes profit motives) the agent would live up with the terms of the agreement even in the case where cheating could be profitable, provided that the agent could signal to the principal that they would not cheat under any circumstances. In a repeated game, playing some tip-for-tat strategy, agents might form personal trust diminishing the costs of monitoring. However, it does not seem economically rational for the agents to do so since they would be giving up bargain power in exchange for nothing (unless the minimisation of monitoring cost[286] allowed production and everyone was thus better off). Lastly, the Brazilian Amazon case study points into the same direction of Institutions Theory, insofar as it claims that the legal system is not necessary for enforcing informal contracts.[287] Local, regional and federal government do not seem to be strong enough to be relied upon, and there is evidence that government jurisdiction was confined to the surroundings of the main cities/villages, not reaching most of the rubber estates inside the jungle and where most of production took place.[288] However, even this weak

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[283] Weinstein (1983) and (1986).

[284] Note that this informal rule was passed into law: "One of the things the [Brazilian] Federal government did was to issue a proclamation forbidding laborers to leave the employ of their master if they were in debt with them. They were usually heavily fined for so doing as were also the owners of *seringaes* [rubber estates] who hired them." See Pearson (1911:165).

[285] Lovejoy and Richardson (1997) show an example of how culture/region-specific institutions can enforce contracts, strengthening Bates (1995) assertion that there are limits to policy prescription from new institutionalism analysis.

[286] According to North (1990), because it is costly to measure the valued attributes fully, the opportunity for wealth capture by devoting resources to acquiring more information is ever present. It is measurement plus the costliness of enforcement that together determine the costs of transacting.

[287] See Greif (1996).

[288] However, lawsuits were sometimes used to secure legal rights. See Bentes (1999, pp. 152; 237) and Costa (2005).

legal system provided the emergence of **wage earners** around the main cities (note that if a legal system is absent[289] and if it is difficult to evaluate labourers' efforts, rubber tappers would always choose to cheat whenever it pays off).

In sum, from the discussion carried out in this section, it is straightforward to see that the *estate owner/tapper* game might have had many more outcomes than the two suggested by neoclassical economic reasoning (no production v. production without cheating). Figure 4.3 below summarises the main outcomes of the game taking into consideration only two possible outcomes (↑ high or ↓ low) for each of the three main variables in condition 4.3: horizon of planning (*J*), reward from cheating (*D*) and expected income from an alternative employment ($\bar{W}$).

Figure 4.3 – Outcomes of the Game

Scenario	*Horizon of Planning*	*Reward from Cheating*	*Expected Income from an Alternative Employment*	*Conditions for Production*	*Bargain Position*
1.	$J\uparrow$	$D\downarrow$	$\bar{W}\downarrow$	High Q*	**Tapper:** Low **Estate Owner:** High
2.	$J\uparrow$ $J\uparrow$ $J\downarrow$	$D\uparrow$ $D\downarrow$ $D\downarrow$	$\bar{W}\downarrow$ $\bar{W}\uparrow$ $\bar{W}\downarrow$		
3.	$J\downarrow$ $J\downarrow$ $J\uparrow$	$D\uparrow$ $D\downarrow$ $D\uparrow$	$\bar{W}\downarrow$ $\bar{W}\uparrow$ $\bar{W}\uparrow$		
4.	$J\downarrow$	$D\uparrow$	$\bar{W}\uparrow$	Low Q*	**Tapper:** High **Estate Owner:** Low

Source: elaborated by me, based on the payoff of the game specified in the text.

[289] It is not at all true that crude rubber in the Brazilian Amazon took place in the absence of a legal system even though in certain areas the jurisdiction of the State was somewhat limited due to the geography of the area or the cost of extending government control. However, as Costa (2005) has shown even in the remote Acre region from 1904-1918, there was a reasonable justice system in place and several disputes were indeed resolved in court.

From the estate owner's viewpoint the best scenario would be the one in which the horizon of planning was high (in other words, when the attrition rates were low) and both the reward from cheating and the expected income from an alternative employment were low. In this case, the estate owner could pay a very low price for the rubber produced which is equivalent to a very high Q^* (in other words, the estate owner has a high bargaining power and appropriates most of the profits from the enterprise). Conversely, only paying a high price for the rubber produced would the estate owner be able to enforce production in the case where the horizon of planning was short and both the reward from cheating and the expected income from an alternative employment were high. Therefore, in order to enforce production, Q^* must decrease from scenario 1 to 4 (and the price paid for additional rubber produced by the estate owner should increase from scenario 1 to 4).

In general, Institutions affect the bargain positions of the transacting players which ultimately define the appropriation of profits along the chain. Without understanding the institutional constraint, it is not possible to fully analyse the power relations between nodes of the rubber chain. For instance, regarding the game specified here, it is very likely that asymmetric information prevailed in the game insofar as the estate owner may have had better information about the true value of the variables of the game. First, they were able to best guess from past experience what the true value of J was in their rubber estate. Secondly, they knew exactly how much the goods they were advancing to the rubber tapper was really worth. Thirdly, they were dealing directly with intermediaries and were more assiduous in the nearby villages so that they may have known the wages prevailing elsewhere.

4.4 – Moving Along the Rubber Production Chain

The next node in the rubber production chain is formed by the interaction between the rubber estate owner and the intermediary (trading house), locally known as *aviador*. Weinstein, for instance, defined the intermediaries as local merchants who informally controlled rubber production and trade in the district by marketing the tappers' output and keeping them supplied with tools, food, and any luxuries they could afford. These intermediaries usually contracted with the importing houses for the goods that were distributed to the small merchant, the roving trader, the estate owner, and ultimately the rubber tapper. Some intermediaries possessed their own boats (see Chapter 6 for details on shipping) so that they could internalise the transport cost by sending steam vessels to the trading posts of their clients and collect the rubber to be sold in the major rubber centres: Belém and Manaus. These agents/firms might have been able then to define when and to whom to sell the rubber. Additionally, these commercial houses (intermediaries) were sometimes responsible for arranging extra credits or short-term loans from the local banks either to supplement advances from the importing firms, or to finance major purchases such as steamboats, docking facilities, or warehouses. They were always looking to establish new commercial relationship with incipient estate owners.[290]

Remember that the degree of competition is instrumental to define the appropriation of profits along the chain and, as discussed in Chapter 3, the intermediary role was indeed disputed by several trading companies with no single one possessing any degree of market share similar to what some export houses achieved in the export trade (next link in the rubber production chain). According to Figure 4.4 below, in 1902/3 the top *aviador* house handled 7.2% of the all rubber channelled through Manaus and at the height of the rubber boom (1910) the top *aviador* house handled even less: 6.9%. Moreover, the top 25 *aviador* houses handled just over 50% of the overall rubber trade in Manaus. Figure 4.4 further suggests that the intermediary trade was much more competitive with huge changes in the ranking over less than 8 years. It is true that at the top these changes were less dramatic with the two Portuguese rubber traders, J.H.Andresen & Co. and B.A.Antunes & Co., remaining among the top commercial houses in Manaus. From 1902/3 to 1910, J.G.Araujo consolidated its leading position climbing one position in the ranking: this Portuguese merchant built up a network of ships, trading posts and agents

[290] Weinstein (1983, pp. 18-19).

along several rivers that gave him a competitive edge in the rubber trade.[291] Mello & Co., in turn, saw its rubber trade decrease by two-thirds. It is difficult to know what happened to the companies that disappeared from the ranking in 1910 because some of them might just have changed their names: as explained in Chapter 3, this was quite common in the Amazon and it is very difficult to have the full track record of all (or even the main) commercial houses in the Amazon. For instance, The Mello Brazilian Rubber Co. was the successor of S. F. de Mello whereas M. Corbacho & Co. was the successor of Fernandes & Co.

Figure 4.4 – Top *Aviador* Houses (Intermediaries) in Manaus and Respective Amount of Rubber Handled, 1902/3-1910

Rank	Aviador Houses	1902-03 kg	1902-03 %	Aviador Houses	1910 kg	1910 %
1	B.A. Antunes & Co.	1,249,058	7.18%	J H Andreses & Succs	1,219,900	6.94%
2	Mello & C.	932,068	5.36%	B.A. Antunes & Co.	1,172,524	6.67%
3	J H Andreses & Succs	607,789	3.50%	Tancredo Porto & C	837,839	4.77%
4	Montenegro & C.	562,977	3.24%	Emanuel Levy & C	809,480	4.60%
5	Leite & C.	476,117	2.74%	J G Araújo	766,952	4.36%
6	J G Araújo	474,599	2.73%	Gomes & C	755,507	4.30%
7	B. Santos & C	468,157	2.69%	Mesquita & C	535,027	3.04%
8	Gomes e Pedreira	386,194	2.22%	B Levy & C	522,542	2.97%
9	D. Nommensen & C	374,356	2.15%	Wesche & C	439,971	2.50%
10	Armindo R. da Fonseca	366,084	2.11%	Antonio dos Santos Cardoso	434,868	2.47%
11	Alves Braga & C.	361,062	2.08%	João Alves de Freitas	432,897	2.46%
12	B Levy & C	358,245	2.06%	E. Kingdom & C	365,459	2.08%
13	Cerqueira Lima & C	326,990	1.88%	Gunzburger & Co.	363,187	2.07%
14	Oliveira Andrade & C	321,673	1.85%	Mendes & Co.	349,136	1.99%
15	Ahlers & C	321,360	1.85%	Barbosa & Tocantins	348,820	1.98%
16	Antonio Cruz & C	299,849	1.72%	Mello & C.	343,225	1.95%
17	Carvalho & Barros	275,592	1.58%	Costa Santos & C	338,894	1.93%
18	Ribas & C	270,163	1.55%	M. Corbacho & C	313,765	1.78%
19	F. Guimarães & C	258,012	1.48%	Arruda & Irmaos	271,963	1.55%
20	S F de Mello	252,935	1.45%	J C Arana & Hermanos	250,933	1.43%
21	Adalbert H Alden	252,187	1.45%	The Mello Brazilian Rubber Co	234,385	1.33%
22	M. Corbacho & C	243,484	1.40%	Bernardo Bockris & Co.	222,833	1.27%
23	Scholz & C	230,757	1.33%	A. Miranda de Araujo	206,365	1.17%
24	Gaspar Almeida & C	214,909	1.24%	Mendes, Filho & Co.	187,608	1.07%
25	Deffner & C	211,853	1.22%	Carlos Montenegro & Co.	182,004	1.04%
	Total Top-25 Aviador Houses	**10,096,470**	**58.06%**	**Total Top-25 Aviador Houses**	**11,906,084**	**67.73%**
	Total Manaus	**17,388,225**	**100.00%**	**Total Manaus**	**17,579,875**	**100.00%**

Sources: a) 1902/3: du Pin e Almeida (1906, p. 44) and; b) 1910: Loureiro (1986, p. 223).

> *"Of the 100 firms listed in the 1869 almanac for Pará, the vast majority seem to have been involved in import-export operations, whereas only eight could be identified as major aviador houses. But by 1880, the*

[291] Wolf and Wolf (1936, pp. 57-57).

membership of Pará's Chamber of Commerce included eighteen aviador firms; and by 1890 that figure had risen to 42."[292]

Therefore, the rising of the intermediaries was also obvious in Belém with the economic power of the trading houses increasing in tandem with their political power. Several *aviadores* and estate owners began their commercial and productive activities by taking over the local municipality which allowed them political and police control over a certain area. Sometimes fraudulent means were used to acquire land rights which were later exercised to either sell the land to another trader/landowner or to control the rubber production and trade in the area. The amassed profits were further reinvested in docking facilities and shipping, strengthening their trade with neighbouring producers and reinforcing their economic position in a broader area.[293] In sum, the intermediaries profited quite substantially from the rubber trade and their economic position was consolidated by their political leadership at the regional and/or local (*coronéis*) levels. But what determined their profits and what were the conditions for intermediating the rubber trade?

Intermediaries can certainly be analysed under a similar game framework to that applied to the estate owner and the tapper. Assuming that they had to rely on initial capital provided by the exporters, their game would be defined in the following way. The **Intermediary** (Principal) advanced d (usually in the form of merchandises) to the **Rubber Estate Owner** (Agent) in exchange for q^* kilograms of rubber[294] and promised to pay p per any additional kilogram of rubber (this constraint is unlikely to be binding if $p + tc < p_i$, where tc stands for the transport cost of rubber, the estate owner will decide to sell their rubber surpluses to another intermediary/exporter[295]). Those merchandises, as explained earlier, were in fact used to ultimately furnish the rubber tappers during the season

[292] Weinstein (1983, p. 72).

[293] For an analysis of the political economy of aviadores, see Weinstein (1983).

[294] Note that from q^* and d it is possible to infer the implicit rubber price in the contract, i.e., $p^* = \dfrac{d}{q^*}$. Moreover, note that p^* might also incorporate an implicit interest rate over the initial capital advanced (d).

[295] Remember that the intermediary market seemed quite competitive so it is assumed here that it is always possible for the estate owners to change intermediaries, especially when it comes to selling the additional rubber produced.

(sometimes also during the off-season). For simplicity, it is assumed here that D is fully passed through to rubber tappers during the year/season, i.e. $d = D$.[296]

The production of the estate owner must result in either of the two outcomes, according to the game specified above:

1. The actual production (Q)[297] is below that required by the principal, or $Q < q^*$:
   - Principal receives Q and earns Qp_i, where p_i is the price by which the principal sells the rubber produced to the exporter (next agent in the rubber chain).
   - Agent receives nothing and increases his indebtedness (i) by $(q^* - Q)p^*$ where $p^* = \frac{D}{q^*}$.
2. The actual production is equal to or higher than that required by the principal, or $Q \geq q^*$:
   - Principal receives Q, earns Qp_i and pays to the Agent $(Q - q^*)p$.[298]
   - Agent receives $(Q - q^*)p$ or decreases his previous indebtedness (i) by the same amount.

In a repeated game, the estate owner will take D and set up production so long as the income from production is at least higher than the income of doing something else (outside option[299]). From the estate owner's viewpoint, production will only occur if:[300]

$$\sum_{l}^{L}\frac{(\overline{Q}_l-\overline{q}_l^{*})\overline{p}_l}{(1+r_l)}-\sum_{l}^{L}\frac{(\overline{Q}_l-\overline{Q}_l^{*})\overline{P}_l}{(1+r_l)}\geq\sum_{l}^{L}\frac{\overline{w}_l}{(1+r_l)}+\sum_{l}^{L}\frac{\overline{\delta}_l}{(1+r_l)} \tag{4.4}$$

[296] It is implicitly assumed here that the intermediary and the estate owner do not consume any D.
[297] Note that Q, the production level, is the same as in the previous game as rubber is not consumed in any node of the rubber supply chain.
[298] Again, ideally, $p^* \leq p \leq p_i$, where p^* is the price of rubber implicit in the contract, p is the price of rubber explicit in the contract for additional kg of rubber produced by the tapper and p_i is the "market" price for rubber, i.e., the price at which the estate owner sells their additional production in the market.
[299] This should be understood as including the income from renting out the rubber estate to another entrepreneur.
[300] It is implicitly assumed that rubber tappers, intermediaries and export houses, all possess the same discount rate r.

where $\overline{w_l}$ stands for the expected wage from an alternative occupation, $\overline{\delta_l}$ is the opportunity cost of the capital invested in rubber production (especially land), $\overline{p_l}$ is the expected price of rubber (paid by the intermediary for additional rubber produced), $\overline{P_l}$ is the expected price to be paid to the rubber tapper for any additional kg of rubber produced in excess of $\overline{Q}*$, $\overline{Q}*$ is the expected level asked by the estate owner to the rubber tapper in exchange for D (which in this example is equal to the level of production required by the rubber estate owner to the rubber tapper to advance D), $\overline{q}_l^*$ is the expected level asked by the intermediary to the estate owner in exchange for D, $\overline{Q}_l$ is the expected actual level of production and r_l is the discount rate (note that $r_0 = 0$), D the advancement of merchandises consumed by the rubber tapper. Note that the horizon of planning of this game is different from the game between the tapper and the estate owner and it is likely that $L >> J$ as this interaction is not plagued by high mortality rates. Moreover, since transacting agents here may be firms rather than individuals, they may outlive their owners/workers.[301]

The first term on the left hand side indicates the earnings from any rubber produced in excess of $q*$ whereas the second term refers to the amount of money paid to the rubber tapper for any rubber produced in excess of the contract between them. Note that it is easier to understand the distribution of profits along the rubber chain, and consequently market power if $q*$ is assumed to be equal to $Q*$. In that case the equation 4.4 can be simplified to:

$$\sum_{l}^{L}\frac{(\overline{Q}_l-\overline{q}_l^*)(\overline{p}_l-\overline{P}_l)}{(1+r_l)} \geq \sum_{l}^{L}\frac{\overline{w_l}}{(1+r_l)}+\sum_{l}^{L}\frac{\overline{\delta_l}}{(1+r_l)} \qquad (4.5)$$

In this simpler case, the estate owner is passing through the minimum level of production from the intermediary to the rubber tapper. The estate owner here only profits

301 It is also assumed that estate owners cannot run away with D as intermediaries could collect the debt by foreclosure of the estate.

from his relative market power within the rubber chain. The more he earns from the intermediary for the additional rubber produced ($\overline{p}_l$) vis-à-vis how much he pays for this very same rubber to the rubber tapper ($\overline{P}_l$) defines his profitability. This is equivalent to the contract in which the estate owner only receives commission (% of rubber prices) over any kg of rubber produced in their rubber estate. However in the more realistic case where $q^* \neq Q^*$ the market power is also embedded in the minimum required level of production each node of production demands and thus market power becomes more intricate and difficult to disentangle.

Moving further along the rubber production chain, it is easy to see that the interaction between exporters and intermediaries would result in a condition for production similar to 4.4. Intermediaries and exporters can thus also be analysed under a similar game framework. The **Exporter** (Principal) advances D (usually in the form of merchandises) to the **Intermediary** (Agent) in exchange for $q^{*\prime}$ kilograms of rubber[302] and promised to pay ρ_i per any additional kilogram of rubber (i.e. market prices[303]). Those merchandises, as explained earlier, were in fact used to ultimately furnish the rubber tappers during the season (sometimes also during the off-season). For simplicity, it is assumed here that D is fully passed through to estate owners during the year/season.

The game must result in either of the two outcomes:

1. The actual production (Q) is below that required by the principal, or $Q < q^{*\prime}$:
    - Principal receives Q and earns $Q\rho_i$, where ρ_i is the market price for rubber.
    - Agent receives nothing and increases his indebtedness (i') by $(q^* - Q)p^{*\prime}$ where $p^{*\prime} = \frac{D}{q^{*\prime}}$.

[302] Note that from $q^{*\prime}$ and D it is possible to infer the implicit rubber price in the contract, i.e., $p^{*\prime} = \frac{D}{q^{*\prime}}$. Moreover, note that $p^{*\prime}$ might also incorporate an implicit interest rate over the initial capital advanced (D).

[303] Note that for simplicity, it is assumed that the exporter pays market price for additional rubber. If he did not, the intermediary could have decided exporting his rubber himself or finding another export house to sell his rubber to. This assumption does not preclude cartelization among exporters though as the market price in this case would also be equal to that offered by the principal.

2. The actual production is equal to or higher than that required by the principal, or $Q \geq q^{*\prime}$:

    - Principal receives Q, earns $Q\rho_i$ and pays to the Agent $(Q - q^{*\prime})\rho_i$.
    - Agent receives $(Q - q^{*\prime})\rho_i$ or decreases his previous indebtedness (i') by the same amount.

If $Q \geq q^{*\prime}$, the intermediary will play the game (i.e., they will decide to produce) so long as:

$$\sum_{z}^{Z}\frac{(\overline{Q}_z-\overline{q}_z^{*\prime})\overline{\rho}_z}{(1+r_z)}-\sum_{z}^{Z}\frac{(\overline{Q}_z-\overline{q}_z^{*})\overline{p}_z}{(1+r_z)}\geq\sum_{z}^{Z}\frac{\overline{w}_z^{\prime}}{(1+r_z)}+\sum_{z}^{Z}\frac{\overline{\delta}_z^{\prime}}{(1+r_z)} \tag{4.6}$$

where $\overline{w}_z^{\prime}$ stands for the expected wage from an alternative occupation, $\overline{\delta}_z^{\prime}$ is the opportunity cost of the capital invested in rubber production (especially boats, docking facilities and warehouses), $\overline{\rho}_z$ is the expected price of rubber (paid by the intermediary), $\overline{p}_z$ is the expected price to be paid for any additional kg of rubber returned by the estate owner in excess of $\overline{Q}*$, $\overline{Q}*$ is the expected level asked by the intermediary to the estate owner in exchange for *D*, $\overline{q}_l^{*}$ is the expected level asked by the exporter to the intermediary in exchange for *D*, $\overline{Q}_Z$ is the expected actual level of production and r_Z is the discount rate, *D* the advancement of merchandises ultimately consumed only by the rubber tapper. Note that the horizon of planning of this game is different again and it is likely that Z >> *J* but *Z* can be set equal to *L*.

On the right hand side, we have the opportunity cost of capital and labour, whereas on the left hand side, we have the expect income from rubber intermediation: since in this simple game *D* is integrally passed through to the next link, the intermediary earns from the difference between what he pays for the additional rubber produced and what he earns from it. The difference is that $\overline{q}_z^{*\prime} \neq \overline{Q}_z^{*}$ as these also reflect the bargaining position in each interaction along the rubber chain.

4.5 – Re-Interpreting the Literature

The present Chapter has unveiled the interactions among economic agents along the rubber supply chain and the first conclusion is that the traditional Marxist/Dependentist view of labour exploitation must be reviewed. As explained in the Introduction, this literature embodies three main features: exploitation, dependence and violence/coercion. In view of the game above, these three features need be revisited.

First, the literature claims that rubber tappers were economically exploited. The main evidences given to support this claim were the price differential between the same goods in the Amazon and in Rio de Janeiro, the initial indebtedness of tappers and the control of credit by the estate owner. There is evidence that a significant price gap existed (see Chapter 6 and Appendix) but the risk of bringing goods to the forest (translated as high freights) and the risks in advancing them to rubber tappers certainly explain part of this price differential as claimed by Barham and Coomes.[304] In turn, tappers usually arrived at the rubber estate in debt and, even if they were luck and very productive, they still needed more than one season to clear their debts. Moreover, the monopoly of credit could have permitted the estate owner to extract all surplus from the rubber tapper. Monitored savings (through price control of the merchandises advanced to tappers) allow the estate owner to adjust the tapper's reservation utility level (given by his outside option) along the optimal sequence of annual contracts.[305] In this context, the Marxist/Dependentist literature was mostly right. What this literature did not account for was the problem of moral hazard and adverse selection.[306]

As explained above, moral hazard appears when effort is non-observable. Typically, in a context of moral hazard (assuming that tappers are now risk averse), the estate owner needs to give rewards to those tappers who produce more rubber.[307] That is exactly the rule devised by the principals in the game discussed in this chapter. Therefore, the optimal contract may embody risk-sharing between the estate owner and the tapper,

[304] Barham and Coomes (1996). Moreover, Chapter 6 shows that freights in the Brazilian Amazon were very high indeed.
[305] Chiappori *et al.* (1994).
[306] Barham and Coomes (1996) do discuss moral hazard but not adverse selection.
[307] See Milgrom (1981) and Malcomson and Spinnewyn (1988).

allowing the tapper to extract part of the chain surplus. Moreover, under adverse selection estate owners had to provide incentives for tappers to correctly signal their type (show how skilled they were or may be) avoiding the so-called ratchet effect. This effect appears when rubber tappers signal their type through their first production outcomes. If they are skilled and work hard, they will produce a large amount of rubber initially. The estate owner will perceive that a given tapper is skilled and will demand a higher Q^* for the next season. However, since the tapper is rational and knows that if they work hard in the first season(s) the estate owner will demand a higher Q^* in the future, it may be optimal from their viewpoint to mimick the production of a non-skilled tapper initially so that they do not jeopardise their future earnings. To induce the skilled tapper to reveal its efficiency, the estate owner finds it advantageous to initially offer a high reward.[308] In this context, it is again very likely that rubber tappers retained part of the surplus. Another way of avoiding adverse selection is by commitment. By charging the tapper upfront a high price for their transport costs and tapping tools in the first season, the estate owner ensures that only the most productive tappers (or those who believe they can be productive enough) will accept the contract. That is why the rubber tapper needs to be in debt at the beginning of the contract. If this indebteness lasts for more than one period, high indebtedness also means that the estate owner, who invested their money, is committed with the tapper. This is especially true under labour scarcity as the estate owner does not have too many other options available apart from inducing their current tappers to continue producing.[309]

Secondly, rubber tappers exploitation translated into exploitation along all other nodes of the rubber chain. According to the literature, the [foreign] export houses were able to extract all surplus from the rubber supply chain. If the rubber chain was really characterised by a series of exploitative relations, it was possible for the export houses to develop a way of extracting the whole surplus. The rubber chain would then become as efficient as if the chain was vertically integrated by one single firm. However, as explained earlier, export houses were not always foreign owned and there are reasons to believe

[308] Laffont and Tirole (1999, pp. 375-436).
[309] Mas-Colell *et al.* (1995, pp. 436-476).

that their market was to a certain extent contestable. Since competition prevailed in several links, part of the surplus was retained along the way.

Thirdly, violence and coercion was not as pervasive as the literature claimed. It was not necessary as a latent threat either. The main evidence the literature provides in that regard refers to poor working and living conditions of rubber tappers. However, it is not at all true that just because tappers were working under appalling conditions they were forced to do so. It is necessary to look at their expected outside option. Was it really much better? Moreover, there were conditions to enforce production via market mechanisms. As there is no reason *a priori* to believe that some combination of the variables in the game would not suffice to induce production.

The rubber production chain in the simple form depicted here can also reveal much more. First, whenever $j \rightarrow J$, i.e., whenever the tapper's horizon of planning approaches the end, the price of rubber must increase to enforce production. This price increase is revealed in the first interaction between the tapper and the estate owner: *coeteris paribus*, when $j \rightarrow J$, Q^* must decrease which causes P^* to increase. This price increase at the rubber estate level reverberates along the rubber chain reaching the exporter who is the ultimate link on the domestic rubber market supply. Since the exporter possesses market power (as shown in Chapter 2 and 3), he was able to push the crude rubber price up to make sure that the optimal level of production would be induced in the rubber estate, given the market power and cost structure of all agents in the chain.

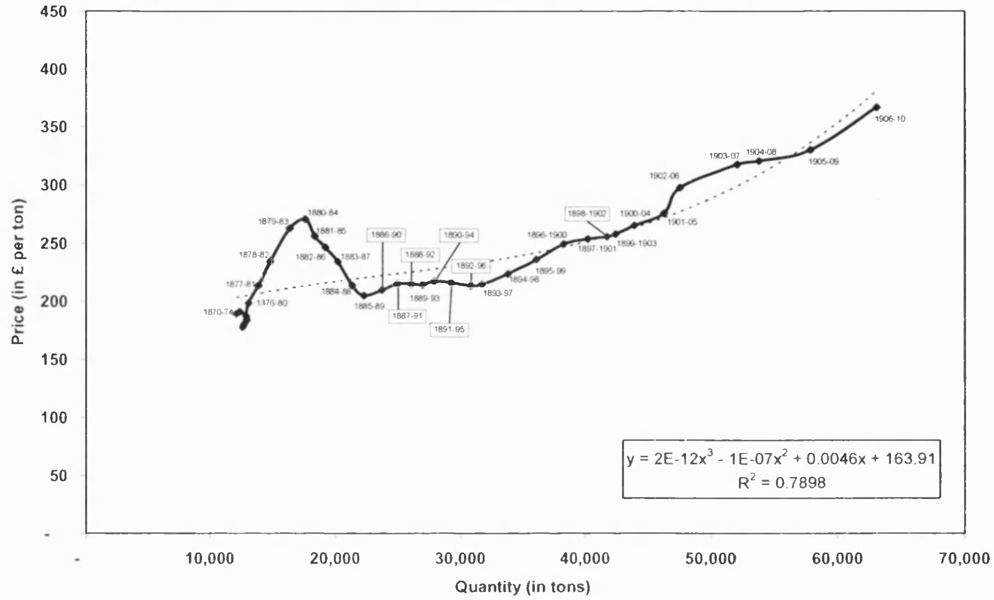
A similar but somewhat more complicated mechanism is in place when the frontier of rubber production is expanding, as it constantly was. At the first interaction (between the tapper and the estate owner), the expansion of frontier would probably increase the disinformation of the tapper about the expected alternative income at the same time that would make cheating more unlikely (because the transport cost to move away of the rubber estate was likely to increase), fostering production especially because the new areas under exploration were generally much more productive (Acre region in Brazil/Bolivia territory). Therefore, from the tapper's viewpoint, the expansion of the frontier of production would naturally induce more production. However, mortality in these new areas was likely to be higher because they were even further away from any medical centre, but certainly more unknown to agents and principal altogether.

From the estate owner's viewpoint though, the likely increase in the wages (given that the labour force did not increase in the short term) would raise the opportunity cost of their activity demanding a higher price to continue operating. Moreover, since the transport cost of the rubber from the production areas to the export trading posts increased (as production was moving further into the jungle), the remuneration of the intermediaries needed to increase as well. Therefore, the net result is that the price would have to rise in order to enforce more production at the margin, reverberating along the production chain reaching again the exporters.

In this context, it is important to investigate how the exporters operated. As analysed in the Chapter 3, rubber exporters in Brazil were not all tied to importers in the consuming countries. It was suggested there that they might have had considerable room for manoeuvre and speculation in the rubber market. It was further shown that a handful of export houses controlled the market and collusion agreements and cartels could have been feasible to organise. If that was really the case, and the export houses acted as monopolists/oligopolists in the rubber market, they certainly set Q^* based on the maximisation of monopolist/oligopolist profits). If however the rubber export market in Brazil was contestable (low barriers to entry and exit) as suggested by Barham and Coomes[310], the quantity produced was given by the market price and by the domestic cost structure. Whatever market structure is assumed, production was required to rise year after year because the demand for rubber was continuously shifting to the right from 1870 to 1910. As Figure 4.5 below shows, the interaction between demand and supply was constantly moving up and to the right, meaning that production was increasing over time and so was the equilibrium price of rubber.

[310] Barham and Coomes (1996).

Figure 4.5 – Market Equilibria (5-year moving average), 1870-1910



Source: *British Parliamentary Papers, several issues* and *US Trade and Navigation Statistics, several issues*. The values and quantities of crude rubber from Brazil were summed up from both series and plotted against one another. Therefore, quantity of Brazilian crude rubber imported into the USA and Britain is shown (in tons) in the horizontal axis against the average price of Brazilian crude rubber (in £ per tons) in the vertical axis. As stated in the text, the figure shows that Brazilian production was constantly expanding but price continued to rise, meaning that demand was increasing faster than production.

There is no doubt then that the exporters were definitely very good positioned: they certainly knew the demand for rubber and they could form a very good guesstimate of the production costs (especially because some of the export houses were rubber producers themselves). They knew better the conditions of demand, in thesis they could enter into a cartelisation agreement to force prices down in the domestic market and up in the foreign market, and, finally, the intermediaries did not possess a counterbalancing market power.

Furthermore, the literature has neglected the role of the inelasticity of demand for rubber in the definition of labour arrangements in the Brazilian Amazon. As shown in Chapter 2, the monopolistic position of Brazilian rubber exporters implied that whichever rise in costs could have been passed through to the world price of rubber with the extent of this effect being determined by the degree of their market power. Therefore, in the context of inelasticity of demand for rubber and market power, rubber production costs would ultimately define its own world price: a high inelasticity of demand would allow production to take place even under high costs without necessarily having to resort to any kind of enforcement such as monitoring, punishment or collective action, for every factor of production could be properly remunerated. In this vein, the rising prices of rubber should not solely be regarded as a result of speculation but also as a movement of the physical frontier of production and its consequent increasing costs.

Supposedly, the inelasticity of demand was unimportant insofar as the supply of Brazilian rubber was also very inelastic due to shortage of labour. This assumption is in fact corroborated by equation 1 on Figure 4.6 below.[311] The figure also presents the price and labour elasticity of supply under three other specifications: a simple time trend, a Koyck-transformation distributed lag (in which the long run supply elasticity is given by *b/(1-c)* where *b* is the price coefficient and *c* the lagged quantity coefficient), and a combination of the two.

[311] The equations were estimated using data from the supply side. Quantities (in tons) and prices (in *contos de réis*) were obtained from *Estatísticas Históricas do Brasil*. In order to assure comparability with the other econometric results in the thesis, the equations were estimated from aggregated data for Brazil as a whole, not for the Amazon region. I nonetheless ran similar regressions using Amazonian data as well as British and US data. The results were much poorer than the ones presented in figure 4.6. Therefore, all quantitative results should be regarded with extreme caution.

Figure 4.6 – Supply Equations, 1870-1910

	Equation 1	Equation 2	Equation 3	Equation 4
Constant	-10.16	15.66	-2.12	10.69
	0.0%	0.2%	36.7%	2.4%
Price(-1)	0.22	0.20	0.08	0.13
	6.6%	2.1%	35.1%	11.8%
Labour Force (-1)	1.55	-0.61	0.37	-0.49
	0.0%	11.9%	15.4%	17.7%
Time Trend	-	0.07	-	0.04
	-	0.0%	-	0.3%
Quantity(-1)	-	-	0.73	0.42
	-	-	0.0%	0.8%
Adjusted-R^2	0.89	0.95	0.94	0.96
Durbin-Watson Stat.	0.58	1.15	n.a.	n.a.
N. of Observations	41	41	41	41

Source: elaborated by me based on data presented in the Appendix. Note: P-values below the estimates (in percentage).

Indeed, equation 1 suggests that the price elasticity of supply for Brazilian rubber was very inelastic (about +0.22), whereas production of rubber was very elastic to labour (+1.55). The adjusted-R^2 was very high but the Durbin-Watson statistic suggested positive serial correlation in the residuals.[312] In equation 2 a simple time trend was added which turned to be statistically significant[313]. This specification changed only slightly the price elasticity (now it is +0.20) but the rubber supply elasticity to labour became negative although statistically significant only at 15% confidence level. In equation 3, a lag of the dependent variable is added which turned out to be very significant in statistical terms[314] even though the price and labour elasticity became statistically non-significant. Finally, equation 4 presents the result including both a lag of the dependent variable and a time trend. Both the time trend and the dependent variable lagged were very significant in

[312] The partial correlogram of residuals spikes at lag one whereas autocorrelation shows a decaying trend from lag one: these two evidences point out to a Autoregressive Model of lag one. This impression is confirmed by running the Breusch-Godfrey Serial Correlation LM Test.
[313] There is still evidence of positive serial correlation among the residuals.
[314] The Breusch-Godfrey Serial Correlation LM test indeed suggests that there is no more serial correlation in the residuals but both the price elasticity and the labour elasticity turned non-significant in statistical terms. Applying the Koyck-transformation to the variables, the price elasticity of Brazilian rubber supply was 0.31 and the labour elasticity 1.37, in line with results of equations 1 and 2.

statistical terms and the labour force once again turned negative although not statistically significant. In this specification, the price elasticity is statistically significant only at 15% confidence level and, according to the Koyck-transformation, its value is 0.22.

What is problematic in Figure 4.6 is the labour force variable which is not very robust with the sign even changing depending on which specification is chosen. This is probably a consequence of the way this variable was constructed. First, it was necessary to interpolate population data for 1862, 1872, 1890, 1900 and 1910 (see Appendix). Then, the percentage of the population between 15 and 59 years old was also interpolated from data for 1872, 1900 and 1910 (for the years previous to 1872, the percentage in 1872 was applied throughout). Finally, the interpolated percentage of people between 15 and 59 years old was multiplied to the total interpolated population series to obtain the series for the labour force. With so scant data, and given the fact that immigration occurred in waves between the data points for population, it is not at all unexpected that the series do not capture correctly the effects of labour supply on the Brazilian rubber supply. The price elasticity, in turn, turned out to be reasonably robust to specification changes and can be taken to lie within the 0.20-0.30 range.[315]

Therefore, the literature was correct in pointing out that the supply of Brazilian rubber was very price inelastic but as it will be shown in Chapter 5, even under low price elasticity of supply, Brazilian producers were still able to exercise market power in world markets of rubber and indeed the government profited quite a lot through taxation on rubber exports.

4.6 – Final Remarks

The literature on the Brazilian Amazon rubber boom has usually focused on labour relations. Debt-peonage was generally regarded as a necessary condition to enforce production as labourers arriving at the Amazonian rubber estates had to pay back for their

[315] It needs be stressed here that a more reliable estimate of the price elasticity of Brazilian rubber supply would have been computed if demand and supply were estimated jointly by instrumental variables. The problem was to find a good instrument. Note however that specifications here show no problem of contemporaneity as the variables were all lagged one year.

travel costs plus maintenance until they were able to produce rubber. Economic exploitation was thus enforced by the rubber estate owners' monopoly over the means of production (possession of rubber trees). Notwithstanding the fact that the revisionist literature tried to discredit this Marxist view, the only two books on the subject did not agree on the mechanisms that could have enforced production. If it was not violence or punishment, what was then?

This chapter offered a game theoretic model that unveiled the bargain positions of labourers and rubber estate owners. Instead of assuming any pre-defined power relationship between these transacting agents, the game simplified the motivations of both parties into a simple and general framework that is further constrained by the institutions existent and created in the Brazilian Amazon. The game suggested that there were several possible scenarios in which production could have been enforced according to the roles of four main variables: tapper's horizon of planning, reward from cheating, expected income from an alternative employment and the implicit and explicit prices paid for rubber produced.

The game is then applied to the analysis of power between the other nodes of the rubber chain within the Brazilian Amazon. The rubber chain becomes then very intricate and the relations of power does not necessarily follow a vertical one in which every forward node is able to exploit the node immediately beneath it, as the GCC approach usually assumes. It is possible though that rubber exporters were still better positioned to extract monopoly rents due to their knowledge of the rubber market and the degree of oligopolisation of their activities. Finally, looking at the whole chain together, it is possible to conclude that rubber production is easily self-enforced under a scenario of constant production expansion and of high inelasticity of demand, just like the one that prevailed from 1870 to 1910. Under this scenario, all factors of production could have been properly remunerated.

5. The Political Economy of Taxation and its Impacts on Amazonian Welfare

5.1 – Introduction

States create, mould and destroy institutions. Its importance has already been emphasised in Chapter 2 when the evolution of the rubber manufacturing industry in the USA and Britain was analysed. There, it was shown that the market structure was basically shaped by the patent system which defined the amalgamation process on both sides of the Atlantic. Chapter 3 stressed the role of the State in an indirect way: even though investment and finance in rubber production was taken as dependent on private entrepreneurs, the rule of law seemed to have been quite an important factor for entrepreneurs as the investment flows usually followed colonial lines. In the Brazilian Amazon, it was no different: the State also influenced the development of the rubber production chain in several different ways and at several different levels. Therefore, whereas the present chapter aims to see how the State (at its several levels) influenced the crude rubber production chain, especially through taxation, the next chapter will further analyse the role of the government as provider and/or guarantor of supporting activities to rubber production.

The departure point for this chapter is the fact that rubber exporters in Brazil faced an inelastic demand (see Chapter 2). In theory, this privileged position might have allowed them to capture substantial monopoly rents. However, recent literature on the rubber boom has advanced that competition was present in all stages of the rubber chain (including, among exporters) and then cartelisation was virtually impossible. Chapter 4 has shown that this claim was not exactly true and that in several contexts there was room for extraction of market power. The present chapter thus argues that the role of the government has been neglected: inelasticity of demand for Brazilian rubber allowed the government to capture monopoly profits even under a perfect competitive market. But how much surplus could have been captured and how much was actually generated? Moreover, in that case, some explanation must be provided for the question of why the government was generating a sub-optimal outcome. Those are the issues dealt with in the present chapter.

In order to address these issues, the chapter re-estimates elasticities using the same methodology as Chapter 2, but out of a merged US and British database. The idea is to generate a single elasticity of demand that will then be applied to evaluate welfare effects of taxation. Therefore, once the extension of Brazilian market power is assessed, it is possible to ask how much the region (optimally?) profited from it.

The chapter is organised in 6 sections, including this introduction. Section 5.2 presents a description of the econometric model and the data used in the estimation of the elasticity of demand for Brazilian rubber. It also discusses the estimation output under different scenarios for the elasticity of substitution and for the elasticity of foreign supply. Section 5.3 analyses the economics of taxation, stressing that the actual export tariff levied by the government was well below its optimum level. Section 5.4 thus computes the welfare effect of the actual export tariff and the counterfactual welfare effect had the government set the tariff at the optimum level. The results indicate that the government could have doubled the welfare effect. Section 5.5 then provides a simple model that gives an explanation of why the government set the tariff at such a low level (16.6% on average between 1870 and 1910). It is suggested that it is possible that government revenue maximisation does not necessarily implied that the region's welfare was being maximised. Finally, Section 5.6 concludes the chapter.

5.2 – Estimating Market Power

As explained in the introduction, the underlying idea of the chapter is to analyse Brazilian market power on crude rubber and the first step is then to re-compute the elasticity of demand facing Brazilian rubber exporters. Chapter 2 showed that there are several ways of computing these elasticities though. One possibility would be to estimate demand and supply equations for the whole market jointly. However, in order to add up crude rubber supplies from several different parts of the world, that procedure would require the assumption that rubber was a complete homogenous commodity. In view of large quality differentials, this procedure does not seem to be satisfactory; notably because quality is an important feature of the story here. Furthermore, by this procedure it is possible to obtain an estimate for the elasticity of demand for Brazilian rubber which is exactly the objective in this Chapter. Another estimation procedure would be to compute a separate demand and supply system for different countries/regions but this procedure would treat each rubber source as a totally different commodity, leaving no room for complementarity or substitutability among the sources: crude rubber was not a homogenous product at all as different grades of crude rubber were substitutes to some extent and sometimes they could also be mixed to achieve some desired minimum quality. Moreover, this procedure would require information about supply conditions in all rubber producing regions, something that does not seem feasible for the exercise here.

As in Chapter 2, the estimation procedure proposed here is thus based on an Almost Ideal Demand System (AIDS) for rubber. Besides looking at the properties of the estimation, like Adjusted-R^2, Durbin-Watson Statistic, Unit Root Tests, etc., the parameters β_i will also be examined, providing a measure of how necessary the different rubber sources were. The second step will then be to retrieve the elasticity of substitution between different rubber sources and the own-price elasticities (through equation 2.3) which, in turn, will be corrected by equation 5.1 below for the more reasonable case in which rubber supply is not perfectly elastic.

Indeed, the own-price elasticities of demand for rubber given by equation 2.3 assumes that rubber supply is perfectly elastic and that rubber exporters in countries like Brazil would rapidly adapt to any change in price. This is not a reasonable assumption here as it is necessary to take into account now the elasticity of supply for other sources of rubber. Since the goal is to analyse the Brazilian market power on rubber, it is possible to follow Irwin[316] and compute the elasticity of export demand facing the Brazilian rubber exporters, η_{BRZ}, which is dependent upon the Brazilian market share, *S*, the elasticity of

[316] Irwin (2003).

substitution between Brazilian and other varieties of rubber, σ, the elasticity of foreign export supply, ε, and the elasticity of demand for Brazilian rubber, η:

$$\eta_{BRZ} = \frac{\varepsilon[(1-S)\sigma + S\eta] + \sigma\eta}{S(\sigma - \eta) + \eta + \varepsilon} \tag{5.1}$$

According to equation 5.1, the elasticity of demand for Brazilian rubber will be smaller, (a) the smaller the elasticity of demand for rubber in general; (b) the smaller the elasticity of Brazilian rubber supply and; (c) the smaller the elasticity of substitution between Brazilian rubber and the other sources of rubber[317].

The dataset used in the estimation was constructed by merging British and US trade data (discounting off the trade between these two countries) as presented in Chapter 2. Since up to 1910 Brazil (BRZ) possessed the largest market share (60.8%) and no other single country consistently exceeded the 10% mark, the other countries had to be aggregated in groups, notably in view that their territory often changed as consequence of colonial policies or simply due to independence or incorporation by another. In order to keep our results here comparable with Chapter 2, all British colonies (BRC) were aggregated (whose combined market share from 1870 to 1910 reached 14.0%) into one category.

From this dataset, a set of equations (in the form of equation 2.1) will be jointly estimated. In practice, the estimation will then have two equations: one for Brazil and another one for the British Colonies. For Brazilian rubber, the Brazilian market share (dependent variable) will be estimated against the price of Brazilian rubber, the price of British Colonial rubber and a variable that capture overall physical demand of the market as it is defined as the total expenditure on crude rubber (total imports of crude rubber) divided by an average price of the raw product. Analogously, for British colonial rubber, the British Colonial share (dependent variable) will be estimated against the price of Brazilian rubber, the price of British Colonial rubber and a variable that capture overall

[317] Van Duyne (1975, p. 603).

physical demand of the market as it is defined as the total expenditure on crude rubber (total imports of crude rubber) divided by an average price of the raw product.

