The London School of Economics and Political Science

Was the first transcontinental railroad expected to be profitable? Evidence from entrepreneur's declared expectations, an empirical entry decision model, and ex-post information

Xavier H. Duran

A thesis submitted to the Department of Economic History of the London School of Economics for the degree of Doctor of Philosophy, London, January 2010

Declaration

I certify that the thesis I have presented for examination for the MPhil/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.

Acknowledgements

I was fortunate to enjoy the support of a wide group of people to complete this thesis and would like to acknowledge my gratefulness here. The LSE offered a stimulating environment to develop my own research. I am indebted to my supervisors Nick Crafts, Tim Leunig and Henry Overman for the conversations, encouragement and guidance they provided. I was fortunate to learn from each one of them. I am grateful to Patrick O'Brien for opening the doors to an enjoyable and productive relationship. I am thankful to the whole faculty and group of graduate students, especially Carlos Brando and Felipe Tamega, with whom I had the privilege to interact and collaborate.

This thesis would not have been possible without a successful field work. The UC-Davis Institute of Governmental Affairs, Greg Clark, Peter Lindert, Shelagh Matthews, Chris Meissner, Alan Taylor, and, particularly, Alan Olmstead all facilitated my work in California by generously providing infrastructure and an enthusiastic academic environment. The staff at the Newbery Library, UC-Berkeley Bancroft Library, UC-Davis, Stanford University, Kristine Ogilvie at California State Library, Luis Martinez and Eugenia Gonzalo at London School of Economics, Kay Geary and Roberto Sarmiento at Northwestern University, and John Bromley at the Union Pacific Railroad Museum provided access and guidance to a wealth of archival material. Kyle Wyatt at the California State Railroad Museum shared his knowledge of the history of the railroad and indicated relevant material in several organizations. Martha Amorocho kept the California roots alive for me.

The LSE, Acworth Foundation and Rosebery Foundation provided funding through research studentships. The Economic History Society, the Radwan Fund and the Royal Historical Society financed field work activities. Their support was indispensable for the completion of this thesis and is gratefully acknowledged.

The thesis has also nurtured from discussions with a wider community. Jeremy Atack and Dan Bogart examined my thesis, made very helpful and encouraging suggestions. Joel Mokyr made very stimulating and support comments. Thanks to Cecile Aubert, James Bushnell, Lou Cain, William Childs, Albert Churella, Stanley Engermann, Joe Ferrie, Robert Fogel, Knick Harley, William Hausman, Peter Howlett, Janet Hunter, Stephen Maurer, Larry Neal, Douglass North, Antoine Reberiox, Albretch Ritschl, Nathan Rosenberg, Alejandro Sanz de Santamaria, Suzanne Scotchmer, Nick von-Tunzelmann, Patrick Wallis and Richard White for influential conversations.

Most important, I am grateful to my wife and parents. My wife, Chiqui, initiated the London adventure and shared with me this English/doctoral journey. Her support, encouragement, patience, and smile were indispensable to reach completion. My parents Maria Lucia and Hernando taught me the joy of intellectual curiosity. Without their continuous encouragement, example, and advice I may have chosen a different path.

ABSTRACT

The construction of the first transcontinental railroad is a key event in the westward expansion of the rail network and the US economy. The railroad was built between 1863 and 1869 with large federal government subsidies. The standard view is that the railroad was not expected to be profitable (built ahead of demand) but turned out to be profitable (built after demand). The thesis develops a novel approach to evaluate whether the first transcontinental railroad was expected to be profitable. The approach emphasises on using information generated during the *ex-ante* period and comparing it to *ex-post* information. The *ex-ante* information comes from two different sources. First, reports written by entrepreneurs (and overlooked by previous literature) are used to identify entrepreneurs' declared expectations. Second, since such expectations could be different from entrepreneurs' true beliefs, an empirical entry decision model is used to evaluate the plausibility of declared expectations – simulated expectations. The *ex-post* information was revealed by the operation of the railroad, once built. The three sets of information (entrepreneur's declared expectations, simulated expectations, and observed performance) are compared to identify unforeseen events that may have affected profitability. The evidence indicates the railroad was expected to be profitable, and thus it was both *ex-ante* and *ex-post* built after demand. Subsidies may have still helped to promote construction during the Civil War.

TABLE OF CONTENTS

FIGURES

TABLES

CHAPTER 1. INTRODUCTION

The construction of the Pacific Railroad was one of the most important events during the expansion of the American economy to the west. The railroad was built between 1863 and 1869 by two private companies: the Central Pacific Railroad Company and the Union Pacific Railway Company. When both railroad companies joined their rail tracks together at Promontory Summit, Utah, on May 10th 1869, the United States became a smaller place.

The event, considered an American feat, was widely celebrated, photographed, and commented on. Photographs testified to the accomplishment of the construction during harsh winters and over steep, arid and thorny mountains (see figure 1).

Figure 1.

Photographs of construction

Source: Best (1969) locomotive in snowstorm p. 142 and wagon road p. 24

The nation embraced the railroad and travelled to the west. The major newspapers sent correspondents to cover the construction works, the inauguration ceremony and to describe the landscapes of the vast west. The diaries of the migrants and tourists were widely diffused.

Miriam F. Leslie travelled to California in 1877 with her husband, a New York newspaper businessman and correspondent. After crossing the Rocky Mountains and traversing Wyoming and Utah she noted in her diary, "Of all the desolate land we have travelled, Nevada may be the worst yet. I cannot imagine that a drop of dew has ever lain on this God-forsaken land. The Humboldt or the Twelve-Mile Canyon breaks up the monotony of the desert with its steep, high cliffs rising nearly perpendicular 300 to 600 feet above us. Coming out of the canyon, we rush by the "Maiden's Grave". This pioneer grave was discovered by the railroad builders and tenderly fenced as a reminder of the many whom died while moving west"[1]. The writings convey a very strong and clear message. The territories over which the railroad was built were "desolate", presented "high cliffs", and many "died" just travelling over them, let alone settling on them.

People did not live along the route of the railroad. The harsh winters, the arid and thorny mountains, the high cliffs and the many who died, all prevented settlement of the lands along the route. And it was difficult to think any of these characteristics would change radically and rapidly enough to promote settlement during the mid 1800s. Why build a railroad into such a territory? Why would an entrepreneur organise construction of a railroad into such difficult territories if no customers were waiting to transport themselves or their goods?

The purpose of this thesis is to examine whether demand for the Pacific Railroad existed before it was built. More precisely, the aim is to identify if entrepreneurs were interested in promoting the Pacific Railroad to profit from its operation, as opposed to promoting the road to profit from federal government subsidies. The issue is important and interesting. The Pacific Railroad reduced transportation time between the eastern and western United States from months to days, and promoted migration and economic development of the west. By enlarging the natural factor endowments of the economy the railroad contributed to the faster growth of America during the second half of the 19th century. Consequently, it is important to

[1] Leslie (1877).

understand the motivations which lead to such a historical event as the construction of the Pacific Railroad and which triggered the beneficial effects it delivered to Americans.

The construction of the Pacific Railroad is not only a historically important and interesting event, it is also a fascinating intellectual problem. The decision to build a railroad is a complex investment decision under any circumstance, but even more under the difficult conditions presented by the territories to be crossed by the Pacific Railroad. The sheer size and sunken nature of investment in building the railroad meant the stakes were high. The unpopulated territory over which the railroad was to be built implied creativity was key to identifying potential sources of transport demand and increasing potential profits. Measurement of the key variables for the decision was full of difficulties, which lead uncertainty to play an important role in investment decisions.

Additionally, identifying and measuring entrepreneurial expectations is difficult. Expectations may be declared in the form of project reports. It is not always easy to identify these documents when they still exist. But even when these documents still exist and may be identified, it is possible the information they convey does not reflect the true beliefs of the people writing the reports. Entrepreneurs frequently face incentives for opportunistic behaviour. The complexity of the investment decision and the difficulties in measuring entrepreneurial expectations create important methodological challenges that make the subject of this investigation even more attractive.

The conventional view is that the railroad was not expected to be profitable, but once it was built it turned out to be very profitable. In the parlance of economic historians, the railroad was expected to be built ahead of demand, but it turned out to be built after demand. Construction of the railroad was promoted by large federal government subsidies. The evidence supporting this view is twofold. Firstly, there are many declarations by members of the board of directors of the Central Pacific and the Union Pacific indicating it was difficult to collect funding to build the railroad. In turn, difficulty in collecting funding has been interpreted by scholars as indication of risk and poor profitability expectations[2]. The photographs, diaries and letters documenting the complications of construction and the desolation and harshness of the territory have also contributed implicitly to strengthening the idea that the railroad could not have been expected to be profitable (the two photographs and the extract from Leslie's diary presented above are good examples of these sources of evidence and their influence). Secondly, the cost-benefit analysis of the private and social returns of the railroad indicates both were high[3].

The key criticism of the conventional view put forward in this thesis is that the evidence it relies on was all generated during construction or afterwards. Therefore the evidence provides little information regarding expectations. And it is information about expectations, more precisely, about entrepreneurial expectations that we need to understand the motivations to build the railroad. Were there high enough incentives for a private company to build the railroad to profit from its operation? In sum, we need more appropriate information to determine whether the railroad was not expected to be profitable.

The approach presented here focuses on expectations, by measuring and understanding better these expectations. The approach is based on collecting information derived from three different sources to evaluate expected profits. Firstly, information left by the entrepreneurs was collected. In particular, the entrepreneurs wrote project reports evaluating the investment opportunity and indicating expected costs, revenues, and profits. These reports represent a valuable window into how entrepreneurs perceived the venture of building the railroad and

[2] Fogel (1960) developed an estimate of the perceived risk of failure of the Union Pacific during construction based on some of these declarations. Most other economic historians and historians take the declarations by the members of the board of directors at face value, see Conkling and Shipman (1887), Griswold (1962), McCague (1964), Dagget (1966), Trottman (1966), Ames (1969), Mercer (1982), Klein (1987), Williams (1988), Stover (1997), Bain (1999) amd Ambrose (2000).
[3] See Fogel (1960) and Mercer (1982).

what were the key technical difficulties, the potential sources of revenue, the level of expected profits and the methods used to evaluate the investment opportunity.

Secondly, since entrepreneurs faced incentives to behave opportunistically, it is possible they were not declaring their true beliefs, and it is necessary to determine the reliability of the information contained in the reports. A model of the investment decision to build the Pacific Railroad is developed based on the methods entrepreneurs used to evaluate railroad investment decisions during the 1850s. The parameters of the model are then set based on information available publicly before construction of the Pacific Railroad started. The purpose of developing a model of the investment decision based on the methods used by entrepreneurs in the 1850s and information publicly available before construction is to conform to the ex-ante spirit of the exercise. The outcomes deduced using the simulation model may be described as simulated expectations.

Thirdly, the information generated during the construction and the first decade of operation of the railroad is used to deduce the pricing decisions by the entrepreneurs and the traffic outcomes. More generally, observed entrepreneurial behaviour is identified.

Finally, the three sources of information are compared. The declared expectations, simulated expectations and ex-post behaviour are compared to identify what events the entrepreneurs predicted correctly and what unforeseen events were experienced. The key is to determine if the Pacific Railroad's observed profits were predicted or were the consequence of an unforeseen event (e.g. luck).

The evidence drawn from the entrepreneurial reports assessing the project to build the Pacific Railroad indicates that entrepreneurs performed rational and costly assessments to evaluate the Pacific Railroad as an investment opportunity. The entrepreneurs determined expected market size for the railroad by focusing on a specific source of transport demand (for instance shipping to and from the Pacific

Ocean), and then identifying the average price and aggregate traffic to calculate expected revenues. The construction and operation costs of American eastern railroads were used to infer expected construction and operation costs for the Pacific Railroad. Next, entrepreneurs deduced profits. All entrepreneurial reports concluded the Pacific Railroad was expected to be profitable.

The project reports may be classified into two groups. One group promoted construction of the Pacific Railroad as a single stage project. The second group promoted construction of the railroad in two stages.

The group of proposals promoting construction of the Pacific Railroad as a single stage project emphasised on international and inter-regional trade as key sources of demand for the Pacific Railroad. The first proposal was produced in 1845 and focused on profiting from Asian trade. The purpose of building the railroad was to carry tea, silk and other commodities of Asian trade. The key for the project was that a railroad across the United States could act as a land bridge reducing transport time and distance between Europe and Asia. Once the Pacific Railroad was built, the travel distance and time between China and England, for instance, would be reduced as it was possible to avoid going via the Cape of Good Hope or Cape Horn.

Between 1846 and 1848 the United States expanded to the west and gained control over the Pacific Coast. Additionally, the gold rush in California was experienced. Demand for transporting trade to and from the Pacific Ocean experienced a large positive boost. Entrepreneurs reacted to these new profit opportunities and proposed several other railroad projects. The aim of these projects was to profit from transporting the Chinese and California trades to eastern United States.

Entrepreneurs were also learning about the level of expected demand. The first entrepreneurs to propose a Pacific Railroad project indicated the railroad would compete directly with shipping around the Capes, diverting traffic by reducing prices (competing on prices). Later entrepreneurs pointed out that the railroad would offer transport time reductions that would, in turn, generate savings for the merchants. As transport time was reduced, a merchant's trade expenses on insurance and working capital would also be reduced. Thus, the railroad could charge a premium compared to ship freight rates and still induce merchants to use the road as the preferred transportation mode (competing on quality). The understanding of the business case for the Pacific Railroad improved as projects to build it appeared and social learning was experienced. In turn, as learning was experienced, even higher private and social gains from the project became apparent.

Moreover, the reports also allow us to spot that the Pacific Railroad entrepreneurs were not alone in the race to profit from providing transportation for the rapidly growing trade with the Pacific Ocean. The expected profits from transporting this trade led to intense international competition. The Clipper ships improved existing shipping technology to increase their speed and reduce the long transport times to the Pacific Ocean, and merchants paid them substantial freight rate premiums to use their services. American, British and French entrepreneurs also considered and promoted projects to build railroads or canals through Central America, the Suez, and the Ottoman Empire. The high expected profits from transporting trade to the Pacific Ocean led to intense international entrepreneurial competition and to the proliferation of projects to supply transportation. The intense international competition is an indirect but important piece of evidence supporting the perception that a Pacific Railroad focusing on large and rapidly growing markets was likely to generate profits.

The first group of projects for a Pacific Railroad had a weakness. The Army had performed a rough technical feasibility survey for several different routes across the American west during the first half of the 1850s. But it was still necessary to produce detailed surveys to demonstrate a railroad could operate over such a route and to produce a reliable estimate of construction costs. Additionally, the project also faced some other complications. Any project to build a Pacific Railroad had to cross federal territories and therefore had to be discussed in Congress. In Congress, the Pacific Railroad generated strong conflicts between regions for the allocation of benefits and costs derived from the project. Additionally, the distribution of benefits and costs had important political implications. Consider the case when a railroad was built on the north. Northern territories would grow faster and gain state status earlier than southern territories, disrupting the delicate political balance of 1850s pre Civil War America. Because of the political conflicts over the distribution of benefits and costs, the railroad projects faced a political deadlock.

The second group of projects were produced during the late 1850s and early 1860s. In 1859 a gold rush was experienced in Nevada. Mining in Comstock, Nevada, generated substantial transport demand to cross from California to the eastern slope of the Sierra Nevada. Entrepreneurs very rapidly realised this was an important source of demand for the Pacific Railroad. They reacted by developing a detailed survey assessing the possibility of building a railroad from Sacramento, California, to the mining camps in Nevada, as a first stage for the Pacific Railroad. The detailed survey contained measurement of grades and curves to a high level of precision. The necessary tunnels and bridges of the route across the Sierra Nevada were identified and their cost estimated. As a result of these surveying activities it had been possible to improve the location of the route. Now it was expected total construction cost to be less than 50% of that indicated by the army surveys in the mid 1850s. Additionally, the entrepreneurs used the grade and curve information to show that the route implied similar technical challenges for operation of a railroad as those posed by the Baltimore and Ohio Railroad, a successful eastern railroad. If the Baltimore and Ohio had been operating successfully, the Pacific Railroad would also do so, the entrepreneurs argued. The survey also contained detailed traffic surveys, revenue estimations and profit expectations. The entrepreneurs declared that they expected the first stage of the Pacific Railroad to be profitable. The second stage was to continue from Nevada to the Missouri river. The outlook for the second stage was also positive. A railroad to Nevada would have overcome the most difficult technical challenge, the Sierra Nevada, and would also generate revenues to build the second stage.

In sum, the project reports written by the entrepreneurs indicate that they performed costly investments to collect information reducing uncertainty about the project and assessing it as an investment opportunity. Entrepreneurs expected the Pacific Railroad to be profitable. The estimated costs were substantially lower than originally expected by the army survey performed in the mid 1850s. The main sources of revenue were the Chinese and Californian trades to eastern United States and the mining trade between Nevada and California. In terms of economic history parlance, entrepreneurs believed the railroad was to be built after demand.

The simulation model produces simulated expectations and allows assessment of the plausibility of the entrepreneurial expectations. The issue is whether what the entrepreneurs were declaring was feasible or not. The simulation model suggests that entrepreneurs were right to consider the first stage of the project profitable. The mining traffic implied market size was large and the technological advantage of the railroad compared to wagon roads was so high that the railroad should have been profitable under many different circumstances. The simulations indicate the second stage of the project should have also been expected to be profitable, but the analysis more interesting and less straight forward. Rail technology cannot compete with shipping around the Cape Horn by reducing transport prices, but it can profit from transporting passengers and goods faster at higher prices. Rail technology was about ten times more expensive to operate than shipping, while the Pacific Railroad route reduced travel distance only by a factor of five. Although crossing the continent allowed for high distance savings on the railroad route, these were not enough to make rail competitive compared to shipping. However, the rail route offered substantial transport time reductions, more stable and less extreme climatic conditions, and passengers and merchants value these attributes. The Pacific Railroad should have charged a premium (compared to shipping around Cape Horn) and the premium was high enough to compensate for the cost disadvantage and generate profits.