The system was then estimated using Iterative Seemingly Unrelated Regressions (SUR) with only symmetry imposed and the results are reported in the Appendix. Homotheticity was not imposed since the system here is equivalent to one in which one extra equation for "all remaining countries" had been deleted whose β coefficient would be given by the adding-up restriction.[318]

The Adjusted-R^2 indicates a reasonably good fit for BRZ equation (0.49) and a poor fit for BRC (0.11). Durbin Watson statistic suggested positive serial correlation in both equations possibly due to omission of price expectations or inflexibility in the short run, as a result of long run contracts between buyers and sellers. Even though the estimated coefficients remain unbiased and consistent, they are not efficient anymore. Augmented Dickey-Fuller tests on residuals in level for BRZ equation (not reported here) indicated that the null hypothesis that the residuals follow a unit root is rejected at 11%. The null hypothesis of unit root is also rejected in first difference at 0.1% confidence level. For the BRC equation, null hypothesis can only be rejected in second differences at 0.1% confidence level.

Remember that under AIDS, changes in real expenditure operate through the β_i coefficients: it is positive for a luxury good and negative for necessities. According to the estimates presented in the Appendix, Brazilian rubber is a luxury good whereas British Colonial rubber is a necessity (both statistically significant at 1% confidence level). However, since the coefficients are very close to zero, changes in the quantity of crude rubber consumed do not cause a significant change in terms of market share: for instance, whenever overall consumption of rubber increased (income rose) there was an increase of Brazilian market share and a slight decrease in the British Colonies' market share. This

[318] In fact, to be strictly correct, the estimated equation should have included a price variable for "all remaining countries". However, the micro properties do not change and the system is equivalent to impose that the coefficients of these prices were equal to zero. All qualitative results are robust to specification changes and it was just chosen here the minimal specification required to support the hypothesis put forward here, i.e., that Britain could, at least partly, pass-through the price of rubber scarcity. Furthermore, it must be stressed that estimates are invariant to the equation deleted. See Barten (1969).

may further indicate that Brazilian supply did not keep up the pace with its demand and/or that consumers regarded Brazilian rubber as of a higher quality.

Applying equation 2.3 to the estimated parameters of the AIDS model in the Appendix, we can retrieve the own-price and cross-price elasticities of demand. According to Figure 5.1 below, the own price-elasticity of rubber for British Colonies was -0.02 (not statistically significant though) and for Brazil -1.32 (highly significant: t-stat = -18.85). The elasticity of substitution between Brazilian and British Colonial rubber was not significant but indicate that it might have been positive (+0.29), i.e., the two rubber sources were considered substitutes.

Figure 5.1 – Implied Elasticites of Demand for Rubber, 1870-1910

	Mkt Share	Beta	BRZ	BRC
BRZ	64.14%	0.08	-1.32	0.29
		6.24	-18.85	0.57
BRC	10.43%	-0.03		-0.02
		-3.00		-0.05

Note: t-statistics below each estimate
Source: computed from methodology and data presented in the Appendix.

It must be stressed again here that own-price elasticies of demand for Brazilian rubber computed above should not be confused with the elasticity of export demand that Brazilian rubber exporters faced (from this point onwards British Colonial rubber will be ignored as it did not register a statistically significant estimate nor is it crucial for the analysis here). The own-price elasticity of demand for Brazilian rubber should then be corrected by applying equation 5.1 in order to obtain the actual elasticity of demand that Brazilian rubber exporters faced. It is possible to infer that the demand for Brazilian rubber was somewhat inelastic and more so compared to the demand for US cotton in the Antebellum period: -1.1 (assuming elasticity of substitution of 0.8[319], elasticity of rubber supply from other producers as 1.0 and market share of 64.1%) against -1.7 for US cotton. Figure 5.2 below presents the elasticity of demand for Brazilian rubber under different

[319] Note that this refers to the elasticity of substitution between rubber from British Colonies and Brazil computed for 1885-1910.

scenarios for the elasticity of supply from other producers (ε) and elasticity of substitution between Brazilian rubber and another types of rubber (σ).

Figure 5.2 – Implied Elasticity of Export Demand for Brazilian Rubber under Different Scenarios

elasticity of substitution (σ)	Elasticity of Foreign Export Supply (ε)				
	0.00	0.50	1.00	1.50	2.00
0.50	-0.83	-0.91	-0.94	-0.96	-0.97
0.80	-1.07	-1.09	-1.10	-1.11	-1.11
1.00	-1.18	-1.19	-1.19	-1.20	-1.20
1.50	-1.38	-1.38	-1.38	-1.38	-1.38
1.80	-1.46	-1.47	-1.47	-1.47	-1.48
3.00	-1.65	-1.70	-1.73	-1.75	-1.77
5.00	-1.79	-1.89	-1.97	-2.04	-2.09
∞	-2.06	-2.34	-2.61	-2.89	-3.17

Note: table shows the output of equation 5.1, assuming Brazilian market share (S) = 64.14% and elasticity of demand for Brazilian rubber (η_{BRZ}) = $|1.32|$.

Source: computed from data presented in the Appendix.

From Figure 5.2, it is possible to infer that, except in the case in which rubber is considered a homogeneous commodity (equivalent to having an elasticity of substitution equals to infinity), elasticity of demand for Brazilian rubber should have lain somewhere between -0.8 and -2.1. Comparing with Irwin's estimates for cotton during the antebellum period, from 1870 to 1910 rubber might have been more inelastic insofar as the elasticity of substitution between Brazilian rubber and rubber produced in British Colonies might have been as low as 0.8, which, according to Figure 5.2, would suggest an elasticity of demand around -1.10.[320] For rubber, it is very unlikely that the elasticity of substitution was actually higher than 1.8[321], which would mean that the elasticity of demand for Brazilian rubber would have fallen within the range of 0.8-1.5. Therefore, demand for Brazilian

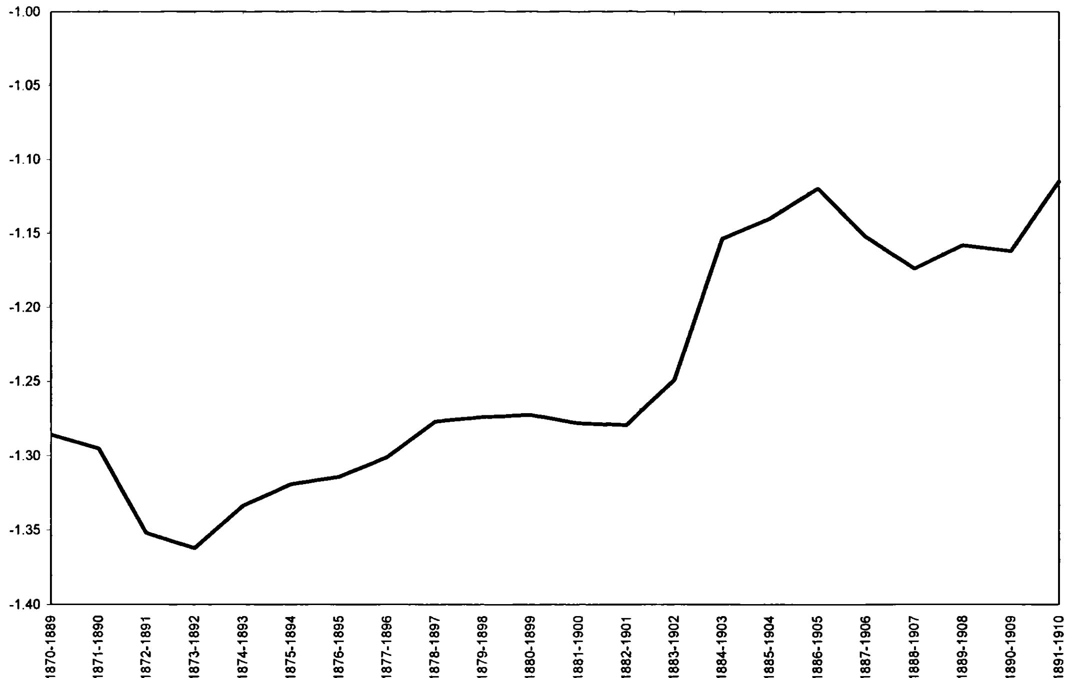
[320] However, using the same parameters as Irwin (2003), i.e., $\sigma = 3$ and $\varepsilon = 0.5$, rubber would be equally elastic: -1.7 for rubber against -1.7 for cotton.

[321] This belief is based on several other different specifications (and different time periods) estimated by the author and not reported here. The elasticity of substitution between Brazilian and British Colonial rubber was usually below 1.5.

rubber from 1870 to 1910 seems to have been more inelastic than the demand for US cotton during the Antebellum period, especially because in the case of rubber the government was intervening in the market quite a lot through an export tariff, implying that the demand for Brazilian rubber might have been even more inelastic. This point will be further explored later on here.

In addition, it should be highlighted here that the demand for Brazilian rubber was becoming more and more inelastic over time. From Figure 5.3 below, it can be seen that at the peak of the rubber boom, the elasticity of demand was probably very close to one (-1.1). If the elasticity of substitution is assumed to be 0.8, the elasticity of demand for Brazilian rubber could have been as low as |0.94| (in absolute terms).

Figure 5.3 – Elasticity of Demand for Brazilian Rubber (20-year Moving Windows) 1870-1910



Note: It assumes a constant elasticity of foreign supply (ε) at 1.0 and an elasticity of substitution (σ) at 1.3. All estimates are statistically significant at 10% confidence level.
Source: Based on methodology and data presented in the Appendix.

As explained in Chapter 3, crude rubber was not a homogeneous commodity at all, registering huge differences in terms of quality and physical properties of the material, notably in terms of tensile elasticity. The higher the quality of the crude rubber, the more applications it would have and of course, the higher the price: prices indeed reflected quality and there were several different grades of rubber in the market whose prices could vary by 3.1 times.[322] Note that quality was also influenced with the crude rubber production technique. Rubber was produced from the latex of the tree and would generate the best quality only if the tree was tapped with care. Depending on the dexterity of the rubber tapper the latex could coagulate once in contact with the air (or depending on the type of tree as well), and the more care they had, the less impurities the crude rubber might have had. As argued in Chapter 3, *hevea* trees produced the best quality of crude rubber. For certain manufactured products, there was a limit to substitution from higher to lower grades of rubber, and therefore there were limits to substitute for Brazilian rubber and then it is not surprising that Brazilian market share went unchallenged until 1910 and that Brazilian rubber always registered a market premium.

Due to the relative inelasticity of demand for Brazilian rubber, it can be said that conditions existed for monopoly profits to be generated, had some oligopolistic (or monopolistic) structure emerged. This contention was long advanced and was probably known at the time of the rubber boom otherwise, how could one explain the article by Pearson, published in 1901 in *India Rubber World* in which the author seemed keen on explaining the reasons why rubber would never be monopolised by Brazil?

> *"No fear need be felt that the supply of rubber will ever be monopolized. (...) [Rubber] is obtained throughout a wide belt, extending around the world, but mostly in regions remote from civilized centers (...); it comes in driblets to innumerable initial markets, from millions of gatherers, whose labor practically is beyond control. Moreover, if all the forests now yielding rubber, and all the rubber gatherers at work, and all the houses trading in rubber in America, Europe, Asia, and Africa, were brought under a single*

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[322] See, for instance, price data presented in the Appendix that shows prices for different grades of rubber traded in New York on 29th January 1906.

control, the possibility would exist of new forests being explored, new workers found, and new trading houses opened, every one of which facts would tend to the overthrow of the monopoly".[323]

What is implicit in Pearson's argument above is that he believes that monopolisation would have never taken place because the elasticity of substitution between Brazilian and other types of rubber was very high and that the elasticity of supply of other countries was also relatively high. However, Pearson's assumptions did not find support in the data or in contemporary accounts. For instance, Chapter 3 has shown that several rubber sources were fastly exhausting due to the method of extraction employed. Moreover, the elasticity of substitution between BRZ and BRC was not at all too high.

Barham and Coomes, in turn, argued that despite the fact that rubber was exported from Belém by a small number of foreign-owned export houses, this did not mean that competition in the rubber market was absent in Brazil. They argued that entrance in rubber market was relatively free and then high concentration levels were consistent with competition due to contestability: rubber was freely traded in major ports in the USA, Europe and the Amazon; there were plenty of information available to participants in the market, especially from two trade journals *India Rubber Trade* (published in New York) and *India Rubber Journal* (published in London); rubber production was very decentralized, being spread over a large territory; etc. In order to further support their argument, they cite Weinstein's account of the unsuccessful attempts by the Vianni trading house to corner Belém rubber exchange over more than a decade in the 1870s and 1880s.[324]

First, Barham and Coomes accounts of the rubber trade are not accurate. Trade was not exactly free inasmuch as some of the transactions were hidden under forward contracts and only part of the trade occurred in spot markets (see Chapters 2 and 3). The free market they refer to is the marginal market: a) the Brazilian spot market was supplied

[323] Pearson (1901, p. 135) also cited by Barham and Coomes (1996, p.34).
[324] Barham and Coomes (1996, pp. 32-35) and Weistein (1983, pp. 139-155).

by the rubber produced in excess of the forward contracts set by the export houses; b) in the USA and in Britain, the spot market was fed by the rubber ordered in excess of the forward contracts. They might differ quite substantially, as it is not clear that Brazilian export houses would only make orders following orders coming from abroad: it is not true that all Amazonian export houses were simply agents of foreign manufacturers (see Chapters 3 and 4). It is very likely that they speculated quite a lot. Secondly, information was definitely available in the major cities but it is unlikely that it reached the far corners of the Amazon basin where production was actually taking place, especially because the main trade journals were published in English and a few people spoke English in the Amazon between 1870 and 1910. It is unlikely that even the majority of immigrants spoke that language, as most of them were Portuguese.[325] Thirdly, production was decentralized but the decision upon levels of production may not have been as decentralized as claimed by Barham and Coomes.

Although the thesis has shown that an oligopolistic structure could have emerged in the Brazilian Amazon (see previous chapters), for the purpose of the present Chapter, this fact does not even need to be proved as the literature so far missed the role of the government and how taxation could have ensured that monopoly profits were generated even under perfect competition among exporters of rubber in Brazil. That is exactly the subject of the next section and the results here seem to provide further evidence to Frank and Musacchio's rubber chain analysis ('from trees to tires'). They acknowledge that even though competition was present at every link of the rubber chain, Brazil was able to reap monopoly profits before about 1900.[326] Here, it seems that it would have been possible to exploit Brazilian market power on rubber even during the first decade of the twentieth century. Once more, the rubber chain seems further and further away from the typical GCC chain in which the core node is located at the industrial end of the chain (and, additionally, it is this core node that benefits the most from the productive chain).

[325] True, information from these articles eventually found their way into the Amazon via local newspapers. However, the level of illiteracy was very high and probably only the elite could read them. Even if it is believed that information could have spread by 'word-of-mouth', it would take long to reach the most remote parts of the Amazon forest.
[326] Frank and Musacchio (2006, p. 288).

5.3 – The Economics of Taxation: Impact on Elasticities

Even if the conditions in the rubber market prevented its oligopolisation and Pearson was right in saying that free entry may have precluded collusion agreements, it was shown in the previous section that conditions existed for the appropriation of monopoly profits and both contemporary and more recent literature neglected the possibility that government may have ensured (partial) monopoly profits for the Treasury.

Following Irwin and Abreu and Fernandes, it is possible to understand why an entire country can be taken as a sole player in rubber market even when production occurs in a decentralised way: government interventions in the market affect all producers to the same extent and a certain production can be assured by government control of rubber price.[327] Indeed, the government possessed several mechanisms to pursue this goal: nationalisation of rubber production, licensing scheme, stockpiling, export tariff and import tariff over goods that affect the rubber cost structure. First, the government could have ensured that the monopoly outcome would have been reached if the government had bought out (or simply appropriated) all rubber production units, something similar to the case of guano production in Peru.[328] Even though this mechanism was not impossible to be applied, it would have faced strong opposition from the Amazonian elite which, especially after the proclamation of the Republic (1889), had access to the government. Secondly, the government could have regulated the amount of rubber produced through a licensing scheme similar to what Chile did in saltpetre.[329] However, this would have depended upon the ability of the government to ensure its directives and to prevent smuggling, something very difficult to apply due to the geography of the Amazon basin:

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[327] Irwin (2003) and Abreu and Fernandes (2005).

[328] In 1841, Peru asserted its rights of ownership over guano deposits. In 1849, the Peruvian government awarded a single contract for extracting guano to a prominent local entrepreneur, Domingo Elías, who was later succeeded by Andrés Álvarez Calderón. According to Miller and Greenhill (2006, p. 243),

> *"(...) [a] central feature of these contracts after 1849 was the employment of merchants to transport and sell guano overseas on consignment for a limited term, in return for a commission and other payments for their services. The Peruvian government stipulated both the quantity of guano to be exported and the price at which it should be sold."*

[329] Abreu and Fernandes (2005) and Miller and Greenhill (2006).

had the government policy pushed prices to a level high enough to compensate for the risk of smuggling, the rubber trade would have probably been shifted to Mato Grosso state or to one of the neighbouring countries. Note that after the proclamation of the Republic in Brazil in 1889 taxation on rubber became a State prerogative. Thirdly, stockpiling could have been used to create some sort of 'valorisation' policy, as São Paulo and Federal governments successfully did for coffee[330] in the first four decades of the twentieth century and that was unsuccessfully pursued in 1911 and 1912 for rubber. Barham and Coomes argue that some unsuccessful attempts of price control through stockpiling by Baron of Gondoriz were indicative of the impossibility of controlling the market. This was true for 1911 onwards, when Brazilian market share on rubber was decreasing very fast and with hindsight it is possible to state that these attempts were doomed to fail. However, it does not follow from this that Brazilian government would have been incapable of controlling the market had it attempted years earlier, especially at the hike of the rubber boom. Fourthly, export tariff was constantly used by State governments, notably after the advent of the Republic in 1889 (and by the federal government in Acre territory after it was bought from Bolivia in 1903) and even though the initial aim was just to generate essential revenues for Pará and Amazonas states, there were consequences in terms of incentives for rubber production: the quantity produced was indeed influenced by government interventions. Lastly, import taxes over rubber inputs, directly affects the cost of production which would result in less rubber being produced as well. This mechanism was largely used by Federal government (sometimes even applied to merchandises from other states of Brazil).

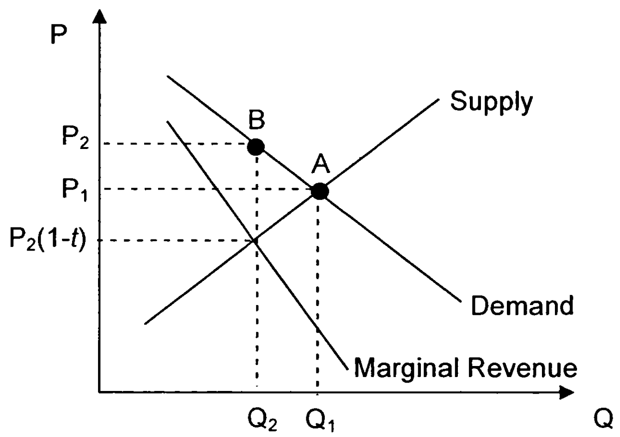
As explained above, nationalisation of rubber production did not occur, a licensing scheme did not emerge and stockpiling was not successfully pursued from 1870 to 1910. And since import taxes were not under the control of state authorities (and because the federal government was more concerned with issues relating to coffee rather than rubber) and its impact was too indirect to provide an estimate of its cost impact, only the effect of the export tax on welfare will be analysed here.

[330] Bacha and Greenhill (1992) and Abreu and Fernandes (2005).

How could the export tax have been used as a way to achieve the maximum level of regional welfare? Figure 5.4 shows an export market in partial equilibrium. Point *A* corresponds to equilibrium in a perfectly competitive market: rubber domestic producers would sell the quantity Q_1 where rubber export supply equals rubber export demand at the world price P_1. The optimal quantity of exports is equivalent to the monopoly outcome, Q_2, corresponding to the point at which the marginal cost of rubber export supply equals the marginal revenue from exports. At this point the country generates the highest producer surplus.

In the simpler case where the government intervenes into the market through the imposition of an export tax only, its optimal level, *t*, would simply be the reciprocal of the price elasticity of rubber export demand. The marginal revenue of commodity exports can be expressed as $P^*\left(1-\frac{1}{\eta_{BRZ}}\right)$, where P^* is the world price and η_{BRZ} is the (positive) elasticity of rubber export demand as defined before. Since the rubber domestic price (i.e. the price actually received by rubber exporters) would be given by $P = P^*(1-t)$, equating marginal revenue to rubber domestic price yields the optimal export tax: $t = 1/\eta_{BRZ}$.

Figure 5.4 – Competitive and Monopoly Market Equilibria



From Figure 5.2, it is then possible to compute the implicit optimal export tariff, which is just the reciprocal of the absolute value of the elasticites reported there. First of all, even in the counterfactual scenario in which rubber is considered a homogeneous product, optimal export tariff would have been as high as 32% and under more realistic assumptions (σ = 0.8-1.5), it could have reached 93% (with 72% as a lower bound).

Figure 5.5 – Implicit Optimal Export Tariff

elasticity of substitution (σ)	Elasticity of Foreign Export Supply (e)				
	0.00	0.50	1.00	1.50	2.00
0.50	120%	110%	106%	104%	103%
0.80	93%	92%	91%	90%	90%
1.00	84%	84%	84%	84%	84%
1.50	73%	72%	72%	72%	72%
1.80	69%	68%	68%	68%	68%
3.00	61%	59%	58%	57%	56%
5.00	56%	53%	51%	49%	48%
∞	49%	43%	38%	35%	32%

Note: table shows the implicit optimal export tariff which was computed as the reciprocal of the absolute values of Figure 5.2. Therefore, it is also assumed here that Brazilian market share (*S*) was equal to 64.14% and the elasticity of demand for Brazilian rubber (η_{BRZ}) was equal to |1.32|.

Source: computed from data presented in the Appendix.

Note that these optimal export tariffs were supposed to be levied in excess of an existing one which amounted to 16.6% *ad valorem* on average from 1870 to 1910 (see Figure 5.6 for the evolution of the Export Tariff levied by the government). Thus, if the government had not intervened in the market, the optimal tariff could have reached 126.5% (with a lower bound at 96.2%), assuming σ would lie between 0.8 and 1.8[331]. In turn, under the same assumptions, the elasticity of demand that Brazilian rubber producers would face, had the government not levied any export tariff would have fallen within the interval -0.78 to -1.03[332]. Therefore, in the absence of government taxation, the demand facing Brazilian rubber exporters might have been quite inelastic implying that there were definitely grounds for appropriation of monopoly rents by the government

[331] This is just the computation of (1+TRF_EXP)*(1+TRF_EXP_OPT)-1; where TRF_EXP is the actual export tax levied by the government and TRF_EXP_OPT is the optimal export tax as of Figure 5.5.

[332] These elasticities were computed as the (negative) inverse of total optimum export tariff range.

during the rubber boom. In this context, taxation increased the welfare of the region but apparently there was room for even more welfare to have been generated there, especially in a context of shortage of labour.

As discussed in Chapter 1, immiserising growth is a theoretical possibility especially under an expansionary economy as the Brazilian Amazon from 1870 to 1910. Improvements in transportation or increases in the price of rubber increased the actual number of trees under production, which is equivalent to an increase in the endownment of the abundant factor. This would have two effects: 1) since the Amazonian income rises, assuming that goods are normal, the Amazonian demand should increase (excluding probably the demand for crude rubber that was hardly consumed domestically); 2) domestic production of rubber (the good intensive in the abundant factor) should increase, whilst domestic production of all other goods should go down (Rybczynski Theorem). This really happened at least in relative terms as the Amazonian economy became more and more specialised on rubber over time even though it is not true that the production of all other products declined over time in absolute terms[333]. Therefore, in relative terms production of rubber (exported good) increased whereas production of imported goods decreased. Increased supply of exports combined with increased demand for imports should normally result in less favourable terms of trade and there is no reason to expect *a priori* that the utility loss caused by less favourable trading terms to be smaller then the direct utility gain of a more abundant factor endowment. However, the terms of trade did not worsen due to shortage of labourers: even though high prices of rubber would have induced a high increase in rubber production, this mechanism was hampered due to the shortage of labour. No overproduction followed and thus no worsening of terms of trade happened. Consequently, there was no immiserising growth in the Brazilian Amazon from 1870 to 1910.

[333] See Anderson (1976, p. 68).

Figure 5.6 – *Ad Valorem* Export Tariff Levied by the Government, 1870-1910

Sources: Data were gathered from several *Provincial Presidential Reports*, *Relatório da Fazenda do Amazonas* (1918) and LeCointe (1922). See Appendix for the raw data from which this Figure was computed.

Note: *Ad valorem* export taxes were computed as the ratio between the rights of rubber (total revenue generated by export tariff on rubber exported) and total value of rubber exported instead of using the actual tariff as defined by laws. The procedure adopted here captures the true tariff burden insofar as the government always established official prices for rubber which sometimes differed quite substantially from market prices. Changes in official prices explain the spikes in Figure 5.6 above. For Acre territory, *ad valorem* export tariff was computed from 1904 to 1912 (note that Acre was officially part of Brazilian Federation only after 1903), resulting in 19.24% on average. For Amazonas, there were figures for 1870 to 1912 and its ad valorem export tariff was on average 19.62%. Finally, in Pará, the most important rubber exporter state, *ad valorem* export tariff amounted to 17.52% from 1885 to 1912.

5.4 – Welfare Analysis

Once having computed the optimal export tariff, it is possible to evaluate the gains from the actual export tax and the counterfactual gain had the government increased the tariff up to its optimum level. This welfare gain would depend upon the elasticity of Brazilian rubber supply, and it is defined as the consumer surplus extracted from foreign consumers, $(P_2-P_1)*Q_2$, minus the domestic deadweight loss, $½*(Q_1-Q_2)(P_1-P_2(1-t))$. In turn, the change in rubber price in international markets is given by:

$$\Delta p = \frac{\varepsilon_{BRZ}}{\varepsilon_{BRZ} - \eta_{BRZ}} \Delta \tau \qquad (5.2)$$

where Δp is $P_2 - P_1$, ε_{BRZ} is the elasticity of Brazilian rubber export supply (see Figure 4.6), η_{BRZ} is the elasticity of demand for Brazilian rubber and $\Delta\tau$ is the change in export tax. Note that when ε_{BRZ} approaches infinity $\Delta p \rightarrow \Delta\tau$, i.e., Brazilian rubber producers could integrally pass through the tax burden to consumers. Analogously, when $\varepsilon_{BRZ} = 0$, Brazilian producers are unable to push prices up and they internalise the whole tax burden.

The welfare gains of taxation depend not just upon the elasticity of demand that Brazilian rubber producers faced but also upon the elasticity of Brazilian rubber supply. In that regard, it should be emphasised that there was no significant change in productivity per rubber tapper, inasmuch as there was no change in production methods from 1870 to 1910. Rubber extraction technique varied according to the type of rubber sought and extraction methods were very simple. According to Roberto Santos, each rubber tapper would operate 1.33 trails (each trail was comprised of 123 rubber trees on average) and would produce around 255kg of rubber per year.[334] Productivity would depend then on the exhaustion of the tree and the type of tree. Remember that *hevea brasiliensis* provided not only the highest quality of rubber but also registered the highest productivity. Since productivity was not under the control of the rubber state owner (it was a given: there was no plantation scheme in Brazilian Amazon worth of note), it is fair to say that increase in production could occur only extensively: adding more rubber tappers to more rubber trees and applying more capital, in the form of advances for the tapping season. The absence of any major improvements in techniques might have resulted, as shown in Chapter 4, in a high price inelasticity of supply due to a claimed shortage of labour despite the fact that during the boom, Amazon population increased fourfold, from 278.3 thousands in 1860 to

[334] Santos (1980, pp. 77-86).

1.2 million in 1910[335], as a result of immigration from other parts of Brazil, notably from Ceará.[336]

In sum, Brazilian rubber supply responsiveness would directly depend on the availability of workers and it was expected that in periods of high immigration, Brazilian rubber supply might have been more elastic whereas in periods of low immigration, the opposite might have been true. Indeed, as show in Chapter 4, regressing total Brazilian exports of rubber against different combinations of variables such as a constant, lagged prices (or current price), population and a time trend, gives an elasticity of supply well below 1, probably close to 0.25. Moreover, according to Weinstein,

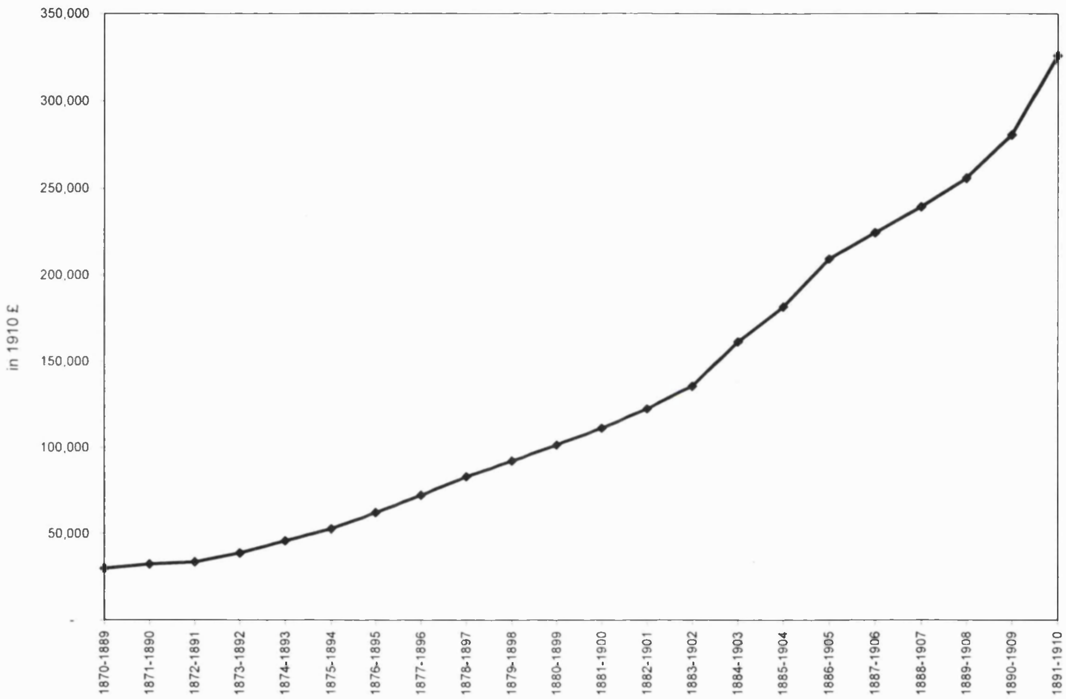
> *"contemporary observers frequently commented on the fact that the volume of Amazonian production was almost completely unaffected by price fluctuations, since the aviador lacked an efficient method of increasing or reducing his 'tapper-client' output."*[337]

Figure 5.7 below shows the real welfare effect of the actual export tariff levied by Amazonian governments, assuming an elasticity of foreign export supply of 1.0 and an elasticity of substitution of 1.3 (which is the middle point between 0.8 and 1.8 used here before). For every 20-year period, the elasticity of demand for Brazilian rubber was computed, which was then applied to equation 5.2 to estimate the change in price, had the tariff not been levied. This new counterfactual price (P_2) was used to compute the correspondent new counterfactual quantity of rubber exported from Brazil (Q_2). As mentioned earlier, the net welfare gain was calculated as the consumer surplus extracted from foreign consumers, $(P_2-P_1)*Q_2$, minus the domestic deadweight loss, $\frac{1}{2}*(Q_1-Q_2)(P_1-P_2(1-t))$. This value was finally transformed into 1910 prices using Rousseaux Price

[335] In this regard, see Akers (1912, pp. 67-70 and 80-81), Woodroffe (1916, pp. 1-24), Santos (1980) and IBGE (1987). See also Appendix for population data.
[336] There was also international migration but it was concentrated at the end of our period here and the numbers were completely dwarfed by the mass of immigrants coming from other regions of Brazil.
[337] Weinstein (1983, p. 157).

Index.[338] Assuming that the elasticity of Brazilian rubber supply (ε_{BRZ}) was 0.25, Real Net Welfare generated by taxation would increase from £29,769 on (annual) average in 1870-1889 to £325,900 on average in 1891-1910. Therefore, the government was generating a higher real net welfare over time because: a) the value of rubber trade was increasing over time and; b) rubber demand was becoming more inelastic.

Figure 5.7 – Annual Real Net Welfare of the Export Tariff (in 1910 £) 1870-1910



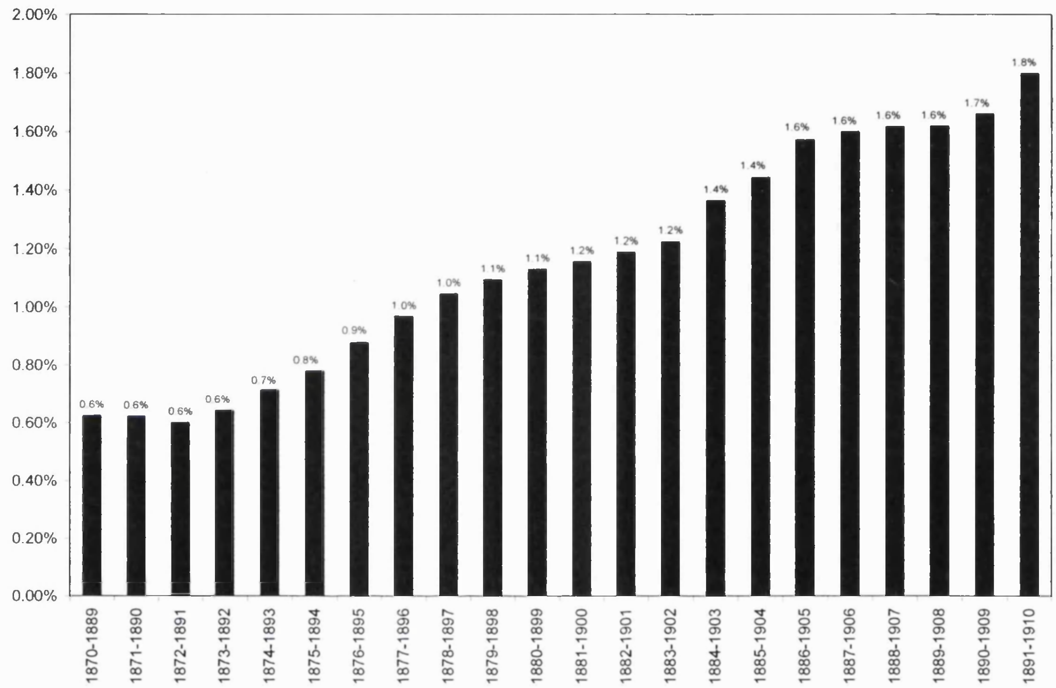
Source: See Appendix for data and text for details on how this Figure was constructed.

Santos provides an estimate of the Amazonian GDP from 1870 to 1910 (on a 5 year basis) which was converted into pounds and then interpolated to provide a full Amazonian GDP series between 1870 and 1910 (see Appendix for GDP data). Then GDP averages over the same periods as of Figure 5.7 were computed, so that the magnitude of the welfare generated by government taxation could be assessed. According to Figure 5.8 below, the government could have generated a welfare effect as high as 1.8% of the

[338] Mitchell (1988, pp. 471-473). Results do not change significantly if the Sauerbeck Price Index from Mitchell (1988, 474-475) is applied.

overall GDP of the region during the last 20 years of the rubber boom (1891-1910), three times larger than what the government could have generated at the beginning of the period. Furthermore, it can be inferred that the government was increasing the net welfare effect generated by the export tariff in a context in which the GDP of the region was also increasing.

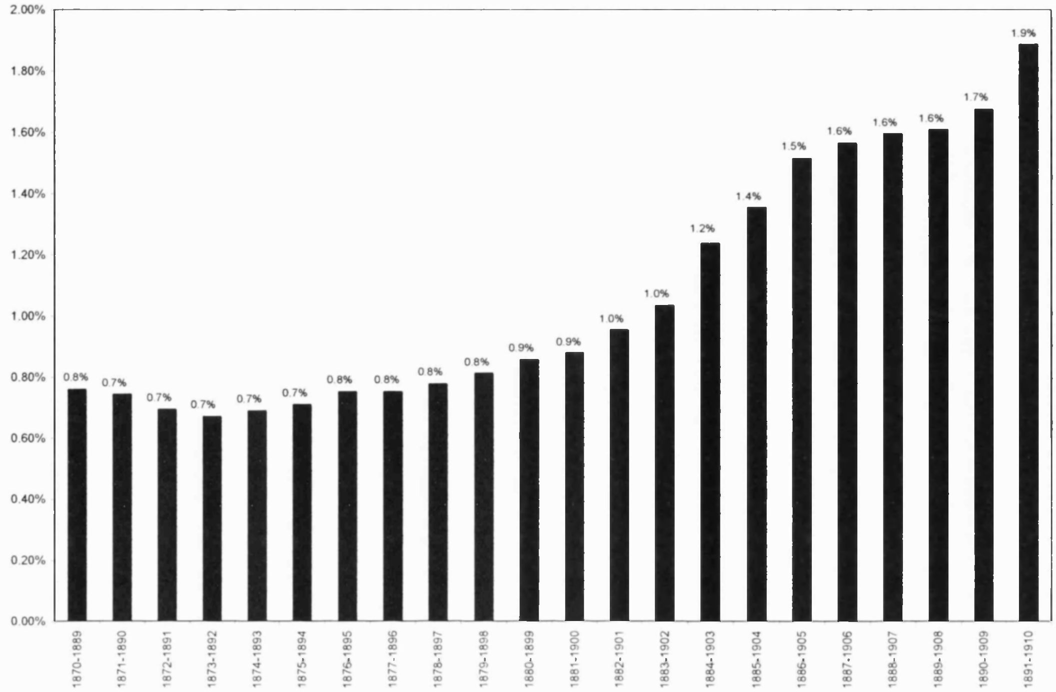
Figure 5.8 – Real Net Welfare of the Export Tariff (% of Amazonian GDP), 1870-1910



Source: See Appendix for data and text for details on how this Figure was constructed.

It is also possible to compute the welfare effect, had the government increased the tariff up to the optimum level. In the best case scenario, the government could have generated an extra £341,444 (expressed in 1910£) on average in the period 1891-1910 as welfare gains for the region had it increased the tariff to the optimum level. This would have been equivalent to 1.9% of Amazonian GDP in the same period.

Figure 5.9 – Real Net Welfare of [Additional] Counterfactual Optimum Export Tariff (% of Amazonian GDP), 1870-1910



Source: See Appendix for data and text for details on how this Figure was constructed.

In sum, had the government set the export tariff at the optimum level, an extra welfare gain would have been accrued by the government. Crude rubber consumers, located mainly in the USA and in Britain would have borne most of the burden of the taxation, as the relative inelasticity of demand for that raw product would have made them dependent, to some extent, on Brazilian rubber. This result is again in stark contrast with the GCC approach inasmuch as it suggests that the rubber manufacturers were not very well positioned *vis-à-vis* other nodes of the rubber chain, quite the opposite. According to Figure 5.10 below, from 1890 to 1909, the government could have generated a total welfare gain of 3.3% of the regional GDP per year at the rubber manufacturers and the final consumers of rubber products expenses. The question then is why did the government set an export tariff that was way below the optimum level? That is exactly what the next section addresses.

Figure 5.10 – Total Possible Welfare had the Government set the Export Tariff at the Optimum Level, selected periods

	(1910 £)	(% GDP)
1870-1889	66,050	1.4%
1880-1899	70,947	2.0%
1890-1909	72,473	3.3%

Source: See Appendix for data and text for details on how this Table was computed.

5.5 – The Political Economy of Taxation

In the previous section, it was shown that even under a high inelasticity of supply, the government could have captured 3.3% of Amazonian GDP per year as a monopoly rent in the last 20 years of the rubber boom (1890-1909) since the burden of taxation would mostly be passed through to the consumers in Europe and in the USA. However, the government captured it only partially. It is important to understand why this was so.

First, as Irwin highlighted, "this partial equilibrium framework is static and ignores several important dynamic issues"[339] and thus the optimal export taxes computed here should be understood as upper bounds, because the demand elasticity is probably biased downwards and then the demand elasticity may have risen when the export tax was imposed.[340] Moreover, the government ability to tax was in fact constrained in three different levels: nationally, regionally and locally. During the Empire, Provinces were usually forbidden to levy any export tax, even though they sometimes did levy taxes on foreign and interprovincial trade. With the advent of the Republic in 1889, export tariffs became a State prerogative whereas the import taxes as well as income taxes stayed in the hands of the Federal government. The political economy of taxation on foreign trade thus became very intricate as presumably the USA and Britain could have actually retaliated against a possible higher export tariff. This retaliation would have probably had small effects over the Brazilian Amazon but for the country as a whole the result could have been quite significant. Retaliation was certainly a big concern for the Federal government as it became clear in the episode involving a surtax that favoured the

[339] Irwin, (2003, p. 287).
[340] Irwin, (2003, p. 284).

Companhia Mercantil, a Brazilian rubber export house. The idea was to establish a 20-réis surtax on each kilogram of rubber exported from Belém but to exempt the Companhia Mercantil from such a surtax. Despite the rapid and fierce objection of the other export houses, Governor Justo Chermont (shareholder and former officer of the Companhia Mercantil) promptly accepted the plan.[341]

Only days after issuing the surtax decree, Governor Chermont received a 'letter of inquiry' from Ruy Barbosa, Minister of Finance enumerating the objections made by the foreign exporters. Despite his rhetoric of protection of national interests against foreigner's attempts to monopolise the rubber trade, Governor Chermont had to bend to Federal pressure. According to Weinstein,

> *"In the final analysis, there was no hiding the fact that international pressure had allowed the foreign exporters to triumph over regional interests. Further, the course of events indicated to Paraenses that the Amazon still occupied a subordinate political position, despite all the rhetoric about decentralization".*[342]

If at the national level Pará (and even more Amazonas) still occupied a subordinate position and were thus forced to put "national" interests before their own, these States also lacked coordination. The competition for rubber proceeds led the Amazonas State to legislate in 1878 a differential tax on rubber exports. The plan was to divert the trade from Belém to Manaus as Amazonense rubber shipped directly from Manaus would pay a slightly lower duty than rubber exported from Belém. The gap between the two export tariffs was subsequently widened in 1885 to 5 percentage points, causing several Paraense export houses to open or expand their businesses in Manaus. This plan was supported by the establishment of a direct shipping line connecting Manaus

[341] Weinstein (1983, pp. 146-155).
[342] Weinstein (1983, p. 152).

to New York and Liverpool (see Chapter 6 for details on Shipping).[343] This competition between the two most important rubber producing states limited the ability of them to increase their export tariffs. Any marginal increase in either export taxes could have triggered even more trade diversion, leading to a suboptimal outcome: due to a lack of coordination, both States ended up levying a much lower export tax than they optimally could. In a strange way, the Amazon State was pursuing a beggar-thy-neighbour policy.

Finally, at the local level, both states were constrained by pressure groups, especially the *Associação Comercial do Pará* (Pará Commercial Association)[344]. The ability of these pressure groups to lobby was due to their access to the government: the higher the access to the government, the lower the costs of changing (or devising) government policies. As explained in Chapter 3 and 4, it is a long contention in the Brazilian rubber historiography that foreign export houses controlled rubber trade from the top of the *aviamento* credit channel. According to Weinstein,

> *"(...)* [export houses'] *primary function was to ensure a steady supply of rubber, at acceptable prices, for the industrial markets. The aviadores* [intermediaries]*, on the other hand, simply sought the highest possible price for their merchandise. (...)*
>
> *During the years before the boom, few aviadores had either the capital or the connections to become involved in transatlantic commerce; thus the exporter performed a strategic function, and he also assured the middleman of a source of additional goods or credit should the need arise."*[345]

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[343] Weinstein (1983, pp. 195-196).

[344] Apart from Associação Comercial do Pará, it is possible to identify several other pressure groups: old Amazonian elite whose wealth was based on traditional activities such as agriculture and cattle ranching; urban professionals; other layers of the government; religious orders (Catholic Church, in general); and etc. No distinction will be made here about the nature of their demands and the way they influence the government. It suffices for the analysis here that there existed pressure groups that influenced and limited the government's room for manoeuvre.

[345] Weinstein (1983, p. 138).

As shown in Chapter 3, it might be true that export houses may have been able to profit the most from their position in the credit chain, and from their connections with importers of rubber in the industrial countries but there were clear limits to this. Moreover, the fact that export houses were usually foreign-owned did not mean that they did not have access to the government as can be inferred from their successful petition to the Federal Government against the tax exemption given to Baron of Gondoriz by Justo Chermont, first governor of Pará in the Republican period.[346] Also, the distinction between foreign and national ownership was not so black and white as some European and American export houses were operated and capitalised in part by Brazilians such as Henrique de La-Rocque and José Armando Mendes[347].

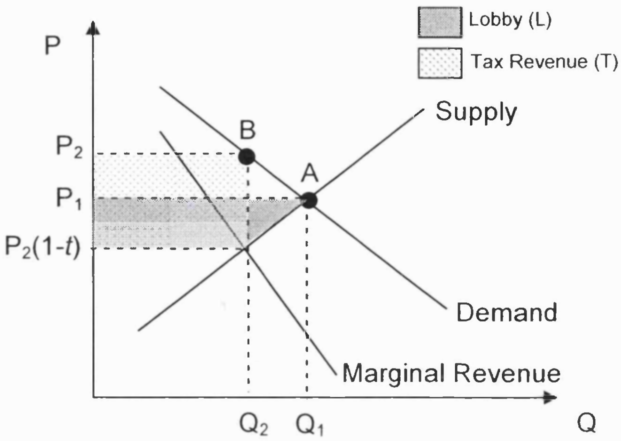
Indeed, since government had an incentive to tax exports (because it would appropriate monopoly rents, as shown in the previous section), the key thing was access to government and not only nationality. Imagine, for instance, that initially export houses had no access to government (e.g., they were all foreign-owned with no local connections) and were facing Amazonian State governments in a context of inelasticity of demand (as computed in previous sections). The government had two options: either levy the tariff or do not levy it whereas the export houses had to decide if they would lobby or not against the tax. Lobbying here means an expenditure that forces the government to change its tax policy or a payment to an intermediary to influence the government as well. Having no access to the government in the model here means that the cost of lobbying (λ) is prohibitively high.

It is then important to understand the incentives of each player and how much money they would commit to enforce the best outcome for them. First, the export houses would spend money lobbying up to what they would lose were the tax imposed. In other words, export houses would pay as much as the producer surplus they would lose, equivalent to the grey (shaded) area, *L*, in the Figure 5.11 below (it is implicitly assumed that once the exporters lobby, the government is always forced to lift off the tariff or, at

[346] Weinstein (1983, p. 152).
[347] Weinstein (1983, p.143).

least, compensate the export houses for their losses). Secondly, the government would commit up to the total revenues generated by the tax equivalent to the dotted area, *T*.

Figure 5.11 – Lobby Incentives



The interaction between the government and the export houses can be analysed with the help of Figure 5.12 which shows the payoff matrix for this game. The government has two options: it either levies the tariff at the optimum level or it does not. The export houses can lobby against the tariff or simply accept it. As explained before, lobbying entails a cost (λ) that once incurred ensures that the government will change its tax policy (do not levy the tax) or at least compensate for the export houses' losses (*L*). In this simple game the government earns nothing if it does not levy the tax and *T* otherwise. However, if the export houses decide to lobby against it, the government needs to compensate them with, for simplicity, exactly *L*. If the export houses do not lobby against the tax, it will earn *L* in case the government do not levy it and $-L$ otherwise. Moreover, whenever it does lobby, its earnings will be equal to $L - \lambda$. For the government, unless $T - L < 0$, it is always a dominant strategy to levy the tax regardless of the reaction of the export houses, especially because the high inelasticity for crude rubber will ensure that $T - L >> 0$. In turn, from the export houses point of view, it is a dominant strategy to lobby as long as $L - \lambda > - L \rightarrow 2L > \lambda$. The key parameter is thus λ: if the cost of lobbying is low enough, the equilibrium would be located in the upper right cell of the Figure 5.12 as the government will set the tariff at the optimum level and will compensate the export houses with at least *L*. Since in this game λ depends on the access to government, export houses need a reasonable access to the government to ensure that the costs of lobbying are reasonable, guaranteeing their compensation for the losses incurred. This is only possible because the inelasticity of demand for crude rubber will ensure that the total welfare appropriated will be larger *post-tax*, allowing this *Pareto* efficient outcome.[348]

Figure 5.12 – Interaction Between Export Houses and State Government

		Government	
		Levy Export Tax	Do not Levy Export Tax
Export Houses	Lobby	(L - λ; T - L)	(L - λ ; 0)
	Do not Lobby	(- L ; T)	(L ; 0)

Source: Elaborated by me, based on the interactions specified in the text.

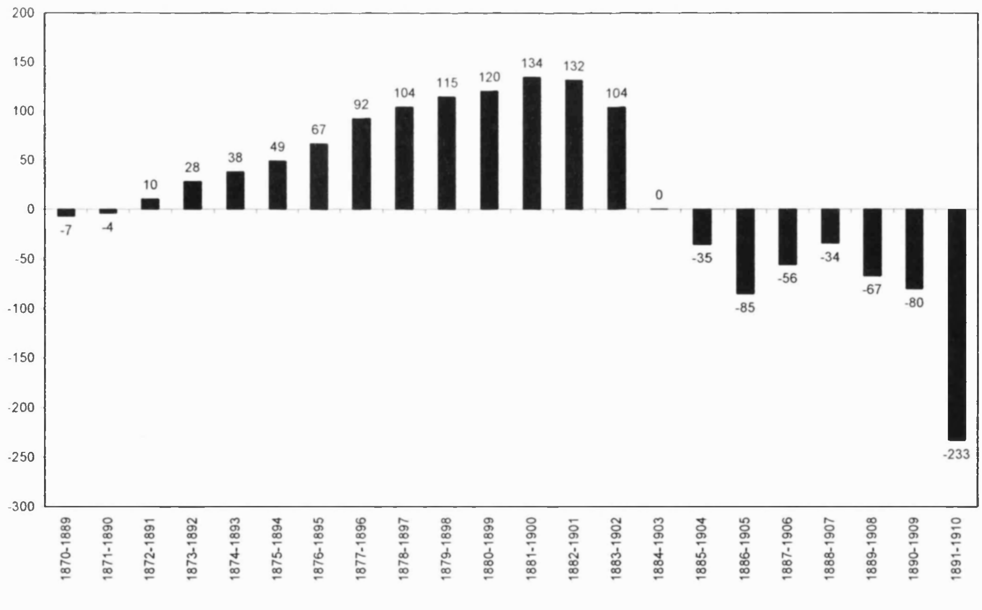
A more interesting case though is the one in which the government can set a tariff that is below the optimum level in a context of high (but not prohibitive) cost of lobbying. In that case, it is possible that the government may find a tariff level *T'* (where *0 < T' < T*) whose associated loss in producer welfare (*L'*) is lower than λ but whose income is higher than *T – L*. This means that the income accrued by the government with the lower tariff but no lobbying would be higher than the income of the optimum tariff with lobbying. In this context, <u>the maximisation of government revenues would not necessarily coincide with the maximisation of the total welfare</u>.

This last case may have been prevalent in Amazon, at least during part of the period under analysis. It is difficult to quantify the cost of lobbying but some hints are

[348] An interesting case would the one in which the export houses have perfect access to the government, or even better, the case in which export houses comprise (or are) the government. This would be equivalent to a case in which the cost of lobbying is zero (λ = *0*). In this case, the government would still set the tariff at the optimum level so long as it agrees with a rebate to the export houses that is equal to the loss in producer welfare generated by the tariff.

provided. Export houses did not have full access to the State government (which was generally more connected with the intermediaries - *aviadores*). Their local connections were sometimes very limited, and there might have been some lobbying/mobilisation cost otherwise an agreement between export houses should have arisen and they would have been the ones extracting monopoly rents out of the market. Only when government set a tariff that harmed enough the whole range of exporters were they willing to collude and lobby against government interventions in the rubber market: in this context it was rational for the government to set a tariff below the optimum level. Indeed, it is possible to compute T' – T + L and whenever this was positive it meant that the government was maximising revenues in a context of possibly imperfect access to the government.

Figure 5.13 – Actual Government Revenue minus Government Revenue under Optimum Export Tax but Full Rebate to the Export Houses (T' – T + L), selected periods



Source: See Appendix for data and text for details on how this Figure was constructed.

Therefore, under the assumptions here, until around the turn of the twentieth century it is possible that the government may actually have maximised its revenues even without having set the tariff at the optimum level. If export houses have imperfect access to the government and if they could have at least enforced full rebate of producer surplus at a higher cost, it is possible that the best strategy for the government may have simply been to set the tariff at the maximum level that did not trigger lobbying reaction from the export houses.[349]

5.6 – Final Remarks

In the present Chapter, an Almost Ideal Demand System for rubber was calculated using data from the UK and the US Balances of Trade from 1870 to 1910. From its estimates, it was possible to compute elasticities of demand for Brazilian rubber as well as cross-elasticities between different types of rubber. The results indicate that from 1870 to 1910 rubber was very inelastic: had the government not set any export tariff, the elasticity of demand that Brazilian exporters faced was probably between -0.78 and -1.03.

The Chapter further shows that the literature on Brazilian rubber has neglected the fact that the government could have been able to ensure the monopoly outcome even under a high degree of competition amongst Brazilian rubber exporters and under a high inelasticity of supply. Indeed, the government possessed several mechanisms to pursue this goal: nationalisation of rubber production, licensing scheme, stockpiling, export tariff and import tariff over goods that affect rubber cost structure. It was argued here that export tariff and import tariff were the main instruments actually used by the government but the welfare analysis focused mainly on the export tariff.

Under reasonable assumptions, results here suggest that the optimum export tariff fell in the 96.2%-126.5% interval but the government levied only 16.6% on average in the years for which data were available (1870-1910). Had the government imposed the optimum export tariff, welfare could have been increased as much as £341,444 per year from 1891-1910, equivalent to 1.89% of Amazonian GDP in the period. This welfare would

[349] Another possible explanation for a lower export tariff than the optimum level could be given by Grossman and Helpman (1995). It is possible to construct a model with two opposing lobbying groups, say export houses and intermediaries. Assume that export houses and intermediaries have opposing goals concerning the export tariff. Whereas the former would lobby against the tariff, the latter would support it, as they would supposedly be the main beneficiaries of the redistribution of rents via public goods. It is possible that export houses lobbying power could partly cancel off intermediaries lobbying power, leading to a suboptimal outcome.

have been generated on top of 1.80% that had already been generated by the government when it set the export tariff at 18.9% in the same period (1891-1910).

However, the ability of the government to tax was constrained at national, regional and local levels. At the national level due to pressure stemming from the Federal government which was more worried about national interests, and probably more with consequences on the Brazilian south-east coffee producing region. The disputes over rubber proceeds between Pará and Amazonas states further constrained the ability of these governments to set the tariff at the optimum level, leading to a suboptimal outcome. Finally, at the local level, pressure groups were also constraining optimal tax policies. Indeed, the political economy of the taxation at the local level further indicated that in fact the government may have maximised its revenues, but not the regional welfare, when it set an export tariff well below its optimum level. Yet, given the lack of evidence on lobbying costs, and the difficulty in assessing access to government, there might have been other reasons to explain why the government set an export tariff below the optimum level. One obvious reason may have been that the government did not know how high the optimum tariff was and it was constrained in some way to test the market to find the right level. Another possible caveat of the simple model presented here would be the cost of setting up the rebate mechanism as the government would have to know how much rubber each exporter was sending abroad and come up with some way of repaying everyone back. As the section shows though, this rebate may have been sanctioned through the provision or subsidisation of public goods, notably in transport and communication.

This chapter stresses the fact that Brazilian Amazon State governments were indeed increasing the welfare of the region through taxation, no matter how competitive the rubber market was. Moreover, the results further indicate that there was room for the government to extract monopoly rents even in a context of high inelasticity of Brazilian rubber supply. Here, the high inelasticity of supply plays a double role: at the same time that it decreased the welfare effect of taxation, it prevented immiserising growth from happening. Therefore, the results indicate the extension of market power Brazil possessed in rubber market and suggest that the government could have ensured the maximum internal welfare at rubber consumer's expense. This conclusion seems to contribute a great deal for the debate about the rubber boom in the Brazilian Amazon and about taxation in general.

First, the Chapter presents an interesting case in which taxation may have been very beneficial for the Brazilian Amazon. Through taxation, the region was able to increase its welfare, even though the best scenario would have been the one in which the government agrees with some sort of rebate or in which it increases its social and economic expenditure. This could be regarded as equivalent to an indirect rebate. This is patently a case in which the government was not detrimental to welfare as, for instance, in Clarence-Smith's cocoa chain.[350] Secondly, the Chapter also contributes with a simple model that shows that it is not always clear that the government should set the export tariff at the optimum level because depending on the domestic political economy of taxation, maximisation of welfare and maximisation of government revenues may differ. Thirdly, the elasticities of demand computed here expand our understanding of the developments taking place in the industrialising countries, especially in the USA and in Britain which were the main rubber consumers. From 1870 to 1910, rubber found more and more uses and became an increasingly strategic commodity: with such an inelasticity of demand it is possible that developments in the Brazilian Amazon were influencing the development of rubber industrial process in the USA and in the UK. These findings are quite different from GCC/Wallerstein approach (see further below). Moreover, dependence on rubber pushed the Amazon region into such a specialisation of production that the region became virtually a monoproducer of rubber importing everything else. Therefore, the region is an interesting case study of trade specialisation due to comparative advantage in which, as explained before, immiserising growth did not occur.

This trade specialisation changed the pattern of integration of the region into the world economy. However, the chapter supports the Frank and Musacchio's view that there was no economic imperialism in the Amazon as the rubber chain does not fit into the

[350] Clarence-Smith (2000).

model of peripherality of raw material and centrality of manufacture.[351] This traditional formulation is at the heart of the GCC approach and it suggests that production in the periphery (Brazil) should have developed in tandem with impulses emanating from the industrial core (USA and Europe). That pattern would ensure that profits in the periphery would either be held down (so as to maximise profits at the industrial core) or be high in order to ensure profitability from investments flowing from the industrial core. It is not surprising that for a quite long period, given the high inelasticity of demand for Brazilian rubber, manufacturers in the core economies were tied to developments occurring within the Brazilian Amazon, diametrically contrary to the traditional assumption of economic imperialism.

However, economic imperialism cannot be completely dismissed since the tax policy was constrained at three different levels, and especially by the (foreign) export houses' lobby. It is true that not all export houses were foreign-owned or foreign-managed but whenever they were not, they might have relied upon a cooperative local elite. In sum, government seemed to be maximising its revenues, given the pressure from export sector and the latter's imperfect access to the government, but there should be no doubt that the government could have reaped much more monopoly profits than it actually did.

In sum, the chapter contributes not only to the understanding of the effects of taxation and its political economy but also to the economic history of the Amazon region. In providing the first measure of elasticity of demand for Brazilian rubber and carrying out, also for the first time, a welfare analysis, the chapter showed that there was room for extraction of monopoly rents from rubber trade even in a context of high degree of competition in the market and without harming the economy as whole, that is, there was no immiserising growth. The chapter has brought the role of the government to the fore by analysing the impact of taxation on the region's welfare.

[351] Frank and Musacchio (2006).

6. Communication and Shipping: The Integration of the Brazilian Amazon

6.1 – Introduction

Due to a combination of quantity and quality, the Brazilian Amazon emerged as the main crude rubber producer, accounting for 60% of the market from 1870 to 1910. As seen in Chapter 2, the demand for crude rubber increased very fast, following the application of this raw material into more and more (new) products. The demand took an exponential trend especially after rubber tyres began to be applied in the motorcar industry. Supply did not follow demand and the ensuing crude rubber famine meant that demand for rubber became very price inelastic. Even though capital was channeled from the rubber manufacturing industries to the rubber gatherers along the rubber chain (see Chapter 3), labour was very scarce throughout the period as shown in Chapter 4. The supply of crude rubber was indeed very inelastic to labour, preventing market forces from balancing supply and demand despite the massive inflow of immigrants (mostly from other parts of the country) to the Brazilian Amazon. Additionally, labour supply might have prevented the economy from suffering immiserising growth.

Taxation also took the Amazonian economy out of the immiserising growth path. According to Chapter 5, the government was able to extract monopoly/oligopoly profits out of the rubber chain even in a context of perfect competition in all nodes of the chain located within the Brazilian Amazon. Through taxation, the government changed incentives to production pushing the Amazonian economy closer to the monopolistic position. Institutions, however, constrained the ability of the government to extract all possible rents and the resultant political economy of taxation meant that the economy was in a suboptimal outcome. The government accumulated considerable wealth that was partly redistributed back to the region in form of investments and subsidies. These funds were instrumental to develop two supporting activities: telegraphs and steamships.

The present chapter analyses the role of the government in the communications sector and the consequent impact on the rubber chain. It is argued that steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported even further the development of the (steam) navigation and the telegraphic system. Government investment and support was instrumental to the creation of this virtuous cycle that resulted in biased integration of the Brazilian Amazon. Based on entirely new data collected in London, Rio de Janeiro and Belém, this subject is explored for the first time within the Brazilian Amazon context. Even though data here could allow the computation of social savings, the chapter will not carry out such analysis, leaving it for future research.[352]

The Chapter is organised into 6 sections, including this introduction. Section 6.2 describes the development of the mail and telegraphic communication in the Brazilian Amazon, highlighting their reliability, speed and cost. Section 6.3 analyses the evolution of ocean navigation, emphasising the introduction of steamship liners and their later domination of the trade with Belém and Manaus. The connection between telegraphic communication and steamship navigation is also explained. Section 6.4, in turn, reviews the development of river and coastal navigation showing that costs were high due to the risk of navigation and market power. Section 6.5 then analyses what impact steamships and telegraphic communication had upon integration of the region within the Brazilian context. Section 6.6 concludes the chapter.

6.2 – Communication: Mail and Telegraphs

As explained in the introduction, the present chapter analyses the role of the government in the communications sector and the consequent impact on the rubber chain. As will be shown, government investment, support and regulation was instrumental to the creation of a telegraphic and postal system connecting the Brazilian Amazon with the main rubber consumer markets and with the Brazilian capital. This communication network partly overcame geographical distances. However, despite geographical proximity to the USA, throughout the rubber boom the Brazilian Amazon was more directly and reliably connected with Europe and Rio de Janeiro than with the USA. As the next

[352] Social savings methodology is based on seminal works of Fogel (1964) and (1979). For Brazil, there are two interesting references on the subject of social savings brought about by railways: Summerhill (2003) and (2005).

section will show, this bias against the USA also affected the shipping connections between the Brazilian Amazon and the main rubber consumers.

The establishment of an organised national postal system in Brazil dates back to 1808 when the Portuguese Royal family fled from the Napoleon army and transferred the capital of the kingdom to Brazil, more precisely to Rio de Janeiro. During their stay, several postal lines were opened connecting the hinterlands and some provinces to Rio de Janeiro. As a consequence a Postal Administration (not yet fully centralised though) was opened on 22nd November 1808. However, the Amazon region still waited 5 more years to see the establishment of its postal system: it was initially centred at São Luís (Maranhão), from which it reached the backlands. Following the defeat of Napoleon, D. João VI was proclaimed King of Portugal and the capital of the Portuguese Kingdom was re-transferred to Lisbon. In 1822, the son of the Portuguese King, D. Pedro, declares Brazilian Independence from Portugal being acclaimed Brazilian Emperor but, despite this political shift, the organisation of the postal system remained basically unchanged until 1828 when all postal lines were unified into a single administration placed in Rio de Janeiro. In 1842, already under the Second Empire (1840-1889), the Brazilian postal system was again reorganised following the English model (imposing pre-payment of letters through postal stamps) and in 1877 the country joined the General Postal Union that had been established in 1874 (in 1879, this postal agreement became known as Universal Postal Union), enabling the country to exchange mail easily with all member countries.[353]

Postal services are important not only because they represent the exchange of information but also because their statistics may be used as proxies for income or economic activity.[354] Even though the thesis does not include an estimation of regional income based on such evidence (not least because GDP estimates were already computed based on more solid data, as presented in the Appendix), postal services still

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[353] There are very few information on the origins of the Brazilian Postal System and basically nothing on its economic impact. Information here was obtained from *Correios* (Brazilian postal System) website:
http://www.correios.com.br/institucional/conheca_correios/historia_correios/historia_correios_brasil.cfm

[354] See for instance Bairoch (1976) and Good (1994).

provide evidence of increasing economic activity in the Amazon region during the rubber boom. From 1870 to 1910, the postal service handled an increasing amount of letters and printed matter. By 1906, the post office in Belém received 12,983 and sent 8,834 mail packages, transferring additional 2,947 mail packages. In terms of letters, 6,330,531 letters were handled in Belém, out of which 300,213 were registered without mention of value and 8,668 with mention of value. Apart from mails and telegraphs (see below), the Brazilian Postal System also performed financial transactions through postal orders (*vales postais*): in 1906 the postal service took charge of 4,865 money orders amounting to £42,392 and received 1,637 money orders of total value of £17,424. This increasing mail traffic was more and more handled by steamers, making postal services a more efficient, reliable and faster means of communication.[355]

During the rubber boom, land telegraphs[356] were mostly managed by the postal service but there were also some private companies.[357] Telegraphs were established first in the capital of the Brazilian Empire and evolved following government's demands for communication among the ministries and main state facilities located there. On 11th May 1852, the first telegraph line was inaugurated. Managed by Guilherme Schüch, future Viscount of Capanema, the line connected the Quinta Imperial to the Quartel do Campo, two military facilities in Rio de Janeiro.[358] Three years later, the first inter-city telegraph line connecting Rio de Janeiro to Petrópolis, the summer capital, was inaugurated, having 50,630m of cables, of which 14,970m were under water.[359] Fostered by the Paraguayan War (1865-1870), the Imperial overland telegraph system initially developed faster

[355] *Álbum do Estado do Pará* (1908, pp. 216-217).

[356] The discussion here refers to the electrical telegraph only. Optical telegraphs had long been operating in Brazil. Their construction followed the arrival of the Portuguese Royal Family in Rio de Janeiro in 1808. The first line was opened in 1809 connecting Rio de Janeiro to Cabo Frio. The purpose of the line was the communication between these two ports. See Silva and Moreira (2007, p. 48).

[357] Most private land telegraphic lines were operated by railway companies. However, in 1896, they were all incorporated into the Federal Land Telegraph system. See Berthold (1922a, pp. 21-22).

[358] Berthold (1922a, p. 4), Vasconcellos (2002) and Silva and Moreira (2007, pp. 49-51).

[359] Actually, Berthold (1922a, p. 5) states that the Rio-Petrópolis line was opened in 1858 but Silva and Moreira (2007, p. 54) showed that it was inaugurated in 1857 instead. Berthold's mistake is likely to have been originated from the fact that the information he got was obtained from a 1858 document that referred to the previous year.

towards the south region of the country[360] and only after the war had ended was it slowly but continuously extended along the Brazilian coast northwards. In 1874, the cables arrived at Salvador (in Bahia) and in 1881, reached Fortaleza (in Ceará). In 1884, the connection with São Luís (in Maranhão) was established and two years later Belém was finally incorporated into the system. [361] In 1891, government telegraph lines began to expand towards the hinterland reaching Cuiabá and Corumbá. In the following years, more precisely from 1907 to 1915, Marshall Rondon installed a connection between the Mato-Grosso and the Amazonas States (today Rondonia).[362] Therefore, by the end of the rubber boom, in 1911, the government overland telegraph system possessed nearly 61,000 kilometres of cables and connected the main cities in Brazil (see Figure 6.1 below). As a consequence, the number of messages exchanged soared from 233 in 1861 to 751,000 in 1890 and 3,700,000 in 1912 (see Figure 6.1 below). Despite its rapid growth, the development of the telegraph in Brazil seems much less impressive in an international perspective. For instance, Argentina, a much smaller albeit richer country, possessed over 200,000 km of wire in 1912 through which 8.6 million telegrams were exchanged. Indeed, as early as 1871, more telegrams flowed over national wires in Argentina than in Brazil.[363]

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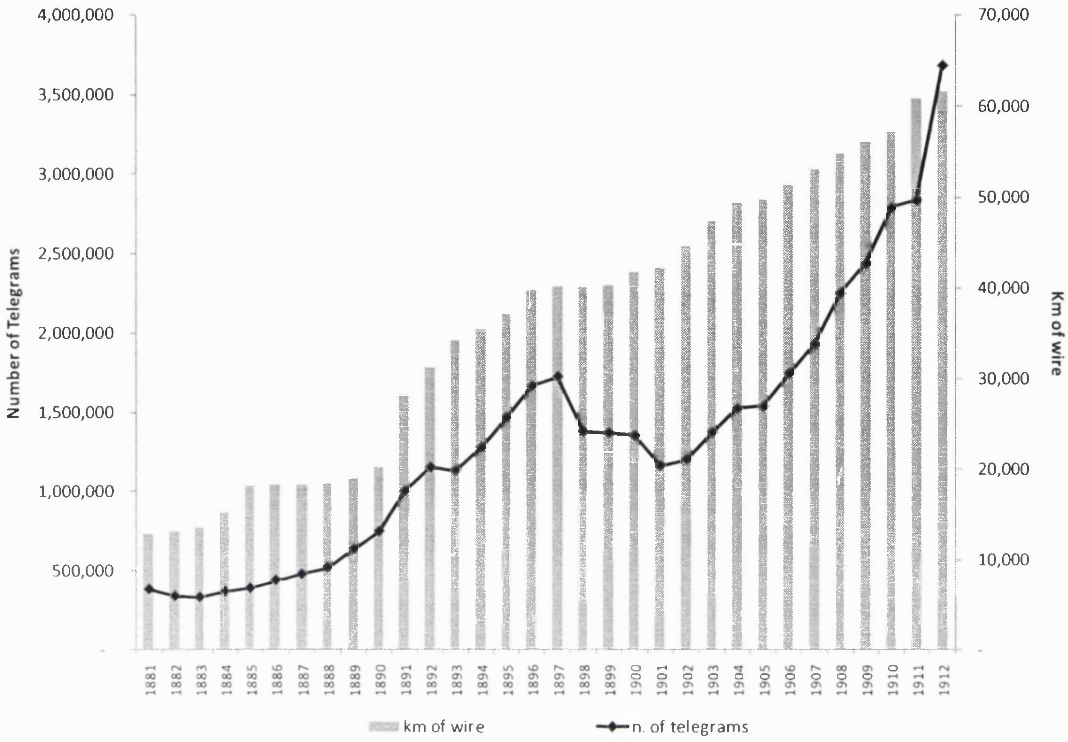
[360] In 1866, the line connecting Rio de Janeiro to Porto Alegre (located at the South of the Brazilian territory) was opened. See Berthold (1922a, p. 7) and Figure 6.2 further below.
[361] Berthold (1922a, p. 7-9) and Vasconcellos (2002).
[362] Diacon (2004, pp. 19-51). The line connected Cuiabá (and consequently Rio de Janeiro) to Madeira River, an important waterway for Acrean and Bolivian rubber production.
[363] Berthold (1922b, pp. 7; 37).

Figure 6.1: Kilometres of Wire and Number of Telegrams Sent, Brazilian Government Land System, 1881-1912



Source: elaborated from Berthold (1922a, pp. 16; 30). Number of telegrams for 1896 and 1897 were estimated based on the trend between 1895 and 1898. The decline in number of messages in 1895 seems to be derived from the change in the way the tariff was computed with additional cost for messages crossing States. See Berthold (1922a, p. 24).

In parallel to the government overland telegraph system, private enterprises were also granted permission from the government to operate in Brazil, giving rise to competing lines as well as different routes, especially through submarine cables.[364] In January 1873, the Brazilian Submarine Telegraph Co. was established aiming to connect Brazil with Europe. Later that year, the first section of the Atlantic cable (620 miles) was already laid from Lisbon (Carcavellos) to Madeira and in the following year, the remaining two sections, Madeira-St. Vincent (Cape Verde Islands, measuring 1,260 miles) and St. Vincent-Recife (in Pernambuco – Brazil, measuring 1,830 miles) were completed, opening the traffic between Brazil and Europe in June 1874. This system was placed in communication with

[364] The Brazilian submarine telegraph expansion should be viewed in the context of worldwide expansion of this means of communication. For instance, see Headrick and Griset (2001).

Great Britain by means of the Eastern Company's line from Lisbon to Porthcurno.[365] Indeed, an agreement had been signed with Eastern Telegraph Co. that provided full access to their lines, putting Brazil already in connection with China, Japan and Australia as well.[366] Due to increasing traffic, the sections Lisbon-Madeira and Madeira-St. Vincent-Recife were duplicated in 1882 and 1884, respectively.[367] However, there was initially no direct connection to the United States and the flow of messages had to go to England first to be then retransmitted to the USA.

The connection from Recife to the rest of Brazil, and especially to Belém (Pará), was initially set up by the Western and Brazilian Telegraph Co. which was incorporated with the purpose of laying cables connecting the main ports of Brazil and worked in unison with the Brazilian Submarine Telegraph Co.[368] The connection between Pará and Rio de Janeiro, along the Brazilian coast, was initially supposed to have only three sections: Pará to Pernambuco, Pernambuco to Salvador (Bahia) and Bahia to Rio de Janeiro. However, when the cables were laid in 1873, another station was included, São Luís in Maranhão.[369] The cables had a total length of 2,500 nautical miles and did not suit very well the topography of the Brazilian coast, especially in the northern section. As the cables were laid in shallow waters, they were particularly subject to fish attacks.[370] Therefore, even though by 1873 Pará was already connected to the capital of the Brazilian Empire, Rio de Janeiro, the connection was still unreliable.[371]

In the following year, the submarine cables were extended southwards from Rio de Janeiro to Rio Grande do Sul, touching Santos and Florianópolis. In 1875, the cables

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[365] Baglehole (1970, pp. 6-7) and Ahvenainen (2004, p. 95).
[366] Ahvenainen (2004, p. 96) and Brazilian Submarine Telegraph Co., Report of the Directors, 1973. The agreement with Eastern Telegraph Co. was facilitated by the fact that the same investor was behind both companies, John Pender. Therefore, submarine cables in Brazil should be regarded in this more comprehensive expansionary plan of the Eastern Telegraph Group around the globe.
[367] Baglehole (1970, p. 7). The duplication of the Recife-Lisbon line was probably due to the several small interruptions in the flow of messages. After the company decided to lay a new cable, two major disruptions occurred: from 22nd September 1883 to 4th December 1883, and from 2nd to 28th of March 1884. See Brazilian Submarine Telegraph Co., Report of the Directors, 27th October 1882, 4th May 1883, 26th October 1883, 23rd April 1884 and 31st October 1884.
[368] Both concessions (Portugal-Brazil and along the Brazilian coast) were owned by the same group of investors who had John Pender as the central figure. See Ahvenainen (2004, pp. 65-66).
[369] Ahvenainen (2004, pp. 67-68; 79).
[370] Bright (1898, 124-125).
[371] For instance, in 1884 the Commercial Association of Pará complained about the unreliability of the submarine telegraphic system as well as about the delays in establishing the connection via land through the government overland telegraph system. Commercio do Pará (1884, p. 12).

were extended even further down to Montevideo, via Chuí.[372] From Montevideo to Buenos Aires, there were two competing lines that were both absorbed later by the Western and Brazilian Telegraph Co. From Buenos Aires, there was a land connection to Valparaíso (on the Chilean coast), which, in turn, was to be soon connected to Chorillos, near Lima, Peru, in 1876. In 1882, this connection was extended by the Central and South American Telegraph Co., reaching the west coast of the United States, and thence the US land telegraph system.

Therefore, as shown in Figure 6.2 below, in 1882 Pará and the rest of Brazil was connected to the USA only via Europe or Argentina. Therefore, regarding communication, the Brazilian Amazon was closer to Europe, notably to Great Britain and Portugal, and Rio than to the United States, despite the fact that the (navigating) distance between Belém and Rio was nearly the same as between Belém and New York. The distance between Belém and Liverpool was almost twice as large.

[372] Baglehole (1970, p. 7).

Figure 6.2: Main Telegraph Connections in 1882

Source: elaborated by me. The map was drawn using modern borders. Moreover, it only shows approximate location of main cities and cable nodes. Note that in 1882, Belém was only connected via submarine cables, as the land connection was only established in 1886. See text for details.

There had been a connection between Belém and New York (by the Central American Telegraph Co.) which was nonetheless discontinued in 1876, following only two years of troublesome operation. This line was successfully completed only in 1891 by a French company. *La Société Française de Telegraphes Sous-Marins* laid out cables connecting Pará (and by extension the rest of Brazil) to the Central American and North American systems. This company connected the French West Indies to Cuba and thence to the United States (from where messages could be sent via the inter-Atlantic systems) but also laid out cables from French Guyana to Viseu/Salinas (in Pará, Brazil) which, in turn, was connected to Belém (and the rest of Brazil) via land lines.[373] This new connection Pará-United States put the region in a doubly-secure position in regard to its communication with Europe since in case of problems with the connection through Recife, communication with Europe could flow via the United States.

In October 1892, another route between Brazil and Europe was opened as the Brazilian Submarine Telegraph Co. started to face competition from the South American Cable Co. which laid out a competing cable, connecting Recife to Senegal (touching Fernando de Noronha Island) and thence to Canary Islands, Gibraltar, Vigo and finally Great Britain.[374]

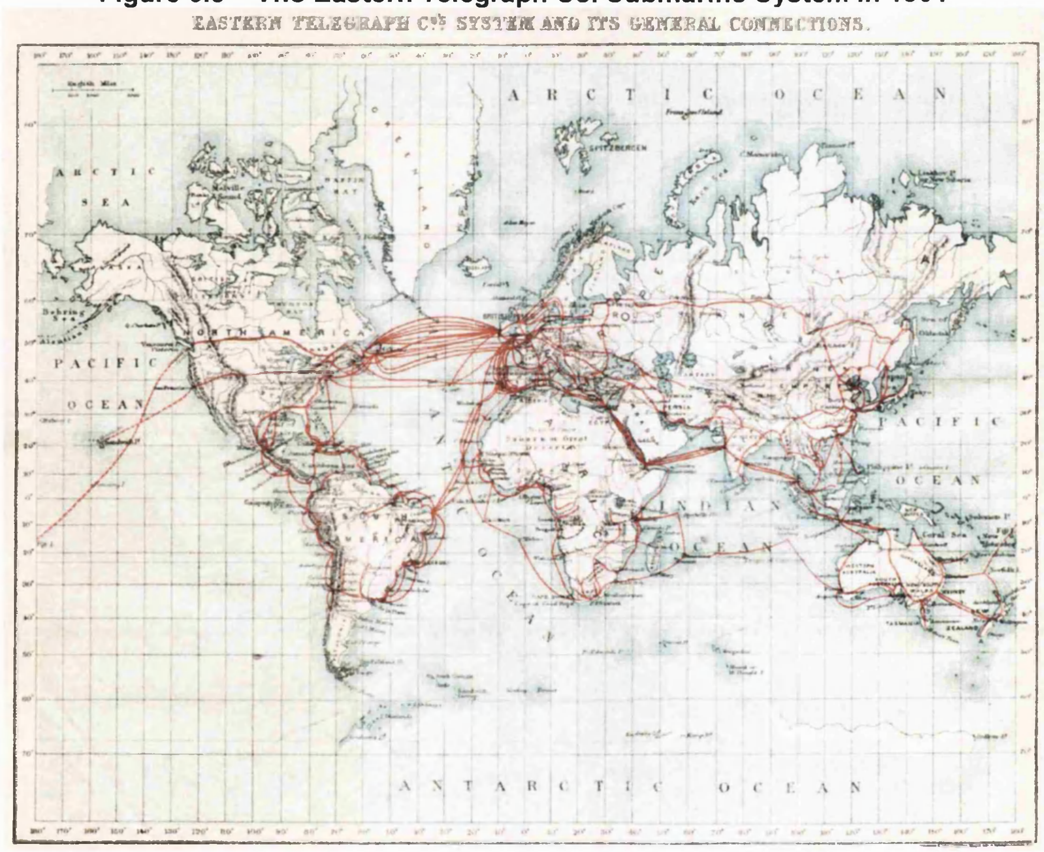
By the early 1890s Belém was connected to Rio via submarine cables and an overland system. Along the way both routes touched Recife which was the hub that connected Brazil to Europe. The United States, in turn, could then be finally reached directly via the French cables in the Caribbean even though that route was somewhat problematic as messages were sent through several different telegraphic systems before reaching their final destination.[375] Therefore, the connection with the United States was still less reliable than the connections with Rio de Janeiro and Europe, not least because these latter routes were eventually doubled and/or tripled. Different routes could be used to reach one specific destination in case of technical problems: for instance, the United States could also be reached through Europe and through Argentina whereas, conversely, Europe could be reached through two different companies as well as via the United States. However, connection to the Amazonian hinterland still needed to be carried out.

In this regard, in 1895 the Western Brazilian Telegraph Co. through a subsidiary, known as the Amazon Telegraph Co., connected Belém to Manaus. The total length of the cables was over 1,300 nautical miles and most of this system was placed on the Amazon

[373] Bright (1898, pp. 137-140).
[374] Ahvenainen (2004, p. 207) and Bright (1898, p. 133).
[375] Bright (1898, p. 138). Furthermore, the topography of the Caribbean was not very suited for submarine cables, causing constant interruptions too.

river bed. The line, however, suffered from constant problems[376], especially in the upper waters as currents and debris scoured out the bottom, leaving the cable unburied in places. The solution was to bury the cable even deeper although this usually brought difficulties and delays when repairs were taken. The connection to other Amazonian outposts was made by wireless stations, established in 1900s.

Figure 6.3 – The Eastern Telegraph Co. Submarine System in 1901



Source: Eastern Telegraph Company System Map from A.B.C. Telegraphic Code 5th Edition. Available at: http://www.atlantic-cable.com/Maps/index.htm.

During the last 10 years of the rubber boom, 1900-1910, the reliability and the speed of the system improved even further. In 1900, in order to speed up the traffic from Belém to Europe, a cable was laid connecting Belém straight to Recife.[377] Additionally, a

[376] For instance, in 1900, the British Consul stated that the telegraph line between Belém and Manaus had been repaired in the spring of 1889 after two years of interruption. See *UK Diplomatic and Consular Report, Annual Series, n. 2580, Brazil, Report for the Year 1900 on the Trade of Pará and District.*

[377] As explained earlier, the connection between Recife and Belém was not direct (there was an original station in São Luís, see Figure 6.2) and a station in Fortaleza was added some time after 1873. See Lesage (1915, p.108).

third cable was laid between Recife and Rio de Janeiro (the second cable had been laid in 1891-1892). The consequence was that in 1900, some 75,000 telegrams were received or sent in Pará and 1907 this amount had jumped to more than 80,000 telegrams.[378]

In sum, by 1913 Pará had access to several telegraphic systems: 1) the French Cable, Compagnie de Cables Français Telegraphiques, from Pará to Cayene, connecting with Haiti and New York; 2) the Western Telegraph Company[379], from Pará to Pernambuco, St. Vincent and Lisbon, and also coastwise to Buenos Aires and Valparaiso; 3) the South American Cable Company Ltd, from Pará to Pernambuco by landlines and cable, thence to Fernando de Noronha Island, Dakar and thence to Cadiz; 4) the German Cable Company (*Deutsch-Südamerikanische Telegraphengesellschaft*)[380], from Pará to Pernambuco by cable and land lines, thence to Monrovia, Dakar and Brest; 5) the Amazon Telegraph Company, stations at Pará, Santarém and Manaus; 6) the Government overland telegraph system, coastwise from Pará to Rio Grande do Sul and Salinas (via Rio de Janeiro); 7) Bragança Railway Company, from Pará to Bragança; 8) Wireless telegraphic communication to Santarém, Manaus, Sena Madureira (in Acre Territory), Cruzeiro do Sul (Acre), Tarauaca (Acre), Rio Branco (Acre), Porto Velho and Xapury.[381]

This development of the overland telegraphic system was initially a government driven enterprise following the need of the state to exercise a tighter control over the region. Politically, a civil war (1835-1840) in Pará had evinced the weakness of the central government's control over the region and the Paraguayan War (1865-1870) did the same in regard to the central region of Brazil, especially in the Mato Grosso Province/State. Indeed, the telegraph was promptly used by the Brazilian government for political reasons, not least as a weapon of war. As mentioned earlier, the telegraph developed faster as a consequence of wars (especially the Paraguayan War). During a Revolution in Rio

[378] Pará (1908, p. 216).
[379] This company was the result of the merge of the Western and Brazilian Telegraph Co. and the Brazilian Submarine Telegraph Co. that took place in 1899. See Baglehole (1978, p. 12).
[380] This connection was established only after the rubber boom, in 1911, and then the interest on its impacts for the purpose of the paper here is more limited. For a discussion on the German telegraphic cables to Brazil, see Lesage (1915).
[381] See *United Kingdom Diplomatic and Consular Reports*, Brazil, Reports for the years 1910-12 and part of 1913 on the Trade of Pará, n. 5262, Annual Series, March 1914.

Grande do Sul, the most southern State of Brazil, the government censored and controlled the flow of messages via the Western Telegraph cables.[382] Moreover, with the telegraphic system, the central government became more accutely aware of Amazonian needs, enabling it to react more promptly. Government directives could arrive at Pará quicker, limiting the possibility of conflicting policies between the central and the Provincial/State governments. The flow of news also became a reality as the region became more aware of what was going on in other regions of the country (as well as in other countries). [383] Analogously, other regions became more aware of what was happening there, and news of the rubber boom would attract people from other parts of the country, notably from Ceará Province/State. In communications as a whole, the government acted proactively: the state was at the same time regulator and provider of services.

However, the development of the telegraphic system was also supported and fostered by domestic and foreign business groups that foresaw the usefulness of the communication system to enhance trade activities.[384] In this regard, one aspect that has been overlooked by the literature is precisely the importance of the telegraphic system in

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[382] The Revolt known as *Revolução Federalista* (Federalist Revolution) lasted from Feb. 1893 to Aug 1895. Several letters sent to Western Telegraph Co. by the *Directoria Geral dos Telégraphos* (Brazilian National Telegraph Administration) show that the government enmeshed with the Company's businesses. The government ordered the closure of the telegraph line connecting that province and or censured the messages wired. See for instance the letters dated 21st July 1893, 29th July 1893, 6th September 1893, 19th September 1893 and 30th September 1893.

[383] From newspapers, it is possible to see that after the telegraph, the news arrived in Belém with fewer lags. Moreover, arrival of ships were constantly cabled to and advertised in Belém and banks based their exchange rates on Rio de Janeiro quotes. There must be no doubt about the importance of the telegraph for the rubber trade. For instance according to Pearson (1911, p. 42),

> *"During the crop season in Pará the operators are in constant communication with their principals in Europe and America, and in semi-constant touch with their houses in Manáos.Each company has its own cipher. None of them know each other's cipher; whether they know the rest of their numerals, it is hard to say."*

Pearson makes direct reference to telegraphs and indirectly emphasises the continuing lack of communication between Manaus and Belém. For instance, Weinstein (1983, p. 204) quotes Augusto de Montenegro, governor of Pará, who a little bit earlier, in 1902, claimed

> *"(...) that Manaus's lack of proper storage facilities and unreliable telegraphic connections had led to a highly damaging accumulation of stocks, and a general disequilibrium in the rubber trade – a view seconded by the Commercial Association of Pará"*

[384] See Ridings (1983).

the development of steam navigation in the same way as it did with railways. This aspect is particularly important for the Amazon region because rivers were the main trade routes as the geography of the region prevented the development of a large railway system. It is important then to understand the relationship between telegraphs and shipping, especially in the Amazonian context.

6.3 – Ocean Navigation

Steamships preceded the telegraphs in most international routes (not so much in the rubber trade though) and consequently time savings had sometimes been achieved before the spread of transatlantic telegraphic communication from the 1870s onwards.[385] However, telegraphs provided the basis for the further development of steamship navigation. Telegraphs meant that the owners of a cargo ship could communicate with a captain whenever a ship reached a port, and shippers could keep track of their shipments. Since steamships were very costly to build and operate, cable communication would then allow profitability as ships could be continuously transporting full loads of cargo. Moreover, the idle time at a certain port could be minimised. Without a cable connection in the port, it would have been difficult for ship owners to maximise their profitability and hence less steamships would have touched that port. Ultimately, telegraphs would cause or strengthen a declining trend in freight rates. Even though the relationship between telegraphs and freights have not yet been established quantitatively[386], freight rates declined concomitantly with the development of submarine telegraphy.

For instance, North shows that freights declined from 1870/3 to 1908/9, with the trend being particularly important in long haul routes. As will be shown here, this decline did not happen in the Brazilian rubber trade as nominal freight rates were slightly higher in 1910 compared to 1870. Indeed, North did not evaluate the rubber trade as his ocean

[385] See, for instance, Kaukiainen (2001).
[386] The only quantitative work on this relationship is that of Lew and Cater (2006). The authors establish this causality through a gravity model which has the number of telegrams as one of the explanatory variables. They found that the telegraph is strongly correlated with trade expansion before the First World War. However interesting their results are, they need to be taken with caution as they did not use the number of telegrams sent to the trading partner but rather the total number of telegrams handled by the country's network.

shipping routes were concentrated in a few bulk commodities: coal, wheat, timber and sugar. Due to their low value, North's freight factors (freight rate divided by commodity CIF price) were usually very high in stark contrast with rubber freight factor: this commodity was so expensive that its freight factor was very low indeed. Whereas the freight factor could have been as high as 50% in the case of timber, in rubber it was often below 1%. Finally, North states that the ocean freight market was generally very competitive.[387] As will be shown here, the rubber trade did not show too much competition as one company (Booth Line) held a large market share of rubber shipments. Despite contemporary outcry against monopolisation of the overseas shipping in the Brazilian Amazon[388], there is evidence that the company may not have been able to enjoy substantial oligopolistic profits due to market contestability.

Several other studies have reached a similar conclusion to North[389]: they suggest that freights were decreasing from 1870 to 1910. For instance, Harley shows that freights decreased rapidly after the 1860s due to mechanical and metallurgical advances in shipping. Therefore, Harley challenges North's assumptions that the declining in freights was due to organisational changes.[390] Shah Mohammed and Williamson confirm a sharp fall in freights for the period 1869-1913 whereas Jacks suggests that shipping costs fell throughout the nineteenth century.[391] Most of these papers rely on the famous Isserlis Index for British freight rates that is criticised on the basis of being constructed from *ex-ante* published rates (instead of actual price paid for the service), integrating sail and steam, and depending on *ad hoc* weighting.[392]

The shipping literature does not provide the basis for explaining shipping in the Brazilian Amazon even though the results here will strengthen Harley's conclusions about

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[387] North (1958).