The comparison of the *ex-ante* and *ex-post* information revealed important information. The outcome of the first stage indicated the entrepreneurs had correctly predicted substantial construction cost reduction, and final cost was just over 50% of what was expected in the mid 1850s. Detailed information for operation of the first stage is not available, but the existing data suggest it was highly profitable. The outcome of the second stage was in line with the expectations of entrepreneurs. Construction cost was reduced and the road competed on quality. Actual construction cost was almost 40% lower than originally expected in the mid 1850s. The *ex-post* information indicates the Pacific Railroad set high prices to charge a premium for its improvement in transport quality (especially speed).

The findings point to several conclusions. Firstly, the entrepreneurs did play an important role in the development of the Pacific Railroad as they collected information to evaluate it as an investment opportunity. Moreover, particularly after the Nevada gold rush and the entrepreneur's division of the project into two stages, their expectation that the first stage of the railroad would be profitable was right. The simulated expectations indicate the first stage of the road was likely to be profitable. And the railroad actually operated profitably. The entrepreneurs were not focusing on settlement as the key source of demand for the railroad. Rather, they focused on the Nevada mining trade as the key source of local traffic. The second stage of the project focused on the Californian and Chinese trades as the key sources for through traffic. For the second stage to be profitable it was also indispensable that entrepreneurs priced to compete on quality. In sum, the entrepreneurs identified sources of transport demand (different to settlement) and expected the railroad to be profitable. The railroad was expected to be built after demand.

Secondly, the reader may have noticed that a major issue connected to the Pacific Railroad has not been mentioned yet in this introduction. The railroad was actually promoted by subsidies provided by the federal government through the Pacific Railroad Act. In fact, one more reason why the Pacific Railroad gained visibility during the 19th century was the corruption scandal surrounding the passage of the Pacific Railroad Act and construction of the Union Pacific. Essentially, in 1872-3 it was discovered that the promoters of the Union Pacific had developed a construction company, the Credit Mobilier, to appropriate subsidies as construction profits. The scandal led to Congressional hearings, investigations and sanctions and has been frequently portrayed as a symbol of the gilded age - a symbol of corruption in an era of corruption. The issue of government subsidies and the corruption scandal had not been mentioned in this introduction because they are all *ex-post* information and are not connected to the operational profits of the railroad. Thus, these political events act more to distract the reader than to illuminate matters when trying to determine if entrepreneurs expected the Pacific Railroad to be profitable or not.

However, the thesis does contribute to the discussion concerning whether subsidies were necessary or not to promote the Pacific Railroad. Note that if one considers the subsidies, the corruption scandal and the *ex-post* profitability of the Pacific Railroad, a natural question arises. Were subsidies necessary to promote private construction of the Pacific Railroad?

The findings presented in this thesis indicate the importance of the Act in providing subsidies cannot be discarded. As indicated above, both the first and the second stage of the Pacific Railroad were expected to be profitable. But the idea the entrepreneurs had in mind was to build sequentially the first and the second stage. The Pacific Railroad Act generated simultaneous construction of the first and the second stage. In doing so it reduced total construction time and also reduced the risk of the first stage being built during the 1860s, but the second stage only later. Essentially, the Pacific Railroad Act promoted coordination between the first and second stages of the railroad and very likely accelerated construction by setting the two railroad companies to build in opposite directions simultaneously, competing against each other.

Thirdly, the evidence on activities performed by the entrepreneurs also allows a contribution to the debates on the rationality of railroad entrepreneurs. Albert Fishlow provided indirect evidence of the high level of rationality of the railroad entrepreneurs. He noted that railroads reached a given county only after it had been settled. Thus, he inferred that entrepreneurs were building railroads after demand. The evidence presented in this thesis confirms Fishlow's inference and provides direct evidence of the entrepreneurs' rationality. Railroad entrepreneurs collected and processed information in a rational manner. In fact, the evidence suggests that entrepreneurs were already more sophisticated by the 1850s than we thought.

Finally, the alternative approach proposed in this thesis, which emphasizes the collection, production and comparison of three distinct sets of information (*ex-ante* expectations as declared by entrepreneurs, *ex-ante* expectations as drawn from a historically plausible simulation model, and *ex-post* information), is not only novel but also valuable. The method identifies the potential biases of information depending on the period during which the information was produced (*ex-ante* or *ex-post*). Additionally, the method also develops techniques to control these biases. The approach allowed the identification of important facts not known before. For instance, expected construction costs were substantially higher than observed ones. And the approach also opens a window to explore in a different way one of the most fascinating topics in history and economics: entrepreneurship. How have the methods employed by entrepreneurs to evaluate investment opportunities evolved through time? What has been driving the evolution of these methods? Do changes in these methods have implications for economic efficiency?

The thesis is organised as follows. The second chapter defines in detail the problem at hand in the context of the historiography. Additionally, the approach proposed here is also explained. The third and fourth chapters present the evidence drawn from the entrepreneurial reports. The third chapter focuses on the projects to build the Pacific Railroad as a single stage project, while the fourth chapter focuses on the projects to build it in two stages. The next chapter uses the evidence collected and presented in chapter three and four to develop a taxonomy of the activities entrepreneurs used to perform in the 1850s. The evidence drawn from projects to build the Pacific Railroad is also complemented with evidence drawn from railroad projects generally, to guarantee the generality of the taxonomy. The sixth chapter presents the simulation model, the empirical approach to anchor it in the 1850s, and discusses the key results. The chapter also compares outcomes expected by the entrepreneurs, simulated outcomes, and *ex-post* performance of the Pacific Railroad to identify what the entrepreneurs predicted and what they did not foresee. Finally, conclusions are put forward.

CHAPTER 2. BUILDING AHEAD OF DEMAND AND THE PACIFIC RAILROAD

2.1. Introduction

The Pacific Railroad has attracted the attention of entrepreneurs, politicians, scholars and, indeed, America since the 1830s. As a key event in the western expansion of the United States the railroad has been a constant object of research. In this thesis our attention is focused on one of the several angles that have been investigated. The literature developed by economic historians has focused on the nature of the expansion of the railroad network (with the construction of the first transcontinental railroad as a key event) and the impact of railroads on economic growth. The main aim of the thesis is to examine the decision to build the Pacific Railroad, the role entrepreneurs played in this decision and their motivation.

In this chapter the problem at hand is clearly defined and the existing literature addressing it is examined. Next, the approach developed here is discussed. The second part of this chapter clearly defines the problem considered and why it matters. The next section discusses the existing literature. The fourth evaluates the existing literature. The approach developed here and the outline of the thesis is presented in the fifth section. Finally, some conclusions are put forward.

2.2. The problem: Building ahead of demand

In this section, the problem to be investigated in this thesis is clearly and carefully identified. The issue is to study the entrepreneurial decision to build the Pacific Railroad and determine whether it was built ahead of demand or not. The nature of the decision and the particular characteristics of the Pacific railroad is complex. The complexity of the decision is one of the reasons why it is an interesting issue to investigate. Other reasons why the problem is important and deserves our attention are identified next.

2.2.1. The Problem

The problem investigated in this thesis is whether an entrepreneur in the early 1860s should have invested in building the Pacific Railroad or not? The Pacific Railroad was a generic label to describe any project proposing to build a railroad from the Mississippi River Valley to the Pacific Ocean, such as Omaha to San Francisco.

Figure 2.

Map of the Central Pacific and Union Pacific

Source: Cisco (1868)

A railroad to the Pacific, connecting the eastern United States to the Pacific Ocean was first dreamed of in the 1830s. During the 1840s and 50s the dream became a project and was intensively discussed in the specialised and general press, and in Congress. The first railroad over to the west was built between Sacramento and Omaha, 1863-1869. In figure 2 the Pacific Railroad corresponds to the single track going horizontally from Omaha (between the states of Kansas, Nebraska, and Iowa) to Sacramento in California, crossing the Rocky Mountains in Colorado and the Sierra Nevada between the states of Nevada and California. It came to be known as the first transcontinental railroad and was built by two different railroad companies: the Central Pacific Railroad Company and the Union Pacific Railway Company. The Central Pacific constructed the railroad from Sacramento eastward to Promontory Point, close to Salt Lake City. The Union Pacific built the railroad from Omaha westward to Promontory Point. Later during the 19^{th} century four additional transcontinental railroads were developed in the United States. However, the decision to build the first one is the only one studied here. The first transcontinental railroad was the key road: its operation demonstrated the technical feasibility and profitability of building railroads over to the west.

The Pacific Railroad, as an engineering problem, represented a challenge in that it would cross the most difficult terrain in the United States. The railroad would cross the Rocky Mountains and the Sierra Nevada, facing steep grades, deep ravines, solid granite walls and harsh winters. It would also cross the deserts between the Rockies and the Sierra, where very little construction inputs like wood, water and food were available. The key engineering challenge was to choose a route minimising all of these difficulties.

The Pacific Railroad, as an investment problem, was a project that required careful evaluation. The sheer size of the project, expected to be the longest railroad in the world, and more than four times longer than any other American railroad, meant that massive investment was required. The engineering problem meant that construction costs were high and construction time long. But neither the level of costs nor the length of time were certain before the decision to build was taken. On the earnings side, it was not clear traffic was high enough to render the project privately profitable. Since the project was proposed when the American economy was still expanding its frontier westwards, substantial parts of the proposed route had not been settled, and some would never be settled as they were deserts.

Consequently, it was not obvious that demand for railroad transportation was already there.

A first approximation to the problem is to suggest that the decision the entrepreneur has to make depends on the size of the market relative to the costs of providing transportation. The simplest expression of this relationship between demand and costs is profitability. In consequence, the entrepreneur should build the railroad if he expects it to be profitable. This simple first approximation hides important complexities that characterised the decision whether or not to build the Pacific Railroad.

First, the cost of building the railroad was high, sunk and had to be performed upfront. Railroad construction was one of the most expensive activities during the 19th century. It required substantial capital to buy tools and pay a relatively large workforce to build the roadbed. The rails had to be bought, transported and then placed on the roadbed. Locomotives and cars were expensive capital goods that had to be sourced and then transported. Stations and freight infrastructure like elevators and warehouses had to be built. And a large workforce had to be employed and trained to operate the railroad. Just to provide a sense of the order of magnitude, the average New York State manufacturing establishment in 1860 invested $7,600 annually, while the average construction cost of just one mile of railroad was $20,000, and the road was expected to be about 2,000 miles long[4]. It is not a coincidence that Chandler called railroads "the first big businesses"[5]. Additionally, railroad investment was to a large degree sunk. Consequently, if the railroad fails, most of the investment cannot then be easily recuperated. Only some items included in construction costs, like the rails, locomotives and cars, may be re-sold. And transport costs will surely consume part of their second hand value. The sunken nature of investment to build the Pacific Railroad implies that stakes are very high. Finally, the investment needs to be made upfront. Construction must be performed

[4] Manufacturing investment comes from US Census data downloaded from University of Virginia website. Railroad construction cost comes from Fishlow (1965) p. 389.
[5] See Chandler (1965).

before the railroad can operate and generate any revenue. All these characteristics make the choice of the appropriate threshold opportunity cost of capital difficult to indentify.

Second, as explained above, the United States was an economy experiencing growth and expanding to the west. The question for an entrepreneur in the early 1860s, before the Pacific Railroad Act was passed, was if enough trade and economic activity between the eastern and western United States was already experienced in order to generate enough transport service earnings to pay for construction and operation costs. The timing of the construction of the railroad was critical. If built too early, the investment would render losses for a relatively long period of time before generating profits. If the decision was made too late, another entrepreneur may have taken the lead and build the railroad. Additionally, it was feasible that the railroad would experience market power. Under these circumstances, the pricing of railroad services could have effects on its own demand. If the transport price was reduced, it would induce higher levels of growth and trade in both the eastern and western United States. In turn, higher levels of growth and trade in the eastern and western United States would result in higher transport demand. Thus, the optimal timing and market power complicated the investment decision problem.

Third, the difficulties measuring the expected costs of building and operating the railroad and the expected demand for transportation were substantial. Some useful information was publicly available, like transport prices of alternative transport modes. Some other important information, like traffic of alternative transport modes, had to be collected and analysed in a private, expensive and judicious effort. Sometimes inferences were necessary. Finally, some critical information could only be forecast, like the rate of future growth of trade between the eastern and western United States. Since the life of the project was long, this information was critical. In sum, the information required for the decision implied measuring things that could not be observed directly, making the analysis of the investment decision even more complex.

Finally, at the most basic level, construction of such a railroad in a frontier economy also implied a coordination problem between demand and supply. For a railroad to be profitable, demand for transportation must exist. In turn, for transport demand to exist, people in the two regions to be connected by the railroad must travel and exchange goods and services frequently. In a frontier economy, by definition, one of the regions will be at most lightly populated, making the flow of passengers, goods and services also light. Under these circumstances it is unlikely such a large investment with a large transportation capacity as a railroad was privately or socially worthwhile. However, it also likely that if transport costs were reduced people would be willing to move from the core region to the frontier region. The population in the frontier region would grow and generate enough transport demand to render the railroad project profitable. Thus, the key issue was how to organise construction of the railroad simultaneously with the movement of people from the core region to the frontier region, a coordination problem. The coordination problem was complicated because the large capital investment required building a railroad across the west. For a railroad of this nature requires a large transport demand to make the project profitable and, in turn, also requires a simultaneous relocation of a large number of people.

To summarise, the problem faced by the entrepreneur was complex. Investment was high, sunk, and upfront, making difficult the choice of threshold opportunity costs to use. The demand was growing, but it was not entirely obvious it was large enough to support a railroad by 1860, making the timing of investment critical. Additionally, the railroad could increase its own demand by coordinating migration to the frontier and by pricing appropriately its services. Demand, to a certain extent, was endogenous to the entrepreneurs' decisions. A substantial part of the information required to analyse the decision to build the Pacific Railroad could not be observed directly. Thus, calculating expected profitability of the Pacific Railroad was a complex process.

2.2.2. Importance of the Pacific Railroad

The construction of the first transcontinental railroad is not only interesting because it was more complex than the typical investment decision, as explained above. It is also interesting because it is a significant event in the history of the United States and in the history of transportation.

The importance of the Pacific Railroad lies in the fact that it crossed about two thirds of the United States, from Iowa to California, allowing for easier and cheaper transportation between the two coasts for the first time. It is easy to understand this point when one considers the alternative routes between New York City and San Francisco by 1860. First, the overland routes of the Oregon, Mormon or California trails allowed communication between the Mississippi River valley and the Pacific coast. People could use Wells Fargo's stagecoaches or mail letters and small items through the Pony express. The route would take 10-15 days through the Pony Express and at least one month, and frequently much more, using the stagecoach. It was also possible to buy horses, a wagon and provisions and join a migrant caravan to the west through any of these trails. The route implied high risk of an accident, assault by Native Americans, or hardship and even death due to the harsh environmental conditions of part of the trip.

Second, people and mail could also take a steamship to Chagres, on the Caribbean coast of Panama, cross the Isthmus by mule or railroad, arrive in Panama City and then connect with another steamship to arrive in San Francisco about a month later. The dangers in this route were associated with malaria, cholera, yellow fever and other tropical diseases while crossing the Panama Isthmus.

Finally, most of the freight took the Cape Horn route, from New York City, all the way around South America, crossing from the Atlantic to the Pacific Ocean via Cape Horn, and then heading north to San Francisco. The trip would take between three to six months, depending on the weather and the type of ship. The dangers were associated with wrecks, epidemic diseases on board and the dangerous crossing from the Atlantic to the Pacific Ocean.

The Pacific Railroad opened in May 1869 and squeezed all this travelling into less than one week for passengers and about two weeks for freight, bringing relative safety and speed to the trip. Moreover, the first transcontinental was not only a major innovation in transportation by providing substantially reduced travel times within the United States. It also helped to reduce travel time around the globe. In November 1869 the Suez Canal opened, and the two projects managed to revolutionize transportation around the globe. An advertisement indicated "A traveller or a business man who, a few years ago, went to Hong Kong or Calcutta, made his will and arranged his affairs with a certain knowledge that at least a year or two of his life were required, and the possibilities were against his returning even then. Today he packs his portmanteau for a run around the globe, transacts important business, and is back in his office in London or New York in ninety days, after having enjoyed an agreeable tour in which he was always communicated with the chief centres of business by telegraph and steam posts"[6]. And the advertisement pointed out it was not only possible to travel in 81 days, but it was also possible to organise the whole trip with one single agent. One cannot prevent connecting these events and the advertisement with the publication of Jules Verne's book "Around the World in 81 Days" in 1873. Not only travelling between New York and San Francisco became shorter, the world became smaller and more connected. If time is money, businessmen captured profits. The event captured the imagination of people around the globe.

[6] See Around the World by Steam (1870) p. 4.

The Pacific Railroad also represents an interesting example of the role governments may have in the diffusion of large-scale technologies typical of infrastructure. In 1862 President Lincoln signed the Pacific Railroad Act. The act stated that two railroad companies would build the Pacific Railroad: the Central Pacific Railroad Company and the Union Pacific Railway Company. Additionally, the act stated subsidies were available to the companies. Soon after construction finished, one of the most visible corruption scandals of the 19th century United States erupted. General Grant's government had been continuously linked to corruption scandals by the newspapers. In September 4, 1872 the New York Sun's headline was: "The king of frauds: how the Credit Mobilier bought its way through congress"[7].

In December 1872 the Poland Committee was appointed to investigate if government officials or congressmen were guilty of accepting bribes. The list of congressmen investigated included vice-president Schuyler Colfax, the current presidential nominee Henry Wilson, James Blaine, James Garfield, and other prominent Republicans. Not a single Democrat was included in the list. The hope was that this would also help Horace Greely to win the election for president[8]. The committee reached the conclusion that Oakes Ames was guilty of offering bribes. The rest of the congressmen were not guilty of accepting the bribes, as they were too naïve to understand what was being offered or they were simply looking to make a profitable investment. The only other congressman found guilty was James Brooks, who was congressman and government director for the Union Pacific, which barred him from holding stock. The committee took action against Oakes and Brooks and recommended both to be expelled from the House[9].

In January 1973 the Wilson Committee was appointed to investigate if government had been defrauded in the transactions between the Union Pacific and the Credit Mobilier. The Wilson Committee found that that the railroad cost to the Union Pacific Railway Company was close to $93.5 million while the cost to the Credit

---

[7] Klein (1987) p. 291.
[8] Klein (1987) p. 292.
[9] Klein (1987) p. 297.

Mobilier Company, subcontracted to build the road and owned by the Union Pacific Railway Company promoters, was close to $50 million. It was inferred that the difference, almost $44 million, was made up of over-costs and a substantial part of it appropriated by the promoters as profits[10]. The Wilson Committee concluded that government had done all it promised to do. In return, builders deceived and defrauded government. Although the government acknowledged the difficulties in building the road, it gave them little weight[11]. Several have suggested the Central Pacific Railroad Company was involved in similar activities, but it was never formally investigated and its books were lost in a fire.

The Credit Mobilier endures as one of the most notorious scandals of its age, the symbol of a generation condemned for its excesses and corruption. Textbooks use it to describe the gilded age and the robber barons. But the Pacific Railroad is not only an icon of an age that lies in the past. It is also one more example in a long list of projects demonstrating the difficulties faced by a society when determining the appropriate role for government when building a large scale infrastructure project. Think about large scale projects and frequently one also has to also think about government participation, long delays, over-costs and corruption scandals. Boston's Big Dig may be a more recent example of the kind of social processes involved in these projects and the challenge we face as a society when developing them in manner more conducive to an efficient and fair allocation of resources.

In sum, this thesis examines the problem an entrepreneur faced when considering whether or not to build the Pacific Railroad. The issue is interesting because it was a complex investment decision, thus it is interesting to think about how these decisions are made. Additionally, the Pacific Railroad was also a key transportation work that increased the speed and safety of transportation to the Pacific, integrating the eastern and western economies and generating substantial social benefits. Finally, the first transcontinental is also a case illustrating the complex and

[10] Fogel (1960) pp. 66-74.
[11] Klein (1987) p. 294.

sometimes perverse social mechanisms in play when large scale infrastructure projects are developed.

2.3. The approach followed by economic historians to study the decision to build a railroad

The study of the entrepreneurial decision to built a railroad or not is an interesting question in its own right. As explained above, it is a conceptually difficult problem. Additionally, railroads were at the centre of the transformation of the American economy during the 19th century. Economic historians have extensively studied the process of the diffusion of the railroad in the United States to identify the nature and magnitude of its impact on the economy. In turn, the process of diffusion is only the consequence of a series of decisions to build individual railroads. In this section, the literature by economic historians on the decision to build a railroad is reviewed.

2.3.1. Building ahead of demand

The key issues involved in the decision to build a railroad were framed by Joseph Schumpeter in his 1939 book "Business Cycles". In this book, Schumpeter hypothesised that economic transformation is experienced through long growth cycles associated with the diffusion of important innovations. The first one of these cycles was what we now call the First Industrial Revolution. The second one, which he called "Railroadization", was experienced between 1843 and 1897.

Schumpeter studied the role of entrepreneurs during this second cycle, "railroadization". He stated that the key entrepreneurial effort to build railroads consisted "not so much in visualizing possibilities or in the solution of technical problems, as in the leadership of groups, in successfully dealing with politicians and local interests, in the solution of management problems and of development in the regions the roads opened up"[12]. Additionally, the entrepreneur also had to co-

[12] Schumpeter (1939) p. 327.

ordinate and organise the "credit creation mechanism" to finance the railroad[13]. Foreign investors were buying railroad bonds, banks were lending directly to (railroad) companies against their notes or on bonds to be sold later to the public, investment was being made by the public and financial speculation was taking place[14].

In the case of the mid-western and western railroads, Schumpeter indicated entrepreneurial activity went even further, as it also "involved creating the conditions of profitability of the enterprise as many of them meant building ahead of demand in the boldest acceptance of the phrase. ... The entrepreneur then secured subsidies or loans amounting to subsidies (and suggested the Southern and the Union Pacific as good examples of these practices)"[15]. More precisely, concerning the Pacific Railroad, he stated that "the first transcontinental route ... led the way and indicated what was to be the particular feature of this boom ... promoters securing options of right of way, having the company chartered and endowed with land grants, selling the options to it and taking securities in payment, finally placing the bonds - the stock being commonly treated as a bonus - in order to provide the means for construction, and buying equipment on instalments through equipment trust certificates. In case of success, issue of further securities would then become possible to consolidate the situation. Failing this, there was reconstruction ... "[16]. Schumpeter chose to exemplify the concept of building

[13] The "credit creation mechanism" is a concept that Schumpeter created to describe how the entrepreneur collects large amounts of resources to finance the development and implementation of the innovation. The "credit creation mechanism" is the way the entrepreneur organises different groups of people/organisations (like banks, public investors, and politicians) to promote the development of the invention into innovation. Moreover, the entrepreneur needs not to be a capitalist as she/he might or not expose her/his capital in the venture. If she/he fails, other people will certainly lose their money. If she/he succeeds, she/he and others will collect the profits from innovation. The distribution of profits/losses will depend on the actual form of the "credit creation mechanism" developed. Additionally, an indirect effect of the "credit creation mechanism" is that it induces a crowding-out effect on the non-innovative sectors. Unfortunately, Schumpeter is not terribly clear about the details of the "credit creation mechanism" or its crowding out effects, but what is clear is that, in Schumpeter's view, it is the key mechanism through which the benefits and risks of the innovative process are distributed throughout society.
[14] Schumpeter (1939), p. 329.
[15] Schumpeter (1939), p. 328.
[16] Schumpeter (1939), p. 334. In this case, Schumpeter refers to boom as the 1867-73 railroad construction boom that ended in the financial panic of 1873, as opposed to the whole railroadization

ahead of demand with the Southern Pacific (initially named the Central Pacific) and the Union Pacific. The first transcontinental railroad became the icon of building ahead of demand.

In short, Schumpeter suggests that when building the Midwest and far west railroads, entrepreneurs perceived that the investment opportunity to build and operate the railroads was not expected to be profitable. Demand was not there yet. In consequence, entrepreneurs proceeded to develop ways to make the investment opportunity profitable. They lobbied government in search of subsidies, and they also promoted "watered stock" and company bonds of dubious quality as if they were first rate investments. In short, entrepreneurs tried different financial manoeuvres to fund construction, with the intention to profit from construction rather than operation of the railroad. The result, in Schumpeter's view, was profit for entrepreneurs and losses for government and investors while the railroads were "built ahead of demand". The icon of this process was the Pacific Railroad.

The next generations of economic historians assumed the entrepreneurial characterisation put forward by Schumpeter was true and devoted their efforts to explore further how the railroads transformed the American economy. However, in this process the entrepreneur turned from a person developing ways to profit from construction of railroads to a visionary leading the process of settlement of the mid and far west. Leland Jenks, for instance, suggests that "It was determination to build the railroad in advance of traffic that gave the "railroad idea" prolonged force in American economic life. ... (The entrepreneur) was rarely limited in outlook to the railroad itself. ... His imagination leaped readily from the concrete problem of securing the right of way to visions of countryside filled with nodding grain, settlements of industrious families, and other evidences of progress and

cycle. This is because in Schumpeter's view, each long term cycle of growth (i.e. the First Industrial Revolution or railroadization) was composed of shorter cycles, one of them being the 1867-71 railroad construction cycle.

civilization"[17]. Thus, the idea that the mid and far west railroads were built ahead of demand was entrenched.

2.3.2. Market equilibrium, building ahead of demand, and empirical testing

The 1960s saw a methodological transformation of economic history. Not only was qualitative evidence and descriptive statistical evidence used to provide interpretation. The role of economic theory and econometrics was also emphasized. Cliometrics was developing and the analysis of the role of railroads in American development was one of the first topics to experience the methodological transformation.

Albert Fishlow was the first one to explicitly and carefully study if Schumpeter's assertion, that railroads were built ahead of demand, did fit the available evidence. He started by describing the notion of building ahead of demand using the tools of economic analysis, mostly supply and demand equilibrium. Building ahead of demand is a sequence of market equilibriums produced by a series of shifts to supply and demand. The first equilibrium was one where the railroad was built and its supply schedule faced initially a demand schedule that did not justify it. The first equilibrium resulted in the inexistence of any profitable price clearing the market and the railroad offered its services at a price lower than its costs. The second equilibrium resulted as lower prices induced demand growth through real income effects and demand shifts to the right. As demand shifted to the right, equilibrium prices and quantity slowly increased, ultimately allowing for profitable prices clearing the market. Under these circumstances investing in building the railroad was "the domain of government subsidy or entrepreneurial error"[18]. A second alternative was that entrepreneurs used expected demand rather than actual demand,

[17] Jenks (1944) p. 2.
[18] Fishlow (1965), p. 167.

and, if the transition period was short enough, investment may have been fully justified[19].

Fishlow made operational his tighter formulation of building ahead of demand by identifying three measures for it[20]. First, ex-ante profits should be negative, and they may be observed as high risk premiums in capital markets or the existence of subsidies. Second, ex-post profits, after being carefully cleaned from any external force inducing profits downwards or upwards, should be initially negative and grow into positive as supply induces rightward shifts in demand[21]. Third, population density should be lower than the "minimum population density to allow for a profitable railroad"[22]. Fishlow also notes none of these three measures on its own is sufficient evidence to determine whether a railroad was built ahead of demand, but the three measures used simultaneously should clearly indicate the nature of the railroad.

Fishlow then proceeded to collect evidence to test the hypothesis that railroads were built ahead of demand in the Midwest during the antebellum period. Evidence collected on the first measure, ex-ante profitability, comes exclusively from local, state, and federal aid. Subsidies during this period were relatively small compared to total investment[23]. Ex-ante profitability could also be approximated by capital

[19] Fishlow (1965), pp. 166-67.
[20] Fishlow (1965) pp. 167-71
[21] Fishlow acknowledges that negative profits does not necessarily imply building ahead of demand, as other forces external to railroad demand may be affecting profits. If a railroad is built during the downturn of the (aggregate) economic cycle, it is possible that a railroad exhibiting negative profits, would have exhibited positive profits if built during the upturn or the crest of the cycle. In this case, it is the economic cycle that determines profits, not that the railroad was built ahead of demand. He also indicates other two sources influencing a railroad's profits that, if observed in conjunction with negative initial profits, would require adjusting experienced profits in order to evaluate the hypothesis of "building ahead of demand" : municipal competition and mismanagement (Fishlow (1965), p. 168).
[22] My own interpretation of Fishlow's explanation (see p. 170). Additionally, also note it is not well defined what number is the "minimum population density allowing for a railroad to be profitable".
[23] Fishlow (1965) p. 189-93. Federal aid financed only two railroads during this period, the Illinois Central and the Hannibal and St. Joseph. State aid was provided in several states to canals and railroads during the 1840s, but generally performed badly, leading to inclusion of prohibitions of State aid in the State's constitutions. Local funds played a more substantial role. "The very fact of contributions by towns and counties along the route gives the lie to the existence of an unsettled wilderness" (p. 191). Moreover, local aid funds represented a small part of the funding. In Indiana it

market quotations, but these were difficult to use due to the unorganised nature of capital markets in 1850s and the aggregate nature of the desired measure[24]. Thus, the ex-ante profitability evidence indicates antebellum railroads were not built ahead of demand

The evidence collected on the second measure, experienced profitability, indicated Midwest railroads were built after demand. Net earnings of western railroads as percentage of construction costs were between 5.6% and 7.2%, positive and close to the rate considered as reasonable. Eastern and western railroads experienced very similar net earnings relative to costs, indicating western railroads had adapted to the lower traffic levels by building cheap roads. Finally, Fishlow emphasised the fact that for several railroads profits had been initially high and then decreased, contrary to the second criteria for evidence for building ahead of demand[25].

The evidence on the third measure, population density, allows Fishlow to conclude that three patterns were observed. First, Ohio received most railroad mileage during the 1850s, when it was already a populated, rich and influential state. Second, construction tended to move sequentially. Initially, railroads were built in eastern states, arriving in Ohio in the early 1850s, then in Indiana two years later, to Illinois during the mid-1850s, and into Wisconsin and Iowa at the end of the 1850s. The railroads were following the expansion of the agricultural frontier and its associated

---

was less than 4%. Only in Iowa and Wisconsin local aid represent a substantial share of total funding, but it was overestimated. Fishlow then notes that more than building ahead of demand, subsidies seem to have promoted construction of excess capacity. Competition between towns induced them to offer aid to secure location in a railroad line intending to achieve economic advantages compared to other towns in the State. The result was many towns contributing to the proliferation of lines, intense competition between railroads, and their bad general financial performance during the late 1850s.

[24] Fishlow (1965) p. 167.

[25] Fishlow (1965) pp. 178-89. Fishlow also provided complementary evidence supporting his conclusion. The loan rate charged to western railroads in the capital markets was about an effective rate of 8-9%, indicative of the positive view investors had of these railroads. The bad financial performance of the railroads during the last years of the 1850s was attributable to the panic of 1857, mismanagement, and entry of competitor railroads squeezing down profits. Entry was highlighted as particularly important, as "competition not only eroded profits but could be carried to excess as well". Excess construction was illustrated by comparing railroads in Ohio and Wisconsin. Ohio had been already settled, but its railroads experienced profits; Wisconsin had not been settled intensively yet, but its railroad experienced moderate profits.

increasing population density. Thus, evidence from population density indicates that the hypothesis that railroads were built ahead of demand may be rejected and that demand in the form of relatively high population density and agricultural activity was already there when railroads arrived[26]. Exactly the same pattern of agricultural and railroad development was highlighted by Harley for the Midwest 1871 construction boom[27].

The evidence from the three measures discussed above led Fishlow to conclude that railroads had in fact demand waiting for them. He suggested an alternative explanation: anticipatory settlement. "Once the railroad reached Ohio, settlement in Illinois and Iowa became more attractive than before. By the time railroads advanced farther west the population and economic development necessary to sustain them was already there – that is why those railroads were built when they were – so that individual, private projects were feasible. But the reason why such settlement was waiting was the railroad itself, considered collectively. ... This interpretation takes us far from a simple Schumpeterian world. Indeed, it almost turns that model on its head: instead of a heroic role for the railroad investor or even the state, the beneficiaries of railroad construction display the crucial attributes of foresight. The western American farmer was different from its European counterpart or agrarians in underdeveloped countries today, and that difference consisted of responsiveness to market forces and ubiquity of a profit motive"[28]. American farmers moved to areas they predicted would be soon connected to the railroad network. As the railroad actually arrived, land prices hiked. Soon after the railroad arrived, the farmers (or at least some of them) sold the land, and continued moving west to speculate further on the future developments of the railroad network

[26] Fishlow (1965) p. 171-4. "The Galena and Chicago railroad from Chicago, and the Milwaukee and Mississippi from its lake rival port, were both attempts to exploit the surpluses of the Rock River Valley, an area that had already contributed importantly to the large grain export of 1847 and 1848" (p. 74). Within each state, railroad mileage was increasing in counties associated with wheat production and higher population density. In Wisconsin "the 7 largest producing counties plus Milwaukee, with but 10% of the total area, contained one half of the state mileage at the end of 1860".

[27] Harley (1980)

[28] Fishlow (1965) pp. 196-7.

and land prices[29]. In this way, "railroads, considered collectively in the region as a whole did create their demand by their initial supply"[30].

In sum Fishlow concludes that little evidence exists for the hypothesis that antebellum Midwestern railroads were built ahead of demand. "No matter if we look to population densities, to government subsidies or gross receipts, our impression must be that the expansion was rooted in rationality, not insanity"[31]. In his view, only the railroads into the far west may have built ahead of demand[32].

Note that Fishlow's approach differs substantially from that of his predecessors. First, the idea is tightly developed to describe profitability derived from operation of the railroad, compared to Schumpeter and Jenks. The possibility that entrepreneurs may profit from construction or other activities connected to construction of the railroad has been excluded from the analysis, and entrepreneurial performance is assessed on operational profits only. All that is left to justify entrepreneurial behaviour in promoting an unprofitable railroad are subsidies or entrepreneurial error. Second, there is no role for non-market coordination. The idea that individuals organise construction or settlement has disappeared. Everything takes place through markets. Third, Fishlow's emphasises on using theory to derive operational hypothesis and on collecting quantitative

---

[29] Fishlow (1965) pp. 196-200.
[30] Fishlow (1965) p. 200.
[31] Fishlow (1965) p. 204.
[32] Fishlow (1965) p. 204. More recently, Jeremy Atack, Fred Bateman, Michael Haines and Robert Margo (Atack, Bateman, Haines, and Margo (2009) and Atack, Haines, and Margo (2008) revisited the hypothesis of building ahead of demand. Atack et al framed the problem in a similar manner to Fishlow. The focus was on identifying the causality between the expansion of the railroad network and growth in population density in Midwest counties, following the spirit of Fishlow's analysis of his third measure, population density. Atack et al improved the railroad network data by collecting and comparing various sources and developing a GIS map of the network. The GIS information was then connected to population and urbanization data at county level. The differences-indifferences and instrumental variable analysis performed by Atack et al established that the railroad network had little impact of population density, confirming Fishlow's findings. But their work also indicates that the railroad network expansion caused part of the growth in the share of urban population per county and establishment size. Thus, the relationship between the expansion of the railroad network and the western expansion and development of the American economy is complex and may not be described in a simple causal relationship.

indicators to evaluate it, is evocative of the Cliometric approach. Finally, Fishlow's empirical results seem to be strong, even though he did not develop a measure for ex-ante profitability[33].