[388] For instance, the British Consul in Pará stated in 1912 that

> *"There is, therefore, now no competition in the overseas traffic between Manáos and Pará and Europe and the United States. Return fares and other reductions have been abolished, and the regular services made less frequent, as noticed above".*

[389] North (1958).

[390] See Harley (1988). See also Harley (1970) and Harley (1980).

[391] Shah Mohammed and Williamson (2004) and Jacks (2005).

[392] Isserlis (1938). For criticisms on this index see Armstrong (1994), Kaukiainen (1990), Yasuba (1978) and Brautaset and Graffe (2006).

the transatlantic meat trade: rubber trade was also dominated by liners, ensuring orderly distribution and economies of scale.[393] As a consequence of the increasing demand for raw rubber, the further development of commerce in the Brazilian Amazon required the establishment of a reliable overseas transport system. A few steamship liners would come to dominate the trade impacting on freight rates and travel time between Belém/Manaus and the rest of the world. Hitherto, the region had been historically more connected with foreign countries than with the rest of Brazil, due to maritime currents and winds but steamships would overcome natural boundaries decreasing travel time for all routes and markedly for those routes along the Brazilian coast.[394] Like telegraphs, steamship navigation was initially driven by the government, which offered subsidies to shipping companies.[395] Shipping was developed even further by national and foreign business groups.

Around the 1850s, the Amazonian economy was incipient being concentrated more and more on the collection of products from the Amazon forest, notably rubber. Products that had played an important role in the past, such as sugar and cotton, were declining[396] and thus the ocean traffic reflected exactly that. The Amazonian trade lacked dynamism and then a few small ships per year generated and sustained the poor development of the region's export sector. Figure 6.4 shows that until the 1850s, usually less than 100 ocean vessels touched the Port of Belém per year whose average registered capacity, albeit increasing, was still very limited. In 1860s, the average size of

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[393] Harley (2008).

[394] It should be mentioned the difficulty imposed by Nature onto sailing vessels exploring the Brazilian North coast. Winds usually pushed ships westwards or southwards causing vessels coming from East to West (or from Recife towards Amazon River, see Figure 6.2) to speed up their voyage or crash into the coast whereas vessels coming from Amazon to Recife would speed up their voyage taking their way to Europe and then back to Brazil. Furthermore, even if they succeeded in arriving at Recife, winds and maritime currents were favourable to head south only from April to July until Cabo Frio (close to Rio de Janeiro, see Figure 6.2).

[395] See next section for details on shipping along domestic routes.

[396] See, for instance, Baena (1915, pp. 29-31). Anderson (1976, pp. 63-69) further shows that, despite the increase in the production of rubber from 1870 to 1910, the region increased the production of several other articles even if less than proportionately. More specifically, he shows that there is no statistical relashionship between production of rubber and agricultural goods to substantiate the thesis that rubber was ruining agriculture. Therefore, it is true that in relative terms the production of everything else was basically declining over time but given the spectacular rise in rubber production, it cannot be inferred that the production of other articles of trade was declining in absolute terms as some contemporaries had claimed. In this regard, see for example the *Falla* (Speech) of Sebastião do Rego Barros, president of the Province of Pará, dated 15th August 1854.

the ships increased, though the number of vessels entering the port of Belém remained relatively the same. However, although it is difficult to draw the order of causation, with the arrival of the cable system in Belém, in 1870s the annual traffic of ocean vessels jumped to 250-350 ships per year while their registered capacity continued to increase. These two factors are clearly connected: the telegraph fostered commerce (and consequently shipping) at the same time that commerce had demanded a telegraph system. As a result, by 1911, 320 Ocean vessels entered the port of Belém and their average registered capacity was 13 times higher than the average registered capacity in 1851. Table 6.4 highlights the increasing transatlantic traffic brought about by the Amazonian rubber boom from 1870 to 1910.

Figure 6.4 – Return of Ocean Vessels Entering the Port of Belém, selected years

Years	Total Number of Vessels	Registered Tons	Average Size of Vessels	N. of Ocean Vessels	Registered Tons	Average Size of Ocean Vessels
1836-1837	n.a.	n.a.	n.a.	100	13,843	138
1840-1841	n.a.	n.a.	n.a.	88	13,543	154
1850-1851	n.a.	n.a.	n.a.	84	14,701	175
1861	n.a.	n.a.	n.a.	116	72,406	624
1871	380	209,327	551	260	140,472	540
1881	n.a.	n.a.	n.a.	311	225,484	725
1891	410	472,257	1,152	n.a.	n.a.	n.a.
1901	649	690,992	1,065	n.a.	n.a.	n.a.
1902	725	772,612	1,066	252	323,617	1,284
1911	n.a.	n.a.	n.a.	320	733,862	2,293
1912	933	1,157,766	1,241	269	654,023	2,431

Source: *UK Diplomatic and Consular Reports*, several issues. n.a. = not available.

Perhaps more important than the number of vessels and their increasing size is the fact that the proportion of the trade carried by steamships increased over time and sailing boats had virtually disappeared by 1910. In 1875, 213 ships entered the Port of Belém, of which 50% were steamers.[397] Twenty years later, steamships outnumbered sailing boats by 294 units: while 399 Ocean steamers entered the port of Belém, only 105

[397] *UK Diplomatic and Consular Reports, Report by the Acting-Consul Brocklehurst on the Trade and Commerce of Pará for the Year 1876.*

Ocean Sailing vessels did in the same year.[398] In 1912, 6 sailing boats entered that port against 927 steamships.[399] Therefore, steamships and sailing vessels competed for the Amazonian trade and in view of higher operation costs (notably in a region that lacked coal), steamships were in a disadvantageous position especially before the advent of telegraphs. Up to around 1900, sailing ships still had a cost advantage *vis-à-vis* steamers and thus whenever speed was not crucial, traders would still prefer sailing ships for bulk, low value, cargo. Only with the increasing size of the vessels, steamers were able to generate enough economies of scale that shrank freight differentials, displacing sailing vessels altogether from the trade. Moreover, at first sailing ships were quite complementary to steamship navigation insofar as they were usually bringing coal to the region and leaving in ballast for the West Indies to seek homeward cargo. For instance, for the Booth Steamship Co.,

> *"[i]t had been unprofitable to carry coal to Pará in 1880s for 20s. a ton, but in 1900 this was performed for 15s. 6d. and to Manaus – 900 miles upriver – for 18s. 6d. In 1911, these rates were, respectively, 13s. and 18s. and to Iquitos, some 6,100 miles from Liverpool, 40s. a ton. In that year, coal f.o.b. Cardiff at 15s. 3d. a ton was delivered at Pará for 38s. (including port duties and discharging expenses), Manaus 42s. 11d. and Iquitos 68s. a ton."*[400]

As a result of the introduction of steamships in the overseas trade, the travel time between Belém and the major international and national ports significantly decreased: for instance, the travel time of 40 to 60 days between Pará and Lisbon was reduced to 11

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[398] *UK Diplomatic and Consular Reports n. 2140 (Annual Series), Brazil – Report for the Year 1897 on the trade of Pará and District.*
[399] *UK Diplomatic and Consular Reports n. 5262 (Annual Series), Brazil – Report for the Years 1910-1912 on the trade of Pará.*
[400] John (1959, p. 93).

days by 1893.[401] Steamships would add another feature to the Amazonian trade: regularity.

Regularity was ensured by the dominance of the trade by large steam liners. The most important company was undoubtedly the Booth Line, later reorganised as the Booth Steamship Co. In 1866, the company started operating a line connecting Liverpool to Pará (Belém), calling at Lisbon, Ceará and Maranhão. Initially the round voyage of 9,500 miles took three months, of which sixty days were spent at sea. The cost of the trip was £1,850 in total (£329 for port charges and £498 for provisions) and subsequent voyage costs appear to have been a third higher (with the proportions of the various components remaining roughly constant).[402]

Until the end of the seventies, freight carried by the Booth Line reflected the economic conditions of the region: it did not increase greatly and the basis of trade relied on cotton and sugar shipments from Ceará and Maranhão, with only occasionally nuts, drugs and rubber providing higher revenue than cotton.[403] From mid-seventies onwards, rubber became the main article of trade: not only was its price increasing fast, so that the high freight rates were at least decreasing per value of the merchandise but, as raw rubber also experienced important loss of weight during travel, speed was crucial. For instance, raw rubber from the Acre region lost 4.1% of its weight from the producing region to Belém. From other regions of Pará, it lost around 2.5% of its weight in transit to Belém.[404] Thus, the sooner the product reached the final buyer, the highest the profit from the trade that could have been accrued.

Initially, the Booth Line faced competition from two companies: R. Singlehurst & Co. (Red Cross Co.) and the Maranhão Steamship Co. However, the company reached an agreement with both of them in 1871 by which the Red Cross Line and the Booth Line integrated their Liverpool departures and also established a common list of freight and passenger rates. The Maranhão Steamship Co., in turn, was given the exclusive rights to

[401] Albuquerque (1894, p. 4).
[402] John (1959, p. 54).
[403] John (1959, p. 56).
[404] Coelho (1982, p. 61, Table 7). Data originally from *Relatório da Alfândega do Pará ao Ministro da Fazenda, em 31 de março de 1905, referente aos trabalhos desta alfândega durante o ano de 1904.*

trade with Maranhão Province and, in exchange, its steamers would not extend their voyage up to the Amazon region anymore. As a result of the agreement, freight rates increased by 25%. The highest freight rates were for rubber which during the seventies brought in between 45s. and 47s. per ton measurement.[405]

In 1880, an even more rigid timetable of ships was enforced, including the cabling of departure dates from foreign ports. Additionally, in the early 1880s as another sign of the development of the rubber boom in the Amazon, the Booth Company separated the Pará trade from the other Brazilian routes and added other routes connecting Pará to New York, Antwerp and Hamburg. These two last destinations were added in order to forestall competition from a proposed German company and from the French Lines (*Chargeurs Rêunis* and *Compagnie Postale Transatlantique*).[406]

In 1897 two new companies were trying to establish themselves in the Amazonian trade: 'La Ligure Brasiliana' and 'Andresen'. The former was an Italian concern that operated a line connecting Manaus to Genoa, calling at Santarém, Óbidos, Belém, Madeira, Lisbon, Tangier, Barcelona and Marseille. From 1897 to 1899 the company transported 5,666 passengers in its transatlantic line and 1,608 passengers in the route Belém-Manaus-Belém. The company also carried 27,412 tons of merchandise in the transatlantic trade in the same period.[407] The Portuguese Aviador House Andresen, from Porto, also opened a steamship line (from 1,500 to 1,700 tons of capacity) connecting Oporto to Manaus. The reaction of the Booth line to these two competitors was to wage a price war.

Therefore, the Booth Line was maintaining its leading position in the Amazonian trade by threatening possible competitors, cartelising the trade and merging with competing firms. For instance, when Red Cross Line first opened its service to the Brazilian Amazon, the first reaction of the Booth Line was to reduce freights and passenger fares to make its threat credible. This would either force the competing shipping company out of the trade (as it did with the French Lines) or compel it to enter

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405 John (1959, pp. 60-62).
406 John (1959, pp. 65-67; 88-89).
407 Caccavoni (1900, p. 60).

into an agreement with the Booth Line (as happened with Red Cross, the Maranhão Steamship Co. and the German Lines). The Booth Line also resorted to amalgamation/merger in order to preserve its leading position especially when the Company feared that some competitor could buy out the Singlehurst family's shares (the biggest shareholders) in the Red Cross Line when the senior partners gave signs that they wanted to retire. In 1901, an agreement was reached between the two companies by which the Booth and the Red Cross Lines would be amalgamated under the new Booth Steamship Co. Ltd. with a capital of £550,000 and a total fleet capacity of 65,000 gross tons.[408] Shortly afterwards, the interests of the Maranhão Steamship Co. Ltd were acquired (but no ships) and so was the Amazon Tug and Lighterage Co.[409] The Company would keep increasing its shipping capacity as by 1910, at the peak of the rubber boom, its overall gross tonnage reached 125,603 tons (excluding the tonnage of the Booth Iquitos Line).

In parallel, the Booth Steamship Co. also expanded its interests in the Amazon region. First, the Company held from 1897 to 1901 a quarter share in a very profitable venture, the Empreza Line, which ran a shipping service along the Brazilian coast. Other important moves of the Company were the acquisition of a substantial holding in the Amazon River Steam Navigation Co. and the incorporation of the Booth Iquitos Steamship Co. Ltd. operating a new line connecting Iquitos (in Peru) to Liverpool.[410] Additionally, the Booth Steamship Co also held, for a period, a controlling interest in the Manáos Harbour Ltd., a company incorporated to improve and manage the Port of Manaus.[411]

The extent of Booth's market power can be grasped from its market shares. In 1907, the company transported to Europe 7,445 tons of rubber and to the United States, 8,254 tons. This is equivalent to 43% of all rubber exported from Brazil (36,490 tons[412]) in

[408] John (1959, p. 96).
[409] Heaton (1987, p. 24).
[410] Heaton (1987, pp. 21-22).
[411] John (1959, p. 100).
[412] Brasil (1987, p. 309).

1907 and to 49.3% of the rubber exported from the Amazon region (32,532 tons[413]) in that same year. Its market share in passenger traffic was even larger: in 1907 the company transported 4,396 passengers in several lines, equivalent to 71.3% of total regional transatlantic passenger traffic. In this very same year, the Company registered £197,319 profit from steamers and other accounts and a total profit of £211,799 that after charging £18,000 Interest on Debenture Stock, debiting the Directors' and Trustees' Fees and writing off depreciation of the ships and other property resulted in a net profit of £70,557.[414]

As emphasised by Wallerstein and discussed in Chapter 1, monopoly and competition are useful concepts to analyse the distribution of profits along the chain. In overseas shipping, the Booth Co. might have extracted substantial monopoly/oligopoly profits. However, the ability of the company to do so was somewhat limited by contestability of the market. This was especially true in the passenger market as the elasticity of travel to passenger fare was probably much higher than the elasticity of rubber shipments to freight costs.

Through several devices, the Booth Steamship Co. succeeded in maintaining a leading position in the overseas trade between Amazonian ports and the industrialised countries, notably Britain. Nonetheless, as explained here, this leading position did not remain uncontested and several competing companies appeared, implying that the ability of the Booth Steamship Co. to manipulate freight rates and passenger fares was limited to a certain extent. In order to preserve its market share the company also threatened competitors and open new lines, as the one connecting Belém to New York. Even though the United States were the main consumer market for crude rubber, there were more regular steamships running from Belém to Liverpool than to New York, possibly due to the lack of a reliable telegraph system along the second route. As emphasised earlier on here, steamships were costly to build and operate and the lack of a reliable cable

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[413] For Acre: 11.192 tons, see LeCointe (1922, pp. 433-444); for Pará: 10.415 tons, see Weinstein (1983, p. 271) and; for Amazonas: 10.924 tons, see LeCointe (1922, p. 433). See Appendix for further data on the rubber trade.
[414] From *Booth Stemaship Co. Ltd. 1907 Report of the Directors.*

communication between Belém and New York might explain why most of the trade between these two cities was carried out in sailing vessels at first, and by a single steamship line later.

In terms of freight rates, by 1910, the Booth Co. was charging 50 shillings per ton of rubber transported from Belém to Liverpool[415] compared to 46 shillings in the 1870s[416]. Thus even though the nominal freight rate increased over time, as a proportion of the price of crude rubber it decreased substantially as the value of that commodity was increasing very rapidly during this period: from £267 per ton in 1870 to £801 in 1910 on average[417]. The transport cost from Belém to Liverpool was thus equivalent to 0.9% of the CIF price of rubber in 1870 compared to 0.3% in 1910, meaning that the Booth Steamship Co. might have been able to extract part of the profits accrued by the rubber sector through increasing nominal freight rates (in a context of decreasing operational costs) which in consequence were the result of its high market power in shipping and the inelasticity of rubber, as computed in Chapter 2. However, probably due to contestability, freight rate adjustments were not able to keep up with the pace of the increasing price of crude rubber. The same might have happened with passenger fares: the first class trip from Manaus to Liverpool was quoted at £24 2s. 9p. in 1884[418] and £30 in 1910[419]. Again the Booth Line was able to exercise its oligopoly power to ensure an increasing nominal fare in a context of possibly decreasing operational costs.

In sum, it is difficult to establish a causal relationship between telegraphs and ocean shipping. However, they were symbiotic: telegraphs decreased freight rates by allowing minimisation of travel costs whereas shipping increased the economies of scale and profitability of the telegraphic network. In the case of the Brazilian Amazon, telegraphs strengthened the dominance of the rubber trade by large steam liners, ensuring regularity, speed and economies of scale. The regulatory framework (institutions) was instrumental by allowing the exploration of the ocean traffic by foreign business

415 *L'État du Pará à Turin* (1911, p. 44).
416 John (1959, p. 62).
417 Brasil (1987, p. 309), prices are CIF. See also Appendix for further data.
418 Loureiro (1989, p. 160) converted into pounds using the exchange rate presented in the Appendix.
419 *L'État du Pará à Turin* (1911, p. 42).

groups which possessed far more capital and knowledge of the business compared to domestic business groups. Although this regulatory framework also allowed foreign business groups in routes on the Amazon river and its main tributaries, it usually forbade their participation in coastal shipping as next section shows.

6.4 – River and Coastal Navigation

Throughout the rubber boom, the Brazilian central government only allowed foreign vessels to carry out coastal shipping for a brief period of time, at the end of the Empire and in the very first years of the Republic. The biggest company in this business was the Lloyd Brasileiro, a government owned company that ran several services lines connecting the main coastal cities in Brazil with the La Plata estuary and the United States. The company possessed 62 steamers, totalling 108,000 tons of capacity (as of 1907)[420], and constantly suffered from financial problems. The internal management, usually delegated to political *protegés*, was certainly to blame.[421]

The Lloyd Brasileiro had two steamship lines connecting Manaus to Rio de Janeiro. The first one was a 'fast service' that ran twice, or sometimes three times, a month and touched at the ports of Belém, São Luís, Fortaleza, Natal, Cabedello, Recife, Maceió, Salvador and Vitória covering some 2,369 miles in about 9 to 10 days. Even though the ships were usually in good condition, according to a contemporary, the company was not able to cope with the increasing demand in passenger traffic.[422] The second line, the 'slow service', ran in the same route but touched some additional ports along the way, such as Tutoya (in Maranhão), Santarém, Óbidos, Parintins and Itacoatiara. Due to the employment of old ships on this line and to the increased loading and unloading times, the trip from Rio to Manaus usually took around 18 days. In 1914, a first class ticket in the routes Belém-Rio and Manaus-Rio was 259$ (£19) and 363$ (£22 7s. 7d.), respectively whereas the first class passenger fare between Belém and Manaus reached 102$ (or £6 5s. 9d.).

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[420] *Álbum do Estado do Pará* (1908, p. 284).
[421] LeCointe (1922, pp. 250-255).
[422] LeCointe (1922, pp. 251-252).

Coastal navigation performed a commercially important role, connecting Pará to other regions in Brazil, especially to Rio de Janeiro. However, more important than the coastal navigation was undoubtedly the river navigation which, as seen in the first chapter, was at the heart of the transportation system of the region. Because of the denseness and extensiveness of the Amazon forest, rivers were the fastest and easiest way to reach the hinterland, providing a communication system between Belém (in Pará) and Bolivia, Peru, Colombia, Venezuela and central Brazil. Rubber production mimicked early Portuguese/Brazilian territorial expansion in the region insofar as rubber estates spread along the Amazon River and its tributaries, turning them the main rubber trade arteries. The geographical position of Belém would also be important to explain the establishment of that city as the main rubber hub in the world: rubber production from the entire Amazon basin, including neighbouring countries, would be channelled through the city.

Navigation in the region was not an easy task though. Currents and rapids were common and the river system was so complex and intricate that boats could easily get lost in the region. However important river navigation was, until 1852 the fleet of boats was still very small and thus insufficient to provide the basis for a vibrant trade in the region. There was no regular steamship service and small sailboats and canoes were responsible for channelling the trade that was still very limited. In the early 1850s, the main route – Belém to Barra (later known as Manaus) – was traversed by 40 to 50 sailboats that usually took 60 to 90 days of travel (distance of 996 miles). For instance, in 1852 the value of merchandises brought from Manaus to Belém reached 27:789$000 of foreign produce and 4:509$984 of national produce. In regard to communication and commerce with central Brazil and the hinterland of the Amazon region, there were 6,000 people involved in the trade employing an armada of more than 2,000 canoes. In 1861, it is estimated that the number of canoes had increased to 4,000 but by the end of the 1880s they virtually disappeared, not being substantially employed anymore in regular trade.[423] Indeed, a

[423] Loureiro (1989, pp.147-149). In 1883, the proportion of the four most important articles of trade (rubber, cocoa, nuts and fish – pirarucu) carried by canoes to Belém was only 8.1% (in value). See *Commercio do Pará* (1884, Annex 68).

transportation revolution had already begun, rapidly displacing canoes out of the Amazonian trade.

It is possible to date this transportation revolution to 1852, when steamships started to be employed in the region, shortening distances and overcoming natural impediments to navigation (as discussed in chapter 1). Nonetheless, before foreign technology and capital could be combined to integrate the Amazon region, it was necessary to change the legal framework that regulated navigation in the Amazon River, amid foreign pressure.

The first attempt to introduce steamships in the Amazon was carried out by a US-based company called New-York Society in 1826, following suggestion of the Brazilian trade envoy to the USA, José Silvestre Rebello. However, Pará authorities barred the steamship "Amazon" at Belém harbour, arguing that the service had to be explored by Brazilian nationals or the State only. After that incident, the Provincial Treasury unsuccessfully tried to foster incorporation of steam navigation companies in the region.[424] As a result, by 1840s, steamships were not employed yet in any regular river line even though the first steamship travel in the Amazon took place in 1843 when the imperial government sent the warship "Guapiassu" up to Manaus. The trip from Belém to Manaus took 9 days 14 hours and 42 minutes much less than the usual 60 to 90 days for sailing boats[425], showing how much could be gained from the regular employment of steamships in the Amazonian trade. Only in 1852 Irineu Evangelista de Souza, Baron of Mauá, incorporated the "Companhia de Navegação do Amazonas" (Amazon Navigation Company) after he was given exclusive rights of navigation in the river as well as generous subsidies from Provincial and Imperial governments. The company would open 8 lines within the first 10 years of operation: Belém-Manaus, Manaus-Nauta (Peru), Manaus-Tabatinga, Manaus-Santa Isabel, Belém-Bayão (by Tocantins River), Belém-Chaves (at Marajó Island), Belém-Itacoã (at Marajó Island) and Belém-Soure (at Marajó

[424] Albuquerque (1894, pp. 10-11).
[425] Loureiro (1989, p. 149).

Island).[426] The service which the company provided was initially both good and extensive.[427]

In parallel with the establishment of the Amazon Navigation Company, there emerged the last defiance of Brazilian sovereignty in the region, concerning the opening of navigation in the Amazon River. With the River closed to foreign flags and the region disconnected from Brazilian economic and political domain, Britain and especially the USA started to defy Brazilian sovereignty. Although British pressure was confined to diplomacy and immediately rejected by the Brazilian government, the US press and government were more diligent, fulled by Mathew Fontaine Maury's series of articles. Maury first stated the importance of the Amazon for the commerce of the United States in an article titled "The Great Commercial Advantages of the Gulf of Mexico" and, some months later, he would put forward the argument that the Amazon valley could be used as an outlet for the US-South slave population. In his words, the Amazon would be the remedy for preserving the Union.[428] Seizing the oppportunity and under US pressure, Peru, Bolivia, Nueva Granada and Venezuela freed navigation in the river within their borders which could only be accessed through Brazil. The Brazilian Central government rushed to revoke its neighbours' dispositions denying in parallel US claim via diplomatic channels.[429] US pressure did not die out until the Civil War but the Brazilian government would still postpone the solution of the matter until 1866 when the Empire freed navigation in the river. As a result, Baron of Mauá lost his exclusive rights and two new navigation companies were incorporated, both heavily subsidised by the government: Companhia Fluvial Paraense (1867) and Companhia Fluvial do Alto Amazonas (1869). In 1874, the three companies merged and a new company was incorporated in London as the Amazon Steam Navigation Company. Eighteen years later the company also amalgamated the Pará and Amazonas Company ('Companhia Pará e Amazonas'). The company definitely strengthened its position in the region but also took measures to expand shipping facilities

[426] Albuquerque (1894, pp. 18-19).
[427] Melby (1942, p. 453).
[428] Bell (1939, p. 495).
[429] Ferreira Reis (1957, pp. 70-74).

according to demand generated by increasing rubber production in the upper reaches of the Amazon Forest. For instance, the Amazon Steam Navigation Company carried an increasing volume of trade as a proportion of the Regional GDP: from 14.2% in 1855 to 63.8% in 1870.

As a consequence, the Amazon Steam Navigation Company enjoyed a considerable market power in river transportation as it possessed by 1902 nearly 60% of total steamship capacity of Pará State (see Figure 6.3 below) but there was scope for other firms to dispute certain routes or to run others not exploited by the company. Such was the case of 'Empreza de Marajó' (subsidised) which ran river navigation in the Island of Marajó (the service was later transferred to Companhia Lloyd Brasileiro).[430] Other examples were the 'Amazon Tug & Lighterage Co. Ltd.' which covered the rivers Solimões and Madeira (English concern, not subsidised) and the Tocantins and Araguaya Co. (heavily subsidised) which ran services in those two rivers (Tocantins and Araguaya rivers). There were also several small companies and private steamboats, usually owned by Aviador Houses centred in Belém. For instance, in 1902 there were 117 steamships registered at the Belém Harbour Authorities, of which 34 were in possession of the Amazon Steam Navigation Company, the remaining vessels being pulverised in the hands of several companies (*aviadores*/intermediaries). For comparison, the second largest steamship company in 1902 was Mello & Co. which owned 7 boats only, compared to 34 of the Amazon Steam Navigation Company. Whilst total capacity of Mello & Co.'s boats was just under 2,000 tons, total combined capacity of the 34 steamships of the Amazon Steam Navigation Company was well over 27,000 tons (see Figure 6.5 below).

[430] Albuquerque (1894, pp. 27-30).

Figure 6.5 – Steamships Registered at the Belém Harbour Authorities, 1902

Companies	Number of steamships	Average capacity (in tons)	Total Capacity
Amazon Steamship Navigation Co.	34	811	27,576
Mello & Co.	7	274	1,919
A. Berneau & Co.	4	362	1,447
Martins Ribas & Co.	4	222	886
Oliveira Andrade & Co.	4	213	851
Salheiro Motta & Co.	3	525	1,576
Caetano Monteiro da Silva	3	160	481
Guilherme Augusto de Miranda Filho	3	189	568
Tocantins and Araguaya Co.	2	125	250
Cerqueira Lima & Co.	2	365	730
Montenegro & Co.	2	324	647
Hilario Francisco Alves	2	195	390
Vieira & Irmao	2	80	160
N. N. Maia	2	72	144
Other	43	202	8,705
Total	117	396	46,330

Source: elaborated from *Annuário Estatístico do Pará* (1902, pp. 36-37). The source provides data on each individual ship. It shows the number of people employed in each ship, the date and place of construction, and the type of boat (wooden, iron or steel).

The main line, Belém-Manaus, was also covered by ocean vessels which, as was already discussed, provided the link between the Amazon region and the main consumer markets of rubber in Europe and the United States. Therefore, after 1866, there was some degree of competition which was not nonetheless enough to ensure a decrease in freight rates as the Amazon Steam Navigation Co. retained a considerable degree of market power. For instance, in 1855 the freight rate for transporting 14.65kg of rubber from the Amazon Province (probably Manaus) to Pará Province (Belém) was $500.[431] Therefore, assuming 996 miles of distance, the freight rate per ton-mile of rubber was equivalent to $034 (or 0.94 pence) in 1855. In 1869, the Companhia Fluvial do Alto-Amazonas was charging a freight rate equivalent to $088 (amounting to 1.94d.) per ton-mile of rubber. Finally, in 1913 the Amazon Steam Navigation Co. was charging $053 (equal to 0.86d.) per ton-mile of rubber transported between Belém and Manaus but $178 (equivalent to

[431] *Relatorio apresentado á Assembléa Legislativa Rovincial [sic], pelo excellentissimo senhor doutor João Pedro Dias Vieira, dignissimo presidente desta provincia, no dia 8 de julho de 1856 por occasião da primeira sessão ordinaria da terceira legislatura da mesma Assembléa. Barra do Rio Negro, Typ. de F.J S. Ramos, 1856, Mappa n. 13.*

2.87d.) per ton-mile from Xapury (in Acre region) – to where rubber production had expanded, located 1,850 miles from Manaus – to Manaus.

From 1855 to 1870, the freight factor decreased from 3.8% to 2.8% and, at least for rubber, this trend seems to have persisted up to 1910, especially because the price of rubber was increasing in both national and foreign currency. Like in the overseas trade, there is thus indication that, throughout the rubber boom, the river transport system was also able to extract monopoly rents from the increasing trade traffic which were probably passed through to the final consumer as the demand for rubber was certainly inelastic, as shown in Chapter 2.

There was a limit however to lowering transportation costs within the Amazon. First, as mentioned earlier, the region had no coal reserves and then the price of coal f.o.b. in Belém and Manaus was an important determinant of the cost of travel and depended on the freight rates charged in the overseas trade (that, in turn, was not decreasing or at least not as fast as the general trend of freight rates elsewhere): according to the Booth Steamship Co. the price of coal in Belém was probably over twice as high as in Cardiff.[432] Secondly, because coal was available mainly in Manaus and Belém, steamships had to carry coal for the round trip decreasing the available space for other merchandises and then increasing the freight rate per ton of merchandise transported. Alternatively, ships could use timber in place of coal but this would imply less horse power for the ships and more stops along the way to collect timber. Both factors would slow the trip. The scarcity of coal thus became increasingly important as trade developed further and further into the forest where, additionally, the conditions of navigation were worse. Rivers became narrower and the geographic knowledge scarcer, meaning that boats could not be so large (otherwise the risk of being sunk or stranded would be even higher) limiting the extraction of economies of scale. Therefore, it is not surprising that the freight rate per ton-mile was not decreasing in the Amazon region and for longer routes price charges were usually higher. There was much less scope for extraction of economies of scale in the river navigation compared to ocean navigation.

[432] 15s. in Cardiff against 38s. in Belém and 42s. in Manaus. See John (1959, p. 93).

For passenger fares the story is a little different as the flow of people was mainly confined to the region between Manaus and Belém. Thus passenger fares measured in national currency seem to have remained relatively constant over time, at least considering the main passenger line of the region, Belém-Manaus. Measuring it in sterling pounds, there was a significant drop from 1855 to 1884, remaining relatively constant thereafter.

Figure 6.6 – Passenger Fares from Belém to Manaus in Selected Years

Year	Company	Passenger Fares	
		in milréis	in £
1855	Amazon Steam Navigation Co.	100$000	£11 10s.
1884	Red Cross Line	60$000	£ 5 3s.
1910	Booth Steamship Co.	100$000	£ 6 15s.
1915	Amazon Steam Navigation Co.	100$000	£ 5 5s.

Sources: for 1855 Loureiro (1989, p. 152); for 1884, Loureiro (1989, p. 160); for 1910, *L'État du Pará à Turin* (1911, p. 43) and; for 1915, Braga (1916, p. 73). Note: for 1855 and 1884 the fares refer to first class tickets while for 1910 and 1915 the sources did not specify it. Sources quoted passenger fares in *milréis* which were converted into £, using exchange rate series provided in the Appendix.

In 1853, 691 tickets were sold by the Amazon Steam Navigation Co. resulting in a total revenue of 21:350$639 or 30$898 per ticket on average. In 1855, the average price of passenger fare had already decreased to 14$867 (with 3,811 tickets being sold). In 1869, the company sold 13,386 tickets earning 151:918$513, equivalent to just 11$349 per passenger. In pounds, this declining trend is even more evident as the average fare decreased from £3 13s. in 1853, to £1 14s. in 1855 and finally to 10s. in 1869. There is no information for the subsequent period (1870-1910) but it is possible to infer that from 1853 to 1869 the average cost of travel was probably decreasing in both national and foreign currency and, additionally, people were probably changing travel classes: there were 3 different fares and since the decrease in the average passenger rate from the Amazon Steam Co. was decreasing faster than the nominal passenger fare (at least measuring by the Belém-Manaus route) the number of people travelling under the lower rate was increasing over time. This probably reflects the increasing number of rubber tappers travelling longer and longer distances to arrive at rubber estates that were located further and further away from Belém. However, judging from the relatively constant passenger fares, river shipping companies were increasing their profits by increasing passenger traffic rather than by increasing passenger fares. If more economies of scale were generated over time (at a lower extent comparing to the overseas trade), they were certainly accrued by the shipping companies, not being passed through to local passengers.

In sum, freight rates and passenger fares in the Amazon region remained quite high. There were certainly some factors that were increasing the economies of scale of the shipping sector such as the increasing size of the ships and the improved efficiency of new ships. Regularity also helped the shipping industry to minimise their costs as loading and unloading required less and less time but here the telegraphs played a lower role compared to overseas trade: telegraphs arrived quite late (see section 6.2) in the Amazonian hinterland and the system was quite costly (as will be shown in the next section). The risk of very known routes, such as Belém-Manaus, might have decreased over time as sailors became more and more experienced and acquainted with the specificities of the Amazon river and its tributaries. Nonetheless, there were several other factors that limited the capture of significant economies of scale. First, the risk of new routes that might be so high that had to be smoothed out along other routes to maintain profitability. Secondly, there were certainly limits to increase the size of the ships, especially in the new routes in the far reaches of the forest where the rivers were invariably narrower. Thirdly, the region did not possess any coal reserve so that its price f.o.b. in the region depended on the freight rate charged in the overseas trade. It is true that the price of coal was decreasing over time (even though by 1910, it was still at a very high level) but since steamships had to carry coal for the round trip, there was limited carrying capacity. That was especially true in the new routes where the amount of coal required was higher and the ships were usually smaller. Finally, we must take into account that the Amazon Steamship Co. might have possessed significant market power that prevented freight rates from falling. Therefore, with the expansion of trade within the forest, the average cost of transportation might have been increased and not decreased as it would be expected. In order to support the existent shipping lines as well as to foster new ones, government subsidies were instrumental: they provided the security for entrepreneurs to incur the risk of exploring ever new routes. In regard to passenger traffic, there was some more room for exploitation of economies of scale as most of the traffic was concentrated along the main lines, notably in the Belém-Manaus route.

6.5 – Communication and Shipping: Measuring Integration

The high levels of freight rates in the Amazon can be best assessed from Figure 6.7 which shows that at the end of the rubber boom, ocean freight rates charged in the region were significantly higher than in the overseas trade. The routes to Europe registered the lowest freight rates, 0.10-0.16 pence per ton-mile, meaning that the total cost of shipping one ton of rubber from Belém to Liverpool was 600 pennies (or £2 10s.) and to Havre, 670 pennies (or £2 16s.). In turn, the freight rate from Belém to New York was 0.29 pence per ton-mile, or nearly twice as high as in the Liverpool route, making the total cost of shipping one ton of rubber to New York (672 pennies) higher than shipping it to Liverpool or Havre, for instance.

It should be noted here that the freight rate for the Belém-Genoa route was significantly lower than in other overseas routes, probably because La Ligure Brasiliana was fighting their way into the Amazonian trade, competing in prices against the Booth Co. Therefore, the freight rate of 0.10 pence per ton-mile along this route should not be indicative of the cost of travel to Europe as a whole as it was probably only transient.

The costs for the Brazilian routes were much larger than in the overseas trade. Excluding the Madeira-Mamoré Railway (whose freight rates were unbelievably high), the freight rate charged varied from 0.86 to 1.28 pence per ton-mile, or nearly ten times higher than in the Belém-Liverpool route and 4 times higher than in the Belém-NY route. The result was that the total cost of shipping one ton of rubber from Manaus to Belém (854 pennies or £3 11s.) was higher than shipping it to any overseas destination! The total cost of shipping one ton of rubber from the confines of the Amazon forest where the frontier of rubber production was located (in the Acre region) to Belém was even higher: 3,159 pennies or £13 3s. The costal shipping was also very expensive as the freight rate charged in the Belém-Rio route was the most expensive one, 1.28 pence per ton-mile.

Figure 6.7 – Freight Rates in British Old Pences at the end of the Rubber Boom

Routes	Year	Company	Travel Time in hours	Distance in miles	Freight pence per ton-mile	Freight pence per hour	Total Freight pence per ton
Belém-New York	1910	Booth Steamship Co.	214	2,295	0.29	3.13	672
Belém-Liverpool	1910	Booth Steamship Co.	420	4,495	0.13	1.43	600
Belém-Genoa	1900	La Ligure Brasiliana S/A	421	4,503	0.10	1.02	431
Belém-Havre	1910	Booth Steamship Co.	382	4,092	0.16	1.68	642
Belém-Hamburg	1913	Hamburg Sudamerikanische	415	4,442	0.16	1.73	720
Belém-Rio	1914	Lloyd Brasileiro	228	2,315	1.28	12.98	2,959
Belém-Sena Madureira (Acre)	1913	Amazon River Steam Navigation Co.	187	2,580	1.22	16.94	3,159
Belém-Manaus	1913	Amazon River Steam Navigation Co.	72	996	0.86	11.86	854
Madeira-Mamoré	1913	Madeira-Mamoré Railway	n.a.	220	16.11	n.a.	3,544

Sources: 1) Travel Time - Belém-Liverpool: John (1959, p. 58), computed from Table 1 average for 1908, ships Hilary and Gregory; Belém-Rio and Belém-Manaus: LeCointe (1922); For Belém-New York, Belém-Genoa, Belém-Havre and Belém-Hamburg, it was assumed the same speed as for Belém-Liverpool whereas the travel time for Belém-Sena Madureira was computed assuming the same speed as for Belém-Manaus. 2) Distance – Belém-Liverpool, Belém-Havre, Belém-Hamburg and Belém-Rio: Pará (1908, pp. 220-224); Belém-Manaus: Albuquerque (1894, p. 13); Belém-Sena Madureira and Madeira-Mamoré: Souza (1914) and; Belém-New York and Belém-Genoa computed from www.dataloy.com imposing the same route as stated in these companies prospects. 3) Total Freight per Ton - Belém-New York, Belém-Liverpool, Belém-Havre and Belém-Hamburg: *L'État du Pará à Turin* (1911); Pará-Genoa: Caccavoni (1900, p. 61); Belém-Rio: LeCointe (1922, p. 253) and; other routes: Souza (1914).

Therefore, in terms of shipping cost, Belém was closer to Liverpool than to New York despite the fact that the travel distance between Belém and Liverpool was nearly twice as high as in the Belém-New York route. Whilst the longer distance partly explains why the price per ton-mile was lower in the Liverpool route, the unreliability of telegraphs in the New York route might further explain why the total cost of travel was higher in that route. However, what is really striking is the fact that Belém was still closer to foreign destinations than to neighbouring cities. The cost of shipping rubber from Manaus to Belém was higher than in the overseas routes and in regard to Rio, Belém was still far away in economic terms. The high cost of shipping goods from Rio to Belém was definitely the result of the inefficiency and/or market power of the Lloyd Brasileiro under the umbrella of the monopoly of coastal navigation to national flags.

The Lloyd Brasileiro charged freight rates substantially higher compared with routes along which companies were also extracting monopoly (oligopoly) rents such as the ones in the Amazon (The Amazon Steam Navigation Co.) and overseas (the Booth Co.), and where the risk of travel was very high (as in some routes ran by the Amazon Steam Navigation Co.). In the international context, the rates were just incredibly high (Figure 6.6): for instance, the freight cost of shipping one ton of rubber to Liverpool was 4.4 times the total cost of shipping coal (3.3 times for grain) along a similar route. The Belém-Rio freight rate was equivalent to 28.7 times higher than the price charged for shipping coal in a similar route (23.7 times for grain): the company charged then high rates despite being heavily subsidised by the Central government: for instance, in 1907 the company received £187,000 in subsidies out of a total subsidisation of £260,000 to navigation companies in Brazil.[433]

[433] *British Diplomatic and Consular Report n. 4358, Annual Series, p. 59.*

Figure 6.8 – Comparison of Amazonian Freight Rates with Equivalent rates for Coal and Grain

Routes	Amazonian Trade		Kaukiainen Coal		Kaukiainen Grain	
	pence per ton	pence per ton-mile	pence per ton	pence per ton-mile	pence per ton	pence per ton-mile
Belém-New York	672	0.29	106	0.05	126	0.05
Belém-Liverpool	600	0.13	137	0.03	184	0.04
Belém-Genoa	431	0.10	137	0.03	184	0.04
Belém-Havre	642	0.16	131	0.03	173	0.04
Belém-Hamburg	720	0.16	136	0.03	183	0.04
Belém-Rio	2,959	1.28	106	0.05	126	0.05
Belém-Sena Madureira (Acre)	3,159	1.22	110	0.04	133	0.05
Belém-Manaus	854	0.86	88	0.09	92	0.09

Sources: 1) Amazonian Trade: Figure 6.8; 2) For selected years, Kaukiainen (2003) estimated terminal charges and cost per ton-mile for coal and grain shipments based on *Fairplay*. To ensure comparability with Figure 6.8, figures for 1911-1913 were used. Counterfactual shipment costs for coal along the rubber lines were computed by applying the appropriate distances (as reported in Figure 6.8) to Kaukiainen's cost per 100m (1.392 pence per 100m) plus his terminal charge (74.172 pence). Analogously, for grain, shipment costs were obtained by applying the same distances to Kaukiainen's cost per 100m (65.268 pence per 100m) plus his terminal charges for grain (65.268 pence).

Even though the cost of shipping goods was still lower in the overseas routes, the gap between the freight rates in overseas and in national (coastal and along the river Amazon) routes might have shrank quite substantially from 1850 to 1910. Before steamship navigation, due to maritime currents and winds, the fastest way to travel from Belém to Rio de Janeiro was to go to Portugal via the Caribbean and then return to Brazil, touching Fernando de Noronha Island and thence coastwise down to Rio de Janeiro. The costs might have been very high indeed as they entailed a trip to Europe before returning to Brazil. Steamships overcame the natural hurdles to navigation in the north Brazilian coast and, especially in terms of travel time, Belém became much closer to the rest of Brazil.

The navigation speed was relatively the same for the Booth Steamship Co. (Belém-Liverpool), the Amazon River Steam Navigation Co. (Belém-Manaus) and the Lloyd Brasileiro (Belém-Rio), making the travel time between Belém and Manaus significantly lower than any of the other routes mentioned here before: 72 hours (Figure 6.5). A vessel of the Lloyd Brasileiro would travel from Belém to Rio de Janeiro in 228 hours whereas the distance between Belém and Liverpool would be navigated in 420 hours by the Booth steamers. Applying the same speed in the Belém-New York route, it seems that Belém was equidistant from New York and Rio de Janeiro in terms of travel time. If some other cities on the Brazilian coast are added, it is possible to see how closer Belém became from them as, for instance, the travel time between Belém and Ceará was nearly 76 hours about the same travel time between Belém and Manaus: no wonder why so many Cearenses (people born in the Ceará Province/State) migrated to the Amazon forest during the rubber boom.

Figure 6.9 – Passenger Fares (1st Class Tickets) at the end of the Rubber Boom

Routes	Year	Company	Travel Time in hours	Distance in miles	Passenger Fare pence per mile	Passenger Fare pence per hour	Passenger Fare in £
Belém-New York	1910	Booth Steamship Co.	214	2,295	1.70	18.16	16
Belém-New York	1914	Lloyd Brasileiro	214	2,295	2.26	24.15	22
Belém-Liverpool	1910	Booth Steamship Co.	420	4,495	1.39	14.86	26
Belém-Genoa	1900	La Ligure Brasiliana S/A	421	4,503	1.15	12.28	22
Belém-Havre	1910	Booth Steamship Co.	382	4,092	1.58	16.95	27
Belém-Hamburg	1910	Hamburg Sudamerikanische	415	4,442	1.46	15.61	27
Belém-Rio	1914	Lloyd Brasileiro	228	2,315	1.66	16.81	16
Belém-Ceará (Fortaleza)	1915	Lloyd Brasileiro	76	767	1.95	19.78	6
Belém-Salvador	1915	Lloyd Brasileiro	155	1,573	1.91	19.39	13
Belém-Manaus	1914	Lloyd Brasileiro	98	996	1.52	15.39	6
Belém-Manaus	1914	Amazon River Steam Navigation Co.	72	996	1.49	20.55	6
Belém-Sena Madureira (Acre)	1914	Amazon River Steam Navigation Co.	254	2,580	2.84	28.83	31

Sources: 1) Travel Time - Belém-Liverpool: John (1959, p. 58), computed from Table 1 average for 1908, ships Hilary and Gregory; Belém-Rio and Belém-Manaus: LeCointe (1922); For Belém-New York, Belém-Genoa, Belém-Havre and Belém-Hamburg, it was assumed the same speed as for Belém-Liverpool whereas the travel time for Belém-Sena Madureira was computed assuming the same speed as for Belém-Manaus. 2) Distance – Belém-Liverpool, Belém-Havre, Belém-Hamburg and Belém-Rio: Pará (1908, pp. 220-224); Belém-Manaus: Albuquerque (1894, p. 13); Belém-Sena Madureira and Madeira-Mamoré: Souza (1914) and; Belém-New York and Belém-Genoa computed from www.dataloy.com imposing the same route as stated in these companies prospects. 3) Passenger Fares: for all routes of Booth Steamship Co. and Hamburg Sudamerikanische, see *L'État du Pará à Turin* (1911, pp. 42-45). For Belém-Salvador and Belém-Ceará routes, see Braga (1916, pp. 68-69) whilst for all the remaining data refer to LeCointe (1922).