2.3.3. Coexistence of building following demand, ahead of demand and railroad construction booms

The late 1970s and 1980s saw more methodological developments to evaluate Schumpeter's hypothesis. Harley formally integrated investment and industrial organisation theory to evaluate if the transcontinental railroads of the northern Midwest (Minnesota, Wisconsin, and Kansas) were built ahead of demand[34]. The key source of demand for Harley was settlement. Drawing on investment theory, Harley showed that, assuming continuous demand growth, the problem is one of timing of construction. The intuition is simple. As demand grows the road goes from not profitable, to break-even and then to profitable. The optimal investment timing is determined by the break-even demand level. In a way Harley was describing more formally Fishlow's second measure indicating building ahead of demand (observed profitability)[35].

Additionally, it is possible for an investment lasting for 15 years or so to start operating before it breaks-even and on average be profitable over the 15 years. Harley noted that the period over which the railroad operated as unprofitable may described as a period during which building ahead of demand was still rational. Moreover, Harley also notes that the railroad in question would have been even

[33] Many scholars also share this view. Reviews of Fishlow's book were generally very positive. Chandler (1969), Locklin (1966), Neu (1966), Potter (1967), Ransom (1967), Supple (1966) and Williamson (1967) were satisfied with Fishlow's approach and finding that railroads were not built ahead of demand. Bruchey (1967) indicates Fishlow overlooked governmental aid to build railroads across the Apalachians and suggested a more detailed look at government activity before concluding that railroads were built following demand. McAvoy (1968) indicates that Fishlow does not provide an adequate benchmark to compare railroad profitability to alternative new ventures. He doe not suggest if the profitability of alternative new ventures is higher or lower than that of established ones. One has to presume that it is higher as it would otherwise not be a source of criticism of Fishlow's analysis.

[34] Harley (1982).

[35] Harley (1982) pp. 800-1.

more profitable if it had executed construction just after demand hit the break even point. Thus, railroads actually faced a range of demand levels giving positive average profitability, and had incentives to wait until demand was fully developed, at least to allow breaking even from day one of operation[36].

Moreover, barriers to entry also existed. Any company intending to connect its existing rail network to a new city had to be as close as other companies competing to connect that city. Otherwise, it had to invest to build the road just to get as close to that city as competitors and overcome this disadvantage. Additionally, since distances between existing cities and a new city tended to be long in the Midwest, minimum investment tended to be high. Consequently, once a company had laid a substantial mileage of road and initiated operations, it enjoyed substantial advantages to build new roads on the boundaries of its existing lines, compared to potential entrants. Additionally, only a few roads existed in the boundaries of a certain city in the western territories[37].

The combination of incentives to wait and the existence of only a few competitors was propitious for the creation of cartels. The cartelised railroad companies allocated the different routes to the different participants and promoted waiting to build until demand reached the break even point. However, once demand began to reach the break even point, incentives for the different roads to build in the most promising direction were too high to maintain the cartel. One company would break the cartel and start building on the routes with the highest perceived potential. The other companies in the cartel would react by trying to build faster and capture the market and a construction boom would be experienced. Construction following demand was the most profitable decision, but competition and first mover advantages induced railroads to build ahead of demand. The effects of subsidies

[36] Harley (1982) pp. 801-3.
[37] Harley (1982) pp. 803-4.

(land grants) would be to reduce the incentive to wait and generate an ordered and slowly increasing rhythm of construction[38].

Harley developed a simulation model for the roads of the northern Midwest (Minnesota, Wisconsin, Kansas, ...). He supported his behavioural assumptions of cartelisation with evidence from the Iowa pool. Demand was measured by rural population. As rural population grew, his model predicted construction in miles per year for the building ahead of demand scenario and the cooperative (cartel) scenario. Simulated construction building ahead of demand essentially grew at a constant growth rate. Simulated construction in the cartel scenario grew more slowly at the beginning and boomed at the end of the period. Observed construction in Kansas (for instance) grew slowly initially, following the cartel scenario construction path. At the middle of the period construction boomed and in a matter of a few years all railroad mileage to be built was built. The model predicted accurately the first phase as resulting from the cartel scenario. However, the boom was experienced before the point predicted by the model. Additionally, during the observed construction boom in Kansas, the rail network was almost completely finished, while the simulation cartel path predicted a smaller boom preceded and followed by continuous construction[39]. Although Harley's cartel simulations experienced difficulties predicting the timing and extent of the construction boom, the simulations predicted much more accurately the case for land-grant railroads. The model predicted a slowly increasing construction rate, and the railroad's experience showed a similar trend, particularly in contrast to the non-land grant roads' explosive growth. Finally, Harley used the detailed narratives of formation and dissolution of the Mid-western transcontinental railroad cartels provided by Grodinsky in his book "Transcontinental railway strategy" to illustrate positively the process predicted by the model[40].

[38] Harley (1982) pp. 804-5.
[39] Harley (1982) pp. 807-9.
[40] Harley (1982) pp. 809-15.

The approach developed by Harley is interesting. It emphasises the timing of investment as the key issue and explains the coexistence of building railroads ahead of demand and following demand. The model also explains the construction booms characteristic of railroad construction. Harley situates his approach closer to Schumpeter in that he emphasises booms and construction waves and cycles. But Harley also situates his approach further away from Schumpeter in that he develops fully rational explanations for both building ahead of demand and following demand. Schumpeter suggests a process of building ahead of demand in which the railroad's operation would not be profitable, not even on average, and therefore the entrepreneur has to look for profits from alternative sources: construction and corruption.

In sum, Schumpeter's research triggered substantial attention to the causality relationship between railroad construction and demand for transportation. His view was that American entrepreneurs had frequently expected Midwest and far west railroads not to be profitable investments opportunities because demand was not already there when they were to be built. The entrepreneurs did not leave the investment option, but rather searched for ways to profit from activities different from operation of the railroad, such as construction, land sales, and financial speculation. Schumpeter coined the term "built ahead of demand" and succinctly framed the analytical problem. During the next two decades, the literature placed more emphasis on the entrepreneur's determination to build ahead of demand than on the search for alternative sources of profits. For instance, Jenks portrayed entrepreneurs as (non-rational) heroes. Fishlow proposed to test the hypothesis and developed a tight definition of the idea in terms of supply-demand equilibriums. Additionally, to make operational the definition he also identified three indicators that should allow one to empirically test the idea: i) expected negative profitability and existence of subsidies, ii) initially negative and monotonically increasing profitability, iii) railroad mileage should precede population settlement. Finally, Harley indicated that it was possible to build ahead of demand while being rational. Optimal investment timing was to build when demand was large enough to break even from the first day. However, it was still possible to derive average positive profits by building before demand allowed to break even, by initially experiencing losses and making profits that more than compensated losses as demand grew.

Conceptually the literature shifted substantially. The emphasis on the entrepreneurial search process and alternative sources of profits disappeared. The issue became essentially one of causality in the statistical sense – what came first, railroad construction or settlement? Empirically, the methods became more quantitative and targeted an increasingly narrow idea of building ahead of demand.

Although the approach adopted in this thesis is discussed below (section 2.5), it is still relevant at this stage to highlight the differences between it and the literature reviewed above. The approach in this thesis focuses on a narrow definition of building ahead of demand. If operational profits are not feasible, then the railroad was built ahead of demand. And it also follows the more recent literature in that it involves substantial quantitative analysis. However, it differs from all previous literature in that it focuses the empirical analysis on the expectations entrepreneurs had. It does not assume that it is possible to derive information about entrepreneurial expectations using ex-post information (revealed preferences). Instead, it emphasises the expectations that entrepreneurs actually had.

2.3.4. The evidence on the entrepreneurial decision to build the Pacific Railroad

The construction of the Pacific Railroad was such an important national event that an extensive literature on the history of the Pacific Railroad does exist. Each of these histories is of qualitative nature and tends to focus on a particular angle or a particular source to enrich the broader literature. Most of these histories implicitly assume the road was not expected to be profitable. The implicit argument seems to be that the railroad was so massive and the technical, financial and organisational difficulties so large that it is somehow ***obvious*** the railroad required subsidies. In their view the corruption scandal has more to do with traits of individuals involved in building the railroad and changes in public mood during and after the Civil War than with the expected profitability of the project and the need of subsidies[41].

Studies explicitly focused on the entrepreneurial decision to build the Pacific Railroad have been profoundly influenced by the Credit Mobilier scandal. As discussed above, the Wilson Committee Report indicated the Union Pacific Railway company paid $93.5 million to subcontractors to build the railroad, while the cost to subcontractors was $50 million[42]. The initial interpretation was that the loan plus the land grants very likely were more than enough to build the road. The subsidy in the Pacific Railroad Act was a giveaway. However, others pointed out that the Wilson Committee and other sources had overestimated profits. Construction costs for the Credit Mobilier had not been well accounted for, and were in reality higher than described by the Wilson Committee. Additionally, the difference in the construction cost to the Union Pacific and to subcontractors was not only paid in cash, but also in stock and company bonds. Only cash could have been appropriated illegally without any economic risk. Stock and bond values were tied to the company's performance. Finally, the maps of the land grants had not been accurately drawn and exaggerated the land granted to the railroad companies[43].

The tension between the two views increased. The case became an icon, focusing most of the attention and energy on the evaluation of the land grants policy to railroads. On the one hand, a group focused on the excesses of the policy, and questioned the policy as a give away. On the other hand, a group qualified the circumstances of the policy, as government had surplus land and little cash to promote expansion to the west. They concluded that the policy, if not the most

[41] See Ambrose (2000), Bain (1999), Stover (1997), Williams (1988), Klein (1987), Ames (1969), Trottman (1966) McCague (1964), Griswold (1962), and Conkling and Shipman (1887). An exception is Dagget (1966) who indicates clearly that subsidies were perceived as necessary to build the Pacific Railroad by the California State legislature and Railroad Conventions. He does not explain why, though. Orsi (2005), Galloway (1950), Lewis (1938) and Sabin (1919) do not address the issue.

[42] Wilson (1873)

[43] White (1895) p. 35-6 reviews the different arguments.

efficient possible one, was relatively effective in promoting the westward movement of the economic frontier and settlement[44].

When Robert Fogel approached the topic, at the suggestion of his supervisor Carter Goodrich, the issue was about the appropriate role for government intervention in such a project as the Union Pacific[45]. The corruption scandal certainly pointed to an unnecessary waste of resources, large or small. But could the waste have been avoided? What was the appropriate instrument to promote construction of the Pacific Railroad?

Initially Fogel stated that the Union Pacific was a premature enterprise – meaning that "unaided private enterprise, guided solely by the search for profits (would not undertake the project)"[46]. Note the similarity between Fogel's definition of premature, the intuition behind Fishlow's definition of building ahead of demand, and the focus on operational profits adopted in this thesis. He continued indicating that the project was premature in 1845, when Asa Whitney presented the first project to Congress, and was still premature in 1862-64 when the Pacific Railroad Act was discussed in Congress[47]. "The building of the road was pushed ahead although it had not yet matured as a profitable private enterprise, and made government intervention inevitable …"[48]. Legislation to promote a premature enterprise was passed through Congress for two main reasons. The American public had judged it was necessary and had been waiting for more than seventeen years. Additionally, there were economic benefits to reap from internal and international

[44] Carstensen's (1962) volume collects eight essays published by historians in the 1940s and illustrating the intense debates between historians on their assessment of the railroad land grants during the 1940s.
[45] Fogel (1960) p. 11. Carter Goodrich had been working intensively on the role of State (federal, State, and local government) in public development projects, mostly transportation and particularly canals (see for instance Goodrich (1948, 1950, 1956)). The influence of Goodrich's interest in the role of State is evident in Fogel's approach.
[46] Fogel (1960) p. 18.
[47] Asa Whitney was the first entrepreneur to formulate a proposal to build a transcontinental railroad to the Congress of the United States. The proposal was submitted to Congress in 1845.
[48] Fogel (1960) p. 18.

commerce (and military and political ones also)[49]. Thus, the picture portrayed by Fogel is that of a railroad that is not expected to be privately profitable but is a national (economic) necessity. In modern economics parlance, it was a project characterised by high positive externalities.

Once the problem was specified, Fogel continued by reviewing the Congressional debates for the Pacific Railroad. The private projects presented to Congress were described. For instance, the Whitney plan was described by Fogel as a mixed economy plan. The idea to build a railroad using sales of federal government land grants and to operate it just to cover repairs and maintenance could not be described in any other way[50]. The next stage of the debates was a series of project proposals varying in the degree to which different instruments (like land grants, government loans, rights to exploit the resources within the boundaries of the land grants, and public ownership)[51]. The final stages of the debates were the discussion of the Pacific Railroad Acts of 1862 and 1864. The 1862 Act was a hybrid between incentives to private investment and protection of public interest. The incentives to private enterprise were a federal government loan (for about half of expected construction cost) and land grants. Public interest was protected by some influence over the board of directors (2 out of 15 members were government named), the provision of some subsidies only after construction of segments of 40 miles, the provision of other subsidies until completion of construction, and some influence on the pricing policies set by the railroad. The Pacific Railroad Act of 1862 was not enough for the capitalists. Once the Union Pacific was organised they sought changes. Congress reduced the mileage to be completed before subsidies were to be provided and increased its influence over the board by electing 5 out of 20 members[52]. In Fogel's view the Act was, however, defective because it did not provide enough resources to cover construction, induced promoters to speculate

[49] Fogel (1960) pp. 20-22.
[50] Fogel (1960) pp. 25-32.
[51] Fogel (1960) pp. 32-44.
[52] Fogel (1960) pp. 44-50.

and, by allowing the issue of first mortgage bonds of the Union Pacific, doubled the debt equity the railroad would carry, increasing greatly financial risk of failure.

The analysis then focuses on the level of profits achieved by entrepreneurs. Fogel argues that the Wilson Committee overestimated profits. As explained above, the Wilson Committee computed profits as the difference between the construction cost to the Union Pacific and the cost to subcontractors, or more than $40 million. However, only part of this $40 million was cash, and Fogel calculated it was about $6 million. The rest was Union Pacific and Credit Mobilier securities that had to be sold in the market to actually capture the profit. The fact that the securities had to be sold in the market implied that the promoters faced the risk the price for these securities would not be high at the time of sale. And this risk was not considered by the Wilson Committee[53].

The gamble as perceived by Fogel is as follows. The promoters were willing to put forward their funds during the first years of the project. Borrowing at 19% (using personal assets, government bonds and Union Pacific's first mortgage bonds as collateral) they collected the funds for construction. Alternatively, the promoters could have sold the Union Pacific securities at cheap prices to collect construction funds. The fact that they preferred to borrow rather than sell the stock and bonds reveals that higher future prices for securities were expected. The gamble was to invest at the beginning their own funds to wait and sell stock and bonds at high prices in the future[54].

The level of risk to which promoters were exposed was identified by comparing the expected price of the first mortgage bond of the Union Pacific to the interest rendered by a government bond. The expected price of the Union Pacific bond during the 1864-66 period comes from the testimony before the Wilson Committee of John Alley, a member of the board of the Credit Mobilier. Comparing the two

[53] Fogel (1960) pp. 57-70.
[54] Fogel (1960) pp. 78-79.

rates Fogel inferred the risk of failure perceived by the public as 72% and argued that it was a lower bound estimate[55].

In July 1867 the market began buying the first mortgage bonds (which previously were only accepted as collateral), and by the end of 1867 about $10 million in bonds had been sold[56]. Fogel argues some kind of certainty arrived during 1867. The Union Pacific engineers were lucky to find an easy pass over the Rocky Mountains at the end of 1865. The track was built at record speed during the late 1866 and whole 1867. The road had passed Evans Pass and reached Cheyenne on the Rocky Mountains. The Central Pacific had crossed the Sierra Nevada. Consequently, during the second half of 1867 the Union Pacific first mortgage bonds began to be marketable. Although Fogel did not calculate the implicit risk of failure after 1867, he indicates the project had become a very low risk one. The funding difficulties of the Union Pacific were over[57].

After adjusting the Wilson Committee estimate of the construction cost to subcontractors, Fogel calculated the maximum profit entrepreneurs could have reaped as $16 million. Additionally, the expected profit rate for promoters, given the probability of failure estimated above, was also estimated. The promoters had invested $3.6 million by June 1867 (the high risk period), faced 72% chance of failure, and should have expected about $11 million profits for their investment[58]. Fogel concluded that observed profits (maximum of $16 million) were not unreasonable given the high risk of failure faced by entrepreneurs.