This decrease in 'distance' and travel time also reflected in the passenger fares charged by the companies. Cearenses would pay £6 to go to Belém whereas someone coming from Rio de Janeiro would pay £16 (Figure 6.7). This was the same fare paid by a New Yorker but significantly lower than the fare paid by the English to go to the region: £22. The traffic of people was probably more competitive and the companies operating in the Amazon probably had a lower degree of market power as the prices seemed to be much more competitive. The demand for travel was probably much more elastic to the passenger fare than the demand of rubber was to the shipping cost, meaning that companies could exercise their market power in freight but not in the passenger market.

Figure 6.10 – Ranking of Proximity to Belém at the end of the Rubber Boom

Rank	Distance	Travel Time	Freight Rate	Passenger Fare	Telegrams
1	Manaus	Manaus	Liverpool	Manaus	Rio de Janeiro
2	New York	New York	New York	New York = Rio de Janeiro	Manaus
3	Rio de Janeiro	Rio de Janeiro	Manaus		Liverpool
4	Liverpool	Liverpool	Rio de Janeiro	Liverpool	New York

Source: Elaborated by me based on costs reported in Figures 6.7, 6.8 and 6.9.

Another effect of the decreasing travel time between Belém and the other cities in Brazil is that the flow of mail was occurring at a higher speed, especially after the introduction of steamers. This communication flow was also enhanced by the telegraphs which brought Belém even closer to the rest of Brazil. Looking at the prices of sending telegrams to different cities (Figure 6.9) it can be seen that the government overland telegraph system provided very low rates. A message from Belém to Rio de Janeiro cost nearly 4 pennies per word (it would go through more than 3 States) whereas via the Western Telegraph Co. (submarine cables) would cost 13 pennies per word. Messages sent to Great Britain would cost some 31 pennies per word and to the United States around 40 pennies per word. It is likely though that the actual cost of sending telegrams to the United States was much lower (although less reliable) through the French cable but unfortunately no data for the traffic on this line was found.[434] In terms of mail, at the end of the rubber boom Pará was also closer to the rest of Brazil than to any foreign destination: the price of sending a letter of up to 15g to Brazil amounted to $100 (or 1 ¼ pence) whilst the cost of sending a letter to any member country of the Universal Postal Union was $200 (equivalent to 2 ½ pennies).[435]

This state of affairs enforced 'social' and political integration but not so much economic integration. Financial markets are usually better integrated than any other market so it should be expected that at least exchange rate transactions in Pará would be relatively in par with the Rio de Janeiro's market. There is no exchange rate for Pará in the period before the advent of the rubber boom but I collected some data from two main newspapers from Pará and also from British Consular Reports for some years after 1876 (Figure 6.10) in order to compare to the exchange rate quoted in Rio (exchange rate was defined as British old pence per Brazilian milréis – see Figure 6.12). The result is that, apart from the period immediately after the Proclamation of the Republic (November 1889), throughout the period the coefficient of variation was usually around 4% but sometimes reached 8% (Figure 6.14 below). This means that during the rubber boom, transactions in foreign currency in Pará embodied a premium over the Rio de Janeiro exchange rate that nonetheless kept confined within certain limits.[436] Quotes for the exchange rate in Rio usually arrived in the morning and sometimes were cabled again in the afternoon, meaning that the spread of information through the telegraph system might have been important to prevent huge deviations between Pará and Rio de Janeiro foreign exchange markets. For some days, it was even stated that banks in Pará refused to close

[434] According to Bright (1911, p.198), the price of sending messages from Great Britain to Belém was lower via the French Cables compared to the route via the Western Telegraph Co.
[435] Braga (1916, p. 80). Conversion to pounds were carried out using the 1915 exchange rate available at http://www.ipeadata.gov.br.
[436] Differences in the exchange rate might also reflect that the quotes refer to different computations: for instance, for Pará the exchange rate referred to the quote for the 15th day of each month (or for the closest date available) whereas the exchange rate for Rio de Janeiro was computed as the average over the whole month. However, I also had the Rio de Janeiro rate for some of the days coinciding with Pará quotes and the comparison between these two more similar quotes resulted in very close estimates to Figure 6.15.

any transaction due to interruptions in telegraphic communication.[437] Furthermore, the British Vice-Consul for the Amazonas States, Mr. Temple stated in 1900:

> *"One of the greatest drawbacks under which the State of Amazonas at present labours is the lack of telegraphic communication with the rest of the world. Business, into which exchange transactions enter, is thereby rendered very speculative. Foreign Banks are unable to establish themselves, and the general progress of the town very much impeded. Attempts are being made to remedy this state of affairs."*[438]

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[437] For instance in 1892, the newspaper *A Província do Pará* stated about the exchange rate market that: "Due to the interruption in the submarine telegraph cable, news from the south arrived quite late (...)". In a previous occasion (on 15th November 1891), the same newspaper mentioned that "we received no news about the rates transacted in Rio de Janeiro and thus here [in Pará], the banks made their payments at the 12d. rate but refused to let people withdraw at that rate".

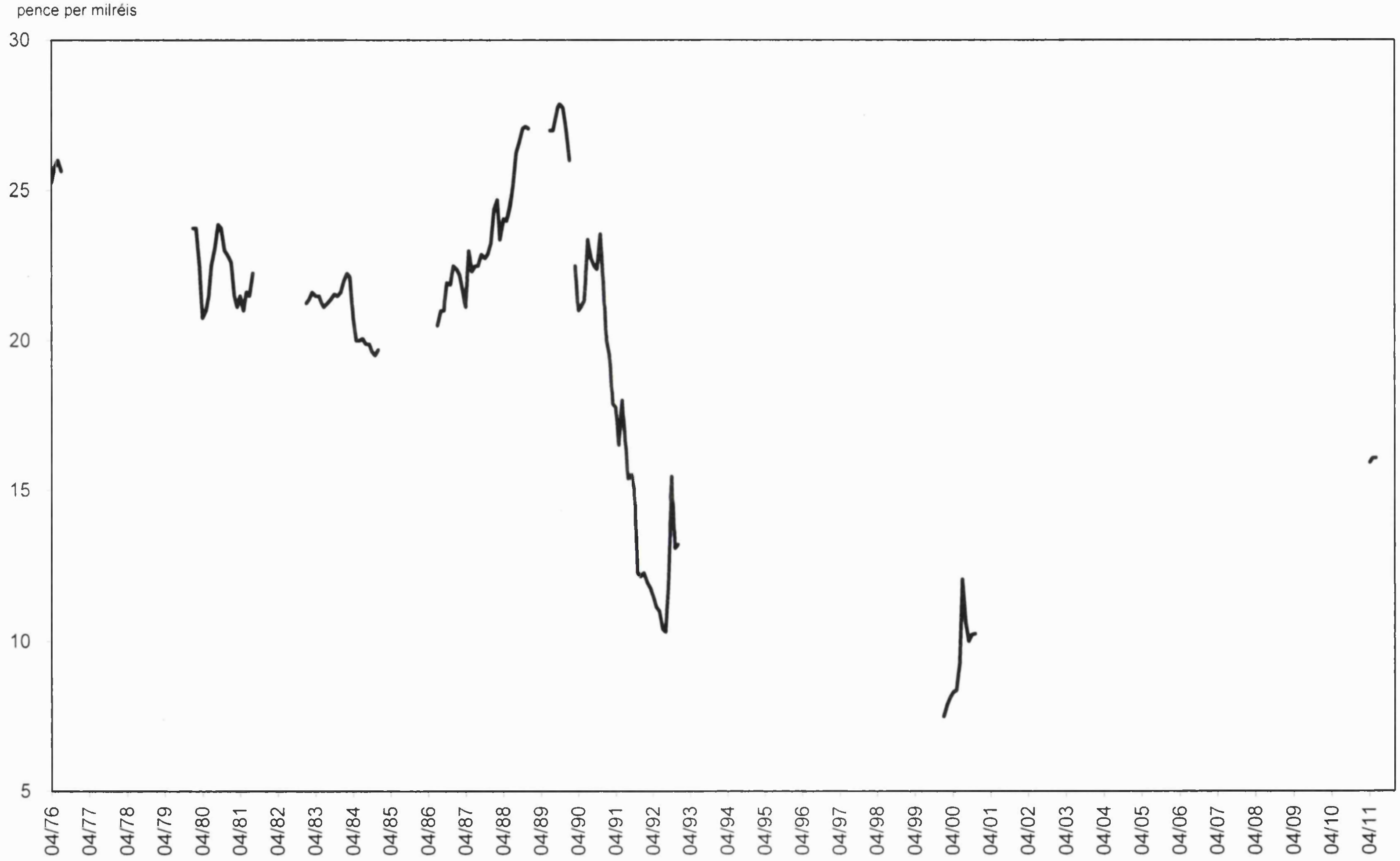
[438] *British Diplomatic and Consular Reports n. 530, Miscellaneous Series, Brazil – Report on the State of the Amazonas, June, 1900, p. 27.*

Figure 6.11 – Price of Telegrams Sent to Several Destinations through different Companies at the End of the Rubber Boom (1915)

Telegrams		Price per Word in pence
Telegrapho Nacional		
Belém to	Any city in Pará State	1
	Crossing 2-3 States	3
	Crossing more than 3 States	4
	Manaus (wireless)	11
	Santarém (wireless)	8
	Senna Madureira (wireless)	19
	Iquitos - Peru (wireless)	36
Bragança Railway Telegraph		
	up to 20 words	13
	urgent telegram up to 30 words	38
Western Telegraph Co. Ltd.		
Belém to	Rio de Janeiro	13
	Ceará	6
	Maranhão	3
	Great Britain	31
	United States (Lousiana and Texas)	40
	United States (others)	42
	Portugal	35
	France	31
	Germany	31
The Amazon Telegraph Co. Ltd.		
Belém to	Manaus (land & submarine)	33
	Santarém (land & submarine)	16

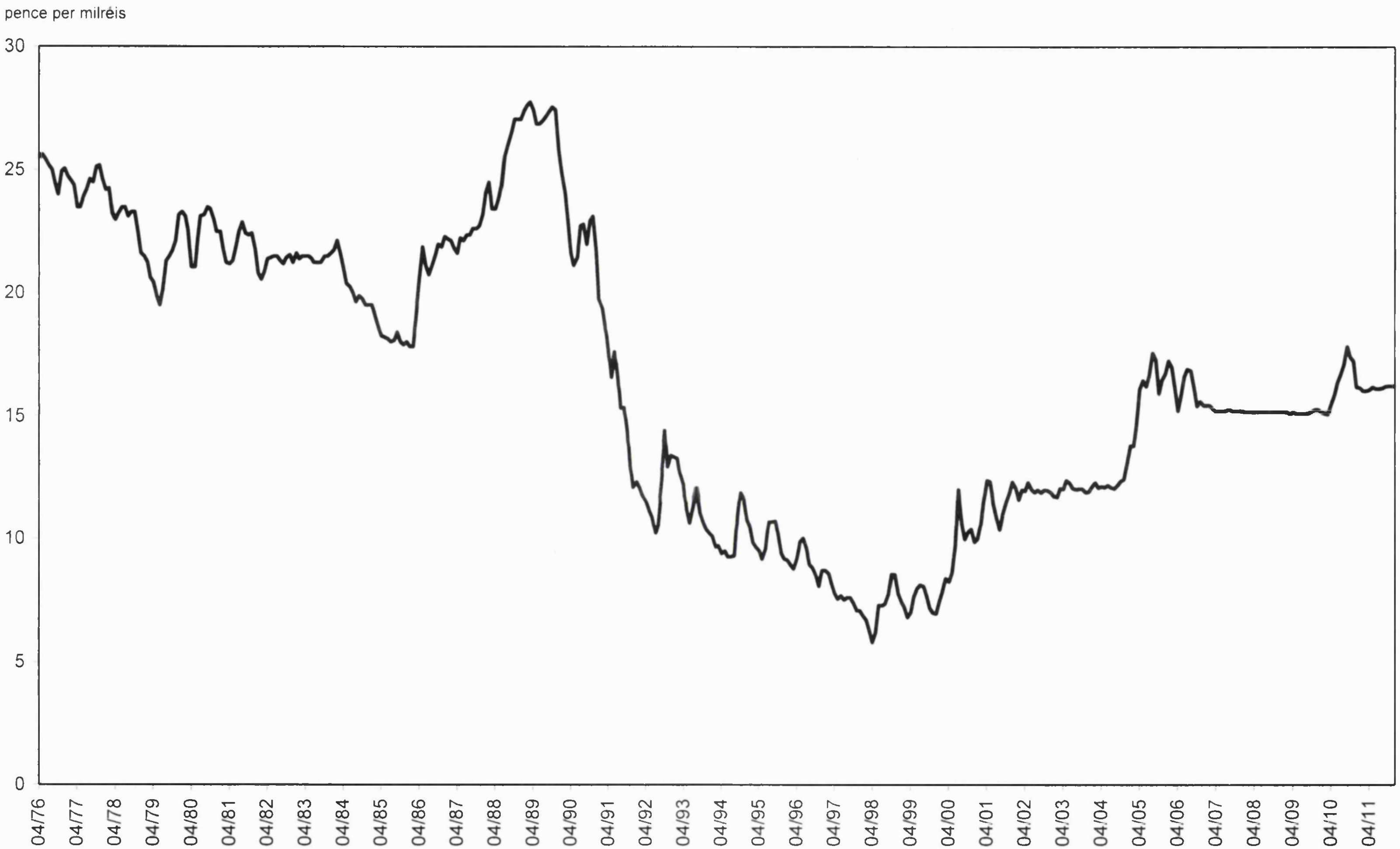
Source: Braga (1915, pp. 82-86).

Figure 6.12 – Exchange Rate in Pará, 1876-1911



Source: Quotes from newspapers: Diario do Para and A Provincia do Para, several issues.

Figure 6.13 – Exchange Rate in Rio de Janeiro, 1876-1911



Source: http://www.ipeadata.gov.br.

Figure 6.14 – Coefficient of Variation of Pará Exchange Rate *vis-à-vis* the Rio de Janeiro Exchange Rate, selected periods

	n. of observations	Coeff. of Variation
Apr/76-Jul/76	4	1,03%
Jan/80-Ago/81	20	4,21%
Jan/83-Dec/84	24	4,02%
Jul/86-Dec/88	30	8,02%
Jul/89-Dec/92	41	30,98%
Jan/00-Jun/00	6	7,85%
Apr/11-Jun/11	3	0,52%

Source: newspapers (A Província do Pará and Diário de Notícias), British Diplomatic and Consular Reports and Ipeadata (for Rio).

However, the high cost of freight prevented this financial integration to translate into price integration, especially because of the exploitation of market power along the several nodes of the rubber chain. For instance, looking at Figure 6.15 it is possible to see that the manioc flour (one of the most important foodstuffs in the Amazon region) was priced at 4 Brazilian milréis in Rio de Janeiro and cost 3.5 milréis in Pará (cheaper, probably because it was imported from locations such as Ceará State which was closer to Pará than to Rio de Janeiro). In the hands of intermediaries (*aviadores*), the price would jump to 6 milréis and including freight rates, tariffs and taxes, the manioc flour would cost as much as 20.1 milréis in Acre without including the commission of the rubber estate owner. Adding that up, the price would reach some 35 milréis, or 8.75 times higher than the price charged in Rio de Janeiro.[439]

It is indeed difficult to discuss price convergence between Acre and Belém or Acre and Rio de Janeiro, since the region was recently populated as a consequence of the development of the rubber production. As seen above, however, there were huge differences in prices between Acre and Rio de Janeiro not only because of high freight rates but also because of market power in several links of the rubber chain. Moreover, it is likely that before the establishment of telegraphic connection in the Acre region, prices

[439] It is not possible to trace back how the author computed the flat freight rate for all products. It is likely that he just diluted the total cost across all products equally.

differed even more as people in the region lacked information of the prices charged in other regions of Brazil.

Figure 6.15 – Prices of Several Goods at Different Locations, 1913

in Brazilian réis	Price in Rio de Janeiro	Official Value at Pará	Aviador Price	Freight	Tariffs and Taxes	Price in Acre	Price in Acre (including commission)
Manioc Flour (40 litres)	4.0	3.5	6.0	12.0	0.3	20.1	35.0
Sugar (40 kg)	14.0	27.0	27.2	12.0	1.4	44.6	80.0
Coffee (60 kg)	57.0	60.0	60.0	12.0	3.0	82.5	240.0
Rice (70 kg)	35.0	35.0	43.2	12.0	2.1	63.1	180.0
Fat (30 kg)	30.0		44.0	12.0	2.2	64.0	180.0
Jerked Beef (60kg)	48.0	48.0	69.0	12.0	3.5	92.9	180.0
Tobacco (14.5kg)	21.6	43.5	80.0	12.0	4.0	105.6	240.0
Kerosene (caixa, 10 galões)	8.0		8.0	12.0	0.4	22.4	60.0
Salt (30 kg)	2.0	3.0	3.0	12.0	0.8	16.7	30.0
Soap (14.5kg)		7.3	8.5	12.0	0.4	23.0	40.0
Cachaça/Alcohol (20 litros)		10.0	15.0	12.0	0.8	30.5	70.0
Matches (1 package)	43.0	48.0	65.0	12.0	3.3	88.3	290.0
Beans (30kg)	7.0	9.0	15.0	12.0	0.8	30.5	60.0
Bacon (15kg)	12.0		16.0	12.0	0.8	31.7	120.0
Butter (50 cans)	100.0		100.0	12.0	5.0	128.7	375.0

Source: Souza (1914, p. 36).

Nonetheless, price integration between Belém and Rio did not occur either as products such as sugar and tobacco registered a 100% price differential. Rice and Jerked Beef (imported into both cities), in turn, had the same price with the other products registering differentials that varied from 5% to 50%. It is difficult to assess if these price differentials just represented different regional tastes and/or endowments but the high freight rates from Brazilian regions to Belém prevented arbitrage mechanisms to work properly.

In regard to "social" integration, since due to the advent of the telegraphic system and faster mail communication, news started to spread quicker within Brazil and thus more and more became known about the Amazonian rubber cycle in other parts of the country. Therefore, the development of the rubber boom attracted many people (especially from poorer areas of the country such as Ceará) to work as rubber gatherers within the Amazon forest in search for a better life. This influx of people towards the Amazon was supported, as was shown here, by cheaper passenger fares and decreasing travel time. As seen in Chapter 5, the result was that the Amazonian population increased nearly four-fold during the rubber boom, from 322,909 people in 1870 to 1,217,024 people in 1910 (see Appendix).

Steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported even further the development of the (steam) navigation and the telegraphic system. The rubber boom demanded a better communication and transport systems and the consequent increased traffic of people and merchandises provided these systems with economies of scale that ensured their ulterior development. The combination of rubber trade, telegraphs and steamships generated a virtuous cycle that altered the economic and social structures of the Brazilian Amazon, as seen along this thesis. Government was instrumental by carrying out investments (as in telegraphs and mail), by providing subsidies (as in the case of shipping companies) and by its regulatory role.

6.6 – Final Remarks

The Brazilian Amazon was very disconnected from other regions of Brazil and from Rio de Janeiro in particular due to geographical hurdles that hampered the navigation along the north coast of Brazil. Therefore, before the 1850s the fastest and easiest way to travel from Belém to Rio de Janeiro was to go to Europe via the Caribbean and then tackle down the way across the Atlantic touching Fernando de Noronha Island and thence coastwise, until Rio de Janeiro.

As in the case of the annexation and unification of the Brazilian Amazon within the Rio de Janeiro's political domain, the central government played a decisive role in the integration process by both subsidising and carrying out investments in transport and communication. In the case of the steamship navigation, the government gave away huge subsidies and did it not only at its inception, as the government continued to subsidise several lines throughout the period. For instance, in 1898 the Pará government alone spent 570:284$000 (or £17,079) with subsidies for steamship navigation companies. Indeed, according to the Commercial Association of Pará, in 1869, "it is not superfluous to repeat that from the establishment of steam navigation dates the extraordinary development of public wealth in Pará".[440]

Steamships shortened distances within the Amazon region, connecting the entire basin with Belém and abroad. However, freight rates in the region remained quite high by international standards, reflecting a combination of market power and high risk of navigation (especially in the domestic routes) and, as shown here, total shipping costs resulted to be higher in domestic routes than in overseas ones: in terms of shipping costs Belém was closer to Liverpool and New York than to Manaus or Rio de Janeiro. Passenger fares, in turn, were relatively cheaper in the domestic routes implying a faster and more reliable movement of people and information (mail, which was also carried by steamers) within Brazil.

The biggest impact on the speed of the flow of information though was brought about by the establishment of telegraphic lines connecting Belém with Rio de Janeiro and with the international telegraphic system. Again, the government played an important role especially by constructing its own telegraphic land system connecting the main cities of Brazil along the coast. Thus by the end of the rubber boom, Belém was indeed connected to several different cables whose prices indicated that, in terms of information, the Brazilian Amazon became closer to Rio de Janeiro than to New York or Liverpool.

Interestingly, rubber had fostered the development of submarine telegraphs for gutta-percha (a kind of low quality rubber, extracted from a tree that grows in Southeast Asia) was used to insulate copper cables against the water.[441] Furthermore, rubber was also important in the improvement of the efficiency of steam engines insofar as this raw material was sometimes used as seals.

Steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported even further the development of the (steam) navigation and the telegraphic system. The rubber boom demanded a better communication and transport systems and the consequent increased intensity in the flow of people and merchandises provided these

[440] Ridings (1983, p. 246).
[441] Headrick and Griset (2001, pp. 545-550).

systems with economies of scale that ensured their ulterior development. The spread of news and the improvement in the transport system also provided the region with the most scarce factor of production, labour, and, as shown in Chapter 4, the Brazilian supply of rubber was very inelastic to this factor of production. Furthermore, the advent of steamship navigation in the Amazon region displaced the canoes, releasing even more labourers to work in the rubber industry. Thus communication and (steam) navigation generated some integration, and the consequent move of people (and other factors of production) and flow of information, created the conditions for further development of the rubber boom by supporting a virtuous cycle that, as seen in this thesis, completely changed the economic, political and social structures of the Brazilian Amazon. In sum, without rubber, steamships might have been even more costly to operate, and the submarine telegraphic system may have never developed. Analogously, without steamships and telegraphic communication, the rubber boom might have never taken place.

CONCLUSION

As stated in the introduction, the thesis examines how institutions and geography explain the development of the rubber chain in the Brazilian Amazon from 1870 to 1910. For the analysis, a new theoretical framework was built. The framework is general enough to be applied to other commodities as well. The departure point was general trade theory that provides two basic explanations for patterns of trade: technology and endowments. However, these standard trade models usually consider trade in isolation from investment, finance, or other relations between traders. It was thus necessary to combine these features as well as institutions and geography in order to generate a more suitable framework for the analysis of commodity chains, and of the rubber chain in particular. A more quantitative-driven analysis from macroeconomic data gave further support to inferences taken from microeconomic behaviour. From this analysis of the rubber chain, contributions to Commodity Chain Literature, and World, Brazilian and Amazonian Economic History are made.

There are two levels of analysis. The thesis analyses interactions that happened within the nodes of the chain as well as interactions between different nodes of the chain. In the within-analysis, competition among agents located in the same node is examined. In the between-analysis, no pre-defined power structure is imposed *ad hoc*: indeed, the location of the nodes did not imply any power structure along the chain, location being merely the result of an historical process that, in turn, was a consequence of technology and endowment factors as well as institutions. Power between nodes of the chain was understood under a game theoretical framework. This was in fact one of the most innovative theoretical concepts developed in the thesis.

The organisation of the thesis followed the stylised chain as presented in Chapter 1. The thesis began by analysing the rubber manufacturing industry. In a Ricardian fashion, at first, the proximity to rubber sources and the dexterity in the manipulation of rubber provided comparative advantage to indigenous rubber manufactures. However, the discovery of the vulcanisation process undermined the superior quality of indigenous production and made possible the centralisation of rubber manufacture in factories:

vulcanisation shifted comparative advantage in rubber manufacturing towards Britain and the USA. From then on, the pattern of trade became mainly understood as a result of Hecksher-Ohlin forces: Brazil specialised in the production of crude rubber due to the relative abundance of rubber trees in the Brazilian Amazon whereas Britain and the USA specialised in the production of rubber manufactures due to the relative abundance of capital, that became a requisite for larger rubber concerns. Therefore, from the 1860s onwards, Britain and the USA deepened their industrial position in rubber manufacturing with a similar technology being used on both sides of the Atlantic.

Even though standard trade models explain the geography of rubber trade (and by consequence the first node of the rubber chain, namely, the rubber manufacturing industry) there were other forces at play. Institutions were, undoubtedly, very important. Formal institutions, notably patent legislation, influenced and shaped the market structure of the rubber manufacturing industry. Patents encouraged a process of amalgamations in Britain and the USA even though the rubber industry remained quite competitive on both sides of the Atlantic. This competition at the manufacturing level resounded along the chain, translating into a struggle for securing a steady and reliable source of crude rubber, the main input in the industry. The thesis enhances the analysis of the rubber chain by acknowledging that trade is not carried out under neoclassical assumptions: the relationship between parties to trade and the role of investment and finance was instrumental to understand the actual pattern of the rubber trade that emerged. Given its scarcity, crude rubber was very expensive and access to resources thus became strategic to determine or influence profitability at the manufacturing level, turning the manufacturing node of the rubber chain into something very different from the ideal GCC/'Wallersteinian' core-node type. True, the British rubber industry was better positioned compared to its American counterpart: since British traders were importing more crude rubber than the British industry needed, they were able to pass through the burden of crude rubber scarcity to American buyers since the latter were unable to meet all their demand from primary sources. Furthermore, there was also scope for exporters placed in Brazil to extract monopoly rents especially from American buyers who registered a more inelastic demand for their product when compared to British demand for Brazilian crude rubber (-1.11 for the USA against -1.54 for the Britain). Inelasticity of demand for rubber was indeed one of the main features of this commodity chain from 1870 to 1910, a feature that actually shaped the market structure in several different nodes of the chain, affected the bargain position of players located in different nodes and defined the division of profits along the chain. Inelasticity of demand was indeed the main determinant of the pattern of British and American investments in rubber production and trade. The scarcity of crude rubber led to a struggle along the rubber chain for a steady supply of that raw product: the rubber manufacturing industry needed to break the dependence upon an unreliable raw product which defined its prices and the ultimate level of its own production.

The consequent geography of trade impacted the quality of the raw material the industrial countries (especially Britain and the USA) were acquiring. As crude rubber was not a homogeneous commodity, the possibilities of production became defined by the quality of the crude rubber imported. In a neoclassical market, prices would have cleared the market: those in need of the best rubber quality could always pay the market price and get the needed amount of the product. However, trade was in fact the result of a constellation of institutions: it was usually hidden behind forward long-term contracts and followed colonial lines. First, the thesis stressed the fact that the rubber market was far from comprised of anonymous and atomised agents transacting with one another. Traders and manufacturers usually established long lasting connections that impacted on the way they traded: it was not easy to by-pass this informal arrangement and the US buyers early understood it. Secondly, traders preferred to establish commercial activities in areas under the jurisdiction of their native countries. This happened sometimes because these traders were prevented from establishing themselves in another country's colonies. Even when jurisdiction was not an issue, the rubber trade followed their country's informal areas of influence, as it happened in the relationship between Mexico and the USA. Thirdly, geographical and economic distances (first and second-nature geographical aspects) further influenced and shaped the pattern of the rubber trade.

In regard to the main rubber producer, the Brazilian Amazon was not a formal or informal colony of either the USA or Britain. The ensuing struggle between American and British buyers to obtain a competitive edge by securing a more stable and reliable access to Brazilian rubber reserves may have prevented concerted action among rubber importers, giving some room for manoeuvre to rubber exporters placed in producing regions, notably in Brazil. Such seemed to be the case of the Brazilian/Portuguese export house, J.H.Andresen. The relationship between this company and its main buyer (a British rubber import house) resembled a usual trade relationship in which both companies benefited and the thesis further indicated that if any company exercised market power, it was probably the Brazilian/Portuguese export house. Export houses in Brazil were not free to act as monopolists or oligopolists in the rubber market though. In the Brazilian supply chain there was a counteracting force that prevented players from extracting monopoly rents fully: the scarcity of labourers. However, the thesis rejects the assumption that production was only possible due the creation of an exploitative labour system. It does not deny that debt enslavement and coercion were present in the Brazilian Amazon, but it rejects the idea that it was a necessary feature of rubber production. In this regard, the thesis advances a game theoretic model that unveils the bargain positions of labourers and rubber estate owners. Instead of assuming any pre-defined power relationship between these transacting agents, the game simplifies the motivations of both parties into a general framework that is further constrained by the institutions existent and created in the Brazilian Amazon. The game suggests that there were several possible scenarios in which production could have been enforced according to the roles of four main variables: tapper's horizon of planning, reward from cheating, expected income from an alternative employment and the implicit and explicit prices paid for rubber produced. The game was further applied to the analysis of power between the other nodes of the rubber chain within the Brazilian Amazon. The rubber chain became then very intricate and the relations of power ceased to necessarily follow a vertical one in which every forward node is able to exploit the node immediately beneath it, as the GCC approach usually assumes. Yet, it was possible that rubber exporters were even better positioned to extract monopoly rents due to their knowledge of the rubber market and the degree of oligopolisation of their activities but they did not necessarily do so. Not least because it was easier to enforce rubber production under a scenario of constant production expansion and of high inelasticity of demand, like the one that prevailed from 1870 to 1910. Under this scenario, all factors of production could have been properly remunerated.

If it is not certain that any particular node of the rubber chain was extracting monopoly rents in full, the government was certainly profiting from the monopolistic position the Amazonian region had in rubber markets. The literature on Brazilian rubber has indeed neglected the fact that the government could have been able to ensure the monopoly outcome even under a high degree of competition amongst Brazilian rubber exporters and under a high inelasticity of supply. The government possessed several mechanisms to pursue this goal: nationalisation of rubber production, licensing scheme, stockpiling, export tariffs and import tariffs over goods that affect the rubber cost structure. It is argued here that export tariff and import tariff were the main instruments actually used by the government but the welfare analysis focused on the export tariff. Under reasonable assumptions, results here suggest that the optimum export tariff could have ranged between 96.2%-126.5%, but the government levied only 16.6% on average in the years for which data were available (1870-1910). Had the government imposed the optimum export tariff, welfare could have been increased as much as £341,444 per year from 1891-1910, equivalent to 1.89% of Amazonian GDP in the period. This welfare would have been generated on top of 1.80% that had already been generated by the government when it set the export tariff at 18.9% in the same period (1891-1910). But why did the government not increase the tariff up to the optimum level? The thesis argues that the government was constrained in three levels: 1) Internationally: the Federal government may have feared international retaliation (especially from consuming countries) from such a tax policy; 2) Regionally: the competition among the three government entities (Para and Amazonas States and Acre Territory) for tax revenues generated a sub-optimal outcome; 3) Locally: pressure from business groups might have constrained the ability of the government to increase the export tax on rubber even more.

Overall, the thesis supports the view of Frank and Musacchio that there was no economic imperialism in the Amazon as the rubber chain does not fit into the model of peripherality of raw material and centrality of manufacture. This traditional formulation is at the heart of the GCC approach which suggests that production in the periphery (Brazil) should have developed in tandem with impulses emanating from the industrial core (USA and Europe). That pattern would ensure that profits in the periphery would either be held down (so as to maximise profits at the industrial core) or be high in order to ensure profitability from investments flowing from the industrial core. It is not surprising that for a quite long period, given the high inelasticity of demand for Brazilian rubber, manufacturers in the core economies were tied to developments occurring within the Brazilian Amazon, diametrically contrary to the traditional assumption of economic imperialism and to that embedded in the GCC approach. However, contrary to Frank and Musacchio, the thesis shows that imperialism cannot be completely dismissed though as the government (as well as all other agents in the rubber chain) was sometimes constrained by foreign pressures.

From taxation, the Amazonian State governments accumulated considerable wealth that was partly redistributed back to the region in form of investments and subsidies. These funds were instrumental to develop two rubber supporting activities, telegraphs and steamships, whose impacts on the chain were analysed in this thesis. Interestingly, rubber had fostered the development of submarine telegraphs for low rubber grades were used to insulate copper. Furthermore, rubber was also important in the improvement of the efficiency of steam engines insofar as this raw material was sometimes used as seals. Steam navigation and telegraphs gave rise to the rubber boom which, in turn, supported yet more the development of the (steam) navigation and the telegraphic system. The rubber boom demanded a better communication and transport systems and the consequent increased intensity in the flow of people and merchandises provided these systems with economies of scale that ensured their ulterior development. The spread of news and the improvement in the transport system also provided the region with the scarcest factor of production, labour, and, as shown here, the Brazilian rubber supply was very inelastic to this factor of production. Furthermore, the advent of steamship navigation in the Amazon region displaced canoes, releasing even more labourers to work in the rubber industry. Thus communication and (steam) navigation generated some integration, and the consequent movement of people (and other factors of production) and flow of information, created the conditions for further development of the rubber boom by supporting a virtuous cycle. In sum, without rubber, steamships might have been even more costly to operate, and the submarine telegraphic system may have never developed. Analogously, without steamships and telegraphic communication, the rubber boom might have never taken place.

As stated in the first paragraph of this conclusion, the thesis makes several distinct contributions. First, the thesis constructs a new theoretical framework that was applied to the study of the rubber chain and which can be adapted for other commodity chains too. The analysis spans two levels: interactions among agents located within the same node of the chain and between agents located in different nodes. Whereas in the within-analysis, competition was the predominant topic of discussion, in the between-analysis game theory was applied in order to model bargaining power. Such analysis offers the most comprehensive study on the rubber chain ever produced, examining the rubber chain from tappers to manufacturers. Analytically, the thesis combines trade models with institutions, economic geography and econometrics, providing a new view on the organisation and evolution of rubber trade from 1870 to 1910. It is argued that institutions shaped the development of the rubber boom and permeated each and every node of the rubber chain. Although the thesis shows that the framework can be fully applied to commodity chains, a word of caution is needed: the framework assumes a partial equilibrium approach and sometimes some connections between different markets may be missing. However, the thesis retains the basic properties and features of the rubber chain. Its validity is indeed corroborated by qualitative and quantitative historical evidences and data.

Secondly, the thesis contributes to Global Economic History. Rubber was an important raw material whose industrial applications increased over time. This raw material is indeed at the heart of two important technological developments of the industrial world, steam engine and motorcars, as rubber provided performance gains for both products. Before the advent of large scale plantations, rubber was a very scarce raw material for which there were virtually no substitutes available: its natural elasticity rendered the product unique. Consequently, scarcity and poor substitutability made demand very price inelastic. That is exactly one of the main features of the story here. Inelasticity of demand drove production methods to be rubber-saving. The more scarce this raw material was the more incentives agents had to innovate: little wonder that the USA led the world in reclaimed rubber, first, and in synthetic rubber later. Therefore, the thesis explains the development of the rubber manufacturing industry in the USA and Britain. The need to secure a steady and reliable source of crude rubber explained how competition resounded along the chain, giving rise to a specific pattern of trade. As the thesis shows, this pattern of trade was yet shaped by institutions and economic geography. Furthermore, the inelasticity of demand for rubber shifted power between nodes of the chain. Indeed, the Wallersteinian pre-eminence of manufacturing over extractive industries is not valid here. Due to a combination of quantity and quality, rubber traders located in the Brazilian Amazon are likely to have possessed the highest degree of market power, allowing them to ultimately influence rubber manufacturing and not the other way around. Even if it is believed that these agents did not exercise this market power, for whatever reasons, the governments of the Amazonian States certainly profited substantially from the monopolistic position of the region on the world rubber markets. The rubber chain thus shows an interesting case in which taxation was beneficial for the region as a whole without generating immiserising growth.

Thirdly, the thesis contributes to Brazilian economic historiography. The rubber chain in the Brazilian Amazon is not analysed in vacuum as economic and political connections with other parts of the country were taken into account. These interactions produced a skewed insertion of the Brazilian Amazon into the world economy. In comparative terms, despite geographical proximity, the region strengthened its ties with Britain in detriment to the USA. Deeper domestic integration was also a reality during the rubber boom. Hence capital, people, goods and information were exchanged between the

Amazon and the rest of Brazil and between the Brazilian Amazon and the rest of the world. Internationally, two places figured prominently: Britain and the USA. Domestically, Ceará (and other Northeastern States) from where most of the immigration originated and Rio de Janeiro, the political capital during the period, stood out. The relationship with Rio de Janeiro was explored in detail. During the empire, the Amazon region lacked autonomy, being thus dependent on Rio de Janeiro. After the Proclamation of the Republic, with the consequent adoption of the Federalist regime, the region was granted more political and economic autonomy. This autonomy was indeed exercised by Amazonian governments via taxation on exports.

Lastly, the thesis fills a big gap in the economic historiography of the Brazilian Amazon. As it is clear from the thesis, there are very few contributions on the economic history of the Brazilian Amazon. Given the importance of rubber, not least due to its impacts on trade and foreign exchange, it is surprising that the literature is so disproportionately poor compared to the literature produced for coffee in the Brazilian South-East. As shown here, one topic of discussion fits prominently: labour relations. The thesis provides a game theoretic approach that changes the long established view about labour relations in the Brazilian Amazon. It is shown that, contrary to existing the literature, violence and coercion were not necessary features of rubber production. Production could have been assured via market mechanisms that were shown to have been more prevalent than what the literature believed or assumed.

The thesis goes beyond labour relations. Not only does it provide a more comprehensive account of the rubber boom (as existing works had also attempted) but it also links rubber supply and demand. The thesis thus analyses the impulses of demand, especially the motorcar industry. It shows that demand became more price-inelastic over time, increasing the room of manoeuvre of agents placed in the Brazilian Amazon. Again, inelasticity is the main feature in the story here. Indeed, due to inelasticity there was scope for taxation to increase the regional welfare. The thesis thus provides a welfare analysis that shows how much the region profited from taxation and how much it could have profited had the government set the tariff at the optimum level. Clearly, there were winners and losers but, overall, the region profited from rubber taxation as rubber consumers paid most of the taxation burden. This gives further support for the absence of imperialism in the Brazilian Amazon even though the government ability to tax was limited to some extent. Moreover, the thesis provides an interesting case study that unveils the behaviour of an important British rubber trader (Schroder) and the connection with its main supplier located in the Brazilian Amazon (J.H.Andresen). It is argued that the relationship between these two companies resembled a usual trade relationship but if any company possessed market power over another, it was probably the Brazilian/Portuguese export house. Once more, there is further indication that economic imperialism does not fit neatly into the picture here.

In order to support all these claims and findings an extensive dataset was collected and organised. New evidence presented in this thesis is based on data organised in the Appendix. An entirely new dataset for the rubber trade was compiled from British, US and French import data. It contains quantities, values and prices of crude rubber imported not only from Brazil but also from all other sources of supply. A more detailed price dataset was constructed from contemporary publications reflecting market quotations for the main rubber grades. As can be inferred from the Appendix, Brazilian official statistics seemed to have underestimated the quantities a great deal, as these three countries have imported more rubber from Brazil than total Brazilian official statistics suggest. This difference is even more strinking if it is taken into account that rubber would probably still lose some weight in transit. The advantage of Brazilian official statistics is that it breaks the data down by administrative units: Pará, Amazonas and Acre. Trade statistics can then be matched with export tax earnings to generate *ad valorem* export taxes at the State/Provincial level. Brazilian official statistics also provided rubber production data on a more detailed level, for lower administrative units (by villages or rivers). It is possible then to combine this very detailed rubber trade data with information on freights. Extensive data on freight rates for rubber are provided, encompassing different methods of transportation (for instance canoes) and several different routes. This vibrant trade was accompanied and sustained by a communication network for which postal and telegraphic communication data were compiled. Moreover, the thesis further provides data on rubber manufacturing, wages in the Brazilian Amazon, investments in the region, etc.

Therefore, the thesis advances in several fronts the current historiography. Yet, there are several improvements that can be made. First, in view of the findings here, the business history of tyre companies (and of rubber companies in general) needs to be revisited and augmented by including French and German rubber manufacturers too. This revision is required in order to explore the rubber famine these companies experienced. Their relationship with rubber traders requires further work as well, especially regarding the share of the market that was spot and how much was actually channelled, on a yearly basis, through forward contracts. More case studies on the rubber trade are needed, so that it is possible to make more general statements about the relationship between traders located in producing and consuming countries. In particular, it is necessary to know more about the behaviour of rubber exporters placed in Brazil. Were they monopolists and monopsonists? Were they only monopolists or monopsonists? Or neither of the above? I believe they were neither of the above, but more information on their behaviour is needed to establish this on more solid basis. In order to fully determine the impact of communications networks (notably shipping and telegraphs) on the rubber trade, more data is required. It would thus allow a more quantitative assessment of domestic and international market integration as well as an analysis of social savings for the Brazilian Amazon. Finally, the interactions between the Brazilian Amazon and the rest of Brazil need deeper analysis too, notably regarding the relationship with the coffee producing areas in South-East Brazil. Here, a computable general equilibrium model could shed more light on how these two booming regions interacted during the period 1870-1910. For instance, the thesis shows that taxation was certainly beneficial for the Amazonian region, but was it good for Brazil as a whole? Furthermore, how did the exchange market clear in a context of two separate markets that barely interacted with each other? These are the sort of questions that could be addressed by building up such model. For now, it is only possible to speculate that Brazil was far from an immense archipelago of separate economic islands as portrayed by Celso Furtado.

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Brazilian Rubber Trust, Ltd. Annual Reports for the London Stock Exchange. Commercial Reports for the year 1896/7, catalogue reference: 978.

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Companhia Estradas de Ferro do Norte do Brasil. Report presented to Dr. Innocencio Hollanda de Lima by Domingos Acatauassu Nunes, Belem, 1910. This report was not catalogued and can be found at the Rare Manuscripts and Books Section of the Biblioteca Arthur Vianna, Belem do Para, Brazil.

Companhia Urbana de Estrada de Ferro Paraense. Annual Reports for the Years: 1878, 1880, 1883, 1885-9, 1891-6, 1898 and 1900-4. These reports were not catalogued and can be found at the Rare Manuscripts and Books Section of the Biblioteca Arthur Vianna, Belem do Para, Brazil.

Confidential Letter of Hulne Cheeltham to Sir Edward Grey, Petrópolis, 14th March 1909, N. 13 Commercial, Public Record Office, catalogue reference: FO365/274.

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Garantia da Amazônia. Sociedade de Seguros Mútuos Sobre a Vida. Legalidade de Sua Organização. Pará, Typ. da Papelaria Americana, 1897.

Historical Survey of Currency, Exchange and Banking in Brazil. Bank of England Archive, Brazil: Montagu Report 1924, Overseas & Foreign Office, catalogue references: OV103/67.

The Rubber Estates of Pará Ltd. Annual Reports for the London Stock Exchange. Commercial Reports for the years 1899/0-1900/1, catalogue reference: 613 & 661.

Voting Lists for Bragança City, 1888-1889. These lists have not been catalogued and can be found at the Arquivo Público Library, Belém do Para, Brazil.

The Western Telegraph Co., 1900-1910. Annual Reports of the Directors for the years 1900-1910. Porthcurno Telegraph Museum (not catalogued).

The Western and Brazilian Telegraph Co. Annual Reports for the London Stock Exchange. Telegraph Reports for the years 1880-1898, catalogue references: 74, 104, 132, 163, 201, 247, 289, 329, 366, 404, 447, 493, 545 and 597.

The Western [and Brazilian] Telegraph Co. Letters exchanged between Pará and Maranhão with the Company's Head-Office. The Library of the University College London hosts 14 boxes containing Letter books and staff lists, 1883-1949, of the Western Telegraph Company Ltd. Catalogue reference: GB 0103 WTC.

B. Official Publications

B.1 Pará State/Province: Serial Speeches and Reports

Speeches (Fallas), (1859-1913).

Annual Reports, (1860-1913).

Transfer of Government Reports, (1860-1913).

B.2 Pará State/Province: *Annuaires* and Statistical Publications

Annuario Estatístico, Estado do Pará 1902, apresentado ao senhor secretário de estado da justiça, interior e instrução pública D'Amazonas de Figueiredo pelo chefe da 2ª seção Egídio Leão de Salles. Paris, Typ. Aillaud & Cie. This item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.

Annuario de Estatística do Estado do Pará mandado organizar pelo Governador do Estado. Anno Primeiro, 1925-1926. Belém, Oficinas Gráficas do Instituto Lauro Sodré, 1927. This item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.

L'État du Pará (États-Unis du Brésil). Ouvrages Illustré de 23 Photographies des divers Monuments de Pará d'un Plan et d'une Vue de la Ville et d'une Carte de L'État du Pará. Paris, A. Lahure Imprimeur-Éditeur, 1897.

L'État du Pará (Brésil): Industrie Extractives du Pará, Publication Officielle pour l'Exposition Internationale de Bruxelles, 1910.

L'État du Pará (Brésil) à Turin: Publication Officielle pour l'Exposition Internationale de Turin, 1911.

O Pará em 1900, publicação comemorativa pelo quarto centenário do descobrimento do Brazil feita pelo governo do Estado. Pará, Imprensa de Alfredo Augusto Silva, 1900.