The study then focused on estimating the private and the social rates of return of the project and identifying the appropriate form of governmental intervention. The estimated private rate of return was relatively high. In 1870 it was 4.2% and grew monotonically up to 17.5% in 1879. The average rate of return was 11.6%. "These

[55] Fogel (1960) pp. 81-84.
[56] Fogel (1960) pp. 51-7.
[57] Fogel (1960) pp. 79-81.
[58] Fogel (1960) pp. 66-74 and pp. 84-86. Expected profits were calculated using a probability expected value assuming the alternative investment was government bonds.

figures lead to a startling conclusion. The Union Pacific was premature by mistake! It was premature because private investors expected it to be unprofitable. But their expectations were based on the incorrect evaluation of the course of economic development. In actual fact the railroad was highly profitable and should have been taken up by unaided private enterprise. Interestingly enough only in the halls of Congress did one find a sizable proportion of individuals who like Senator James H. Lane of Kansas predicted that the completed Union Pacific would be "one of the great paying through fares of the world". This fact might be taken as an indication that Congress perceived the true state of nature while private businessmen had failed to do so"[59]. The estimated social rate of return was 29.9%. Finally, the ideal governmental intervention was for government to build the railroad and sell it later, when it was operationally profitable, to the private sector.

In sum, Fogel argued the Union Pacific was expected to be premature - built ahead of demand. A measure of the expected probability of failure was identified using bond sales during the early period of construction: 72%. However, the railroad actually turned out to be profitable from the beginning and highly profitable on average. The financial instability that characterised the history of the Union Pacific once it was completed had to do more with the (unintended) inducement for promoters to create excess debt implicit in the Pacific Railroad Acts of 1862 and 1864. Note that implicitly in this purely empirically oriented piece of work, Fogel pointed out several of the issues later identified in a more explicit and structured framework by Fishlow. The definition of premature, the importance of a measure of expected profits and subsidies, and the pattern of monotonically increasing profitability were all in Fogel's work.

During the 1970s Mercer followed Fogel and Fishlow's work and performed a similar analysis for the rest of the land grant railroads[60]. In particular, when testing whether the land grant railroads were built ahead of demand, Mercer followed

[59] Fogel (1960) p. 97.
[60] Mercer (1969, 1970, 1974 and 1982)

Fishlow's specification. He evaluated the time pattern of profit rates. Mercer found that the Central Pacific and the Union Pacific experienced profits from the beginning of operation and took them several years to reach the market capital rate of return. Over the project life (20 years of operation) the average rate of return was above the opportunity cost of capital for both railroads[61].

Additionally, Mercer complements Fishlow's empirical specification of the building ahead of demand by analysing the level of utilisation of capacity. The point is simple. If the railroad was built ahead of demand, excess capacity should be observed. Consequently, capacity should not be expanded at the beginning of operation and utilised capacity should increase with time[62]. After estimating an investment demand function, Mercer found that observed investment is sensitive to previous output level (accelerator principle) and to capital costs. The measure of capacity utilisation is negatively related to time. Investment was responsive to contemporaneous output level and capacity utilisation declined, contrary to what one would expect to observe if the railroads were built ahead of demand[63]. The work by Mercer as a whole suggests that the Central Pacific and the Union Pacific were not built ahead of demand, but he still adhered to the view that subsidies were necessary (as the roads were probably not expected to be profitable).

In the 1980s and 1990s the attention centred on evaluating the need for land grants. Fleisig focused on opportunistic behaviour.[64] Entrepreneurs could profit from construction (as opposed to operation) by appropriating the subsidies as construction profits. He concluded that in fact entrepreneurs profited from construction, faced little risk, and enjoyed high profits. Land grants did not affect entrepreneurial behaviour and were not necessary to induce them to invest or accelerate construction. However, even though he did not explicitly address the issue, it is possible to deduce that in his analysis the loan subsidies do play an

[61] Mercer (1982) pp. 119-123 and p. 139.
[62] Mercer (1982) pp. 123.
[63] Mercer (1982) pp. 124-39.
[64] Fleisig (1974 and 1975).

important and positive role in inducing entrepreneurship effort[65]. A similar approach was developed succinctly by Atack and Passell[66].

The profession's evaluation of the literature seems to suggest agreement on one point: The Pacific Railroad was expected to be built ahead of demand. But the consensus breaks down when discussing whether the Pacific Railroad was actually built ahead of demand and the need for land grants.

Some argue that the Pacific Railroad was built ahead of demand and land grants did induce private effort into building the railroad[67]. Additionally, since social savings cannot capture the whole benefits and ramifications of any positive effects railroads had on the economy, the social benefits must be so large that they dwarf the size of the subsidies. They finish by acknowledging that land grants may not have been the most efficient instrument to provide subsidies, but given the circumstances, fiscal pressure and land abundance, the railroad land grant policy was certainly a positive one.

Some others indicate the Pacific Railroad was actually built following demand. The Central Pacific and Union Pacific railroads experienced relatively low initial profit rates (but not losses), profit rates growing along time, and higher average profit rate than alternative investment opportunities. Land grants were not necessary to induce

---

[65] Also note that Fleisig claims he develops an ex-ante approach to evaluation the issues. What Fleisig means by an ex-ante approach is an evaluation of the profits entrepreneurs may have legally derived from construction, given the provisions in the 1862 Act.

[66] Atack and Passell (1994) pp. 442-41.

[67] Boyd and Walton (1972), Engerman (1972), Gunderson (1970), Hunt (1967), Lebergott (1966) and McClelland (1968). Hughes and Cain (2003) summarise and articulate this view. Some historians have suggested that the key argument for subsidies was non-economical. White (1895) indicates the Union Pacific attained non immoderate profit, and by 1862 when the Pacific Railroad Act was approved in Congress several congressmen expected financial success. But the key argument for State involvement was political – war with Indians and potential war with England (pp. 37 and 69-72). Haney (1910) also shares this view. More precisely, he suggested that subsidies (particularly the loans) to the Central Pacific and Union Pacific were politically necessary under the circumstances of the Civil War. But the other transcontinental railroads should have been built privately. These views are similar to those expressed by people who doubt the ability of capturing the political and military benefits of the railroad through the evaluation of the social savings derived from subsidies and land grants.

entrepreneurial effort to build the railroad. But none seem to object to the need for a loan subsidy[68].

In short, there seems to be a strong consensus that the Pacific Railroad was expected to be built ahead of demand. And, although a weaker consensus, there seems to be agreement that the Pacific Railroad was actually built following demand (in the sense that it was privately profitable).

2.4. Evaluation of the literature

Consensus

The Pacific Railroad was a milestone in the development of the American transport network, the expansion of the United States to the west and its subsequent growth. Understanding the nature of the expansion of the railroad network to the Pacific Ocean surely deserves our attention. The issue has been approached essentially under the lens framed by Schumpeter when he indicated that the Pacific railroad was built ahead of demand. Schumpeter suggested entrepreneurs had searched, found and used different means to organise the different agents necessary to build the road when demand was not there already.

The conceptual framework has been narrowed down. The idea of building ahead of demand initially involved the entrepreneur organising by non-market means and acting in many markets. As time passed by the idea has been increasingly framed by the analysis of supply and demand of a single market, the transportation market. A supply-demand framework was used to identify the conditions for a railroad to be built ahead of demand. These are i) that expected profits are negative and subsidies are observed, ii) observed profitability should increase monotonically and average

[68] Walton and Rockoff (2005), Huneke (2003), Atack and Passell (1994), and Fishlow (1972 and 2000) articulate this view based mostly on Fogel and Mercer's work. Note that Atack and Passell also mention capital market imperfections as an argument to provide subsidies. A bond loan was an adequate subsidy to overcome, but not land grants.

observed profits should be below the opportunity cost of capital, and iii) settlement should follow railroad mileage expansion geographically. Note the emphasis on simple causality – the railroad is observed first, settlement and profits lag behind. Additionally, an oligopoly model was also used to identify the difference between building ahead of demand and following demand under entrepreneurial rationality. Both building strategies may be observed. Although only one is optimal, both are profitable. Competition may lead railroad companies to accelerate slightly the optimal entry date, compared to a break even demand level. Finally, the role of the entrepreneur was lost in the process of narrowing down the hypothesis.

The empirical studies for the Pacific Railroad have followed the approach above (see previous section – Fogel and Mercer emphasise testing the second condition). The first condition has been partially tested as subsidies were a major issue in the story of this road. The second condition has been tested and results indicate the road was profitable from the beginning, profits increased monotonically and on average experienced higher profitability than the capital opportunity cost. The third condition, to my knowledge, has not been tested. In short, the consensus indicates the railroad was expected to be built ahead of demand but turned out to be actually built after demand.

The consensus naturally raises the question of what unforeseen event was experienced for the Pacific Railroad to turn from privately unprofitable to profitable. The literature has developed two explanations. First, Fogel has suggested that an unforeseen positive demand shock may be the key explanation. Second, implicitly, Fogel and others have argued that the project experienced some kind of technological uncertainty that was overcome during construction.

Unforeseen increase in demand

Fogel's explanation of the sources for unexpected profits is that entrepreneurs misjudged the course of economic development – possibly meaning that there was demand waiting for the railroad in places initially described as wastelands[69]. Fogel is, unfortunately, vague about what the course of economic development was. Was it settlement of the region or mining activities or the California trade? When and why did demand actually arrive?

Technical uncertainty

Implicitly, Fogel also argues for a second explanation: the project overcame technical risks in 1867. Fogel's argument is that since the Union Pacific entrepreneurs preferred not to sell almost any company first mortgage bonds before July 1867 and sold more than $10 million during the rest of 1867, it is possible to infer the public's perception about the project was transformed. Initially, the public predicted failure with high probability, and then turned to predicting failure with low probability after July 1867. The public's perception turned because, Fogel argues, technical difficulties like the pass over the Rockies were overcome[70].

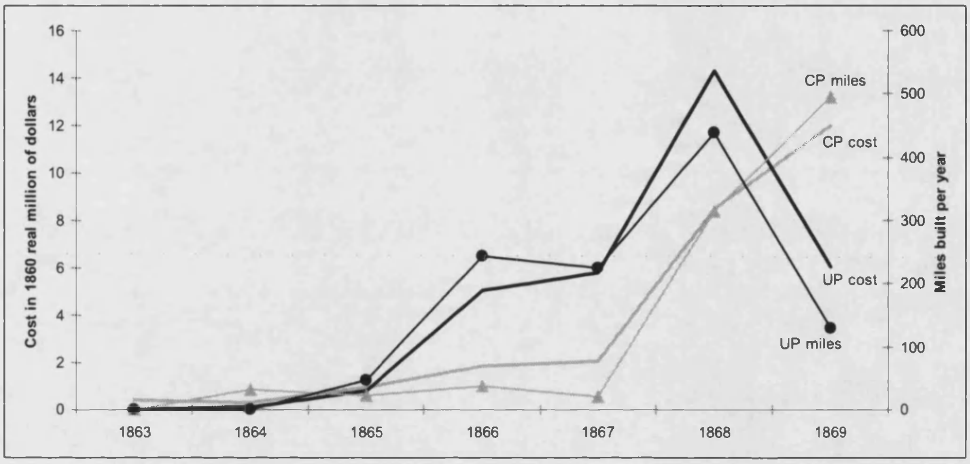
Several difficulties interpreting bond sales information as evidence of technical risk do exist. First, the entrepreneurs could have not expected bond sales to be large until mid-1866. The Pacific Railroad Act of 1862 and 1864 prohibited the sales of the companies' first mortgage bonds in advance of actual construction. The Act was changed in March 1865 to allow for sales of bonds connected to the next 100 miles to be built. Additionally, it was not until July 1866 that the Central Pacific Railroad was allowed to continue building to the east after the California State line. Thus, before March 1865 any bond sales by any of the two companies were limited to what had already been built. It should not be surprising that the entrepreneurs could not perform large bond sales at the beginning when construction speed was slow. As construction gained speed, bond sales also accelerated. Bond sales were high in 1868 and 1869, precisely at the same time the two railroads construction gained speed (see figure 3). Thus, the level of bond sales may be, at least partially,

[69] Fogel (1960) p. 97. See discussion in previous section.
[70] Fogel (1960) p. 79-81. See discussion in previous section.

explained by the constraints imposed by the Pacific Railroad Acts and its amendments[71].

Figure 3.

Construction cost Central Pacific and Union Pacific



Source: Miles: Central Pacific and Union Pacific Bond Prospectuses, 1863-69; Cost: Central Pacific comes from Mercer (1982) p. 154; Union Pacific comes from Mercer (1982) p. 164. Deflator: CPI index from David and Solar (1977).

Second, recall that entrepreneurs preferred not to market the Union Pacific first mortgage bonds and instead used these bonds as collateral for loans. But if the bonds were as risky as Fogel implies, why would they be taken as collateral? Collateral, as an instrument to reduce risk exposure of the lender, only works if it is connected with assets whose value is high and independent of the project for which funds are loaned. The bond's value was low and directly connected to performance to the project for which money was lent. Moreover, the reaction of bond sales to the arrival of information on technical risk was, at least slow. Fogel indicates the pass over the Rocky Mountains was discovered in 1866 and information only leaked to

[71] Government Printing Office (1897) Acts and Joint Resolutions of Congress and Decisions of the Supreme Court of the United States Relating to the Union Pacific, Central Pacific and Western Pacific Railroads, pp 25-27. I am grateful to Richard White for pointing out, during our conversation, that the bond sale in advance of construction was illegal in the Pacific Railroad Acts 1862 and 1864.

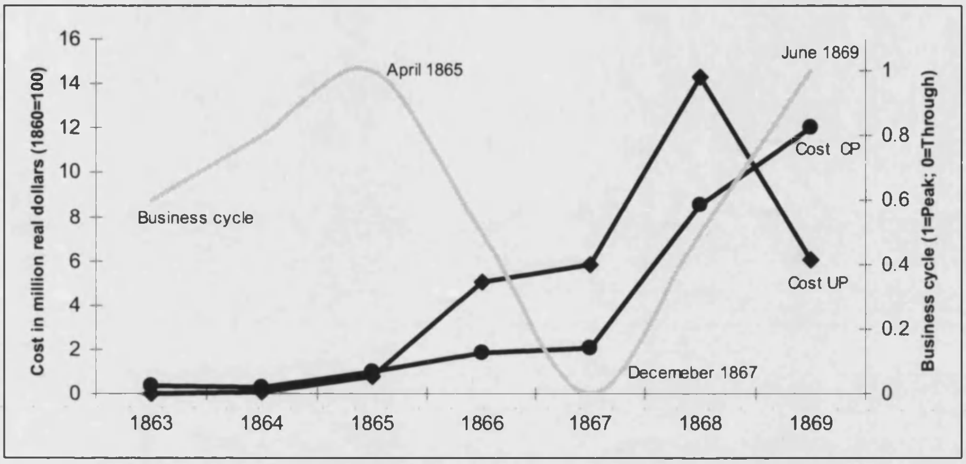
public domain by January 1867[72]. But bond sales only hiked after mid 1867. Moreover, the case of the Central Pacific also strengthens this point. The route was known in a high level of detail (including the pass over the Sierra Nevada) by 1862, but still sales of first mortgage bonds of the Central Pacific only triggered in late 1867. One may ask, if information about overcoming technical risk was the key, why it took more than six months (four years in the case of the Central Pacific) to have effects of bond sales. Put another way, why did the Union Pacific entrepreneurs delay the spread of the information and take so long after the information was made public to organise the bond sale? It is intriguing why the entrepreneurs preferred to use the company's first mortgage bonds as collateral rather than selling them, but it is certainly far from clear that this had to do with the public's perceived risk of the failure of the Union Pacific.

Third, it is also difficult to identify the effects of technical risk on bond prices and sales because many other factors were also acting simultaneously on these two variables. Major instability was experienced during most of the period during which the railroads were built. The Civil War, between 1862 and 1865, crowded out investment that under normal circumstances may have been attractive, possibly including the Pacific Railroad. The post-war depression did not help either. However, during late 1867 and early 1868 the economy began to experience strong growth again (see figure 4). In fact, aggregate railroad construction roughly also followed this pattern. Construction experienced a sharp decline during the 1857 panic. The decline continued during the Civil War, until the post-war reconstruction effort. In 1867 railroad construction had recovered and approached the 1857 levels. A new railroad construction boom started in 1867 and continued into 1873, when the financial panic broke the boom (see figure 5). Thus, aggregate economic and railroad investment fluctuations may have acted as a third variable explaining the pattern of sales of Union Pacific first mortgage bond, as described by Fogel.

[72] Fogel (1960) pp. 118-9.

Figure 4.

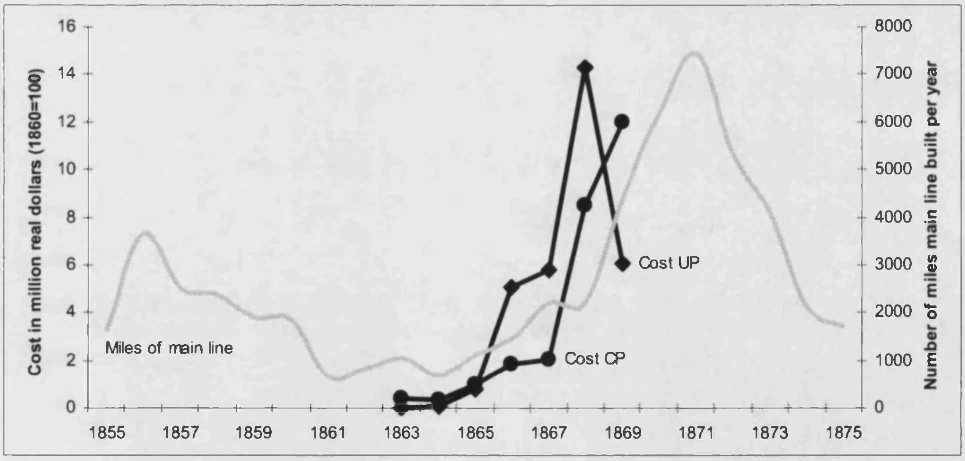
Business cycle and construction cost of Central Pacific and Union Pacific



Source: Construction cost CP comes from Mercer (1982) p. 154 and UP from Mercer (1982) p. 164. Deflator: CPI index from David and Solar (1977). Business cycle comes from NBER in Carter (2006) p. 3-79, table Cb5-8.