O Pará em 1922, administração do exmo. sr. dr. A. E. de Souza Castro, exposição nacional do centenário. Producção do Estado e Dados Estatísticos. Pará, A Semana, 1922.

Questionários sobre as condições da agricultura dos municípios do Estado do Pará, organizados pelo serviço de inspecção e defesa agrícolas, 10º districto, inspeccionados de 10 de maio de 1910 a 18 de fevereiro de 1912. Rio de Janeiro, Typ. do Serviço de Estatística, 1913.

B.3 Pará State/Province: Miscellaneous

Barros, S. R. "Falla que o exm. snr. conselheiro Sebastião do Rego Barros, prezidente desta provincia, dirigiu á Assemblea Legislativa provincial na abertura da mesma Assemblea no dia 15 de agosto de 1854." edited by Pará: Typ. da Aurora Paraense, 1854.

Brusque, F. C. A. "Relatorio apresentado á Assembléa Legislativa da provincia do Pará na primeira sessão da XIII legislatura pelo exm.o senr. presidente da provincia, dr. Francisco Carlos de Araujo Brusque em 1.o de setembro de 1862." edited by Pará: Typ. de Frederico Carlos Rhossard, 1862.

Officio com que o exmo. snr. dr. Couto de Magalhães passou a administração da província ao exmo. snr. dr. João Maria de Moraes, 1º vice presidente, 1866.

Annexos ao relatorio com que o excellentissimo senhor vice-almirante e conselheiro de guerra, Joaquim Raymundo de Lamare, passou a administração da provincia do Gram-Pará ao excellentissimo senhor visconde de Arary, 1.o vice-presidente, em 6 de agosto de 1868. Pará, Typ. do Diario do Gram-Pará, [n.d.]

Officio com que o exmo. sr. dr. José da Gama Malcher, 1º vice-presidente, passou a administração da província do Pará ao exmo. sr. dr. José Joaquim do Carmo em 18 de março de 1878.

Manifesto ao Estado do Pará, pelo governador Dr. José Paes de Carvalho. Pará, Typ. Diário Official, 1897.

Relatorio apresentado ao Governador do Estado do Pará Dr. João Antônio Luiz Coelho pelo Secretário da Fazenda Dr. José Antônio Picanço Diniz, relativo ao anno de 1909. Pará, Imprensa Official do Estado do Pará, 1910. This report is not catalogued and can be found at the rare book section of the Library of the Ministry of Finance in Rio de Janeiro, Brazil.

Relatorio apresentado ao Governador do Estado do Pará Dr. João Antônio Luiz Coelho pelo Secretário da Fazenda Dr. José Antônio Picanço Diniz, relativo ao anno de 1910. Pará, Imprensa Official do Estado do Pará, 1911. This report is not catalogued and can be found at the rare book section of the Library of the Ministry of Finance in Rio de Janeiro, Brazil.

Relatorio apresentado ao Governador do Estado do Pará Dr. João Antônio Luiz Coelho pelo Secretário da Fazenda Dr. José Antônio Picanço Diniz, relativo ao anno de 1911. Pará, Imprensa Official do Estado do Pará, 1912. This report is not catalogued and can be found at the rare book section of the Library of the Ministry of Finance in Rio de Janeiro, Brazil.

Relatório da Recebedoria de Rendas do Estado concernente ao semestre de 1913 apresentado ao exmo. sr. dr. Alfredo Souza, secretário de estado da fazenda, pelo director Coronel Manoel Leopoldino Pereira Leitão Cacella. Pará, Imprensa Official do Estado do Pará, 1913. This item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.

Relatório apresentado ao exmo. sr. dr. José Paes de Carvalho, governador do Estado do Pará, por Raymundo Diniz Pinto Marques administrador da Recebedoria de Rendas 1899. This item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.

Relatório apresentado ao sr. dr. Lauro Sodré, governador do Estado do Pará, pelo administrador da recebedoria de rendas públicas, Pedro da Cunha, relativo ao serviço dessa repartição, no anno de 1892. Belém, Typ. Diario Official, 1893. This *item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.*

Relatório apresentado ao exmo. sr. dr. José Paes de Carvalho, governador do Estado do Pará, por J. F. Monteiro da Silva, inspector de Terras e Colonisação, 1899. This item has not been catalogued and can be found at the rare manuscripts and books section of the Library Arthur Vianna in Belém do Pará, Brazil.

Relatório apresentado ao exmo. sr. Presidente da Provincia do Gram-Pará, Dr. João da Silva Carrão, pelo inspector do thesouro público provincial, José Coelho da Motta, no anno de 1858. Pará, Typ. Santos e Filhos.

Relatório e Balanço da Directoria Geral do Thesouro Público 1899. Relatório apresentado ao exmo. sr. dr. José Paes de Carvalho, Governador do Estado do Pará por Bernardino de Sena Pinto Marques, inspector do Thesouro Público. Pará, J. Chiatti & C.

Relatório apresentado ao exmo. sr. dr. José Paes de Carvalho, Governador do Estado do Pará, pelo engenheiro dr. Victor Maria da Silva, director dos trabalhos públicos.

Relatório dirigido ao exmo. sr. presidente da província do Gram-Pará Dr. Francisco Carlos d'Araujo Brusque, pelo inspector do thesouro público provincial, José Coelho da Motta, em 1º de setembro de 1862. Pará, Typ. Commercial de Antônio José Rabello Guimarães, 1862.

Relatório apresentado ao Governador do Estado pelo Secretário Manuel Baena em janeiro de 1897. Pará, Typ. Diario Official, 1897.

Relatório apresentado pelo Director da Repartição de Obras Públicas, Terras e Colonisação em 9 de janeiro de 1897. Belém, Typ. Diario Official, 1897.

Relatório apresentado ao Sr. Secretário de Obras Públicas, Terras e Viação, Victor Maria da Silva, engenheiro civil pelo chefe da 1ª seção, Euclydes Faria. Belém, 1902.

Relatório sobre Rendas Públicas e Commercio apresentado ao Governador do Estado do Pará, dr. Lauro Sodré, pelo Administrador da Recebedoria de Rendas Públicas, Tenente-Coronel Pedro da Cunha. Pará, Typ. Diário Official, 1897.

B.4 Amazonas State/Province: Serial Speeches and Reports

Speeches (Fallas), (1860-1913).

Annual Reports, (1860-1913).

Transfer of Government Reports, (1860-1913).

B.5 Amazonas State/Province: Miscellaneous

Relatório apresentado ao exmo. sr. dr. Presidente da Província Domingos Monteiro Peixoto pelo dr. Aprígio Martins de Menezes encarregado da enfermaria de variolosos. Manaos, Typ. Commercio do Amazonas, 1874.

Relatório apresentado ao exmo. sr. dr. Presidente da Província Domingos Monteiro Peixoto pelo director de obras públicas Joaquim Leovigildo de Souza Coelho. Manaos, Typ. Commercio do Amazonas, 1874.

Relatório apresentado ao exmo. sr. dr. Presidente da Província do Amazonas Domingos Monteiro Peixoto pelo inspector do thesouro público provincial Aristides Justo Marignier. Manaos, Typ. Commercio do Amazonas, 1874.

Relatório apresentado ao exmo. sr. dr. Presidente da Província do Amazonas Domingos Monteiro Peixoto pelo inspector do thesouro público provincial Thomaz Luiz Simpson em 27 de fevereiro de 1875. Manaos, Typ. Commercio do Amazonas, 1875.

Relatório apresentado ao Governador do Estado do Amazonas José Cardoso Ramalho Junior pelo Secretário de Estado dos Negócios da Fazenda, major Nicolau Tolentino, em 30 de junho de 1899.

Relatório apresentado ao exmo. sr. dr. Antonio Constantino Nery, Governador do Estado, por Cyrillo Leopoldo da Silva Neves, inspector do thesouro, acompanhado dos respectivos annexos (1907). Manaos, Typ. A vapor do Amazonas, 1908.

Relatório apresentado ao exmo. sr. dr. Raymundo Affonso de Carvalho, Governador do Estado, por Cyrillo Leopoldo da Silva Neves, inspector do thesouro em comissão, acompanhado dos respectivos annexos – Anno 1908. Manaos, Secção de Obras da Imprensa Official, 1909.

Relatório apresentado ao exmo. sr. dr. Antonio Clemente Ribeiro Bittencourt, Governador do Estado, por Cyrillo Leopoldo da Silva Neves, inspector do thesouro em comissão, acompanhado dos respectivos annexos – Anno 1909. Manaos, Secção de Obras da Imprensa Official, 1910.

Relatório apresentado ao exmo. sr. dr. Antonio Clemente Ribeiro Bittencourt, Governador do Estado, por Cyrillo Leopoldo da Silva Neves, inspector do thesouro em comissão, acompanhado dos respectivos annexos – Anno 1910. Manaos, Secção de Obras da Imprensa Official, 1911.

B.6 Brazilian Government Publications

IBGE, Fundação Instituto Brasileiro de Geografia e Estatística. *Estatísticas históricas do Brasil: séries econômicas, demográficas e sociais de 1550 a 1988.* Edited by IBGE. Vol. 3, *Séries estatísticas retrospectivas.* Rio de Janeiro: IBGE, 1987.

IBGE, Fundação Instituto Brasileiro de Geografia e Estatística. *Estatísticas do Século XX.* Edited by IBGE. Rio de Janeiro: IBGE, 543pp, 2003.

Ministério da Agricultura, Industria e Comércio - Diretoria do Serviço de Inspecção e Fomento Agrícolas: *ASPECTOS DA ECONOMIA RURAL BRASILEIRA*, 1922.

Ministério da Fazenda. *Importação e Exportação, Movimento Marítimo, Cambial e do Café da República dos Estados Unidos do Brazil*, Serviço de Estatística Commercial. Years: 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910-12.

B.7 UK Diplomatic and Consular Reports (Pará)

Brazil. Report by Consul Green on the Trade and Commerce of Pará for the Years 1877 and 1878. [Parliamentary Papers, 1880, LXXIII].

Brazil. Report by Consul Green on the Trade and Commerce of Pará for the Years 1879 and 1882. [Parliamentary Papers, 1884, LXXIX].

Brazil. Report by the Acting-Consul Johnson on the Trade and Commerce of Pará for the Years 1883 and 1884. [Parliamentary Papers, 1884-5, LXXIX].

Brazil. Report for the Year 1897 on the trade of Pará and District. N. 2140 (Annual Series).

Brazil. Report for the Years 1898-9 on the trade of Pará and District. N. 2389 (Annual Series).

Brazil. Report for the Year 1900 on the trade of Pará and District. N. 2580 (Annual Series).

Brazil. Report for the Year 1901 on the trade of Pará and District. N. 2844 (Annual Series).

Brazil. Report for the Year 1902 on the trade of Pará. N. 3107 (Annual Series).

Brazil. Report for the Years 1903-04 on the trade of Pará. N. 3436 (Annual Series).

Brazil. Report for the Years 1905-06 on the trade of Pará. N. 3874 (Annual Series).

Brazil. Report for the Year 1907 and previous years on the trade of the consular district of Pará. N. 4111 (Annual Series).

Brazil. Report for the Years 1910-12 and part of 1913 on the trade Pará. N. 5262 (Annual Series).

Brazil. Report for the Year 1913 on the trade of the consular district of Pará. N. 5380 (Annual Series).

B.8 UK Diplomatic and Consular Reports (Other Brazilian States)

Brazil (Amazonas). Report on the trade of Amazonas (1900). N. 530 (Miscellaneous Series).

Brazil (Rio de Janeiro). Report for the Year 1900 on the Trade &c. of Rio de Janeiro. N. 2724 (Annual Series).

Brazil (Bahia). Report for the Year 1908 on the Trade of Bahia. N. 4313 (Annual Series).

B.9 UK Diplomatic and Consular Reports (Brazil)

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1859, XXXI].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1866-7, LXVII].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1867-8, LXVIII].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1870, LXIV].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1875, LXXV].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1878, LXXIII].

Brazil. Report on the Trade and Commerce of Brazil. [Parliamentary Papers 1881, LXXXIX].

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Brazil. Report for the Year 1906 on the Trade and Commerce of Brazil. N. 3878 (Annual Series).

Brazil. Report for the Year 1908 on the Trade of Brazil. N. 4358 (Annual Series).

Brazil. Report for the Year 1909 on the Trade of Brazil. N. 4575 (Annual Series).

B.10 UK Diplomatic and Consular Reports (Miscellaneous)

Africa (Congo). Correspondence and Report from His Majesty's Consul at Boma respecting the Administration of the Independent State of the Congo. No. 1 (Africa, 1904: Correspondence).

Africa (Congo). Correspondence respecting the Report of the Commission of Inquiry into the Administration of the Independent State of the Congo. No. 1 (Africa, 1906: Commission of Inquiry).

Peru (Putumayo). Correspondence relating to the treatment of British Colonial subjects and native Indians employed in the collection of rubber in the Putumayo District, including Sir Roger Casement's Report. (Miscellaneous Papers n. 8, 1912).

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B.11 Other Foreign Governments Publications

US Trade and Navigation Reports (1861-1912).

US Census of Manufactures (1904 and 1909)

UK Parliamentary Papers – Annual Statements of Trade (1849-1913)

UK Census of Production (1907 and 1912)

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C. Newspapers and Periodicals

India Rubber World, several issues.

India Rubber Journal, several issues.

A Província do Pará, several issues.

Folha do Norte, several issues.

Diário de Notícias, several issues.

New York Times, several issues.

Rubber Producing Companies (Capitalised in Sterling), with list of directors and secretaries, compiled by the Mincing Lane and Tea & Rubber Share Brokers' Association, Ltd. (1911).

Rubber Share Handbook – Details of Companies owing rubber and other produce properties in Ceylon, The Malay Peninsula, British Borneo, Sumatra, Java, Africa and South America. London: The Financier and Building Ltd., September 1910.

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D. Contemporary Publications

D.1 Albums and Almanacs

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Álbum do Amazonas 1901-02, Manaus, F. A. Fidanza (fotografias).

Barbosa, P. *Almanak do Pará: commercial, industrial e administrativo para o anno de 1890*. Pará: Typ. Pinto Barbosa & C., 1890.

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D.2 Traveller's Accounts and Miscellaneous

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IBGE: http://www.ibge.gov.br

Dataloy: http://www.dataloy.com

Projeto Nêmesis - Memória Estatística do Brasil:
http://www.nemesis.org.br/sec-est.php?s=800&i=pt

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Appendix A: Econometric Results

A.01 - Underlying Model: Almost Ideal Demand System[442]

The aim of Almost Ideal Demand System (AIDS) is to provide with a framework that is general enough to be used as a first-order approximation to any demand system. Preferences are assumed to be represented by a *PIGLOG* preference, a function that allows for exact aggregation over consumers: the market outcome can then be understood as the result of independent decisions taken by all agents (or, analogously here, by a representative consumer). This class of preferences, *PIGLOG*, are in turn represented via an expenditure function:

$$\log e(u,p) = (1-u)\log a(p) + u \log b(p) \tag{a.1}$$

where u lies between 0 (subsistence) and 1 (bliss) so that the positive linearly homogeneous functions a(p) and b(p) represent the cost of subsistence and bliss, respectively.

The expenditure function defines the minimum expenditure required to attain a specific utility level at given prices and it can be shown that this function will exist whenever preferences satisfy the assumption of local non-satiation (since in that case indirect utility function would be strictly increasing in income). In this context, the problem of utility maximisation can be analogously solved by the minimisation of the expenditure function for a given utility level, u^*:

$$\text{e(u,p)} = \min \text{px} \tag{a.2}$$
$$\text{s.t. } \text{u(x)} = \text{u}^*$$

Any expenditure defined in that way would have the following properties provided that p >> 0 and $u > u(0)$ where u is a continuous utility function representing a locally nonsatiated preference relation defined on the consumption set $X = \Re^n_+$:

1. $e(p,u)$ will be non-decreasing in p_k for any k and strictly increasing in u;
2. $e(p,u)$ is homogeneous of degree 1 in p;
3. $e(p,u)$ is concave in p;
4. $e(p,u)$ is continuous in p and u;
5. *If* $h(p,u)$, the hicksian demand function, is the bundle with the least cost to attain a certain level of utility at prices p, then $\text{h}_\text{i}(\text{p,u}) = \frac{\partial \text{e(p,u)}}{\partial \text{p}_\text{i}}$, $\forall i = 1,\ldots,n$. Provided that these derivatives exist for every $p > 0$.

This last property is particularly interesting insofar as it is known that the hicksian demand at utility u is equal to the marshallian demand at income $e(p,u)$. Therefore, it follows that the price derivatives of $e(u,p)$ are the quantities demanded. Conveniently defining *log a(p)* and *log b(p)* so that at any single point the first and second order derivatives of $e(u,p)$ exist:

$$\log a(p) = a_0 + \sum_K a_k \log p_k + \frac{1}{2}\sum_K \sum_J \gamma^*_{kj} \log p_k \log p_j \tag{a.3.1}$$

$$\log b(p) = \log a(p) + \beta_0 \prod_K p_k^{\beta_k} \tag{a.3.2}$$

It will follow that,

[442] This section follows Deaton and Muellbauer (1980).

$$\frac{\partial e(u,p)}{\partial p_i} = q_i \qquad \text{(a.4)}$$

Multiplying both sides of equation a.4 by $\frac{p_i}{e(u,p)}$, it is straightforward to see that:

$$\frac{\partial \log e(u,p)}{\partial \log p_i} = \frac{p_i q_i}{e(u,p)} = w_i \qquad \text{(a.5)}$$

Where w_i is the budget share of good *i*. Therefore, substituting a.3.1 and a.3.2 into equation a.1 and logarithmic differentiating it, it is possible to obtain the budget shares as a function of prices and utility:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i u \beta_0 \prod p_k^{\beta_k} \qquad \text{(a.6)}$$

where $\gamma_{ij} = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ji}^*)$

As argued earlier, the expenditure minimisation problem is equivalent to the problem of maximisation of utility, meaning that the relations below must always hold, provided that *v(p,m) = max u* and *e(p,u) = min px*, where *v(.)* is the indirect utility and *w*, income:

$$e(p,v(p,w)) \equiv w \qquad \text{(a.7.1)}$$
$$v(p,e(p,u)) \equiv u \qquad \text{(a.7.2)}$$

Condition a.7.1 simply states that *w* is the lowest income from which it is possible to achieve utility *v(p,w)*, whereas condition a.7.2 establishes that the maximum utility at income *e(p,u)* is *u*. Note that it is implicit the assumption that the individual must spend their entire income *w* otherwise they will not satisfy the maximisation axioms. Hence, solving equation a.1 for *u* as a function of *p* and *x* and substituting it into a.6, it follows that:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log \frac{x}{P} \qquad \text{(a.8.1)}$$

where $\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \log p_j$ (a.8.2)

Provided that the three set of conditions below hold, equation a.8.1 then represents a system of demand functions that add up to total expenditure ($\sum w_i = 1$), are homogeneous of degree zero in prices and total expenditure taken together, and satisfy Slutsky symmetry.

$\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \gamma_{ij} = 0$ and $\sum_{i=1}^{n} \beta_i = 0$ (a.9.1)

$$\sum_j \gamma_{ij} = 0 \qquad \text{(a.9.2)}$$

$$\gamma_{ij} = \gamma_{ji} \qquad \text{(a.9.3)}$$

Equation a.8.1 will be the specification to be estimated in this paper. As it is explained elsewhere before, from the results obtained, it is possible to compute elasticities of demand that each rubber supplier faced, notably Brazilian rubber exporters. It is also possible to compute cross elasticites between different sources of rubber, providing a notion of substitutability and complementarity between different types of rubber. Lastly, it is possible to evaluate welfare analysis between different scenarios of government intervention in the market, with focus here lying on Brazilian government taxation over rubber exports.

A.02 - AIDS System from British Data, 1870-1910

UK Data

Estimation Method: Iterative Seemingly Unrelated Regression
Sample: 1870 1910
Included observations: 41
Total system (balanced) observations 82
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 3 weight matrices, 4 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(10)	-0.68	0.32	-2.15	3.50%
C(20)	-0.28	0.07	-3.76	0.03%
C(30)	0.08	0.06	1.49	14.17%
C(100)	0.07	0.02	3.99	0.02%
C(11)	0.79	0.34	2.30	2.39%
C(31)	0.01	0.06	0.14	88.94%
C(102)	-0.03	0.02	-1.77	8.00%

Determinant residual covariance	2.05E-06

Equation: BRZ_MKT = C(10) + C(20)*LOG(BRZ_PRC) + C(30)
LOG(BRC_PRC) + C(100)(LOG(ALL_VAL)-LN_PRICE)
Observations: 41

R-squared	0.35	Mean dependent var	0.60
Adjusted R-squared	0.30	S.D. dependent var	0.05
S.E. of regression	0.04	Sum squared resid	0.06
Durbin-Watson stat	1.41		

Equation: BRC_MKT = C(11) + C(30)*LOG(BRZ_PRC) + C(31)
LOG(BRC_PRC) + C(102)(LOG(ALL_VAL)-LN_PRICE)
Observations: 41

R-squared	0.10	Mean dependent var	0.16
Adjusted R-squared	0.02	S.D. dependent var	0.05
S.E. of regression	0.05	Sum squared resid	0.08
Durbin-Watson stat	0.64		

A.03 - AIDS System from US Data, 1870-1910

USA Data

Estimation Method: Iterative Seemingly Unrelated Regression
Sample: 1870 1910
Included observations: 41
Total system (balanced) observations 82
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 6 weight matrices, 7 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(10)	-0.97	0.30	-3.27	0.16%
C(20)	-0.02	0.05	-0.32	75.30%
C(30)	-0.18	0.04	-5.09	0.00%
C(100)	0.08	0.02	5.06	0.00%
C(11)	0.52	0.22	2.41	1.85%
C(31)	0.23	0.04	5.91	0.00%
C(102)	-0.02	0.01	-1.44	15.26%

Determinant residual covariance	2.94E-06

Equation: BRZ_MKT = C(10) + C(20)*LOG(BRZ_PRC) + C(30)
LOG(BRC_PRC) + C(100)(LOG(ALL_VAL)-LN_PRICE)
Observations: 41

R-squared	0.44	Mean dependent var	0.58
Adjusted R-squared	0.39	S.D. dependent var	0.07
S.E. of regression	0.05	Sum squared resid	0.11
Durbin-Watson stat	0.85		

Equation: BRC_MKT = C(11) + C(30)*LOG(BRZ_PRC) + C(31)
LOG(BRC_PRC) + C(102)(LOG(ALL_VAL)-LN_PRICE)
Observations: 41

R-squared	0.30	Mean dependent var	0.17
Adjusted R-squared	0.25	S.D. dependent var	0.04
S.E. of regression	0.04	Sum squared resid	0.05
Durbin-Watson stat	1.05		

A.04 - Symmetry Test for the British System

Wald Test:			
Test Statistic	Value	df	Probability
Chi-square	0.23	1	62.92%

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(21) - C(30)	0.04	0.08

Restrictions are linear in coefficients.

A.05 - Symmetry Test for the US System

Wald Test: USA (1870-1910)			
Test Statistic	Value	df	Probability
Chi-square	7.46	1	0.63%

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-C(21) + C(30)	-0.23	0.09

Restrictions are linear in coefficients.

A.06 – AIDS System for British and US data combined, 1870-1910

Estimation Method: Seemingly Unrelated Regression

Date: 02/05/08 Time: 17:39
Sample: 1870 1910
Included observations: 41
Total system (balanced) observations 82
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(10)	-0.90	0.24	-3.76	0.03%
C(11)	-0.15	0.04	-3.44	0.10%
C(12)	-0.05	0.03	-1.41	16.18%
C(100)	0.08	0.01	6.24	0.00%
C(20)	0.75	0.22	3.48	0.08%
C(22)	0.10	0.04	2.82	0.62%
C(101)	-0.03	0.01	-3.00	0.37%

Determinant residual covariance 0.00

Equation: BRZ_MKT = C(10) + C(11)*LOG(BRZ_PRC) + C(12)
LOG(BRC_PRC) + C(100)(LOG(X)-LN_PRICE)
Observations: 41

R-squared	0.53	Mean dependent var	0.64
Adjusted R-squared	0.49	S.D. dependent var	0.05
S.E. of regression	0.04	Sum squared resid	0.05
Durbin-Watson stat	1.17		

Equation: BRC_MKT = C(20) + C(12)*LOG(BRZ_PRC) + C(22)
LOG(BRC_PRC) + C(101)(LOG(X)-LN_PRICE)
Observations: 41

R-squared	0.18	Mean dependent var	0.11
Adjusted R-squared	0.11	S.D. dependent var	0.03
S.E. of regression	0.03	Sum squared resid	0.03
Durbin-Watson stat	0.69		

A.07 – Symmetry Test for British and US data combined, 1870-1910

Wald Test

Test Statistic	Value	df	Probability
Chi-square	6.93	1	0.85%

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(12) - C(21)	-0.15	0.06

Restrictions are linear in coefficients.

Appendix B: Macroeconomic Data

B.01: Total Population in the Brazilian Amazon (divided by Provinces/States)

1840-1910

Years	Amazonas State	Pará State	Acre Federal Territory	Amazon Region	Amazon/ Brazil
1800	n.a.	n.a.	n.a.	90,000	2.5%
1810	n.a.	n.a.	n.a.	108,639	2.6%
1820 /a /b	18,506	118,494	n.a.	137,000	2.9%
1830	n.a.	n.a.	n.a.	128,896	2.4%
1840 /b	19,570	109,960	n.a.	129,530	2.2%
1850	n.a.	n.a.	n.a.	200,391	2.8%
1860	46,187	232,063	n.a.	278,250	3.3%
1870	54,895	268,014	n.a.	322,909	3.3%
1880	120,899	269,098	n.a.	389,997	3.1%
1890	147,915	328,455	n.a.	476,370	3.3%
1900	249,756	445,356	n.a.	695,112	4.0%
1910	358,695	783,845	74,484	1,217,024	5.1%
1920	363,166	983,507	92,379	1,439,052	4.7%

Notes: n.a. = not available. Note that Acre Federal State was part of Bolivia until 1903 when through Petropolis Treaty Brazil bought this Area from Bolivia.

/a Breakdown figures by Provinces/States based on 1819 shares.

/b Brazilian population for 1820 and 1840 was obtained by linear interpolation from the nearest years for which data was available.

Sources: Elaborated from Santos, Roberto. História Econômica da Amazônia, 1980 and Giorgio Mortara (Estatisticas Historicas do Brasil, p. 31, Tab. 1.5).

B.02: Population Breakdown (selected years), 1854-1920

	Amazonas				Para			
	Free		Slaves		Free		Slaves	
	Sex Ratio	Total	Sex Ratio	Total	Sex Ratio	Total	Sex Ratio	Total
1854	100	41,411	94	1,189	90	173,750	103	33,650
1872	121	56,631	99	979	108	247,779	103	27,463
1890	121	147,915	-	-	103	328,455	-	-
1900	121	249,756	-	-	105	445,356	-	-
1920	118	363,166	-	-	105	983,507	-	-

Note: Sex ratio is defined as males/females.

Sources: a) 1854 and 1872: Botelho, Tarcisio Rodrigues. Populacao e Nacao no Brasil do Seculo XIX, tese de doutorado, sp, usp, 1999; b) 1890, 1900 and 1920: Brasil. Estatisticas Historicas do Brasil. Series Economicas, Demograficas e Sociais de 1550 a 1985. Rio de Janeiro, IBGE, 1987.

B.03: GDP Estimates for the Brazilian Amazon, 1800-1915

	Total GDP BRZ mil-réis	Primary Sector BRZ mil-réis	Secondary Sector BRZ mil-réis	Terciary Sector BRZ mil-réis
1800	$698.328	n.a.	n.a.	n.a.
1805	$718.786	n.a.	n.a.	n.a.
1810	$376.307	n.a.	n.a.	n.a.
1815	$491.146	n.a.	n.a.	n.a.
1820	$503.333	n.a.	n.a.	n.a.
1825	$554.118	n.a.	n.a.	n.a.
1830	$748.235	n.a.	n.a.	n.a.
1835	$611.111	n.a.	n.a.	n.a.
1838	$945.000	n.a.	n.a.	n.a.
1840	$1,402.728	n.a.	n.a.	n.a.
1845	$1,945.554	n.a.	n.a.	n.a.
1850	$3,641.895	n.a.	n.a.	n.a.
1855	$8,644.666	n.a.	n.a.	n.a.
1860	$14,242.303	n.a.	n.a.	n.a.
1865	$16,161.342	n.a.	n.a.	n.a.
1870	$24,704.963	n.a.	n.a.	n.a.
1875	$37,291.930	n.a.	n.a.	n.a.
1880	$47,077.464	n.a.	n.a.	n.a.
1885	$85,549.250	n.a.	n.a.	n.a.
1890	$106,222.192	$53,953.169	$548.222	$51,720.801
1895	$175,697.357	n.a.	n.a.	n.a.
1900	$371,138.276	$181,039.545	$6,221.963	$183,876.768
1905	$283,938.000	n.a.	n.a.	n.a.
1910	$485,833.410	$218,286.714	$19,605.371	$247,941.325
1915	$153,568.000	n.a.	n.a.	n.a.

Source: Elaborated from Santos (1980, pp. 332-8).

B.04: Rural Wages in the Brazilian Amazon, 1911

Rural Wages in 1911	Pará in BRZ milréis			Amazonas in BRZ milréis		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Agricultural Worker	3$000	10$000		3$000	6$500	10$000
Carpenter	5$000		15$000	15$000	25$000	35$000
Stonemason				15$000	25$000	35$000

Note: It does not include payments in kind, especially in form of food. For Amazonas, the total wage with food would be increased by 1$000 to 1$200 BRZ *milréis.*

Source: Elaborated from Ministério da Agricultura, Indústria e Comércio - Diretoria do Serviço de Inspecção e Fomento Agrícolas: ASPECTOS DA ECONOMIA RURAL BRASILEIRA, 1922.

B.05: Price Differential in the Brazilian Amazon

	Price Differencials	
	At Solimões River	At Madeira River
Tappers/Rio de Janeiro	4.9	10.2
Tappers/Estate Owner	1.6	3.4
Tappers/Intermediary	2.4	5.0
Estate Owner/Intermediary	1.5	1.5
Intermediary/Rio de Janeiro	2.1	2.1

Source: Santos (1980, p. 170). Figure shows the difference in prices of merchandises, practised by different nodes along the rubber chain.

B.06: Exchange Rates, 1870-1912

	US$/£ (1)	Pence/*milréis* (2)	US$/*milréis* (3)
1870	$5.59	22.06	$0.51
1871	$5.46	24.03	$0.55
1872	$5.45	25.00	$0.57
1873	$5.55	26.09	$0.60
1874	$5.42	25.78	$0.58
1875	$5.59	27.22	$0.63
1876	$5.42	25.34	$0.57
1877	$5.08	24.56	$0.52
1878	$4.89	22.94	$0.47
1879	$4.85	21.38	$0.43
1880	$4.84	22.09	$0.45
1881	$4.83	21.91	$0.44
1882	$4.87	21.16	$0.43
1883	$4.85	21.56	$0.44
1884	$4.85	20.69	$0.42
1885	$4.86	18.59	$0.38
1886	$4.86	18.69	$0.38
1887	$4.85	22.44	$0.45
1888	$4.87	25.25	$0.51
1889	$4.87	26.44	$0.54
1890	$4.86	22.56	$0.46
1891	$4.86	14.91	$0.30
1892	$4.87	12.03	$0.24
1893	$4.86	11.59	$0.23
1894	$4.88	10.09	$0.21
1895	$4.89	9.94	$0.20
1896	$4.87	9.06	$0.18
1897	$4.86	7.72	$0.16
1898	$4.85	7.19	$0.15
1899	$4.86	7.44	$0.15
1900	$4.87	9.50	$0.19
1901	$4.87	11.38	$0.23
1902	$4.87	11.97	$0.24
1903	$4.86	12.00	$0.24
1904	$4.87	12.22	$0.25
1905	$4.87	15.68	$0.32
1906	$4.85	16.19	$0.33
1907	$4.86	15.22	$0.31
1908	$4.87	15.16	$0.31
1909	$4.87	15.16	$0.31
1910	$4.86	16.23	$0.33
1911	$4.86	16.11	$0.33
1912	$4.87	16.16	$0.33

Sources: (1) Lawrence H. Officer, "Dollar-Pound Exchange Rate From 1791," MeasuringWorth, 2008. URL: http://www.measuringworth.org/exchangepound/

(2) Taxa de câmbio - libra esterlina / mil réis - RJ - Pence - Outras fontes - HIST_ERVL. IPEADATA, 2008 URL: http://www.ipeadata.gov.br

(3) = (1)*(2)/240

Appendix C: Rubber Trade Data

C.01: Notes on Rubber Trade Statistics, 1870-1912

Statistics during the Second Empire (1840-1889) were noticeably better when compared with the First Republic (1889-1930). The Second Empire was an exercise of State building in which the Emperor tried to extend the central government authority over all corners of the country. For this aim, he needed up to date and reliable information about the Provinces. Presidents of the Provinces were appointed by the Emperor and usually drawn from the central elite. In order to weaken political ties between the Presidents and the local elites, Presidents were constantly changing seats. In 1889, a peaceful military coup overthrew the Emperor and established a Republican Federation but the government was handed to civilians just a few years later. Provinces became States and appointed Presidents were replaced by locally elected Governors. Under the Federation, States were given rights to tax exports while import taxation stayed in the hands of the central government. During the Empire, only the central government had right to tax trade even though States sometimes applied export taxes on foreign and inter-Provincial commerce.

The first decade of the Republic was marked by political and economic instability with high inflation, falling exchange rates and external default. Yet, at the turn of the century, economic policy started leaning towards monetary orthodoxy. From 1906 to 1914 the country formally adopted the gold standard. Sudden changes in the exchange rates were particularly damaging for trade statistics. Trade values denominated in foreign currency may have varied widely, depending on which parity was used as a benchmark: average over the year, end of the year, etc. Sometimes, for taxation purposes, values were computed from official prices generating additional problems for the trade statistics. Smuggling, double-counting and inaccuracies may have turned trade quantities very unreliable too.

There are three sources for exported quantities of rubber: regional, central and foreign. Regional data come from the Provinces/States and were reported in regional publications such as *Fallas* (Speeches) of Presidents/Governors and Annual Reports. Central statistics were produced by the Empire and later by the Federal governments. These national data on rubber exports were later compiled and organised by IBGE (National Institute of Geography and Statistics in the *Anuário Estatístico do Brasil, Ano V, 1939/40*) and republished in the volume *Estatísticas Históricas do Brasil*. Lastly, foreign data were obtained from importing statistics of the main rubber consumers: France, United States and Britain. Figure C.02 below shows that these three sources do not agree on the amount of rubber exported by either the Brazilian Amazon or Brazil.

Due to changes in the quality of data reporting, it is necessary to break Figure C.02 into two different periods representing the Empire and the Republic. In the first period (until 1889), regional statistics suggest a higher amount of rubber was exported when compared to central Statistics. There are at least three possible reasons for this: 1) there was systematic error in one of the sources, possibly in the provincial data due to the fact that the central series was supposedly corrected backwards by IBGE in the 1940s; 2) Different definition of what exported rubber was[443] as, for instance, caucho may have not been considered as rubber; 3) As exports from inland provinces (and some neighbouring countries) had to pass through a coastal province (as was the case of the Mato-Grosso and Amazonas), there may have occurred double-counting. However, foreign statistics were systematically higher than those reported by the country as a whole, meaning that central statistics were undoubtedly under-reported (assuming that foreign statistics are correct)[444]. Yet the foreign statistics do not even include other important markets for Brazilian rubber: Portugal, Belgium and Germany. In turn, apart from a few years[445],

[443] In the statistics, rubber (borracha) was reported under different categories: borracha fina, borracha entrefina, borracha sernamby, caucho, mangabeira, maniçoba, and massaranduba.

[444] It is important to remember that the exports of rubber reported by Brazilian Statistics must be at least as large as those reported by importing countries, not least because of shrinkage of rubber in transit. It is more likely that smuggling occurred in the Brazilian Amazon than, say, in Liverpool.

[445] Some differences in the statistics may arise due to the time of travel: for instance, if rubber was shipped in Brazil in December 1900, it may only arrive in Europe or in the USA in January 1901.

regional statistics were always higher than foreign ones. Therefore, during the Empire, regional statistics seem more reliable than central ones. From 1890 to 1912, the opposite was true.[446] First, central statistics were systematically higher than regional statistics. This makes sense and it is expected as there were some other states in Brazil that also produced rubber. The difference may come from their exports of rubber. However, looking at the original sources of the central statistics (for instance: *Importação e Exportação, Movimento Marítimo, Cambial e do Café da República dos Estados Unidos do Brazil, Serviço de Estatística Commercial, Ministério da Fazenda*), it is possible to see that figures for the Amazonas and Pará States and the Federal Territory of Acre were considerably larger than that reported in their regional statistics. Moreover, the difference does not stem from different definition of what rubber represented. Comparing regional statistics against foreign ones, it is possible to see that regional statistics were under reported. Even if rubber exports from other Brazilian states are added, foreign imports of rubber are considerably higher in nearly all years after 1889. In this period, central statistics of rubber exports are higher than than reported by major importing countries and thus are considered more reliable.

In sum, during the Second Empire regional statistics are more likely to be correct and, during the First Republic, central statistics seem more reliable. Yet it is impossible to know how reliable these two series really are. Therefore, unless otherwise stated, foreign statistics, which refer to rubber imports from Brazil as a whole, will be used as representative for the Brazilian Amazon. Other States did export rubber but only in insignificant quantities. Foreign statistics may have encompassed rubber exports from neighbouring countries (such as Peru, Colombia and Bolivia) but this may not be a significant problem. For instance, as econometric exercises are interested to assess the degree of market power by exporters placed in Brazil, it is possible that these agents did have some degree of control of rubber that was being channelled through the Brazilian Amazon, even if produced elsewhere.

[446] This stroke me as odd though. I was expecting that the administrative unit which was responsible for taxing would produce the most reliable series of rubber exports. It seems that the opposite happened.

C.02: Comparing Different Sources of Rubber Trade Statistics, 1870-1912

in tons	Regional Data (1)	Central Data (2)	Foreign Data (3)	Central - Regional (2) - (1)	Foreign - Regional (3) - (1)	Foreign - Central (3) - (2)
1870	6,239	4,912	5,195	-1,327	-1,044	283
1871	6,684	5,369	4,741	-1,315	-1,942	-627
1872	6,991	5,381	5,667	-1,611	-1,324	287
1873	7,754	5,882	6,279	-1,872	-1,476	397
1874	8,004	6,266	6,127	-1,738	-1,877	-139
1875	7,723	5,785	7,108	-1,938	-615	1,323
1876	7,819	5,956	6,797	-1,864	-1,023	841
1877	8,562	6,409	7,393	-2,153	-1,169	984
1878	9,222	6,549	7,583	-2,673	-1,639	1,034
1879	9,678	6,668	7,708	-3,010	-1,970	1,040
1880	8,679	6,802	7,623	-1,878	-1,056	822
1881	8,620	6,782	8,860	-1,839	240	2,078
1882	9,806	7,170	9,030	-2,636	-776	1,860
1883	10,542	8,326	9,667	-2,216	-875	1,341
1884	10,393	8,528	10,537	-1,865	145	2,009
1885	12,316	8,045	11,988	-4,272	-328	3,944
1886	13,164	8,414	12,806	-4,750	-357	4,393
1887	13,711	6,695	14,013	-7,016	302	7,318
1888	15,458	17,062	17,051	1,604	1,593	-11
1889	15,938	15,990	15,623	52	-316	-367
1890	15,355	15,355	15,921	0	566	566
1891	16,650	16,650	16,246	0	-404	-404
1892	15,990	18,250	18,859	2,260	2,869	609
1893	17,965	19,050	19,826	1,085	1,861	776
1894	16,821	19,710	18,747	2,889	1,926	-963
1895	17,786	27,794	20,695	10,008	2,909	-7,099
1896	18,008	24,370	21,471	6,362	3,463	-2,899
1897	19,700	21,621	19,937	1,921	237	-1,684
1898	19,830	21,218	23,983	1,388	4,153	2,765
1899	22,930	20,790	22,786	-2,140	-144	1,996
1900	24,427	24,302	26,557	-125	2,130	2,255
1901	25,746	30,241	29,351	4,495	3,605	-890
1902	24,212	28,632	28,440	4,420	4,227	-192
1903	26,921	31,717	28,949	4,796	2,027	-2,768
1904	26,801	31,866	28,060	5,065	1,259	-3,806
1905	31,342	35,393	32,484	4,051	1,142	-2,909
1906	31,081	34,960	30,379	3,879	-702	-4,581
1907	32,532	36,490	35,774	3,958	3,243	-716
1908	32,270	38,206	33,121	5,936	851	-5,085
1909	32,609	39,027	38,472	6,418	5,863	-555
1910	32,224	38,547	40,456	6,323	8,232	1,909
1911	31,303	36,547	33,568	5,244	2,265	-2,979
1912	33,869	42,286	42,307	8,417	8,438	21

Sources:
(1) = Figure C.19, series 1 + Figure C.20, series 1 + Figure C.21, series 1
(2) = Figure C.05, series 1
(3) = Figure C.05, series 2 + series 3 + series 4.

C.03: Brazilian Official Statistics of Trade, 1870-1912

	Value of Brazilian Rubber Exported	Total Brazilian Exports	% Rubber in Total Exports
	£1,000	£1,000	%
	(1)	(2)	(1)/(2)
1870	741	15,446	4.80%
1871	988	17,264	5.72%
1872	1,050	20,741	5.06%
1873	1,099	21,506	5.11%
1874	1,126	21,506	5.23%
1875	1,125	21,606	5.20%
1876	1,154	20,697	5.58%
1877	1,181	19,818	5.96%
1878	1,142	19,286	5.92%
1879	1,086	19,649	5.53%
1880	1,091	20,519	5.31%
1881	1,093	20,194	5.41%
1882	1,173	18,258	6.42%
1883	1,050	18,436	5.70%
1884	883	19,499	4.53%
1885	901	17,307	5.21%
1886	941	17,806	5.28%
1887	1,164	21,954	5.30%
1888	4,024	27,566	14.60%
1889	2,788	39,409	7.07%
1890	2,550	40,658	6.27%
1891	2,686	40,327	6.66%
1892	3,012	44,422	6.78%
1893	3,403	47,434	7.17%
1894	3,554	46,495	7.64%
1895	5,055	47,832	10.57%
1896	3,774	44,626	8.46%
1897	4,232	40,050	10.57%
1898	5,325	37,961	14.03%
1899	6,126	38,055	16.10%
1900	6,429	45,936	14.00%
1901	8,627	57,204	15.08%
1902	7,294	56,748	12.85%
1903	9,734	55,052	17.68%
1904	11,220	57,847	19.40%
1905	14,416	64,358	22.40%
1906	14,056	75,381	18.65%
1907	13,690	80,707	16.96%
1908	11,785	71,244	16.54%
1909	18,926	85,802	22.06%
1910	24,646	94,954	25.96%
1911	15,057	98,385	15.30%
1912	16,095	108,069	14.89%

Sources: (1) Estatisticas Historicas do Brasil, 1550-1985, Table 6.40, p. 309.
(2) Estatisticas Historicas do Brasil, 1550-1985, Tables 11.1 and 11.2, pp. 523-524.

Note: Both series were adjusted for calendar year.

C.04: Value of Brazilian Rubber Traded, 1870-1912

	Value of Brazilian Rubber Exported	Value of Brazilian Rubber Imported into Selected Countries France	Britain	USA
	£1,000	£1,000	£1,000	£1,000
	(1)	(2)	(3)	(4)
1870	741	34	721	425
1871	988	31	993	208
1872	1,050	10	961	386
1873	1,099	12	949	561
1874	1,126	28	720	600
1875	1,125	28	1,015	451
1876	1,154	64	940	395
1877	1,181	39	928	511
1878	1,142	47	879	503
1879	1,086	44	1,082	680
1880	1,091	52	1,297	1,007
1881	1,093	103	1,267	1,232
1882	1,173	41	1,460	1,683
1883	1,050	70	1,953	1,786
1884	883	128	1,373	1,494
1885	901	125	1,256	1,108
1886	941	64	1,331	1,419
1887	1,164	147	1,605	1,707
1888	4,024	139	1,604	2,220
1889	2,788	131	1,756	1,554
1890	2,550	158	1,908	1,884
1891	2,686	282	1,765	2,532
1892	3,012	228	1,729	2,818
1893	3,403	195	2,030	2,406
1894	3,554	237	2,021	2,266
1895	5,055	291	2,176	2,698
1896	3,774	386	3,018	2,096
1897	4,232	416	2,672	2,346
1898	5,325	447	3,603	3,088
1899	6,126	646	3,089	3,498
1900	6,429	756	4,322	3,671
1901	8,627	705	3,747	3,474
1902	7,294	713	3,621	3,233
1903	9,734	605	4,518	3,543
1904	11,220	687	4,553	4,608
1905	14,416	993	6,009	5,847
1906	14,056	1,660	5,905	4,915
1907	13,690	1,049	6,244	6,779
1908	11,785	1,243	5,332	3,960
1909	18,926	1,777	8,643	7,036
1910	24,646	3,458	14,473	9,737
1911	15,057	1,840	7,940	5,869
1912	16,095	2,598	6,792	6,548

Source: (1) Estatisticas Historicas do Brasil, 1550-1985, Table 6.40, p. 309. Adjustments were made for different calendar years.
(2) Commerce and Navigation of the United States, 1870-1912.
(3) Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.
(4) Tableau general du commerce et de la navigation: commerce de la france avec ses colones et les puissances etrangeres, 1970-1912.