Figure 5.

Railroad construction in United States and construction cost of Central Pacific and Union Pacific



Source: Construction cost CP comes from Mercer (1982) p. 154 and UP from Mercer (1982) p. 164. Deflator: CPI index from David and Solar (1977). Miles of main line built per year comes from Poor (1881) and excludes mileage by CP and UP.

The implicit argument that the railroad experienced some kind of technical uncertainty is also found in many of the qualitative histories of the two railroads. In a nutshell, the books initially portray the difficulties experienced by the workers, engineers and entrepreneurs with full details and many photos, then highlight that construction work was too hard, and then ask if such demanding work did not deserve subsidies.

The construction of the Summit tunnel is one of the examples of this hard work. The histories of the Central Pacific all agree it was one of the key (if not the key) milestones during construction. And excavating the Summit tunnel was indeed very hard work. It took 13 months and was excavated in four different directions. Nitro-glycerine was used in some segments of the tunnel although it had not been stabilised yet. Black powder was used in the rest of the segments. The expenditure in nitro and black powder was high. The rate of advance during some days was measured in a few inches. Many workers died. It is clear excavating the Summit tunnel was painful and required a long, sustained and expensive effort to achieve success[73].

However, the important issue cannot be that construction was hard work, as the histories acknowledge. The important issue is whether it was expected to be hard and how this difficulty deterred investors. Since the literature has provided no indication of entrepreneurial expectations, it sheds no light on this. Neither can the literature bring any light on whether actual construction was more difficult than expected.

Moreover, an example makes clear the limitations of the hard work argument, as an explanation for the difficulties the Union Pacific entrepreneurs faced when trying to sell the railroad's bonds. The Panama Railroad was a competitor of the Pacific Railroad. It was completed in 1855 using stock and bond issues to collect the required funding. The dividends were 6% annually and bonds paid 6% interest, within the range of 5%-7% return normally paid by railroads. The railroad cost $8 million and was only 47 miles long, making it one of the most expensive railroads

[73] Ambrose (2000) p. 147

in the world at an average cost per mile of more than $170,000 per mile (almost twice as much as the entrepreneurs expected the crossing of the Sierra Nevada to cost ($88,000 per mile) and more than three times higher than the expected average cost of the whole Pacific railroad ($50,000 per mile) – see more on this in chapters 3 and 4 below). The main difficulty was that the best crossing identified through the Panama Isthmus was over an extremely humid jungle and a cut was required, making landslides tricky to control and human survival unlikely due to yellow fever, cholera and malaria. Construction was, as expected, hard work. It took almost five years, an average of 9 miles per year (while the crossing of the Sierra Nevada was performed at an average rate of 31 miles per year and the full railroad at a rate of 172 miles per year). The death toll is not known, but it is accepted to be very high (informal estimates range from 6,000 workers upwards). Thus, the Panama Railroad was expected to be difficult and expensive to build, and it was actually difficult and expensive to build[74]. Still entrepreneurs and the capital market were willing to invest in the venture and it became one of the most profitable businesses in America. The Panama Railroad provides an important, relevant and powerful counterexample to idea that difficult projects improving transportation to and from the Pacific Ocean cannot be funded through the capital market.

In sum, it is not clear why the Pacific Railroad was not expected to be profitable but turned out to be profitable. No research on what the entrepreneurs believed, researched, or expected is available in the literature. Nor is a good explanation available of what unexpected event positively affected profits. Rather, a strong, inarticulate and implicit assumption that the railroad simply could not have been profitable by 1860, prevails in the literature. It is this assumption that leads economic historians to suggest the Pacific Railroad was expected to be built ahead of demand, while ex-post evidence indicates it was not.

In order to overcome our limited knowledge about the development of the Pacific Railroad it is necessary to understand better what entrepreneurs expected. What

[74] Poor (1872/73) p. 402 and Mack (1944) pp. 149-60.

were the sources of demand the entrepreneurs expected to profit from? Was there any uncertainty regarding demand? What were the technology and routes proposed by the entrepreneurs? Was there any uncertainty regarding technology (as Fogel and others imply)? And, also very importantly, how can we identify and measure the entrepreneur's expectations? If declarations by entrepreneurs were to be used to identify entrepreneurial expectations, then there is the question of how to know if these declarations reflect their true beliefs? Only after identifying and understanding better entrepreneurial expectations it is possible to determine whether the Pacific Railroad was expected to be built ahead of demand or not. Moreover, if it is found that entrepreneurs expected to build the railroad ahead of demand, only after carefully identifying the entrepreneurial expectations and comparing these to what actually happened it will be possible to identify the unforeseen events that boosted profits.

Finally, the literature described above has provided us with substantial knowledge regarding the economic effects of the first transcontinental railroad, but has also obscured some very interesting features of the project. First, a feature of the literature by economic historians reviewed above is that entrepreneurs progressively disappeared from the analysis of the process of building ahead of demand. As economic analysis tools were increasingly used to specify the hypothesis of building ahead of demand, entrepreneurs disappeared. This process is not surprising as it has been noted that the entrepreneur has little, if any, role in formal economic theory[75].

Second, the strong association between the first transcontinental and the land grant debates has obscured many important and interesting angles of the Pacific Railroad. Whether land grants were efficient or effective, and more efficient or effective than other alternative given policy instrument, is a debate that has focused attention on settlement and agriculture exclusively. However, the non-agricultural local activities and the international angle of the railroad were also very important.

[75] See Baumol (1968) and Casson (2003).

Localised enclave activities may also generate substantial transport demand. For instance mining booms were experienced in Colorado and Nevada in the late 1850s and represented potential local traffic demand for transportation. From the international angle, the United States was expanding precisely at the time the road's project was launched. And the railroad would have been politically unfeasible had America not acquired an exit to the Pacific Ocean, and California in particular. In fact, there would have been little to settle after 1860 had America not developed its territorial expansion in the 1840s. Additionally, the first era of globalisation was also starting during the period. Flows of goods to and from the Pacific Ocean were increasing as the gold rushes in California and Australia were experienced and China opened to trade. International and Californian trade may have been important sources of transport demand for the road. The movement of American agriculture westwards is certainly an important issue, but it is unlikely to be the whole story of the first transcontinental railroad.

Third, another important and curious feature of the existing economic history literature is the insistence on treating the Central Pacific and the Union Pacific as two entirely different entities. The Pacific Railroad was a project to be built by a single company for almost its whole life as a project. The Central Pacific and the Union Pacific shared markets, and faced similar problems and advantages because they were conceived as a single road. The fact that the road was divided into two companies by the Pacific Railroad Act of 1862 does not imply the project was not conceived and pursued as a single road. The project was originally for only one company, but the Pacific Railroad Acts acknowledged several possible different companies and branches, and in practice two companies came to dominate the operations and the story. The insistence on treating the two companies as entirely different entities may have accountancy advantages but neglects the past as it actually was.

2.5. Approach

Extensive literature on the history of the Pacific Railroad exists. The consensus among economic historians is that by 1862 the road was expected to be built ahead of demand. But it turned out to be built following demand and to be very profitable.

Unfortunately, the information regarding the activities entrepreneurs performed and what they actually expected is very limited. The attempts in the literature to assess entrepreneurial expectations have examined information generated in Congress during construction or the Poland and Wilson Committees hearings. The position of the entrepreneurs when declaring in front of Congressional committees and the murky environment of the Civil War make it difficult to construct an unbiased assessment of entrepreneurial expectations. More important, any declaration during the Poland and Wilson Committees is ex-post and has benefited from hindsight, so it is not really an expectation.

The purpose of this thesis is to develop an investigation allowing these shortcomings to be overcome, illuminating our understanding of the western expansion of the railroad network, as the first transcontinental railroad was built. The approach is simple and follows four steps. First, entrepreneurial declared expectations are identified and described. Second, since entrepreneurial declared expectations do not necessarily reflect the entrepreneur's true beliefs, a simulation model is developed to generate "simulated expectations" and check the plausibility of declared expectations. Third, observed outcomes and how entrepreneurs actually behaved when operating the railroad are identified. Fourth, declared expectations, "simulated expectations" and observed outcomes are compared. The purpose is to determine if any unforeseen events may explain the profitability of the railroad.

First step – entrepreneurial declared expectations

Entrepreneurial activity promoting construction of the Pacific Railroad is identified by tracing back the documents supporting different projects discussed in Congress. Since all of the projects for the Pacific Railroad implied crossing federal territories, these projects had to go through congressional debates before they could acquire the right of way. Thus, congressional debates do provide an appropriate way to identify the projects promoted by entrepreneurs.

The documents identified are the actual plans developed by entrepreneurs to build the Pacific Railroad. The documents are project reports, reports of the chief engineer on the preliminary surveys, and bond prospectuses. These documents provide a description of the motivation for the Pacific Railroad, the proposed route and construction costs (engineering research), and the expected operation costs, earnings and profits (market research). Exactly the information required to provide an idea of entrepreneurial expectations regarding the railroad. Moreover, these documents were known by some of the historians of the Central Pacific and Union Pacific, but not examined carefully[76].

Next the nature of the plans proposed by the entrepreneurs is described. Essentially the point is to identify the markets targeted and the competitive strategy proposed by the entrepreneurs. The expectations regarding profitability are also identified. Additionally, the information included in these documents is put in historical context by reviewing other relevant events at the time, paying particular attention to events experienced by potential competitors to the Pacific Railroad.

The information set describing entrepreneurial activities, plans, and expected profitability for the Pacific Railroad project are called here declared expectations.

[76] More precisely, some historians like Ambrose (2000) and Bain (1999) identified some of these documents but did not use the content of the documents. Some other historians do not seem aware these documents exist, as they are not mentioned in their writings. All economic historians belong to this last group.

These are expectations as declared by the entrepreneurs in the documents they wrote to promote the project.

Second step – entrepreneurial simulated expectations

Once the entrepreneurial declared expectations have been identified it is necessary to develop a method to evaluate how closely these expectations reflected the true beliefs of the entrepreneurs. More precisely, the entrepreneurs knew their own framing of the investment decision, the information used to evaluate the decision, and the outcome of the decision. But entrepreneurs did not have to reveal their own true beliefs regarding the investment decision (framing, information, and outcome). Rather, they could provide the markets or Congress the set of framing, information and outcomes that the entrepreneurs thought markets or Congress wished to hear and obtain in this way the capital for the project. Thus, entrepreneurs held private information – information on whether the information revealed is the closest to their true beliefs.

Moreover, since entrepreneurs required other agents to participate in the project, they also faced incentives to behave opportunistically. Revealing a certain set of framing, information and outcomes may have allowed them to convince the other agents to participate in the project, even though the interests of entrepreneurs and the other agents may not be aligned. Thus, entrepreneurs may provide a set of framing, information and outcomes that please other agents but do not reflect their true beliefs and withhold private information about this distinction. Formally, the interaction between the entrepreneurs and the other agents is described as a game with asymmetric information.

For instance, as any project of a Pacific Railroad had to go through Congress, at the very least to acquire the right of way through federal territories, the entrepreneurs faced incentives to understate group specific benefits and costs and overstate nation wide benefits (assuming that Congress prefers to maximize national welfare rather than group-specific welfare). Under these circumstances the entrepreneurs would provide a different set of framing, information and outcomes than the ones truly believed and withheld private information about the distinction between their declared set and their truly believed set.

The implication is that the information included in the project reports does not necessarily reflect the entrepreneur's true beliefs. Since the relevant information for determining whether the entrepreneurs expected the railroad to be profitable or not is the truly believed set of framing, information and outcomes, it is necessary to devise a method to determine whether the declared expectations are in fact truly believed expectations. The method used to control any potential opportunistic behaviour from the entrepreneurs is a simulation model. The model focuses on the fundamentals of the transport industry – determinants of supply and demand. The procedure is to use a historically reasonable model of the railroad industry and use information publicly available before construction to set the model's parameter values. The simulation outcomes may be described as "simulated expectations".

The simulation exercise performed is connected to two different strands of research methods in economic history and provides a new methodological tool for analysis of subjective data. First, the simulation model allows the development of a quantitative counterfactual scenario as to what entrepreneurs could have expected, controlling for any incentives for opportunistic behaviour they may have faced. The simulation model is a simple laboratory to study entrepreneurial expectations while controlling for the existence and effects of asymmetric information on economic behaviour. This line of analysis follows the research strategy developed by Robert Fogel in his seminal methodological contribution to the analysis of the economic impact of railroads on American growth[77]. Second, the simulation model continues a line of research methods initially promoted by Donald Schaefer and Tom Weiss, and Jeremy Atack in the 1970s, and later continued by Knick Harley in the 1980s[78].

[77] Fogel (1964).
[78] Schaefer and Weiss (1971), Atack (1979), and Harley (1982).

Simulation techniques are an important tool for economic history analysis as they allow consideration of counterfactual questions and the careful examination of hypothesis when little data exist. Both of these circumstances are frequently faced by economic historians. As important, combining counterfactual analysis and simulation techniques allows an analysis of subjective statements including testing their plausibility. Thus, the method here proposed is an alternative to the time consuming and not always successful conventional approach to analysis of subjective data, which consists of comparing it with the subjective statements of other contemporaries, particularly those for whom asymmetric information would not be an issue, such as wife, business partner and so no.

Comparison of declared expectations and "simulated expectations" allows determining if some of the outcomes expected by entrepreneurs were simply not feasible given the information available at the time they developed their plans and expectations. The simulation does not allow the identification of whether each single declared expectation is a reflection of the entrepreneur's true belief. But by identifying which declared expectations could simply not have been an outcome for the railroad industry in the 1860s, it does allow the identification of declared expectations that are unlikely to reflect the entrepreneur's true beliefs. The presumption is that entrepreneurs do not make big mistakes in their predictions – they behave in some sort of bounded rational way. Additionally, the spirit of the model by focusing on operational profits and no other sources of profits for the entrepreneurs continues the spirit of the cliometric work by Fishlow and Harley.

Third step – observed entrepreneurial behaviour and market outcomes

The third step is completed by collecting information on the observed entrepreneurial behaviour and market outcomes. The entrepreneurial behaviour is provided mostly by the pricing policies observed in the market, when compared to alternative transport modes. The observed market outcomes are given by the traffic outcomes for each of the different transport modes.

Fourth step – comparison of declared expectations, simulated expectations and observed behaviour and market outcome

Once the entrepreneurs' declared expectations about plans and profits have been identified, the "simulated expectations" have been drawn from the simulation exercise, and the observed behaviour and market outcomes also identified, it is possible to compare them. The purpose of the comparison is to identify the key differences between what was expected and what was observed. More precisely, the aim of the comparison is to identify i) if entrepreneurs expected the Pacific Railroad to be profitable and ii) if they were right to expect the road to be profitable or if an unexpected event boosted profitability.

The examination of declared expectations sheds light onto what was actually declared to be expected by entrepreneurs. The comparison between declared expectations and simulated expectations points out whether the declared expectations may have been close to the true beliefs of the entrepreneurs. At this stage it should be possible to determine whether entrepreneurs expected the Pacific Railroad to be profitable or not. Next, contrasting the expectations identified to be plausible with entrepreneurial behaviour and market outcomes actually observed, highlights the unexpected events that may explain the Pacific Railroad's profitability.

In short, the exercise is to collect three sets of information: i) declared expectations (possibly involving biases), ii) simulated expectations (cleared of any biases), and iii) observed performance. Comparing the three sets of information should allow the identification of whether entrepreneurs expected the Pacific Railroad to be profitable (and had good reasons to expect so) or whether a fortuitous event was responsible for the positive performance of the road.

The next chapter of the thesis examines entrepreneurial activity promoting the Pacific Railroad as a single stage project. The promoters are identified and their projects are described. Additionally, these projects are set in the context of (potential) competition with other projects. Chapter 4 studies entrepreneurial activity promoting the Pacific Railroad as a two stage project. The promoters are identified and a very detailed description of their projects is provided. Chapter 5 examines the evidence on entrepreneurial activity documented by the previous two chapters and considers the degree of rationality demonstrated by the entrepreneurs. The chapter also identifies the approach entrepreneurs used to evaluate the Pacific Railroad investment opportunity, and therefore sets the skeleton of the simulation model developed in the next chapter. The sixth chapter uses the skeleton developed in the previous chapter and information publicly available before construction to develop a simulation model and generate "simulated expectations". Whether entrepreneurs expected the railroad to be built ahead of demand or not is discussed. The chapter also presents observed entrepreneurial behaviour and market outcomes and compares the three sets of information (declared expectations, simulated expectations and observed outcomes) to deduce if unforeseen events boosted the railroad profits. Finally, chapter 8 puts forward conclusions.

2.6. Conclusions

The construction of the Pacific Railroad was a major event in the westward expansion of the rail network and the economic frontier of the United States. Additionally, the event has captured the imagination of generations of American because of the sheer size of the work, the amazing travel time reductions it provided (in combination with the Suez Canal), and as a symbol of the sins of the gilded age.

Economic historians have focused their attention on the topic by trying to disentangle the causality between the westward movement of the frontier and the extension of the railroad network. The dominant perception is that the Pacific Railroad was expected to be built ahead of demand but actually turned out to be built after demand. However, evidence of entrepreneurial expectations is slim and depends essentially on impressions developed from accounts by the entrepreneurs during construction and declared during Congress investigations. Additionally, it has not been clearly identified yet why was the road actually profitable.

The purpose of the thesis is to contribute to our understanding of the development of the railroad network and its westward expansion. The approach follows four steps. First, the entrepreneurial expectations are identified, as they were declared. Second, to check the plausibility of the declared expectations, a historically plausible model of the railroad industry and information publicly available before construction are used to simulate entrepreneurial expectations. The point is to identify if any of the declared expectations could simply have not been an outcome of the Pacific Railroad once in operation. Next, the observed entrepreneurial behaviour and market outcomes are identified. Fourth, the three sets of information, entrepreneurial declared expectations, simulated expectations and observed behaviour and market outcomes, are compared. The purpose of this comparison is to identify if entrepreneurs really did expect the Pacific Railroad to be built ahead of demand and if an unexpected event rendered the venture highly profitable.

CHAPTER 3. EX-ANTE ENTREPRENEURIAL ACTIVITY AND THE PACIFIC RAILROAD AS A SINGLE STAGE PROJECT

3.1. Introduction

Economic historians have continuously indicated that the Pacific Railroad was built ahead of demand. Schumpeter suggested that entrepreneurs developed arrangements with other organisations to finance construction of the railroad, while profiting from activities different from operation of the railroad. Jenks indicated that entrepreneurs were determined to build railroads across the United States. Fogel argued entrepreneurs expected the railroad to be a premature enterprise (and were mistaken not to expect profits from the operation of the railroad). Finally, Mercer also indicated that the venture was perceived as premature.

The assumption underlying the intuition regarding building ahead of demand is that entrepreneurs did not expect demand to be high enough for the operation of the railroad to be profitable in the 1850s and 60s. However, as noted in the previous chapter, little evidence of what entrepreneurs expected exists in the literature. The purpose of this chapter is to provide direct evidence of what entrepreneurs actually expected.

In order to answer this question, several documents produced by entrepreneurs were collected and examined. The project reports, reports of chief engineers on the preliminary surveys, and the bond prospectuses constitute the key primary sources. These primary sources have been overlooked by economic historians, but they provide direct evidence on what entrepreneurs expected (or claimed to expect) for the railroad. Additionally, these primary sources are complemented with other primary sources to provide a sense of how the entrepreneurial expectations were perceived by the rest of society. Newspapers and magazines, specialised press and Congressional debates were also examined.

The findings indicate that entrepreneurs made expensive efforts to produce and analyse information. Analysis of information reduced uncertainty. Additionally, it also allowed a better understanding of the Pacific Railroad as an investment opportunity. Entrepreneurs consistently declared an expectation that the railroad would be profitable and would bring substantial social benefits. The differences between projects were mostly connected to the choice of the route for the railroad. In short, entrepreneurs did perform important efforts to assess the Pacific Railroad as an investment opportunity, developed plans to build the railroad and expected it to be profitable.

The evidence on entrepreneurial expectations is presented in two chapters. In this chapter, the expectations by entrepreneurs developing the Pacific Railroad project as a single stage construction project are presented. These entrepreneurs considered that the railroad was a single line connecting the eastern and western United States. Since no major location of economic activity existed between the Rocky Mountains and the Sierra Nevada, it was simply not feasible to divide the project into stages. The railroad had to be built complete or it did not make any economic sense. In the late 1850s two gold rushes were experienced in Nevada and Colorado. In turn, these two events opened the possibility of building the railroad in stages. The entrepreneurs acknowledged these changes and developed projects to build the Pacific Railroad by stages. Initially, a first stage railroad from California to the mining camps in Nevada, to profit from transport demand derived from mining. In the east another first stage was proposed between the eastern United States (Missouri) and Colorado. Next came a second stage completing the full railroad and allowing the transportation of trade between eastern and western United States. The second group of projects, those proposing to build the Pacific Railroad in at least two stages are discussed in chapter 4.

The second section in this chapter presents and discusses the first unsuccessful project for a Railroad to the Pacific, 1845-55. It describes how Asa Whitney, the entrepreneur behind this proposal, framed the business opportunity as a single investment decision – whether to build the whole railroad or not – and generally concluded it would be profitable. The third section sets Whitney's project in the context of competition to build the Pacific Railroad. Several entrepreneurs were competing in Congress to obtain the rights to build the road. The fourth section explores a wider sense of competition. Whitney's Railroad to the Pacific was not only competing with other plans for a transcontinental railroad in the United States, but it was also competing with other projects based on different technologies and regions, all intending to profit from transporting trade to and from the Pacific Ocean. American clipper ships were transporting trade to California and China. American, British and French entrepreneurs were developing projects for canals through Central America and the Suez Isthmus. American, British and French entrepreneurs were also developing plans for railroads across Central America, the Suez, Constantinople, and Canada. Finally, conclusions are put forward.

3.2. A Railroad to the Pacific

The first major project promoting the Pacific Railroad involved two challenges. First, it had to turn an idea into a plan, into something perceived as feasible and practicable by many actors such as the public, Congress and the entrepreneurial community. Second, it also had to align the interests of the key stakeholders for such a large project to receive enough support to go ahead. The key to understanding how entrepreneurs engaged in these two challenges are the project reports. In the documents, entrepreneurs argued that the railroad could be a reality (not only an idea) and explained how they thought the project could be built and who would benefit from it.

3.2.1. Antecedents

The dream of a railroad crossing American territory to link both coasts was born soon after the first railroads were built in the eastern United States in the 1830s. An anonymous editorial in Michigan in 1832 had suggested building a line from New York City to Oregon. The proposal was audacious to say the least. In 1832 only 229 miles of track were available in the United States. And, as important, Oregon, through which the road would be built, did not belong to the United States[79]. Samuel Bancroft in 1833 or 1834 advocated the construction of a road from New York to the mouth of the Columbia River, in Oregon. John Plumbe, a Welsh engineer organised a meeting in Dubuque, Iowa, in 1836 to discuss the issue of building a transcontinental railway. Journalist Hartley Carver in 1837 and Senator Thomas Hart Benton in 1844 had already predicted that Asian commerce would be carried across the Rocky Mountains by rail within the lifetime of men then living[80]. All of them indicated the way forward.

However, it was not until Asa Whitney's arrival from China to the United States that the dream of a Railroad to the Pacific was transformed into a plan. Asa Whitney was born in 1797 in rural Connecticut[81]. He moved to New York City, probably when he was 20, and rapidly moved from being an average farmer's son to become a prestigious merchant[82]. He also spent several years' abroad, as a buyer for F. Sheldon and Company and experienced railroads first hand in England. He rode the Liverpool and Manchester Railroad[83]. He returned to the United States to become a partner of the firm he had been working for abroad. During the 1830s he founded his own trading firm, married Sara Jay Munro and did business with the Jay family[84]. The late 1830s were to bring adverse fortune to Whitney. The

[79] Klein (1987) p. 7.
[80] Conkling and Shipman (1887) p. 6 and Loomis (1912-13) p. 166.
[81] Brown (1933) p. 209.
[82] Some unconfirmed sources indicate that Asa Whitney was not born in an average family, but a prominent family of inventors and manufacturers and his cousin was Eli Whitney (see for example American Experience's website - http://www.pbs.org/wgbh/amex/tcrr/peopleevents/e_early.html visited 05/09/2006). However, the American Dictionary of Biographies does not include an entry for Asa Whitney and has not allowed confirmation of this information.
[83] Brown (1933) p. 209 and Cotterill (1919) p. 396.
[84] Sara Jay Munro was daughter of Peter Jay Munro, New York merchant and nephew of John Jay, diplomat and chief justice of the United States Supreme Court, and influential revolutionary (Combs (1999) pp. 891-4).

financial crises of 1837 hit him hard, and his wife died in 1840. He decided to move to China in June 1842, where he would act as agent for New York merchants[85].

Asa Whitney's trip to China coincided with the end of the Opium wars and the opening to British trade of five Chinese ports, through the Treaty of Nanking[86]. In China he spent less than two years acting for a merchant house. He returned just after a preliminary agreement similar to the Treaty of Nanking had been signed between the United States and China. On his way back, in March 1844, and most likely motivated by his experience in China, Whitney formulated his plan for a Railroad to the Pacific[87].

3.2.2. Whitney's Railroad to the Pacific

In January 28th 1845 Whitney presented his plan to the United States Congress. The idea was to connect the existing "railroad network between New York and Lake Michigan to a railroad traversing the west and linking Lake Michigan to the Pacific Ocean"[88]. The purpose of the Railroad to the Pacific was to substantially reduce the time and cost to reach Asia and boost United States-Asia trade. "From Columbia river (in Oregon) to Amoy, in China, the port nearest to the tea and silk provinces, is 6,200 miles, making from New York to Amoy only 9,200 miles which, with a Railroad to the Pacific, and thence to China by steamers, can be formed in 30 days, being now a sailing distance of nearly 17,000 miles and requiring now from 100 to 150 days for its performance"[89]. And, the project continued, "the drills and sheetings of Connecticut, Rhode Island, and Massachusetts and other manufactures of the United States, may be transported to China in 30 days, and the teas and rich silks of China, in exchange, come back to New Orleans, to Charleston, to

---

[85] Brown (1933) p. 210.
[86] Brown (1933) p. 211.
[87] Brown (1933) p. 211.
[88] Whitney (1845) p. 2.
[89] Whitney (1845) p. 2.

Washington, to Baltimore, to Philadelphia, to New York, and to Boston, in 30 days more"[90].

The plan submitted to Congress by Whitney indicated he viewed the Pacific Railroad as much more than a railroad. It was a plan to develop the nation, to control the forthcoming problems brought by mass in-migration and turn them into an opportunity for economic empire based on territorial expansion and control over international trade. A proposal was made that a grant or sale of sufficient quantity of the public domains (a strip 60 miles wide following the road's route) that in turn should be sold to "industrious and frugal" people to settle the region[91]. These people were to come mostly from "over-populated Europe ... (where) thousands fear starvation ... and are driven to our shores ... and fear the wilderness and the prairie, and refuse to leave the city ... necessity plunges into vice, and perhaps crime, ... unless there can be some great and important point in our interior to which such emigrants can be attracted ... and where their little means, with their labour, can purchase lands ... and their labour from their own soil will produce, not only their daily bread, but, in time, an affluence ... that will relieve our cities from vast amount of misery, vice and crime"[92].

In this way, the railroad would organise in-migration into the United States by promoting settlement of the prairies. In turn, settlement would pay for construction of the railroad with the revenue collected from sales of land granted to the railroad[93]. Additionally, settlement would also pay, partially, for the operation of the railroad, with agricultural production requiring transportation to the cities. The consequence of the plan, of the interconnection of in-migration, settlement of the west, construction and operation of the Pacific Railroad, would be American

[90] Whitney (1845) p. 2.
[91] Whitney (1845) p. 3 and Whitney (1848) p. 3. The 1845 memorial indicated Whitney requested a land grant while the 1848 memorial indicated he was willing to buy the land from the Federal government.
[92] Whitney (1845), p. 3.
[93] Whitney (1845), p. 4. Additionally, Whitney indicated that, as expected form an entrepreneur, any "balance of moneys received for lands sold and which have not been required for the building of this road, then all and every of them shall belong to your memorialist, his heirs and assigns forever".

territorial expansion and domination of international trade, both clearly positive elements to the development of the United States.

Whitney also stressed that co-ordinating settlement and construction of the Railroad to the Pacific was the only possible way to build the road. Otherwise, individuals would not have incentives to build the road, as returns would arrive late during a lifetime. States would not do it either, as they had not been formed in the west yet[94]. Federal government would not, and should not build it either. Sectional (regional or party) differences would impede agreement on a route and government would have incentives to exploit the railroad through patronage. Federal government was not likely to focus on the road's mission to promote international trade[95].

Whitney's 1845 "memorial" provided the motivation to organise construction of the road. In the next memorials and other public documents he developed more on the details regarding construction and expected business for the road. Here, a summary version of the main points is presented.

First, Whitney re-stated the main motivation behind the project. The plan was to build a railroad across the west to use the United States' geographical position to reduce travel time and distance to Asia and to divert and increase United States-Asia and Europe-Asia trade. The intention was the positioning of the United States as a trade empire.

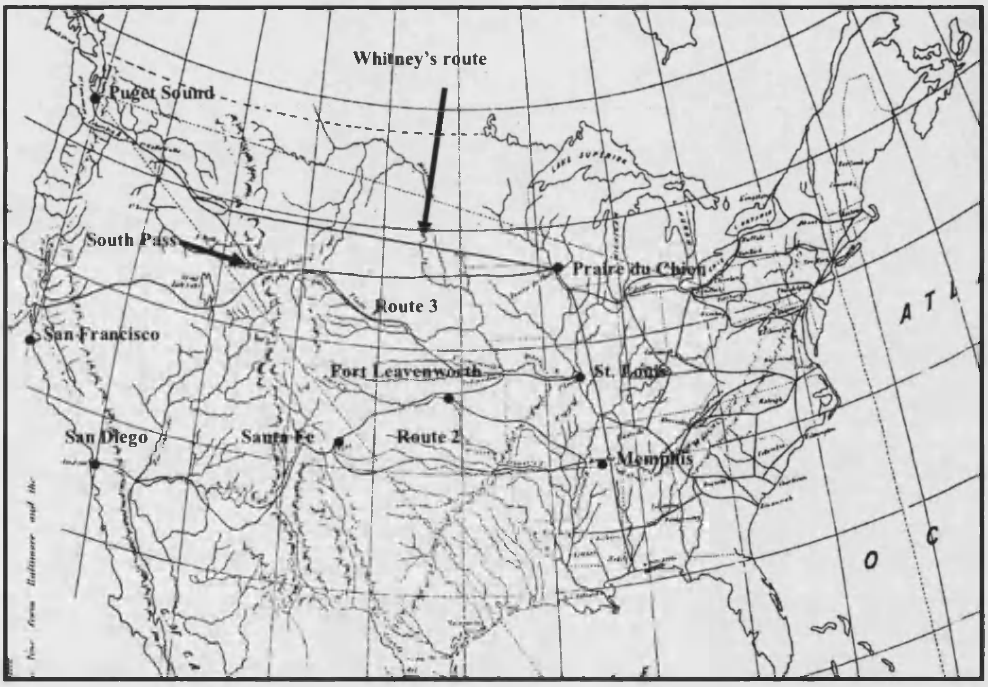
Second, Whitney explained details about the route. Whitney argued that the best route, the one that reduced the most travel time and distance, followed the 45° latitude (see figure 6). It started in Prairie du Chien, close to Lake Michigan, and crossed the prairies, providing good land for settlement and timber for construction of the railroad. The route continued through the Rocky Mountains (through a pass

[94] In fact, in 1845, when Whitney formulated his first memorial the United States did not even have an exit to the Pacific Ocean.
[95] The argument about why government should not get involved was mentioned in the 1845 memorial, but a detailed explanation was provided in the 1849 project pp. 7-8.

north of “south pass”), then into the Columbia River, and finishing in Puget’s Sound. As the most northern route in the United States, it would take full advantage of the globe’s curvature. Trading with Asia or Australia by steam would take 20-30 days. Prairie du Chien, would be close to equidistant to all major Atlantic cities. And Vancouver had abundant coal[96].

Figure 6.

Map of Whitney’s railroad route



Source: Whitney (1849) Appendix.

Third, the feasibility of construction of the road through the chosen route was argued based on reports by explorers Lewis, Clark and Freemont[97]. Whitney also requested written advice from Freemont, Fitzpatrick and Pollock regarding the

[96] Whitney (1849) pp. 23-5. He showed distances from different United States Atlantic cities, including New Orleans, Charleston, Richmond, Washington, Baltimore, Philadelphia, New York and Boston to Prairie du Chien, ranging from 830 to 1,341 miles, with New Orleans the shortest and Boston the longest. Additionally, he also included distances from these cities to Pacific Ocean ports like Japan, Shanghai, Australia, and Singapore (see p. 25).
[97] Whitney (1849)

appropriate route for the road and the three of them supported his route choice[98]. Moreover, he also argued the virtues of the route by indicating the advantages in terms of the temperate climate of the route (an important issue for some products like tea and silk)[99].

Fourth, Whitney estimated the railroad's total distance as 2,030 miles. Expected average construction cost per mile to build a "good road" was $20,000, total construction cost $40.6 million, and construction time 10 years[100].