C.05: Quantity of Brazilian Rubber Traded, 1870-1912

	Official Brazilian Export of Rubber	Imports of Rubber from Brazil		
		France	Britain	USA
	tons	tons	tons	tons
	(1)	(2)	(3)	(4)
1870	4,912	121	2,700	2,374
1871	5,369	134	3,640	967
1872	5,381	43	3,462	2,162
1873	5,882	54	3,511	2,714
1874	6,266	132	2,874	3,121
1875	5,785	143	4,229	2,736
1876	5,956	329	4,106	2,361
1877	6,409	223	4,311	2,860
1878	6,549	299	4,619	2,665
1879	6,668	180	4,349	3,179
1880	6,802	213	3,885	3,526
1881	6,782	392	3,938	4,530
1882	7,170	145	3,737	5,148
1883	8,326	235	4,733	4,699
1884	8,528	491	4,626	5,421
1885	8,045	519	4,940	6,530
1886	8,414	265	4,620	7,921
1887	6,695	566	5,789	7,658
1888	17,062	536	5,416	11,099
1889	15,990	546	6,231	8,846
1890	15,335	659	5,817	9,444
1891	16,650	1,005	5,561	9,680
1892	18,250	951	6,339	11,570
1893	19,050	814	6,879	12,133
1894	19,710	988	7,151	10,608
1895	27,794	1,212	7,468	12,015
1896	24,370	1,610	9,866	9,995
1897	21,621	1,486	8,537	9,915
1898	21,218	1,596	10,656	11,731
1899	20,790	1,700	8,628	12,458
1900	24,302	2,262	11,583	12,713
1901	30,241	2,109	11,459	15,783
1902	28,632	2,131	12,006	14,303
1903	31,717	1,808	13,025	14,116
1904	31,866	1,773	11,268	15,018
1905	35,793	2,644	13,241	16,599
1906	34,960	4,100	12,900	13,380
1907	36,490	2,981	14,520	18,274
1908	38,206	3,071	15,242	14,808
1909	39,027	2,804	15,712	19,955
1910	38,547	4,466	18,068	17,922
1911	36,547	3,484	16,013	14,071
1912	42,286	5,678	15,418	21,211

Source:

(1) Estatisticas Historicas do Brasil, 1550-1985, Table 6.40, p. 309. Adjustments were made for different calendar years.
(2) Commerce and Navigation of the United States, 1870-1912.
(3) Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.
(4) Tableau general du commerce et de la navigation: commerce de la france avec ses colones et les puissances etrangeres, 1970-1912.

C.06: Price of Brazilian Rubber Traded, 1870-1912

	Implicit Price of Brazilian Rubber Exported	Implicit Price of Brazilian Rubber Imported into Selected Countries		
		France	Britain	USA
	£ per ton	£ per ton	£ per ton	£ per ton
	(1)	(2)	(3)	(4)
1870	151	282	267	179
1871	184	229	273	215
1872	195	229	277	179
1873	187	229	270	207
1874	180	211	251	192
1875	194	194	240	165
1876	194	194	229	167
1877	184	176	215	179
1878	174	158	190	189
1879	163	246	249	214
1880	160	246	334	286
1881	161	264	322	272
1882	164	282	391	327
1883	126	300	413	380
1884	103	260	297	276
1885	112	240	254	170
1886	112	240	288	179
1887	174	260	277	223
1888	236	260	296	200
1889	174	240	282	176
1890	166	240	328	200
1891	161	280	317	262
1892	165	240	273	244
1893	179	240	295	198
1894	180	240	283	214
1895	182	240	291	225
1896	155	240	306	210
1897	196	280	313	237
1898	251	280	338	263
1899	295	380	358	281
1900	265	334	373	289
1901	285	334	327	220
1902	255	334	302	226
1903	307	334	347	251
1904	352	387	404	307
1905	403	375	454	352
1906	402	405	458	367
1907	375	352	430	371
1908	308	405	350	267
1909	485	634	550	353
1910	639	774	801	543
1911	412	528	496	417
1912	381	458	441	309

Source: (1) Estatisticas Historicas do Brasil, 1550-1985, Table 6.40, p. 309. Adjustments were made for different calendar years.
(2) Commerce and Navigation of the United States, 1870-1912.
(3) Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.
(4) Tableau general du commerce et de la navigation: commerce de la france avec ses colones et les puissances etrangeres, 1970-1912.

C.07: Value of Rubber Imported into Britain, 1870-1912

	Value of Rubber Imported into Britain from selected places							
	Brazil	Rest of the Amazon	Mexico & Central America	Africa	Re-Exporters	British Possessions	Others	Total
	£	£	£	£	£	£	£	£
1870	720,951	107,588	34,460	75,295	281,406	344,417	33,511	1,597,628
1871	992,955	214,265	27,418	81,112	126,222	203,571	38,738	1,684,281
1872	960,602	105,496	40,293	108,744	142,614	369,879	34,631	1,762,259
1873	949,201	117,906	53,818	140,244	170,240	295,398	19,288	1,746,095
1874	720,210	89,100	42,030	122,957	142,850	197,363	12,095	1,326,605
1875	1,015,204	60,256	47,408	113,863	145,192	165,745	22,890	1,570,558
1876	939,886	34,040	44,290	140,007	126,210	199,730	52,497	1,536,660
1877	928,308	20,094	31,536	164,554	111,709	210,987	17,606	1,484,794
1878	879,409	15,060	22,145	144,243	59,318	160,804	32,230	1,313,209
1879	1,082,044	15,003	19,026	195,667	55,345	212,535	46,670	1,626,290
1880	1,297,373	12,165	29,005	406,607	121,112	463,434	58,251	2,387,947
1881	1,267,008	21,849	30,882	314,892	163,774	341,785	114,428	2,254,618
1882	1,460,219	21,014	22,915	471,951	259,033	476,563	42,997	2,754,692
1883	1,953,142	37,893	47,122	513,692	356,390	726,591	17,987	3,652,817
1884	1,372,823	28,590	24,921	233,441	162,851	442,144	7,729	2,272,499
1885	1,255,978	3,946	20,401	206,118	162,922	324,546	7,824	1,981,735
1886	1,330,854	5,045	5,714	262,836	147,007	462,556	8,144	2,222,156
1887	1,605,115	14,823	13,219	263,897	208,830	591,197	7,484	2,704,565
1888	1,604,108	22,402	6,067	233,250	264,099	422,679	2,736	2,555,341
1889	1,755,718	15,500	2,247	256,481	263,001	317,334	7,088	2,617,369
1890	1,908,062	28,349	994	483,999	372,253	465,197	6,234	3,265,088
1891	1,765,450	23,573	4,147	314,519	659,765	574,583	6,943	3,348,980
1892	1,729,366	21,840	-	209,521	465,926	541,877	13,882	2,982,412
1893	2,029,858	36,071	4,545	234,348	356,759	654,089	14,748	3,330,418
1894	2,020,799	51,508	7,835	257,283	301,203	604,719	28,757	3,272,104
1895	2,176,189	24,871	2,976	242,450	393,347	885,959	34,386	3,760,178
1896	3,017,921	59,541	2,302	206,972	592,800	1,034,996	76,590	4,991,122
1897	2,671,569	145,759	548	285,972	338,275	1,077,050	34,243	4,553,416
1898	3,603,198	222,719	1,110	394,419	601,826	1,329,508	62,153	6,214,933
1899	3,089,499	234,884	4,775	476,880	837,606	1,205,135	75,118	5,923,897
1900	4,322,471	111,622	11,620	488,644	1,056,282	879,839	115,655	6,986,133
1901	3,746,909	279,821	1,620	358,136	935,765	419,575	88,398	5,830,224
1902	3,621,211	149,596	10,584	297,859	746,409	272,431	82,172	5,180,262
1903	4,518,101	287,814	2,051	557,157	833,710	449,923	94,210	6,742,966
1904	4,553,497	557,867	1,952	782,157	783,354	899,641	120,242	7,698,710
1905	6,008,967	622,467	1,314	677,235	1,108,381	1,075,033	150,556	9,643,953
1906	5,905,282	419,317	1,608	815,163	1,359,146	1,251,667	214,437	9,966,620
1907	6,244,393	773,128	2,249	849,431	1,168,315	1,577,333	219,910	10,834,759
1908	5,331,842	559,177	378	488,705	698,609	1,135,044	157,150	8,370,905
1909	8,642,829	851,474	34,885	741,703	975,896	2,624,732	266,685	14,138,204
1910	14,472,701	1,278,899	79,988	1,158,374	2,235,532	6,505,759	365,536	26,096,789
1911	7,940,106	907,918	38,825	800,014	1,120,477	7,033,143	492,019	18,332,502
1912	6,791,666	813,101	50,117	777,743	1,106,922	11,417,995	622,709	21,580,253

Source : Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.

Notes:
(1) Rest of the Amazon = Ecuador, 'Nueva Granada', Colombia, Venezuela and Peru.
(2) Central America & Mexico = 'Central America', Nicaragua, Guatemala, Haiti and Mexico
(3) Africa = 'Western Coast Africa', 'German West Africa', 'German East Africa', 'British West Coast Africa', 'British East Coast Africa', 'East Coast Africa', Madagascar, China, 'British South Africa', Natal, Mauritius, 'Zanzibar & Pemba', 'Gold Coast (incl. Lagos)', Nigeria, 'Sierra Leone', Gambia, 'Niger Protectorate', 'French West Africa', 'French Somaliland', 'Portuguese West Africa' and 'Fernando Po'.
(4) Re-Exporters = Hanse Towns, Russia, Holland, Belgium, Turkey, United States, France, Portugal, Spain, Italy, Hamburg, Bremen and Germany.
(5) British Possessions = 'Channel Islands', 'New South Wales', 'British West Indies', 'British East Indies', 'British India', 'Madras', 'Bombay & Scinde', 'India Singapore & Ceylon', Singapore & Eastern Straits', 'Ceylon', 'Federated Malay States', 'Borneo', 'Mauritius', 'Aden', 'Australasia', 'British West Coast Africa', 'British East Coast Africa', 'British South Africa', 'Natal', 'Zanzibar & Pemba', 'Gold Coast', 'Lagos', 'Nigeria', 'Sierra Leone', 'Gambia', 'Niger Protectorate' and finally 'Other British Possessions'.
(6) Others = all other countries not included in the categories above.

C.08: Quantity of Rubber Imported into Britain, 1870-1912

	Quantity of Rubber Imported into Britain from selected places							
	Brazil	Rest of the Amazon	Mexico & Central America	Africa	Re-Exporters	British Possessions	Others	Total
	tons	tons	tons	tons	tons	tons	tons	tons
1870	2,700	641	205	651	1,018	2,282	232	7,728
1871	3,640	1,327	242	693	532	1,439	311	8,183
1872	3,462	563	270	718	771	2,011	187	7,982
1873	3,511	660	341	860	820	1,680	127	7,998
1874	2,874	514	266	869	720	1,270	49	6,562
1875	4,229	373	300	816	739	1,194	151	7,801
1876	4,106	199	276	1,051	706	1,397	327	8,062
1877	4,311	127	200	1,158	662	1,538	118	8,114
1878	4,619	105	141	970	358	1,184	230	7,606
1879	4,349	85	106	1,159	314	1,383	255	7,651
1880	3,885	52	124	1,641	470	2,134	310	8,615
1881	3,938	110	132	1,474	717	1,756	616	8,742
1882	3,737	84	81	1,916	936	2,250	228	9,232
1883	4,733	139	159	2,010	1,324	3,190	85	11,639
1884	4,626	136	108	1,319	1,442	2,428	42	10,102
1885	4,940	22	108	1,195	945	1,904	38	9,152
1886	4,620	27	25	1,440	1,021	2,724	36	9,894
1887	5,789	64	56	1,506	1,272	3,336	43	12,066
1888	5,416	93	26	1,560	1,521	2,549	28	11,194
1889	6,231	60	10	1,744	1,881	2,007	72	12,005
1890	5,817	115	5	2,635	2,151	2,623	67	13,412
1891	5,561	88	17	1,791	3,132	3,524	53	14,166
1892	6,339	78	-	1,292	2,756	3,260	101	13,827
1893	6,879	151	17	1,484	2,309	3,956	107	14,904
1894	7,151	210	34	1,636	2,422	3,780	132	15,365
1895	7,468	103	15	1,510	2,851	5,263	142	17,352
1896	9,866	241	10	1,263	4,014	6,191	318	21,903
1897	8,537	579	3	1,608	3,011	6,302	125	20,165
1898	10,656	732	5	2,101	4,334	6,828	215	24,872
1899	8,628	693	18	2,256	5,399	5,593	256	22,843
1900	11,583	361	39	2,418	7,292	3,925	457	26,076
1901	11,459	961	5	1,890	6,995	2,041	346	23,698
1902	12,006	551	46	1,634	5,289	1,428	348	21,303
1903	13,025	919	8	2,235	6,015	2,081	411	24,695
1904	11,268	1,521	7	2,807	5,317	3,886	394	25,200
1905	13,241	1,536	5	2,259	8,360	4,229	519	30,148
1906	12,900	1,047	5	2,621	9,007	4,595	666	30,841
1907	14,520	1,796	6	2,881	8,566	5,323	809	33,900
1908	15,242	1,658	2	2,044	5,735	3,819	714	29,215
1909	15,712	1,957	93	2,371	8,445	5,998	990	35,565
1910	18,068	2,032	167	2,510	10,591	10,275	909	44,552
1911	16,013	2,149	118	2,211	9,709	14,389	1,435	46,024
1912	15,418	1,924	128	2,432	10,145	24,192	1,667	55,906

Source : Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.

Notes:
(1) Rest of the Amazon = Ecuador, 'Nueva Granada', Colombia, Venezuela and Peru.
(2) Central America & Mexico = 'Central America', Nicaragua, Guatemala, Haiti and Mexico
(3) Africa = 'Western Coast Africa', 'German West Africa', 'German East Africa', 'British West Coast Africa', 'British East Coast Africa', 'East Coast Africa', Madagascar, China, 'British South Africa', Natal, Mauritius, 'Zanzibar & Pemba', 'Gold Coast (incl. Lagos)', Nigeria, 'Sierra Leone', Gambia, 'Niger Protectorate', 'French West Africa', 'French Somaliland', 'Portuguese West Africa' and 'Fernando Po'.
(4) Re-Exporters = Hanse Towns, Russia, Holland, Belgium, Turkey, United States, France, Portugal, Spain, Italy, Hamburg, Bremen and Germany.
(5) British Possessions = 'Channel Islands', 'New South Wales', 'British West Indies', 'British East Indies', 'British India', 'Madras', 'Bombay & Scinde', 'India Singapore & Ceylon', Singapore & Eastern Straits', 'Ceylon', 'Federated Malay States', 'Borneo', 'Mauritius', 'Aden', 'Australasia', 'British West Coast Africa', 'British East Coast Africa', 'British South Africa', 'Natal', 'Zanzibar & Pemba', 'Gold Coast', 'Lagos', 'Nigeria', 'Sierra Leone', 'Gambia', 'Niger Protectorate' and finally 'Other British Possessions'.
(6) Others = all other countries not included in the categories above.

C.09: Implicit Price of Rubber Imported into Britain, 1870-1912

	Implicit Price of Rubber Imported into Britain from selected places							
	Brazil	Rest of the Amazon	Mexico & Central America	Africa	Re-Exporters	British Possessions	Others	Total
	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton
1870	267	168	168	116	276	151	145	207
1871	273	161	114	117	237	141	125	206
1872	277	187	149	151	185	184	185	221
1873	270	179	158	163	208	176	152	218
1874	251	173	158	142	198	155	248	202
1875	240	162	158	140	196	139	151	201
1876	229	171	161	133	179	143	161	191
1877	215	158	157	142	169	137	149	183
1878	190	144	158	149	166	136	140	173
1879	249	176	180	169	176	154	183	213
1880	334	234	234	248	258	217	188	277
1881	322	198	234	214	228	195	186	258
1882	391	249	281	246	277	212	189	298
1883	413	273	297	256	269	228	211	314
1884	297	210	231	177	113	182	182	225
1885	254	181	189	172	172	170	206	217
1886	288	188	226	183	144	170	228	225
1887	277	233	235	175	164	177	174	224
1888	296	241	229	149	174	166	99	228
1889	282	260	216	147	140	158	99	218
1890	328	247	208	184	173	177	93	243
1891	317	267	241	176	211	163	130	236
1892	273	280	n.a.	162	169	166	137	216
1893	295	239	270	158	154	165	138	223
1894	283	245	227	157	124	160	218	213
1895	291	243	197	161	138	168	242	217
1896	306	247	230	164	148	167	241	228
1897	313	252	204	178	112	171	273	226
1898	338	304	228	188	139	195	289	250
1899	358	339	268	211	155	215	293	259
1900	373	309	297	202	145	224	253	268
1901	327	291	295	190	134	206	255	246
1902	302	271	232	182	141	191	236	243
1903	347	313	254	249	139	216	229	273
1904	404	367	291	279	147	232	305	306
1905	454	405	287	300	133	254	290	320
1906	458	400	330	311	151	272	322	323
1907	430	431	349	295	136	296	272	320
1908	350	337	240	239	122	297	220	287
1909	550	435	375	313	116	438	269	398
1910	801	629	480	461	211	633	402	586
1911	496	422	329	362	115	489	343	398
1912	441	423	390	320	109	472	373	386

Source : Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions (Parliamentary Papers), 1870-1912.

Notes:
(1) Rest of the Amazon = Ecuador, 'Nueva Granada', Colombia, Venezuela and Peru.
(2) Central America & Mexico = 'Central America', Nicaragua, Guatemala, Haiti and Mexico.
(3) Africa = 'Western Coast Africa', 'German West Africa', 'German East Africa', 'British West Coast Africa', 'British East Coast Africa', 'East Coast Africa', Madagascar, China, 'British South Africa', Natal, Mauritius, 'Zanzibar & Pemba', 'Gold Coast (incl. Lagos)', Nigeria, 'Sierra Leone', Gambia, 'Niger Protectorate', 'French West Africa', 'French Somaliland', 'Portuguese West Africa' and 'Fernando Po'.
(4) Re-Exporters = Hanse Towns, Russia, Holland, Belgium, Turkey, United States, France, Portugal, Spain, Italy, Hamburg, Bremen and Germany.
(5) British Possessions = 'Channel Islands', 'New South Wales', 'British West Indies', 'British East Indies', 'British India', 'Madras', 'Bombay & Scinde', 'India Singapore & Ceylon', Singapore & Eastern Straits', 'Ceylon', 'Federated Malay States', 'Borneo', 'Mauritius', 'Aden', 'Australasia', 'British West Coast Africa', 'British East Coast Africa', 'British South Africa', 'Natal', 'Zanzibar & Pemba', 'Gold Coast', 'Lagos', 'Nigeria', 'Sierra Leone', 'Gambia', 'Niger Protectorate' and finally 'Other British Possessions'.
(6) Others = all other countries not included in the categories above.

C.10: Value of Rubber Imported into the USA, 1870-1912

	Value of Rubber Imported into the USA from selected places							
	Brazil	Rest of the Amazon	Mexico & Central America	Africa	Asia & Oceania	Europe	Others	Total
	£	£	£	£	£	£	£	£
1870	425,135	113,342	23,449	855	21,087	34,738	297	618,903
1871	208,335	109,813	5,287	57	7,945	50,132	32	381,601
1872	386,308	375,628	25,634	9	29,061	52,063	10,121	878,824
1873	561,268	486,462	31,008	8,130	56,321	95,165	4,990	1,243,342
1874	600,470	365,388	39,108	10,090	55,281	71,656	1,315	1,143,308
1875	450,704	259,804	39,143	6,133	39,908	40,636	75	836,403
1876	395,122	242,991	34,918	7,486	18,854	50,366	16	749,753
1877	511,486	311,798	26,804	4,782	12,670	213,797	9,641	1,090,978
1878	502,535	207,641	38,249	19,760	20,654	174,548	28	963,416
1879	679,746	220,797	37,794	22,993	8,768	281,055	-	1,251,152
1880	1,007,073	397,256	90,550	16,363	8,921	464,597	-	1,984,760
1881	1,231,833	397,689	182,398	17,496	12,535	393,798	53,062	2,288,809
1882	1,682,521	168,172	261,888	38,781	26,360	557,716	193,701	2,929,138
1883	1,786,178	220,968	324,655	35,142	64,267	534,257	232,690	3,198,157
1884	1,494,191	181,441	319,071	49,505	37,145	605,337	145,475	2,832,166
1885	1,108,449	78,796	190,007	20,998	41,406	364,549	67,248	1,871,452
1886	1,418,660	74,690	211,684	48,788	45,395	577,259	69,667	2,446,142
1887	1,707,050	188,469	267,635	60,218	55,663	556,043	1,372	2,836,450
1888	2,220,113	152,215	256,833	40,244	80,562	548,695	569	3,299,232
1889	1,554,210	112,553	211,306	33,773	68,120	563,597	-	2,543,559
1890	1,884,207	96,483	155,929	16,387	58,992	843,315	1,171	3,056,484
1891	2,531,735	168,403	181,464	20,558	52,412	752,852	561	3,707,984
1892	2,818,002	128,584	125,105	25,514	32,923	942,375	-	4,072,503
1893	2,405,752	130,868	120,291	21,960	31,108	954,473	-	3,664,452
1894	2,266,149	103,614	102,659	23,181	24,774	569,377	-	3,089,753
1895	2,698,416	107,412	110,418	11,034	23,386	802,529	-	3,753,194
1896	2,095,553	118,075	106,853	1,400	24,349	1,063,014	-	3,409,244
1897	2,345,891	95,138	102,424	312	27,835	1,020,577	-	3,592,176
1898	3,088,224	127,579	103,590	790	29,017	1,884,875	154	5,234,229
1899	3,497,808	195,951	211,781	470	70,534	2,547,241	419	6,524,204
1900	3,670,661	196,091	209,870	-	58,597	2,306,348	1,322	6,442,889
1901	3,474,272	121,320	175,291	-	50,932	2,021,179	-	5,842,994
1902	3,232,747	109,208	144,576	-	32,347	1,593,849	51	5,112,778
1903	3,542,905	120,485	133,081	-	25,670	2,439,432	1,124	6,262,698
1904	4,608,265	194,625	175,368	-	80,566	3,245,578	372	8,304,774
1905	5,847,280	255,445	211,984	2,299	164,380	3,758,952	1,625	10,241,964
1906	4,914,966	246,917	342,386	627	186,247	3,598,496	12,310	9,301,948
1907	6,778,558	277,526	757,823	1,568	226,592	4,081,000	385	12,123,453
1908	3,959,929	208,970	921,377	503	137,164	2,286,080	4,085	7,518,108
1909	7,036,100	259,055	1,223,845	-	131,652	4,020,066	683	12,671,401
1910	9,736,869	462,716	2,457,573	1,124	496,095	7,642,025	1,711	20,798,112
1911	5,868,697	429,939	373,480	6,341	1,144,160	7,862,052	3,522	15,688,190
1912	6,547,931	426,642	533,482	927	1,405,167	10,166,969	18,113	19,099,231

Source: Commerce and Navigation of the United States, 1870-1912. All values were converted into pounds sterling using exchange rate provided earlier in this Appendix.

Notes: (1) Rest of the Amazon = 'New Granada', Colombia, Ecuador, 'British Guiana', 'Dutch Guiana', 'French Guiana', Peru and Venezuela.

(2) Mexico & Central America = 'British Honduras', 'Costa Rica', Guatemala, Honduras, Nicaragua, Panama, Salvador, Mexico, 'British West Indies', Cuba, 'Puerto Rico', 'Dutch West Indies', Haiti, 'Santo Domingo', 'Central American States', 'Spanish West Indies', and 'French West Indies'.

(3) Africa = 'British Africa', 'Portuguese Africa', 'French Africa', Liberia, Madagascar and 'All Other Africa'.

(4) Asia & Oceania = China, 'British East Indies', 'Dutch East Indies', Hong Kong, Japan, Siam, Philippines, 'All Other Asia' and 'British Australasia'.

(5) Europe = Austria-Hungary, Spain, Belgium, Denmark, France, Germany, Italy, Netherlands, Portugal, Russia, Turkey and Britain.

(6) Others = all other countries not included in the categories above.

C.11: Quantity of Rubber Imported into the USA, 1870-1912

	Quantity of Rubber Imported into the USA from selected places							
	Brazil	**Rest of the Amazon**	**Mexico & Central America**	**Africa**	**Asia & Oceania**	**Europe**	**Others**	**Total**
	tons	tons	tons	tons	tons	tons	tons	tons
1870	2,374	1,179	232	15	263	296	7	4,365
1871	967	849	45	1	85	264	2	2,212
1872	2,162	2,439	170	0	203	301	79	5,354
1873	2,714	2,605	207	52	450	534	32	6,594
1874	3,121	2,056	275	72	437	436	41	6,437
1875	2,736	1,725	290	47	343	318	1	5,459
1876	2,361	1,603	267	61	175	337	0	4,803
1877	2,860	1,805	183	36	110	1,208	68	6,269
1878	2,665	1,336	253	141	173	1,107	0	5,675
1879	3,179	1,521	256	167	56	1,571	-	6,749
1880	3,526	1,768	418	96	47	1,777	-	7,632
1881	4,530	1,707	823	87	69	1,626	236	9,079
1882	5,148	710	1,244	194	137	2,124	746	10,302
1883	4,699	808	1,319	145	294	1,753	800	9,819
1884	5,421	795	1,430	233	184	2,364	722	11,147
1885	6,530	420	1,086	135	275	2,127	407	10,981
1886	7,921	393	1,136	291	302	2,796	435	13,274
1887	7,658	911	1,163	288	343	2,627	6	12,995
1888	11,099	828	1,162	180	573	2,770	3	16,614
1889	8,846	757	1,104	177	533	3,252	-	14,669
1890	9,444	592	834	91	423	3,961	7	15,351
1891	9,680	869	863	85	598	3,595	37	15,727
1892	11,570	788	710	137	196	4,872	-	18,273
1893	12,133	758	670	134	272	4,879	-	18,846
1894	10,608	664	627	132	191	3,089	-	15,312
1895	12,015	786	689	51	285	4,201	-	18,026
1896	9,995	720	595	7	282	5,082	-	16,681
1897	9,915	560	565	2	223	4,872	-	16,136
1898	11,731	699	539	5	208	7,708	1	20,890
1899	12,458	899	853	3	454	8,494	2	23,162
1900	12,713	810	867	-	292	7,711	4	22,397
1901	15,783	572	756	-	255	7,706	-	25,073
1902	14,303	583	673	-	255	7,052	1	22,867
1903	14,116	619	613	-	206	9,394	5	24,952
1904	15,018	814	748	-	493	9,695	1	26,769
1905	16,599	960	811	11	967	11,145	4	30,497
1906	13,380	824	1,361	3	951	9,661	59	26,238
1907	18,274	924	3,800	8	1,014	10,890	1	34,910
1908	14,808	698	4,655	1	561	7,491	15	28,228
1909	19,955	891	7,411	-	513	11,307	2	40,079
1910	17,922	1,136	11,301	2	1,098	14,371	4	45,833
1911	14,071	1,136	997	15	2,103	14,347	11	32,680
1912	21,211	1,296	1,643	3	2,876	22,927	34	49,990

Source: Commerce and Navigation of the United States, 1870-1912. All values were converted into pounds sterling using exchange rate provided earlier in this Appendix.

Notes: (1) Rest of the Amazon = 'New Granada', Colombia, Ecuador, 'British Guiana', 'Dutch Guiana', 'French Guiana', Peru and Venezuela.
(2) Mexico & Central America = 'British Honduras', 'Costa Rica', Guatemala, Honduras, Nicaragua, Panama, Salvador, Mexico, 'British West Indies', Cuba, 'Puerto Rico', 'Dutch West Indies', Haiti, 'Santo Domingo', 'Central American States', 'Spanish West Indies', and 'French West Indies'.
(3) Africa = 'British Africa', 'Portuguese Africa', 'French Africa', Liberia, Madagascar and 'All Other Africa'.
(4) Asia & Oceania = China, 'British East Indies', 'Dutch East Indies', Hong Kong, Japan, Siam, Philippines, 'All Other Asia' and 'British Australasia'.
(5) Europe = Austria-Hungary, Spain, Belgium, Denmark, France, Germany, Italy, Netherlands, Portugal, Russia, Turkey and Britain.
(6) Others = all other countries not included in the categories above.

C.12: Implicit Price of Rubber Imported into the USA, 1870-1912

	Implicit Prices of Rubber Imported into the USA from selected places							
	Brazil	Rest of the Amazon	Mexico & Central America	Africa	Asia & Oceania	Europe	Others	Total
	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton	£ per ton
1870	179	96	101	56	80	118	44	142
1871	215	129	117	106	94	190	21	173
1872	179	154	151	65	143	173	127	164
1873	207	187	150	158	125	178	156	189
1874	192	178	142	141	126	164	32	178
1875	165	151	135	130	116	128	82	153
1876	167	152	131	123	108	150	210	156
1877	179	173	146	134	116	177	143	174
1878	189	155	151	140	119	158	185	170
1879	214	145	148	138	158	179	n.a.	185
1880	286	225	216	170	191	261	n.a.	260
1881	272	233	222	202	181	242	225	252
1882	327	237	211	200	192	263	260	284
1883	380	274	246	242	219	305	291	326
1884	276	228	223	213	202	256	202	254
1885	170	188	175	156	150	171	165	170
1886	179	190	186	168	150	206	160	184
1887	223	207	230	209	162	212	230	218
1888	200	184	221	224	141	198	176	199
1889	176	149	191	191	128	173	n.a.	173
1890	200	163	187	181	140	213	171	199
1891	262	194	210	242	88	209	15	236
1892	244	163	176	187	168	193	n.a.	223
1893	198	173	180	164	115	196	n.a.	194
1894	214	156	164	175	130	184	n.a.	202
1895	225	137	160	216	82	191	n.a.	208
1896	210	164	180	194	86	209	n.a.	204
1897	237	170	181	144	125	209	n.a.	223
1898	263	183	192	148	140	245	205	251
1899	281	218	248	181	156	300	252	282
1900	289	242	242	n.a.	201	299	299	288
1901	220	212	232	n.a.	200	262	n.a.	233
1902	226	187	215	n.a.	127	226	42	224
1903	251	195	217	n.a.	124	260	217	251
1904	307	239	235	n.a.	163	335	357	310
1905	352	266	261	210	170	337	382	336
1906	367	300	252	233	196	372	210	355
1907	371	300	199	208	224	375	302	347
1908	267	300	198	360	244	305	274	266
1909	353	291	165	n.a.	256	356	349	316
1910	543	407	217	659	452	532	474	454
1911	417	378	375	431	544	548	309	480
1912	309	329	325	274	489	443	533	382

Source: Commerce and Navigation of the United States, 1870-1912. All values were converted into pounds sterling using exchange rate provided earlier in this Appendix.

Notes: (1) Rest of the Amazon = 'New Granada', Colombia, Ecuador, 'British Guiana', 'Dutch Guiana', 'French Guiana', Peru and Venezuela.

(2) Mexico & Central America = 'British Honduras', 'Costa Rica', Guatemala, Honduras, Nicaragua, Panama, Salvador, Mexico, 'British West Indies', Cuba, 'Puerto Rico', 'Dutch West Indies', Haiti, 'Santo Domingo', 'Central American States', 'Spanish West Indies', and 'French West Indies'.

(3) Africa = 'British Africa', 'Portuguese Africa', 'French Africa', Liberia, Madagascar and 'All Other Africa'.

(4) Asia & Oceania = China, 'British East Indies', 'Dutch East Indies', Hong Kong, Japan, Siam, Philippines, 'All Other Asia' and 'British Australasia'.

(5) Europe = Austria-Hungary, Spain, Belgium, Denmark, France, Germany, Italy, Netherlands, Portugal, Russia, Turkey and Britain.

(6) Others = all other countries not included in the categories above.

(7) n.a. = not available.

C.13: Quarterly Price of Brazilian Rubber Traded in New York, 1870-1894

	Para Rubber Price		
Date	US cents per pound	Date	US cents per pound
1870.01	100.00	1882.07	106.00
1870.04	95.00	1882.10	115.00
1870.07	105.00	1883.01	107.00
1870.10	95.00	1883.04	106.00
1871.01	100.00	1883.07	110.00
1871.04	75.00	1883.10	101.00
1871.07	81.00	1884.01	96.00
1871.10	78.00	1884.04	69.00
1872.01	72.50	1884.07	59.00
1872.04	86.00	1884.10	53.00
1872.07	84.00	1885.01	56.00
1872.10	70.00	1885.04	61.00
1873.01	74.00	1885.07	66.00
1873.04	74.00	1885.10	55.00
1873.07	76.00	1886.01	61.00
1873.10	67.00	1886.04	67.00
1874.01	75.00	1886.07	81.00
1874.04	68.00	1886.10	81.00
1874.07	63.00	1887.01	76.00
1874.10	60.00	1887.04	83.00
1875.01	58.50	1887.07	85.00
1875.04	69.00	1887.10	71.00
1875.07	67.50	1888.01	76.00
1875.10	62.50	1888.04	78.50
1876.01	64.00	1888.07	74.50
1876.04	61.00	1888.10	70.50
1876.07	63.00	1889.01	74.00
1876.10	58.50	1889.04	68.50
1877.01	58.00	1889.07	71.00
1877.04	57.00	1889.10	73.00
1877.07	55.00	1890.01	80.00
1877.10	52.00	1890.04	92.00
1878.01	49.00	1890.07	102.00
1878.04	43.00	1890.10	93.00
1878.07	49.00	1891.01	78.00
1878.10	50.00	1891.04	92.00
1879.01	51.00	1891.07	86.00
1879.04	50.00	1891.10	66.00
1879.07	69.00	1892.01	67.00
1879.10	73.00	1892.04	70.50
1880.01	81.00	1892.07	68.50
1880.04	92.00	1892.10	67.00
1880.07	90.00	1893.01	68.00
1880.10	77.00	1893.04	78.00
1881.01	76.00	1893.07	67.00
1881.04	76.00	1893.10	67.50
1881.07	87.00	1894.01	68.00
1881.10	80.00	1894.04	65.50
1882.01	87.00	1894.07	66.00
1882.04	108.00	1894.10	69.00

Note: From 1892 onwards, prices refer to 'Upriver Para'.

Source: Baker, Rubber Statistics 1900-1937, 1938, p. 42.

C.14: Monthly Prices of Different Grades of Brazilian Rubber Traded in New York

1894-1900

cents per pound	Monthly Prices of Different Grades of Brazilian Rubber in New York									
	Upriver				Island				Cametá	
	Fine		Coarse		Fine		Coarse		Coarse	
	min	max	min	max	min	max	min	max	min	max
1894.11	71	73	55.5	57	68.5	70	47	48	52	53
1894.12	72	76	56.5	58	69.5	73	48	51	51.5	55.5
1895.01	74	75.5	55	58	71.5	74	50	52	54	56
1895.02	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1895.03	73.5	74.5	52	54.5	71.5	72.5	47	48	51.5	53
1895.04	73	74	53	55	71	72	46.5	47.5	51.5	53
1895.05	73	76	55	57	72	74	47	49	52.5	55
1895.06	75	76	56	57	72	74	47.5	50	53	55
1895.07	72	74	55	56	70	72	46	47.5	50	51
1895.08	72	74	56	58	70	73	45.5	48	50	51.5
1895.09	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1895.10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1895.11	77	83	57	61	74	81	44	51	48	53
1895.12	77	78	57	58	75	76	45	46.5	48	49
1896.01	74	77	53	56	71	75	43	45	46.5	48.5
1896.02	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1896.03	75	76	53	55	73	74.5	42.5	45.5	47.5	48
1896.04	76	82	54	57	73.5	81	44	47	50	54
1896.05	82.5	89	57	60	80	85	46.5	49	50.5	53
1896.06	86	89	56	59	80	85	44	48.5	50	52.5
1896.07	86	88	56	58	81	85	43	47	50	52
1896.08	82	86	54	57	77	81	41.5	44	51	52
1896.09	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1896.10	81	84	54	56	80	82	47	48.5	51	52
1896.11	83	84.5	56	57	81	83	47	48	51	52.5
1896.12	82	85	53	58	79	83	44	48	51	53
1897.01	82	83	52	54	78.5	80	44.5	46	50.5	51.5
1897.02	82	84	52.5	55	80	82	44.5	46	51	52
1897.03	82	83.5	52	54	80	82	44.5	45	51	54
1897.04	84	88	54	58	82	84	45	48	55.5	57
1897.05	85.5	88	55.5	57.5	83	84	45.5	48	59	60
1897.06	84	86	54.5	56	82	83	45.5	47	58	59
1897.07	84	86	55	56	82	84	46.5	48	56	58
1897.08	86.5	88	57	60	84	86.5	49	50	56	58
1897.09	87	88	59	61	85	86	50	51	55	56.5
1897.10	87.5	88	60	65.5	85	86	52.5	55	55.5	61
1897.11	86	88	62	66	83	86	52.5	55	60	61.5
1897.12	83	87	59	63	80	84	49	52.5	57	59
1898.01	84	90	62	70	82	87.5	53	60	57	61.5
1898.02	89.5	95	71	75	88	93	60	65	61.5	70
1898.03	94	95	73.5	75	92.5	93	62.5	64	69	71
1898.04	92.5	95	74	75	91.5	93	62.5	64	68	70
1898.05	94	95	73.5	75.5	92	93	63	65	68.5	69.5
1898.06	95	97	75	80	92.5	96	64	65	69	71
1898.07	98	105	80	88	95.5	102	64.5	68	71	75
1898.08	103	106	86	89	100	103	68	72	74	75
1898.09	96	103	82	87	93	99	63	68	68	74
1898.10	89	96	79	85	85	94	58	65	59	67
1898.11	95	99	83	87	89	95	62	67	66	68
1898.12	96	98	85.5	88	90	94	65	69	66.5	70
1899.01	96	104	86	93	93	101	67	72	69	75
1899.02	100	104	86	92	99	101	69	73	71	74
1899.03	102	107	88	90	101	105	71	75	72	77
1899.04	100	103	85	88	100	103	96	73	72	74
1899.05	99	102	82	86	99	101.5	67	71	69	72
1899.06	97	101	77	83	95	98	63	66	65	68
1899.07	99	102	78	80	95	98	64	66	64	68
1899.08	100	103	77	79	95	97	62	66	62.5	66
1899.09	101	104.5	77	83	96	99	61	63	62	64
1899.10	103	105	81	84	97	99	61.5	64	63	65
1899.11	105	111	84	90	99	108	64	70	64.5	70
1899.12	108	110	86	90	105.5	108	65	69	66	70
1900.01	108	110	84	87	105	108	64	66	65	69
1900.02	104	109	80	86	103.5	108	61.5	66	64	68
1900.03	99	105	75	80	98	104	59	64	62.5	65
1900.04	98	102	73	76	96.5	99	57.5	60	63	65
1900.05	89	102	65	75	87	99	47	61	56	65
1900.06	89	97	65	72	87	95	47	55	55	60
1900.07	93	97	67	71	87	93.5	51	54	54.5	59
1900.08	93	99	68	71	88	97	55	58	55	59
1900.09	99.5	103	70	72	95.5	99	55	58	56	57.5
1900.10	93	100	69	74	92	100	52	57	56	58
1900.11	84	87	63.5	66	76.5	80	46.5	50	48	51
1900.12	92	95	68	69	86	89	53	55	54	56

Source: India Rubber World, several issues. Note: n.a. = not available.

C.15: Monthly Prices of Different Grades of Brazilian Rubber Traded in New York

1901-1905

cents per pound	Monthly Prices of Different Grades of Brazilian Rubber in New York									
	Upriver				Island				Cametá	
	Fine		Coarse		Fine		Coarse		Coarse	
	min	max	min	max	min	max	min	max	min	max
1901.01	87	92	65	69	84	88	48	52	54	55
1901.02	86	88	63	66	83	85	46	48	53	54
1901.03	83	86	59	60	83	84	45	50	53.5	54
1901.04	85	94	59	68	84	93	52	60	54	63
1901.05	89	93	62	65	85	90	51	60	58	63
1901.06	87	90	62	64	84	87	47	53	54	58
1901.07	84	87.5	61	63	82	85	46.5	48.5	50	55
1901.08	85	92	61	68	81	88	46	50	50	51
1901.09	87	91	65	66	84	88	48	50	50	51
1901.10	84.5	90	63.5	66	78	85	46.5	48	48	49
1901.11	93	97	68	70	89	94	52	57	55	56
1901.12	85	87	65	66	79	81	48	51	50	51
1902.01	77	86	62	65	75	81	47	52	50	53
1902.02	72	79	60	63	69	76	45	48	48	50
1902.03	72	76	58	61	70	73	46	48	48	53
1902.04	73	74.5	59	60	71	73	47	49	53	53.5
1902.05	71	74.5	56	60	70	73.5	45	49	51.5	53
1902.06	70	72	55	56.5	68	70	45	46	48	52
1902.07	70	72	55	56.5	67	69	44	46	46	48
1902.08	70	76	56	61	67	73	45	48	46	48.5
1902.09	74.5	78	59	62	71	75	46	48	47	50
1902.10	74.5	79	60	64	72	74	46	49	47	49
1902.11	78.5	82	63	68	73	76	48	51.5	48.5	52.5
1902.12	80	91	65	73	74	88	49	60	54	61
1903.01	86	92	71	76	84	89	53	62	55	64
1903.02	84	90	70	73	82	87	50	54	52	57
1903.03	90	93	72	74	86	90	55	58	57	61
1903.04	90	93	72	74	87	91	56	60	61	63
1903.05	91	94	71	73	87	91	56	60	60	64
1903.06	89	93	70	74	85	89	54	57	56	60
1903.07	94	96	74	76	89	92	56	58	58	60
1903.08	95	100	75	79	90	97	59	61	58	61
1903.09	100	110	79	91	97	108	60	70	61	68
1903.10	100	109	83	91	96	106	56	68	56	67
1903.11	92	102	78	83	90	98	54	58	53	58
1903.12	93	98	76	81	88	94	54	57	54	57
1904.01	94	105	77	83	90	102	56	65	55	64
1904.02	101	107	82	86	99	104	64	67	64	67
1904.03	106	112	84	87	103	108	66	70	66	70
1904.04	107	112	84	88	105	109	64	69	64	69
1904.05	111	115	86	90	108	112	65	69	66	70
1904.06	111	114	87	90	108	111	64	68	64	68
1904.07	112	119	87	91	109	115	63	66	64	66
1904.08	118	121	90	91	114	116	65	67	65	66
1904.09	109	121	85	91	107	116	59	67	60	66
1904.10	112	117	86	90	109	114	61	65	61	65
1904.11	116	131	89	98	112	126	62	73	63	72
1904.12	118	130	89	97	114	126	65	72	65	71
1905.01	118	125	90	94	114	122	65	71	64	71
1905.02	125	129	93	96	122	126	70	75	70	76
1905.03	128	134	94	100	125	131	75	80	77	82
1905.04	131	134	96	99	127	130	73	77	76	80
1905.05	131	135	95	97	129	132	73	76	78	81
1905.06	130	135	94	97	128	133	72	76	74	80
1905.07	128	131	90	95	125	128	68	71	71	76
1905.08	127	129	90	92	125	127	68	70	71	73
1905.09	129	132	91	94	126	129	69	72	71	74
1905.10	122	130	89	93	119	127	69	71	70	72
1905.11	121	124	89	91	118	121	68	72	69	72
1905.12	123	129	90	97	120	126	71	77	72	78

Source: India Rubber World, several issues.

C.16: Monthly Prices of Different Grades of Brazilian Rubber Traded in New York

1906-1912

cents per pound	Monthly Prices of Different Grades of Brazilian Rubber in New York									
	Upriver				Island				Cametá	
	Fine		Coarse		Fine		Coarse		Coarse	
	min	max	min	max	min	max	min	max	min	max
1906.01	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1906.02	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1906.03	125	129	93	96	123	125	73	75	74	77
1906.04	125	128	92	95	122	125	70	74	72	76
1906.05	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1906.06	123	125	90	92	119	122	65	66	70	72
1906.07	122	124	89	91	118	120	64	65	69	71
1906.08	122	124	90	92	118	120	65	67	68	70
1906.09	122	124	92	94	118	120	66	69	68	70
1906.10	122	124	93	96	119	121	68	73	69	72
1906.11	122	124	95	97	118	120	71	73	70	71
1906.12	122	124	96	98	118	120	71	73	72	74
1907.01	121	124	96	98	117	120	71	73	72	74
1907.02	119	123	95	98	117	119	69	72	71	73
1907.03	116	121	92	96	114	119	66	70	71	73
1907.04	115	118	91	94	114	116	66	68	71	72
1907.05	112	116	88	92	110	115	62	67	70	72
1907.06	108	112	86	88	104	110	61	63	70	71
1907.07	108	115	86	90	104	108	61	64	70	71
1907.08	108	115	89	92	104	109	60	62	66	69
1907.09	106	110	88	90	99	105	58	60	62	66
1907.10	98	106	84	88	91	99	56	59	55	62
1907.11	83	99	68	85	72	92	44	56	42	56
1907.12	82	86	66	72	72	79	44	50	43	48
1908.01	74	82	56	65	71	76	45	50	45	50
1908.02	66	76	48	56	65	74	41	46	42	46
1908.03	70	83	48	59	68	80	41	43	41	48
1908.04	78	84	55	58	75	80	42	44	44	48
1908.05	83	94	58	65	80	90	43	48	48	57
1908.06	88	94	62	65	84	89	43	46	53	56
1908.07	91	96	64	67	83	88	42	46	52	55
1908.08	89	96	65	69	83	90	43	46	51	53
1908.09	96	103	69	73	90	96	44	48	51	53
1908.10	103	113	72	82	95	104	47	54	53	56
1908.11	112	130	82	100	104	124	54	70	56	72
1908.12	115	123	89	94	112	116	52	61	57	64
1909.01	120	122	90	92	113	116	55	59	62	64
1909.02	120	126	91	96	115	120	57	60	62	65
1909.03	122	126	93	97	118	121	55	61	63	67
1909.04	121	126	92	96	118	123	56	59	63	69
1909.05	126	135	96	98	123	131	59	67	69	78
1909.06	135	151	98	105	131	142	67	70	78	82
1909.07	150	195	105	120	141	184	70	75	80	92
1909.08	179	195	110	120	165	184	62	75	80	92
1909.09	190	215	112	132	172	202	65	82	83	96
1909.10	202	215	120	132	183	202	72	82	83	96
1909.11	193	203	117	121	172	184	69	72	80	84
1909.12	175	193	111	121	164	172	69	72	79	82
1910.01	178	187	111	115	167	181	71	75	79	85
1910.02	187	210	115	128	181	204	75	89	85	98
1910.03	209	258	130	170	203	245	90	107	95	128
1910.04	258	292	170	187	245	278	107	115	128	135
1910.05	235	280	160	182	226	272	93	109	110	127
1910.06	223	245	150	163	213	230	93	105	110	125
1910.07	216	240	148	155	208	225	98	103	110	123
1910.08	187	220	140	148	178	210	94	98	96	110
1910.09	155	190	122	142	150	182	90	92	90	98
1910.10	137	150	102	120	120	146	73	90	75	89
1910.11	136	152	102	107	120	128	73	75	75	78
1910.12	136	150	100	105	119	125	70	73	72	76
1911.01	115	130	90	98	100	115	62	69	64	73
1911.02	128	168	98	120	115	156	65	90	68	95
1911.03	145	166	108	118	130	156	62	90	79	92
1911.04	118	145	88	110	112	135	60	63	75	80
1911.05	93	128	82	89	92	122	58	67	67	76
1911.06	95	103	81	85	91	98	58	63	67	71
1911.07	99	107	82	96	92	110	58	63	70	75
1911.08	109	117	95	99	102	109	61	63	66	68
1911.09	113	120	94	99	106	112	62	64	66	68
1911.10	100	112	90	96	96	107	56	63	60	66
1911.11	99	106	87	91	93	100	57	60	60	62
1911.12	104	107	90	93	95	101	60	64	60	65
1912.01	103	111	90	94	97	107	62	64	63	66
1912.02	107	111	92	94	105	108	62	65	65	67
1912.03	111	123	93	99	108	118	63	67	66	72
1912.04	112	118	92	96	110	114	63	66	66	70
1912.05	109	112	89	92	105	110	58	63	65	67
1912.06	108	112	86	91	101	106	55	59	63	65
1912.07	110	119	85	91	100	108	54	57	62	65
1912.09	110	122	87	95	107	113	55	59	61	67
1912.10	104	111	81	86	99	106	53	56	56	61
1912.11	102	108	80	84	94	100	53	58	55	58
1912.12	106	112	82	85	96	102	54	58	56	60

Source: India Rubber World, several issues.

C.17: Prices for Different Grades of Rubber in New York on 29th January 1906

(cents per pound)

	Min	Max	Med
Para			
Islands Fine, new	118.0	119.0	118.5
Islands Fine, old	n.a.	n.a.	n.a.
Upriver Fine, new	123.0	124.0	123.5
Upriver Fine, old	127.0	128.0	127.5
Islands Coarse, new	72.0	72.5	72.3
Islands Coarse, old	n.a.	n.a.	n.a.
Upriver Coarse, new	97.5	98.0	97.8
Upriver Coarse, old	n.a.	n.a.	n.a.
Caucho (Peruvian) sheet	78.0	79.0	78.5
Caucho (Peruvian) ball	96.0	97.0	96.5
Ceylon (Plantation) fine sheet	137.0	138.0	137.5
African			
Sierra Leone 1st quality	108.0	108.5	108.3
Massai, red	108.0	108.5	108.3
Benguella	78.0	79.0	78.5
Cameroon ball	77.0	78.0	77.5
Accra flake	22.0	23.0	22.5
Lopori ball, prime	116.5	117.0	116.8
Lopori strip, prime	107.0	108.0	107.5
Madagascar, pinky	90.0	91.0	90.5
Ikelemba	117.5	118.0	117.8
Soudan niggers	93.0	94.0	93.5
Centrals			
Esmeralda, sausage	94.0	95.0	94.5
Guayaquil, strip	76.0	77.0	76.5
Nicaragua, scrap	92.0	93.0	92.5
Panama, slab	70.0	71.0	70.5
Mexican, scrap	93.0	94.0	93.5
Mexican, slab	71.0	72.0	71.5
Magabeira, sheet	67.0	71.0	69.0
Guayule	44.0	45.0	44.5
East Indian			
Assam	94.0	95.0	94.5
Borneo	40.0	50.0	45.0

Source: The India Rubber World, 1st February 1907, p. 165.

Note: n.a. = not available.

C.18: Rubber Stocks, selected dates

	Dates				
	30/6/1900	30/6/1901	30/6/1902	30/6/1903	30/6/1904
			in tons		
Pará Rubber at					
Liverpool	2,137	1,467	2,448	1,601	905
Havre	95	70	30	65	25
New York	601	875	392	383	102
Pará	195	28	60	129	174
in transit	1,099	995	900	1,185	878
Total Pará Rubber in Stock	4,127	3,435	3,830	3,363	2,084
Average Rubber from other sources at					
Liverpool	1,082	946	585	456	715
London	646	742	560	224	306
Antwerp	726	954	681	488	689
Lisbon	717	544	505	220	290
Rotterdam			80	56	66
New York	571	320	575	246	238
Total Average Rubber in Stock	3,742	3,506	2,986	1,690	2,304
Total Rubber in Stock	7,869	6,941	6,816	5,053	4,388

Source: Miguel Calmon du Pin e Almeida. Producção e Commercio de Borracha: Parecer da Comissão de Agricultura e Indústria da Câmara dos Deputados sobre o projeto de monopolização do commercio de borracha, 1906, p. 52.

C.19: Proceeds from Exported Rubber from Pará State, 1870-1912

	Quantity of Rubber Exported from Pará	Value of Rubber Exported from Pará	Rights on Rubber Exported from Pará	Export Tariff on Rubber	Rights on Total Exports from Pará	Export Tariff
	tons	BRZ mil-réis per ton	BRZ mil-réis per ton	%	BRZ mil-réis per ton	%
	(1)	(2)	(3)	(3)/(2)	(5)	(5)/(2)
1870	5,010	$8,720,596.743			$1,145,512.031	13.14%
1871	5,318	$10,210,249.214			$1,163,538.842	11.40%
1872	5,300	$10,147,206.752			$1,118,734.191	11.03%
1873	5,796	$10,328,882.247			$1,235,795.866	11.96%
1874	5,954	$9,932,375.517			$1,029,073.842	10.36%
1875	5,544	$9,760,863.908			$941,947.626	9.65%
1876	5,870	$10,419,540.159			$782,017.137	7.51%
1877	6,409	$11,390,095.777			$1,136,509.478	9.98%
1878	6,548	$11,527,152.315			$1,542,274.211	13.38%
1879	6,668	$11,775,475.134			$1,948,038.943	16.54%
1880	5,317	$9,418,706.337			$1,738,681.176	18.46%
1881	5,431	$9,554,998.913			$3,238,102.310	33.89%
1882	5,780	$10,536,946.256			$3,021,952.232	28.68%
1883	5,714	$8,356,600.688			$2,549,855.152	30.51%
1884	5,362	$6,374,347.814			$1,534,441.174	24.07%
1885	6,808	$9,328,881.991	$726,877.350	7.79%	$1,792,315.813	19.21%
1886	6,987	$10,053,253.120	$822,628.532	8.18%	$2,332,953.321	23.21%
1887	6,967	$12,958,509.958	$957,224.381	7.39%	$2,237,167.179	17.26%
1888	7,447	$16,697,953.998	$688,568.737	4.12%	$2,023,002.679	12.12%
1889	8,120	$12,844,899.079	$548,107.876	4.27%	$2,134,878.776	16.62%
1890	7,556	$13,365,469.299	$2,148,693.000	16.08%	$2,246,754.873	16.81%
1891	7,640	$19,941,358.674	$3,384,741.000	16.97%	$3,058,896.959	15.34%
1892	8,062	$26,667,628.784	$6,139,164.000	23.02%	$6,677,155.431	25.04%
1893	8,374	$31,163,184.944	$7,137,097.000	22.90%	$7,887,096.711	25.31%
1894	8,181	$35,295,885.186	$7,667,424.000	21.72%	$8,126,832.692	23.02%
1895	8,615	$38,030,865.288	$8,992,956.000	23.65%	$8,984,228.102	23.62%
1896	8,895	$36,732,897.957	$10,819,111.000	29.45%	$10,855,707.132	29.55%
1897	9,235	$57,569,617.623	$14,019,674.000	24.35%	$14,016,333.807	24.35%
1898	9,342	$78,945,023.435	$16,211,787.000	20.54%	$17,004,884.898	21.54%
1899	9,549	$91,644,013.831	$18,593,903.000	20.29%	$18,715,834.082	20.42%
1900	9,720	$66,645,607.224	$14,123,255.000	21.19%	$14,169,501.981	21.26%
1901	10,052	$60,681,863.134	$9,826,156.000	16.19%	$10,132,753.114	16.70%
1902	10,501	$54,179,301.907	$8,681,186.000	16.02%	$9,111,588.491	16.82%
1903	11,135	$68,883,735.742	$11,180,222.000	16.23%	$11,679,684.098	16.96%
1904	11,429	$79,299,128.541	$12,844,082.000	16.20%	$13,259,965.572	16.72%
1905	11,325	$71,562,779.315	$11,648,959.000	16.28%	$11,947,793.786	16.70%
1906	11,747	$70,656,626.162	$11,529,338.000	16.32%	$11,696,757.155	16.55%
1907	10,415	$62,081,095.592	$9,704,188.000	15.63%	$10,141,976.721	16.34%
1908	11,016	$54,307,852.240	$8,579,396.000	15.80%	$8,974,113.972	16.52%
1909	11,586	$89,638,192.827	$14,603,063.000	16.29%	$14,941,494.027	16.67%
1910	10,257	$100,312,261.913	$14,702,091.000	14.66%	$15,088,501.895	15.04%
1911	10,341	$64,060,815.181	$9,518,716.000	14.86%	$9,919,778.018	15.48%
1912	11,632	$66,410,259.063	$9,538,638.000	14.36%	$9,897,616.876	14.90%

Sources for Figure A.16:

Weinstein, Barbara. The Amazon Rubber Boom 1850-1920. Stanford, S. UP, 1983. Tabela A.1, pg. 271.
Le Cointe, Paul. L'Amazonie Brésilienne. Paris: Challamel, 1922, pág. 433.
Mensagem presidencial do pará, 1916, p. A-139.
Mensagem da província do pará, 1889.
Falla com que o exm. sr. conselheiro Francisco José Cardoso Junior, primeiro vice-presidente da provincia do Pará, abrio a 1.a sessão da 26.a legislatura da Assembléa Provincial no dia 4 de março de 1888. Pará, Typ. do "Diario de Noticias," 1888.
Falla com que o exm. sr. conselheiro Francisco José Cardoso Junior, 1.o vice-presidente da provincia do Pará, abrio a 2.a sessão da 25.a legislatura da Assembléa Provincial em 20 de outubro de 1887. Pará, Typ. do Diario de Noticias, 1887.
Falla com que o exm. sr. general barão de Maracajú abriu a 2.a sessão da 23.a legislatura da Assembléa Legislativa da provincia do Pará em 15 de fevereiro de 1883. Pará, Typ. do Jornal da Tarde, 1883.
Falla com que o exm.o snr. dr. João José Pedrosa abrio a 1.a sessão da 23.a legislatura da Assembléa Legislativa da provincia do Pará em 23 de abril de 1882. Pará, Typ. de Francisco da Costa Junior, 1882.
Relatorio apresentado á Assembléa Legislativa Provincial na 2.a sessão da 22.a legislatura em 15 de fevereiro de 1881 pelo exm. sr. dr. José Coelho da Gama e Abreu. Pará, Typ. do Diario de Noticias de Costa & Campbell, 1881.
Relatorio apresentado pelo excellentissimo senhor doutor José Coelho da Gama e Abreu, presidente da provincia, á Assembléa Legislativa Provincial do Pará, na sua 1.a sessão da 22.a legislatura, em 15 de fevereiro de 1880. Pará, 1880.
Falla com que o exm. sr. dr. João Capistrano Bandeira de Mello Filho abrio a 2.a sessão da 20.a legislatura da Assemblea Legislativa da provincia do Pará em 15 de fevereiro de 1877. Pará, Typ. do Livro do Commercio, 1877.
Relatorio apresentado ao exm. senr. dr. Francisco Maria Corrêa de Sá e Benevides pelo exm. senr. dr. Pedro Vicente de Azevedo, por occasião de passar-lhe a administração da provincia do Pará, por ocasião de passar-lhe a administração da Província, 1875.

C.20: Proceeds from Exported Rubber from Amazonas State, 1870-1912

	Quantity of Rubber Exported from Amazonas	Value of Rubber Exported from Amazonas	Rights on Rubber Exported from Amazonas	Export Tariff on Rubber
	tons	BRZ mil-réis per ton	BRZ mil-réis per ton	%
	(1)	(2)	(3)	(3)/(2)
1870	1,228	$2,172,063.231	$464,623.317	21.39%
1871	1,366	$2,621,741.109	$558,099.905	21.29%
1872	1,691	$3,260,103.815	$676,548.324	20.75%
1873	1,959	$3,501,732.761	$679,201.540	19.40%
1874	2,050	$3,432,703.618	$600,032.226	17.48%
1875	2,179	$3,836,097.470	$590,519.250	15.39%
1876	1,949	$3,456,372.764	$651,027.342	18.84%
1877	2,153	$3,822,972.278	$691,377.592	18.08%
1878	2,674	$4,705,672.768	$869,163.006	18.47%
1879	3,010	$5,319,730.044	$1,135,206.530	21.34%
1880	3,362	$5,929,580.095	$1,342,301.530	22.64%
1881	3,189	$5,597,067.982	$1,704,195.146	30.45%
1882	4,027	$7,615,370.688	$2,068,702.155	27.16%
1883	4,827	$4,989,356.879	$2,157,685.013	43.25%
1884	5,030	$6,760,862.122	$2,022,474.564	29.91%
1885	5,509	$7,694,125.680	$2,080,037.025	27.03%
1886	6,177	$9,149,071.789	$2,167,221.925	23.69%
1887	6,744	$12,544,354.241	$2,057,805.230	16.40%
1888	8,011	$17,963,506.859	$2,556,079.480	14.23%
1889	7,819	$12,368,606.410	$2,916,308.140	23.58%
1890	7,799	$13,795,908.594	$3,563,837.440	25.83%
1891	9,010	$23,518,641.326	$7,064,550.420	30.04%
1892	7,928	$26,226,620.145	$5,268,347.240	20.09%
1893	9,591	$35,691,050.794	$7,249,548.320	20.31%
1894	8,640	$37,273,979.588	$7,583,983.418	20.35%
1895	9,171	$40,485,396.833	$14,450,837.819	35.69%
1896	9,114	$37,635,787.838	$13,935,828.669	37.03%
1897	10,465	$65,233,518.218	$13,420,819.518	20.57%
1898	10,488	$88,623,056.026	$25,893,418.982	29.22%
1899	13,381	$128,424,427.727	$22,368,630.830	17.42%
1900	14,708	$100,847,362.120	$20,188,204.101	20.02%
1901	15,694	$94,745,487.557	$15,130,950.153	15.97%
1902	13,711	$70,738,482.113	$12,115,619.076	17.13%
1903	15,787	$97,665,095.484	$16,666,608.784	17.07%
1904	13,123	$91,054,010.103	$16,760,980.543	18.41%
1905	11,751	$74,250,820.623	$12,746,288.711	17.17%
1906	10,782	$64,851,063.928	$11,397,574.223	17.57%
1907	10,924	$65,115,970.807	$11,374,726.475	17.47%
1908	9,984	$49,222,255.261	$8,358,040.572	16.98%
1909	10,193	$78,860,899.174	$13,316,487.569	16.89%
1910	10,454	$102,231,927.303	$14,629,452.543	14.31%
1911	10,386	$64,334,722.964	$9,999,031.526	15.54%
1912	10,484	$59,854,593.446	$9,824,010.705	16.41%

Sources: Le Cointe, Paul. L'Amazonie Brésilienne. Paris: Challamel, 1922, pág. 433.
Relatório da Fazenda do Amazonas, 1918.
Souza, Eloi. A Crise da Borracha e o Esquecimento da amazonia, coleção mossoroense, serie c, volume dlxxii, 1990 (original written in 1914), table 14.

C.21: Proceeds from Rubber Exported from Acre Territory, 1904-1912

	Quantity of Rubber Exported from Acre	Value of Rubber Exported from Acre	Rights on Total Exports from Acre	Export Tariff
	tons	BRZ mil-réis per ton	BRZ mil-réis per ton	%
	(1)	(2)	(3)	(3)/(2)
1904	2,249	$15,441,988.000	$2,376,932.377	15.39%
1905	8,266	$43,350,036.000	$8,688,284.140	20.04%
1906	8,553	$44,945,604.000	$9,167,776.000	20.40%
1907	11,192	$57,440,859.000	$13,545,117.000	23.58%
1908	11,270	$48,088,589.000	$9,467,295.725	19.69%
1909	10,830	$74,076,902.000	$14,073,496.372	19.00%
1910	11,513	$107,706,504.000	$19,866,541.559	18.45%
1911	10,576	$63,159,130.000	$9,671,715.000	15.31%
1912	11,753	$61,561,393.000	$12,389,612.000	20.13%

Sources: Le Cointe, Paul. L'Amazonie Brésilienne. Paris: Challamel, 1922, pp. 413; 433-4 and 446.

C.22: African Rubber Concerns Incorporated in London and still active in March 1911

Firm	type	Incorporation Date	area claimed (In Acres)	Authorised Capital (In £)	Issued Capital (In £)	Region1	Region2	Region3
Anglo-East African Rubber Plantations, Ltd	plantations	jul/1910	4,165	100,000	52,500	East Africa	British East Africa	n.a.
Gazi (British East Africa) Rubber and Fibre Estates, Ltd	plantations	ago/1910	10,000	60,000	45,000	East Africa	British East Africa	near Mombasa
Kisumu Rubber Estates, Ltd	plantations	fev/1910	6,000	45,000	30,000	East Africa	British East Africa	Uganda
Kivuvu (Uganda) Rubber Co., Ltd	plantations	fev/1910	957	25,000	25,000	East Africa	British East Africa	Uganda
Mabira Forest (Uganda) Rubber Co, Ltd	both	ago/1906	96,000	120,000	120,000	East Africa	British East Africa	Uganda
Matwapa Rubber Estates, Ltd	plantations	abr/1910	1,788	30,000	25,500	East Africa	British East Africa	near Mombasa
Meritini Rubber Estates, Ltd	plantations	mar/1910	1,690	45,000	40,000	East Africa	British East Africa	n.a.
Nyassa Rubber Co	n.a.	mar/1910	200,000	400,000	30,000	East Africa	British East Africa	Companhia do Nyassa
Sabaki Cotton and Rubber Co, Ltd	plantations	out/1906	10,000	22,000	12,180	East Africa	British East Africa	Sabaki River
Witu Rubber Estates, Ltd	plantations	mar/1910	1,500	35,000	35,000	East Africa	British East Africa	n.a.
Kibwezi Rubber Lands, Ltd	plantations	abr/1910	32,430	100,000	85,885	East Africa	British East Africa, Kenya	Kibwezi
Imperial Ethiopian Rubber Co.	wild	jan/1907	n.a.	160,000	85,000	East Africa	Ethiopia	n.a.
East African Rubber Plantation Co., Ltd	mainly plantations	set/1909	4,575	90,000	75,000	East Africa	German East Africa	n.a.
Kamna Rubber Estate, Ltd	plantations	mar/1910	3,000	110,000	110,000	East Africa	German East Africa	n.a.
Kifulu Rubber Estates, Ltd	plantations	jun/1910	10,670	100,000	80,000	East Africa	German East Africa	Loga
Lewa Rubber Estates, Ltd	plantations	fev/1910	9,882	250,000	220,000	East Africa	German East Africa	Bondei district
Manihot Rubber Plantations, Ltd	plantations	jun/1910	1,950	50,000	45,000	East Africa	German East Africa	Tanga
Marangu Rubber and Coffee Estates	plantations	jul/1909	1,000	10,000	9,250	East Africa	German East Africa	Marangu
Mkumbi Rubber Plantations, Ltd	plantations	abr/1910	890	70,000	52,000	East Africa	German East Africa	Tanga
Muhesa Rubber Plantations, Ltd	plantations	fev/1910	5,670	135,000	90,000	East Africa	German East Africa	Tanga
Madagascar Rubber Co., Ltd	n.a.	jan/1910	212,000	350,000	350,000	East Africa	Madagascar	n.a.
Beira Rubber ad Sugar Estates, Ltd	plantations	ago/1909	50,408	250,000	107,428	East Africa	Mozambique	Buzi River, Beira
Seychelles Rubber and Coconut Estates, Ltd	plantations	jun/1910	5,910	100,000	95,000	East Africa	Seychelles, Indian Ocean	Mahé
Amatongaland Rubber Corporation	both	jul/1910	443,000	300,000	220,000	Southern Africa	South Africa	Natal
Pongola Rubber Estates, Ltd	n.a.	out/1910	400,000	300,000	250,000	Southern Africa	South Africa	Natal
Keraia Rubber Estates, Ltd	wild	abr/1910	12,480+ right to buy 16,320	100,000	45,000	West Africa	British West Africa	Ashanti
Aguna Rubber and Trading Co, Ltd	wild	abr/1910	n.a.	100,000	100,000	West Africa	Dahomey (Benin)	N.W.Coomassie
Ivory Coast Corporation, Ltd	n.a.	jul/1910	667,000	330,000	241,214	West Africa	French Ivory Coast	San Pedro
Ivory Coast Rubber Estates, Ltd	wild	ago/1909	45,240	150,000	33,948	West Africa	French Ivory Coast	n.a.
African Plantations, Ltd	plantations	jun/1906	n.a.	100,000	89,432	West Africa	Gold Coast Colony	Axim
African Rubber Co, Ltd	plantations	nov/1905	9,000	80,000	53,858	West Africa	Gold Coast Colony	Axim
Ankobra Rubber Estates, Ltd	wild	abr/1910	3,300	50,000	29,560	West Africa	Gold Coast Colony	Axim
Aowin Rubber and Produce Co., Ltd	wild	mai/1910	6,400	85,000	70,000	West Africa	Gold Coast Colony	Aowin
Avreboo Rubber Estates, Ltd	plantations	nov/1909	3,200	65,000	50,446	West Africa	Gold Coast Colony	Axim
Aywara Rubber & Cotton Estates, Ltd	n.a.	mai/1910	135,720	120,000	80,000	West Africa	Gold Coast Colony	Axim
Boinsu Rubber Co.	n.a.	abr/1910	271,440	125,000	117,211	West Africa	Gold Coast Colony	Aowin
Bukit Sympa Rubber and Cotton Estates, Ltd	wild	mar/1910	1,280	80,000	46,354	West Africa	Gold Coast Colony	Tarkwa
Gold Coast Rubber and Mahogany Estates, Ltd	wild	abr/1910	3,306	75,000	60,000	West Africa	Gold Coast Colony	Wassau
Koshea Rubber and Produce Co.	both	mai/1910	6,400	50,000	24,513	West Africa	Gold Coast Colony	Axim
Mamia River Rubber Estates, Ltd	wild	abr/1910	51,200	90,000	20,850	West Africa	Gold Coast Colony	Wassau
Panni Lands and Rubber Estates, Ltd	n.a.	abr/1910	64,000	80,000	80,000	West Africa	Gold Coast Colony	Axim
Rom Tyre & Rubber Co, Ltd	wild	nov/1909	12,800	50,000	29,929	West Africa	Gold Coast Colony	Dompein
Sikassoo Rubber Estates, Ltd	n.a.	abr/1910	4,852	100,000	75,000	West Africa	Gold Coast Colony	River Tano
The West African Rubber Plantations, Limited	plantations	out/1905	8,093	35,000	22,412	West Africa	Gold Coast Colony	Akim
Liberian Rubber Corporation, Ltd	wild	dez/1905	n.a.	270,000	270,000	West Africa	Liberia	n.a.
Agilete (Lagos) Rubber Estates	wild	fev/1910	32,000	100,000	92,300	West Africa	Nigeria	Lagos
Ilaro Rubber and Produce Estates, Ltd	n.a.	abr/1910	32,000	80,000	51,000	West Africa	Nigeria	Badagry
Ilo Valley Rubber and Cocoa Plantations, Ltd	plantations	abr/1910	1,000	45,000	35,000	West Africa	Nigeria	Lagos
Anglo Belgian (Sierra-Leona) Corporation, Ltd	wild	Sept/1899	128,000	300,000	255,840	West Africa	Sierra Leone	n.a.
Christineville Rubber Estates, Ltd	plantations	fev/1909	2,550	80,000	70,000	West Africa	Sierra Leone	near Freetown
Rio Grande Rubber Estates, Ltd	n.a.	mar/1910	n.a.	70,000	70,000	Southeast Asia	Phillipines	Mindanao
Crude Rubber Washing Co.	n.a.	mar/1910	n.a.	250,000	135,600	n.a.	n.a.	n.a.
Lami River Rubber, Cocoa and Banana Plantations	plantations	jun/1910	1,673	50,000	30,000	South Pacific Ocean	Fiji	n.a.
Upolu Rubber & Cacao Estates, Ltd	plantations	abr/1910	1,092	90,000	33,539	South Pacific Ocean	Samoa	Upolu
Total			3,017,511	6,457,000	4,602,748			

Source: Rubber Producing Companies, Capitalised in Sterling, March 1911. Note: It includes some companies located in the South Pacific Ocean. Note: n.a. = not available.

C.23: American Rubber Concerns Incorporated in London and still active in March 1911

Firm	type	Incorporation Date	area claimed (in Acres)	Authorised Capital (in £)	Issued Capital (in £)	Region1	Region2	Region3
British Honduras Rubber, Ltd	plantations	fev/1910	18,513	95,000	70,000	Central America	British Honduras	n.a.
Posoltega Rubber Estates, Ltd	plantations	set/1907	700	30,000	22,507	Central America	Nicaragua	n.a.
Castilla Rubber Plantations, Ltd	plantations	abr/1910	13,400	115,000	115,000	Central America	Panama	Veraguas
Henriquez Estates, Ltd	both	nov/1908	over 40,000 acres	36,000	31,000	Central America	Panama	n.a.
Henriquez South Rubber Estates, Ltd	both	fev/1910	10,330	50,000	40,500	Central America	Panama	n.a.
Amistad Rubber Plantations and Estates, Ltd	plantations	ago/1910	27,961	120,000	103,500	North America	Mexico	Chiapas
Anglo Mexican Rubber Estates, Ltd	n.a.	mai/1910	160,540	895,000	895,000	North America	Mexico	Coahuila
El Palmar Rubber Estates, Ltd	wild	mar/1910	4,680	145,000	145,000	North America	Mexico	Vera Cruz
Filisola Rubber and Produce Estates	plantations	abr/1910	24,000	120,000	92,000	North America	Mexico	Tehuantepec
Guayule Rubber Co, Ltd	wild	abr/1910	n.a.	400,000	400,000	North America	Mexico	n.a.
Mano Marquez (Mexico) Rubber and Tobacco Estates	plantations	n.a.	20,000	100,000	91,918	North America	Mexico	Oaxaca
San Cristobal (Mexico) Rubber, Tobacco and Estates Co., Ltd	plantations	nov/1909	17,000	60,000	60,000	North America	Mexico	Oaxaca
Soconusco Rubber Plantations, Ltd	n.a.	abr/1910	5,600	200,000	173,400	North America	Mexico	Chiapas
Standard Rubber Corporation of Mexico	n.a.	mar/1910	980,000	300,000	200,000	North America	Mexico	n.a.
Anglo-Bolivian Rubber Estates, Ltd	wild	abr/1910	900,000	125,000	115,000	South America	Bolivia	Velasco
Galvez Rubber Estates, Ltd	wild	mar/1907	n.a.	150,000	130,688	South America	Bolivia	Caupolican
La Martona Rubber Estates, Ltd	wild	fev/1910	1,280,000	250,000	66,619	South America	Bolivia	Santa Cruz
Zongo Rubber Estate, Ltd	wild	fev/1910	110,000	120,000	100,000	South America	Bolivia	La Paz
Alves Braga Rubber Estates and Trading Co., Ltd	wild	jan/1909	215,000	440,000	276,357	South America	Brazil	Pará
British and Brazilian Rubber Planters and Manufacturers, Ltd	plantations	fev/1910	375,000	250,000	119,952	South America	Brazil	Bahia
Ceará Rubber Estates, Ltd	plantations	fev/1910	4,000	50,000	30,000	South America	Brazil	Ceará
Diamantino Rubber Plantations, Ltd	plantations	mar/1910	16,000	100,000	97,490	South America	Brazil	Pará
Island (Pará) Rubber Estates, Ltd	wild	jul/1910	3,400	70,000	57,000	South America	Brazil	Pará, Marajó Island
Jequie Rubber Syndicate, Ltd	plantations	ago/1908	80,000	40,000	40,000	South America	Brazil	Bahia
Lagoa Rubber Plantations, Ltd	n.a.	mai/1910	988	50,000	21,500	South America	Brazil	Pará
Pará (Marajó) Islands Rubber Estates, Ltd	wild	abr/1910	150,000	125,000	100,000	South America	Brazil	Pará, Marajó Island
Rubber Corporation of Brazil, Ltd	plantations	abr/1910	1,235,000	250,000	191,666	South America	Brazil	Bahia
Serinha Rubber Estate, Ltd	n.a.	mar/1910	5,000	50,000	40,000	South America	Brazil	Ceará
St. Antonio (Pará) Rubber Estates, Ltd	wild	abr/1910	15,840	75,000	75,000	South America	Brazil	Pará
West Jequié Rubber Estates, Ltd	both	jan/1910	5,000	50,000	50,000	South America	Brazil	Bahia
British Guiana Balata Co.	mainly wild	mai/1910	448,000	60,000	38,700	South America	British Guiana	Essequibo River
Consolidated Rubber and Balata Estates, Ltd	n.a.	set/1909	n.a.	250,000	246,466	South America	British Guiana	n.a.
Coverden Rubber & Produce Co., Ltd	n.a.	jun/1910	1,525	50,000	40,000	South America	British Guiana	Demerara River
David Young Rubber Estates (British Guiana), Ltd	plantations	jun/1910	3,841,000	85,000	51,000	South America	British Guiana	Aruka River
Demerara Rubber Co., Ltd	both	abr/1910	2,561,210	90,000	80,000	South America	British Guiana	n.a.
Essequibo Rubber and Tobacco Estates, Ltd	wild	abr/1910	128,000	100,000	97,373	South America	British Guiana	n.a.
H. & U. Rubber and Coffee Estates, Ltd	wild	abr/1910	400,000	195,000	180,000	South America	Colombia	Magdalena River
La Libertad Rubber and Cocoa Estate Co., Ltd	plantations	jul/1910	12,500	60,000	60,000	South America	Colombia	Magdalena River
Dutch Guiana Balata and Rubber Concessions, Ltd	n.a.	mai/1910	n.a.	100,000	-	South America	Dutch Guiana	n.a.
Paramaribo Rubber and Timber Estates, Ltd	plantations	fev/1909	25,000	60,000	10,315	South America	Dutch Guiana	Surinam
Pacaya Rubber and Produce Co., Ltd	wild	mar/1910	187,000	175,000	155,000	South America	Peru	Pacaya River
Peruvian Amazon Co., Ltd	wild	set/1907	7,680,000	1,000,000	850,732	South America	Peru	n.a.
Castara Estates, Ltd	plantations	fev/1908	over 1,000 acres	100,000	100,000	South America	Trinidad and Tobago	n.a.
Total			**21,003,187**	**7,186,000**	**5,860,682**			

Source: Rubber Producing Companies, Capitalised in Sterling, March 1911. Note: n.a. = not available.

Appendix D: Productivity in Rubber Manufacturing

D.01 Notes on Productivity in the Rubber Manufacturing Industry

A standard measure of productivity in rubber manufacturing is only available for the period after the First World War. For earlier years, productivity is usually measured as consumption of crude rubber, the main input in the industry, over the number of wage earners in that very same industry. As Figure D.02 shows, in the current measure of productivity there is no persistent productivity gap in favour of either Britain or the United States. According to Woodruff[447], also cited by Broadberry[448], labour productivity gap (measured as consumption of crude rubber per wage earner) only opened up after WW1.

Although this measure of productivity provides an idea of how much crude rubber a worker was able to process, it is probably more a technological than a productivity measure *per se*. In order to understand how misleading this measure of productivity may be, consider the extreme example. Imagine that to produce one tyre, Industry A consumes 5kg of crude rubber and employs 1 worker whereas Industry B consumes 40kg of rubber and employs 4 workers. According to the current measure of productivity based on consumption of crude rubber per wage earner, we would have a productivity gap of 2:1 favouring Industry B. However, both industries are producing only one tyre and whereas technology in Industry A allows it to employ only one worker, Industry B requires 4 workers, implying an actual productivity gap of 4:1 in favour of Industry A (see Figure D.03).

In the absence of any measure of prices and physical production of rubber manufactures, and in view that the rubber industry comprises several different products, productivity in the US rubber industry can only be computed from 1849 onwards as gross production of rubber goods per wage earner, deflated by the price of crude rubber. True, the best measure of productivity would be based on a composite index of rubber manufactures but in the absence of such index, crude rubber price will be used as unit value instead. As the thesis shows, this unit value measure discounts off quality differentials to some extent.

Figure D.05 shows the results for the period under analysis here. From 1869 to 1909, the current value of production increased 13.6-fold and in real terms 6.2-fold. The implicit price of crude rubber from US import statistics was used as deflator and, as can be inferred from column 2, crude rubber price increased 2.2-fold in the same period. Based on the number of wage earners in the industry, it is possible to compute the gross production per worker at 1910 US dollars and the results are shown in the last column. Apart from 1869, when a wage earner produced US$7,541 worth of rubber goods, the other years seem to indicate that between 1879 and 1909, a rubber worker would have produced on average US$5,177 worth of rubber goods (this is just the average of the last column). Note that productivity decreased quite drastically in 1899 reaching US$4,400 and only with the further development of the tyre production at the turn of the century did it increase again.

Unfortunately, there is no equivalent dataset for Britain that would allow us compare productivity in the nineteenth century as the first UK Census of Production was only taken in 1907. Figure D.06 below then compares productivity in rubber manufacturing between the United States and Britain in the nearest years possible: 1904 and 1909 for the United States against 1907 and 1912 for Britain. The difference here is that implicit rubber prices from imports registered different values in these two countries and we are faced with two possible deflators: the British rubber price and the US rubber price. However, regardless of which deflator we choose, productivity in the British rubber industry (converted into US dollars) in 1907 and 1912 is much smaller than the values computed for the USA.

Once converting all productivity estimates into US dollars, it is possible to compute the productivity gap across the Atlantic. Using US crude rubber prices as deflator, the productivity gap ranged from 2.1:1.0 to 2.5:1.0 favouring the United States whereas under UK crude rubber prices, the productivity gap stood around 2:1. These estimates are in line

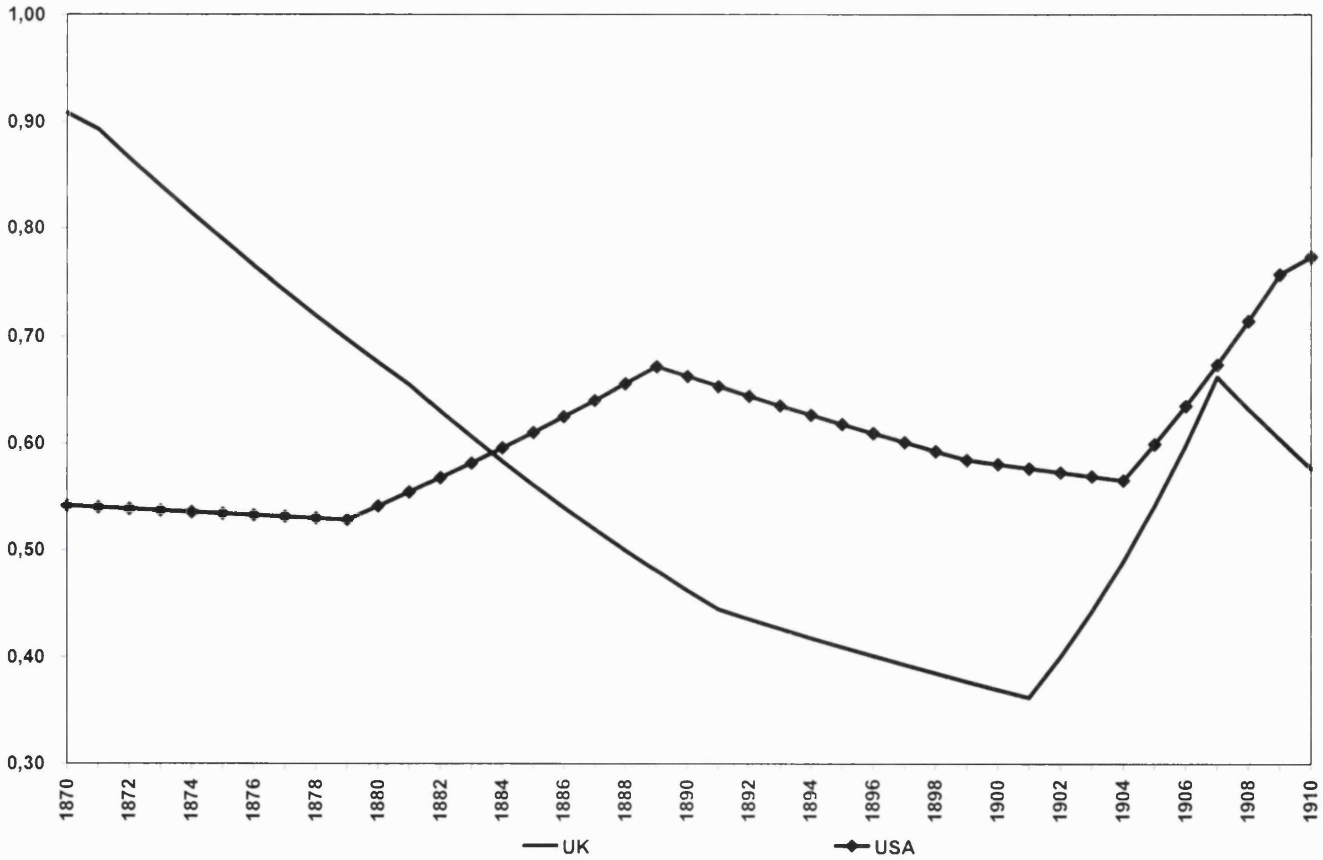
[447] Woodruff (1955, p. 380).
[448] Broadberry (1997, p. 208).

with Broadberry's figures for the whole manufacturing sector[449] despite the fact that they do not take into account specialisation of production or quality differentials (as our unit value measure is crude rubber and not an index of the price of rubber manufactures). Indeed, the production mix of rubber goods was quite different: whereas rubber tyres accounted for only 32% and 38% of overall rubber manufacture gross production in the UK in 1907 and 1912, respectively, rubber tyres accounted for 74% of overall US rubber production in 1914. Conversely, footwear and waterproofing clothes remained relatively more important in Britain compared to the USA. However, product structure might be disregarded as an explanation of the productivity gap insofar as after 1930s the product mix in the two countries was basically the same but the productivity gap remained.[450] Quality differentials, in turn, are more difficult to assess, but it might be the case that the United States were buying low quality rubber (at least at the margin) which could have limited and influenced the quality of their rubber manufacture products.

In sum, there is evidence that the productivity gap between the United States and Britain in rubber manufacturing was very substantial already in the first decade of the twentieth century, probably in line with the rest of the manufacturing sector. However, given the high estimates of productivity in the US rubber industry in the nineteenth century, it is possible that the British rubber industry might have always been a laggard, a result that would be in stark contrast with the current measure of productivity.

[449] Broadberry (1997).
[450] Broadberry (1997, p. 285).

D.02: Productivity as Consumption of Crude Rubber per Wage Earner, 1870-1910



Sources: a) US consumption of rubber in long tons and number of wage earners in the US Rubber industry were both obtained by interpolation of data for 1869, 1879, 1889, 1899, 1904, 1909 and 1914: all data from several issues of the US Census of Manufactures; b) UK rubber consumption in long tons computed as Net Imports of crude rubber into the UK from (Barker, p. 14); c) Number of rubber workers were obtained by interpolation of data from Woodruff (1855, p. 71), Census of England and Wales (1871, 1881, 1891, 1901 and 1911) and UK Census of Production (1907 and 1912).

D.03: Computation of Rubber Productivity

		Industry	
		A	B
(1)	Production (in tyres)	1	1
(2)	Rubber Consumption (in kg)	5	10
(3)	Employment (in number of people)	1	4
	Current Measure of Productivity: (2)/(3)	5/1:40/4 → 1:2	
	Standard Measure of Productivity: (1)/(3)	1/1:1/4 → 4:1	

Source: Elaborated by me, based on a hypothetical example explained in the text.

D.04: Growth of US Rubber Manufacturing Industry, 1849-1909

	Establishments	Average number of Earners	Annual Wages	Value of Products	Rubber Consumption (long tons)	Rubber Consumption per Wage Earner	Production Value per Wage Earner	Average Wage
1849	36	2,602	544,236	3,039,735	1,000	0.38	1,168.23	209.16
1859	37	3,047	858,062	5,945,710	1,500	0.49	1,951.33	281.61
1869	56	6,025	2,559,877	14,566,374	3,756	0.62	2,417.66	424.88
1879	104	11,789	4,051,431	25,309,648	7,500	0.64	2,146.89	343.66
1889	167	20,152	9,526,909	42,853,817	14,960	0.74	2,126.53	472.75
1899	301	36,566	15,426,573	99,880,693	20,308	0.56	2,731.52	421.88
1904	265	43,873	20,084,166	148,015,391	26,089	0.59	3,373.72	457.78
1909	267	49,264	25,136,976	197,394,638	39,789	0.81	4,006.87	510.25

Source: Elaborated from Barker, PT. Rubber Industry of the United States, 1839-1939, US Department of Commerce, Bureau of Foreign and Domestic Commerce, Trade Promotion Series n. 197, 1939, p. 13.

D.05: Productivity in the US Rubber Industry, 1869-1909

	Gross Value of Production (current US$)	US Price (US$) per kg of Rubber	Value of Production (1910 US$)	Gross Production per Worker (1910 US$)
1869	14,566,374	0.71	45,436,636	7,541
1879	25,309,648	0.90	62,078,693	5,266
1889	42,853,817	0.84	111,917,719	5,554
1899	99,880,693	1.37	160,905,682	4,400
1904	148,015,391	1.51	216,054,484	4,925
1909	197,394,638	1.54	282,737,669	5,739

Source: Elaborated from Census of Manufactures, US Trade and Navigation Reports and Barker (1939).

Note: Values were deflated using the US Price per kg of rubber as the unit value.

D.06: Rubber Manufacturing Productivity, 1904-1912

	USA 1904	UK 1907	USA 1909	UK 1912
Production Levels				
Current Price (US$)	148,015,391	43,292,880	197,394,638	62,336,000
at 1910 US Rubber Price (US$)	216,054,484	56,570,149	282,737,669	73,886,059
at 1910 UK Rubber Price (US$)	283,210,432	79,344,672	290,260,706	94,399,922
Number of Wage Earners	43,873	24,039	49,264	31,900
Unit Value (in US$)				
Current Rubber Prices in the USA	1.51	-	1.54	-
Rubber Price in 1910 in the USA	2.21	-	2.21	-
Current Rubber Prices in the UK	-	1.55	-	1.88
Rubber Price in 1910 in the UK	-	2.85	-	2.85
Productivity (in US$)				
at 1910 US Rubber Prices	4,925	2,353	5,739	2,316
at 1910 UK Rubber Prices	6,455	3,301	5,892	2,959

Productivity Gap	US Prices	UK Prices
USA1904/UK1907	2.1	2.0
USA1909/UK1907	2.4	1.8
USA1909/UK1912	2.5	2.0

Sources: US Census of Manufactures (1904 and 1909) and UK Census of Production (1907 and 1912). Rubber prices were used to estimate Unit Value and were computed as the implicit price from crude rubber imports: total value of crude rubber imports over total quantity of crude rubber imported. Crude rubber import data were obtained from US Trade and Navigation Reports and from UK Parliamentary Papers. UK values were converted into US dollars using exchange data presented in Appendix B.