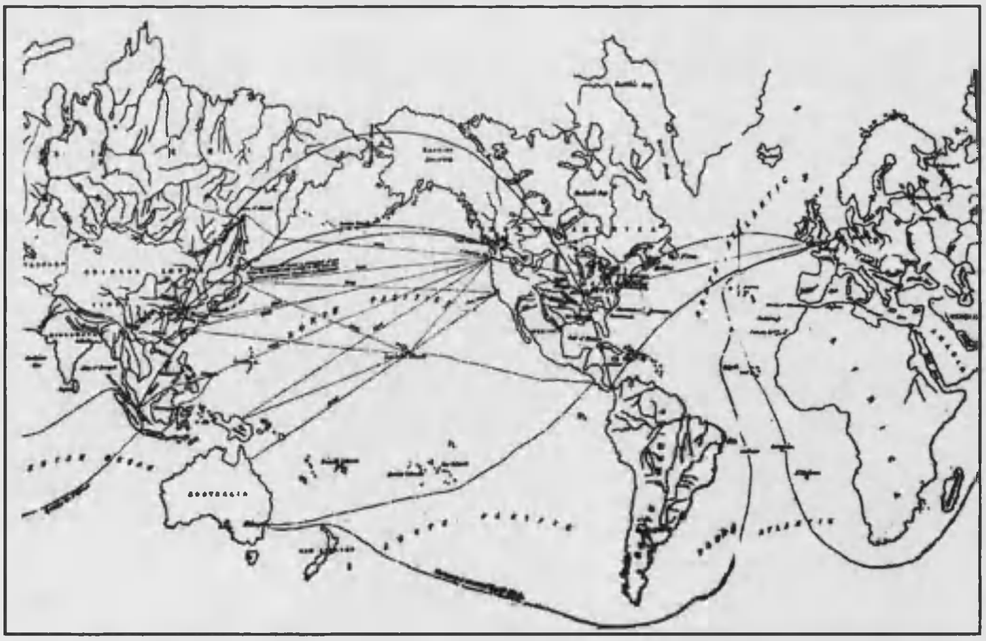
Fifth, the expected business for the road was identified by illustrative examples indicating the effects of the railroad route on transport time and cost savings. Whitney's favourite example (but not the only one) to illustrate the magnitude of transport time and cost reductions due to the railroad route was tea trade. Transporting "Young Hyson teas ... from Shanghae to the terminus on the Pacific, $7 per ton measurement ... thence (via rail) to Lake Michigan, 2,000 miles at 0.5 cents per ton mile, would be for a ton measurement, a half a ton weight, $5; and stopping here, as would all for the consumption of the Mississippi Valley, would be only $12, and $15 less than if by the present route. From the Lake (Michigan) to the Atlantic cities, 1,000 miles at one cent per ton mile, for the half a ton weight $5 more, together $17. For the present voyage around the Cape, $22.5 is but a fair freight, and often much higher"[101]. Note the substantial transport cost reduction implied by this calculation, from $22.5 to $17. A 25% cut for a very light good. Additionally, travel time reductions were also substantial. The road would allow at most two weeks from New York to Puget's Sound and a 25 days steamship trip to Shanghai, compared to the 100 to 160 days just to go around the American continent[102]. Time savings in turn generate insurance and inventory savings[103].

98 Whitney (1849) p. 7.
99 Whitney (1849) p. 17 and 27.
100 Whitney (1848) p. 3.
101 Whitney (1849) p. 37.
102 Own calculations based on data provided by Whitney (1849) p. 25.
103 Whitney (1849) p. 53.

After illustrating the substantial travel time and cost reductions, Asa Whitney moved to identify the magnitude of the traffic to be diverted to the Pacific Railroad route. He insisted the main motivation for the road was that "our continent is placed in the centre of the world; Europe with 250 millions of population, on one side, and all Asia on the other side, with 700 millions of souls … and no part more than 25 days from us; and it will be seen that this proposed road will change the present route for all the vast commerce of all Europe with Asia, bring it across our continent, make it and the world tributary to us, … . It would bind Oregon and the pacific coast to us … It would open the vast markets of Japan, China, Polynesia and all Asia to our agricultural, manufacturing, and all other products"[104]. Note the audacity of the plan. The idea implied diverting Anglo-Chinese trade from the long sea routes around Africa to the overland bridge provided by the proposed railroad. Whitney also provided a map to illustrate the point (see figure 7).

Figure 7.

Whitney's map of potential business for the Pacific Railroad



Source: Whitney (1849) Appendix.

[104] Whitney (1848) p. 7 and Whitney (1849) p. 59.

More precisely, Whitney identified traffic that could be diverted to the Pacific Railroad as traffic "entered and cleared at the ports of England, the United States, France, Antwerp, Bremen, Hamburg, the Netherlands, Russia and China from and to ports beyond the Cape of Good Hope and the Pacific" and calculated a total of about 1.26 million tons were traded on these routes.[105] The main table of the report is reproduced here in Figure 8 to illustrate the nature of the information used by Whitney. The table shows the lion's share of the traffic came from British ships with almost 680,000 tons or 50% of total traffic over these routes, while the United States and the Netherlands each carried slightly more than 210,000 tons per annum or 16% of total traffic. A second main table summarises the value of imports and exports for the same group of countries, with a total value of trade of more than $245 million[106].

Figure 8.

Statement of the number of vessels, amount of tonnage, and crews, which entered and cleared at the ports of the following countries, from and to ports beyond the Cape of Good Hope and the Pacific

No. 5.

STATEMENT OF THE NUMBER OF VESSELS, AMOUNT OF TONNAGE, AND CREWS, WHICH ENTERED AND CLEARED AT THE PORTS OF THE FOLLOWING COUNTRIES, FROM AND TO PORTS BEYOND THE CAPE OF GOOD HOPE AND THE PACIFIC.

		Inward.			Outward.		
		Ships.	Tonnage.	Men.	Ships.	Tonnage.	Men.
England,	1842; particulars, A.	877	329,404	16,896	[illegible]	348,724	18,468
United States,	1845; " B.	329	111,180	6,998	[illegible]	[illegible]	[illegible]
France,	1833; " C.	117	36,040	2,048	117	36,040	2,048
Antwerp,	1839; " D.	7	2,860	125	....	[illegible]	12
Bremen,	1841; " D.	6	1,800	100	1	....	....
Hamburgh,	1841; " D.	10	5,000	200	10	5,000	200
The Netherlands,	1840; " D.	168	97,231	5,150	[illegible]	[illegible]	[illegible]
Russia with China, estimated from the amount of commerce now overland to require	....	50	25,000	1,000	50	25,000	1,000
Total	....	1,584	608,515	32,319	1,589	654,480	35,843

Source: Whitney, A. (1849) Project for the Pacific Railroad. George Wood, New York. p. 69.

---

[105] Note that Whitney focused only on trade diversion and ignored trade creation.
[106] Whitney (1849) p. 71.

Once Whitney identified each of the trades expected to be diverted to the Pacific Railroad, he then proceeded to calculate the distance reduction of the rail route compared to the all sail routes. He calculated distance and time reduction and claimed it would be substantial for each route. For instance, the trip between Canton and London was 13,730 miles during the south-west monsoon season and 15,340 during the north-east monsoon season. The distance via rail was expected to be 11,424 miles. The trip via sail would take between 110-160 days, while using the railroad route it would take 37 days[107]. Whitney argued that international trade demand for the railroad was large as traffic "must" pass through the Pacific Railroad, "because the saving of time, so all important to the merchant, from the long and hazardous voyage around either of the capes, would compel it"[108]. The information was collected from the Treasury Reports on Commerce and Navigation for the United States and from various sources for the other countries, like McCulloch, McGregor's Commercial Tariff and Statistics, Hunt's Merchant Magazine, Waterson's Cyclopedia of Commerce, and Britain's Parliamentary Reports. Whitney presented individual tables for the United States and seven major European countries[109].

Finally, Whitney predicted "after a comparatively short period of years, and at the very lowest possible rate tolls, (the railroad) must earn more than ample for its repairs and expenses"[110]. Whitney promised to set freight rates at 0.5 cents per ton-mile, or equal to maintenance and repair costs, in order to maximise trade diversion from shipping around the two horns and the positive effects of the project in building a United States trade empire. He also approximated observed shipping traffic as 1.3 million tons traffic per year, and since expected distance was 2,030 miles and promised freight rate was 0.5 cents per ton-mile, he calculated expected

[107] Whitney (1849) pp. 58 and 81.
[108] Whitney (1845) p. 4.
[109] Whitney (1849) pp. 69-82.
[110] Whitney (1845), p 3.

earnings close to $13 million[111]. Moreover, Whitney expected earnings to increase rapidly as "in a few years would be built towns, cities, and villages from the lake to the ocean, which would alone support the road"[112]. Furthermore, even assuming the road had to pay dividends (which Whitney thought would deviate the railroad from its empire building mission), he indicated the different pricing policies (between 0.81 to 1.27 cents per ton-mile) that would lead the Pacific Railroad to be profitable enough to pay capital costs and dividends[113].

After presenting the memorial to Congress in 1845, Whitney organised an exploration of the proposed route and, through a letter sent to the Washington National Intelligencer newspaper, invited men from every section in the United States to go with him[114]. Whitney kept several newspapers informed of his exploration and findings, and through them the whole country was informed of Whitney's activities. Even more, Whitney was able to convince the newspapers of the importance of the exploration. When Whitney was not able to arrive to Memphis on time for the opening of the Pacific Railroad Convention in November 1845, the editor of the New York Tribune sent a special correspondent to join Whitney via the Ohio River, as he was perceived to be one of the key players in promoting the railroad project[115]. This campaign has been described as one of the first publicity campaigns in the United States[116]. Whitney's activities in Congress and his publicity campaign led to positive results. By 1850 much of the public and the States directly benefited by Whitney's route (Illinois, Indiana, Michigan, Pennsylvania, New York) and most of the eastern board States supported his plan[117]. The States competing for the eastern terminus of the railroad, Missouri, Arkansas, Texas, Louisiana and Mississippi, did not support the project[118].

---

[111] Whitney (1849) p. 60.
[112] Whitney (1845) p. 4.
[113] Whitney (1849) pp. 36-37. Whitney cited the Railroad Journal 1847 p. 138 as his source for these calculations.
[114] Brown (1933) pp. 212-3 and Loomis (1912-13) p. 171.
[115] Brown (1933) p. 213.
[116] Brown (1933) pp. 209-24.
[117] For declarations of public support see for example American Railroad Journal December 5 1846 p. 781, December 9 1846 p. 809, December 26 1846 p. 825, and January 4 1851. See also Whitney (1849) pp. 98-108 for a compilation of expressions of support. The legislatures of Illinois, Indiana,

In short, Whitney's project provides evidence that he understood the complexity of the project for the Pacific Railroad and performed entrepreneurial activities to promote the project. First, the difficulties imposed by the lack of demand for local transportation were identified. The project clearly identified the need to co-ordinate migration, settlement and construction, a difficulty typical of large transportation projects. Whitney proposed a plan to co-ordinate both transport demand (settlement) and supply (railroad construction) and finance construction of the railroad. Thus, he was aware of the main co-ordination failure behind the strategy of "building ahead of demand" and proposed a solution to the co-ordination failure (whether one judges the solution as feasible or not is a different issue). Second, Whitney performed time consuming and expensive efforts to identify and quantify other non-local sources of demand that were large and did not suffer the co-ordination difficulties (international and United States inter-regional trade) of local traffic. He also performed efforts to investigate how much transport time and cost would be reduced for these sources of demand via the railroad route to determine how advantageous the proposed route would be and what the likely earnings of the railroad would be (a summary of Whitney's proposal is presented in table 1). Third, Whitney estimated roughly the practicability of the route and its construction costs. Fourth, he developed a publicity campaign to demonstrate the advantages and practicability of the road. The evidence indicates that his efforts were successful in demonstrating the likely private and social benefits derived from such a project as a Railroad to the Pacific.

Michigan, Ohio, Pennsylvania, New Jersey, New York, Maine, Vermont, Connecticut, New Hampshire, Maryland, North Carolina, and Georgia resolved to support Whitney's plan (Whitney (1849) pp. 89-98.

[118] Remember that west of the Mississippi river most territories were Federal. California only became a State in 1850.

Table 1.

Summary table of expectations declared by entrepreneurs proposing single stage railroad

	Whitney (early 1840s)		Degrand (year 1849)	McDougall (year 1953)	
	Freight	**Tea example**	**Passenger**	**Freight**	**Passenger**
Source	Whitney (1849) p. 36	Whitney (1849) p. 37	Degrand (1849) pp. 11-2	McDougall (1854) p. 365	
Observed traffic	1.26 mlls tons		150,000 1st class 50,000 2nd class	423,230 tons	110,000
Observed price		$22.5 per ton	$150 1st class $50 2nd class	$30 per ton	$250
Observed earnings			$22.5 mlls 1st class $2.5 mlls 2nd class	$12.7 mlls	$27.5 mlls
Observed time		100-160 days	100 days	150 days	40 days (at least)
Price policy		$17 per ton	$60 1st clas $30 2nd class	$30 per ton	$50
Implied elasticity		0 (time savings advantage)	0	0 (time savings advantage)	0 (time savings advantage)
Expected time		40 days	5 days	10 days	10 days
Expected earnings	$13 mlls a		$9 mlls 1st class $1.5 mlls 2nd class	$12.7 mlls	$5.5 mlls
Expected operation costs	$13 mlls			$9.90 per ton	
Expected profits	$0 (objective is max trade diversion)		Profits > 0	$8.5 mlls	Profits > 0
Expected construction costs	$40.6 mlls		$100 mlls	$100 mlls	
Expected social gains	Yes, insurance and working capital		$14.5 mlls pass fares $53.2 mlls time & food	$4 mlls insurance $4.7 mlls interest $7 mlls non-insured loss	$22 mlls fares $6.6 mlls value of time

a Whitney rounded up $12.6 mlls into $13 mlls.

3.3. Competition to build the Pacific Railroad

The competing projects proposed by American entrepreneurs

Whitney became a victim of his own success in convincing people about the importance and practicability of the railroad to the Pacific. The project was popular and had to be approved by Congress, as it crossed federal territories. However, the several bills drawn by House and Senate transportation committees to promote the railroad did not pass in the final plenary votes in Congress[119]. The reasons were

[119] In 1846 the Committee on public lands considered Whitney's 1846 memorial and brought a bill setting aside the strip of land Whitney had asked for. The bill stated Federal Government had the

varied. At least two need to be highlighted. First, the engineering part of the project was weak. No detailed preliminary survey indicating the key characteristics of the road like grades, curves, tunnels and bridges existed. Also connected to the inexistence of these preliminary surveys, the construction cost estimate was based on a rough average construction cost per mile from eastern railroads, not accounting for the specific difficulties of the route to the Pacific. Second, Whitney was probably too successful in convincing others about the feasibility of the project. As Whitney presented the project and developed his publicity campaign, Whitney not only managed to convince the public and Congress of the advantages of the project. He also convinced potential competitors, as indicated by the refusal to support Whitney's project by the States potentially competing with Praire du Chien for the eastern terminus of the railroad.

Whitney's success in convincing other entrepreneurs of the practicability of construction and the private and social benefits of the Pacific Railroad coincided with some crucial events promoting competition to build the railroad. At the same time as Whitney had been developing his plan for a Railroad to the Pacific, 1845-51, the United States' physical and political landscape was changing drastically. Expansionist policies were developed. An editorial in New York in the mid 1840s suggested it was "manifest destiny" for the United States to dominate the whole North American continent[120]. In 1846 the United States gained direct access to the

---

right over the lands, the project was practicable, and approved the means indicated by Whitney to build the road. The project also remarked the positive effects the project would have on land demand, agriculture, manufacture, mining, internal and international commerce. The House committee on roads and canals also provided favourable support. In the Senate the project was blocked by Senator Benton (Coterill (1919) p. 402). Early 1848, between January and March, Whitney perfected and submitted a second memorial to Congress, finally introduced in March 17th 1848 (Whitney (1849) pp. 55-60). The memorial received favourable reports in both House and Senate. Additionally, public reception to the project was positive, and several newspapers and specialised magazines pronounced positively about Whitney's plan (Coterill (1919) p. 405). However, the memorial was made into a bill that failed to pass through Congress, even after several modifications and on the same year a motion for consideration of the bill in the Senate was lost 27 to 21 (Coterill (1919) pp. 405-6 and Loomis (1912-13) p. 172). In 1850 and 1851 Whitney also submitted another memorial and again his project was defeated, and Senator Benton's opposition was very visible (Haney (1910) p. 50).

[120] Jones (1995) p. 177.

Pacific Ocean as the Oregon question was settled with the British[121]. In 1848 the United States won the war over Mexico. New Mexico and California were ceded to the United States, and the Rio Grande was recognised as the new United States-Mexico boundary (effectively ceding Texas)[122].

In just a couple of years the United States expanded into a massive territory on the Pacific. Puget's Sound was a natural port, and had been included in Whitney's plans. However, California also possessed a natural port in San Francisco's bay, and it became a potential alternative terminus for the Pacific Railroad. San Diego, as the most southern port on the Pacific also became a potential alternative terminus. On the Mississippi, St. Louis, Memphis and New Orleans were also potential eastern termini. The issue of the route was to become a crucial one[123].

The economic landscape of the United States was also changing as much as the physical one. James Marshall and John Sutter discovered gold in Coloma, California, on January 24 1848[124]. Initially they kept the secret, but the news was leaked out in conversations, letters, trips and an application for a mining lease[125]. Soon after, huge migrations joined together into the Gold Rush. Gold was, however, not the only potential of California's lands and as miners arrived others also came to develop non-mining activities[126]. San Francisco was located in a large and protected bay that allowed for large ships to arrive. Sacramento and Stockton, the mining cities, could only be reached by small vessels or wagon. As the Gold Rush was experienced, San Francisco grew rapidly, even faster than Sacramento and Stockton[127]. San Francisco became the largest and fastest growing city in the far west and the mining regions in Sacramento and Stockton propelled it. The west was developing and with it trade between eastern and western United States was rapidly increasing.

---

[121] Jones (1995) p. 182
[122] Jones (1995) p. 187.
[123] Loomis (1912-13) p. 172.
[124] Lotchin (1974) p. 3.
[125] Lotchin (1974) p. 3.
[126] Lotchin (1974) p. 5.
[127] Lotchin (1974) p. 6.

In this new environment Whitney's project became much more plausible and necessary. The territories over which the railroad would be built were all under control of the United States and economic interaction with the Pacific provided rapidly growing transport demand. Communication with California also became a political and security issue. Unfortunately for Whitney, the territorial expansion and more central (rather than northern) development of the west also increased potential for competition, particularly from a more central route.

Several other projects for a Railroad to the Pacific appeared. Essentially all the projects were similar to Whitney's project. The key differences between projects were the form of subsidy requested and the chosen route. The subsidy requested by some projects was a land grant, by other projects a government loan, and by other projects a government guarantee to a bond emission in London and Paris. It is intriguing why entrepreneurs expected profits and still requested subsidies. However, in the documents examined there is no explicit justification for the subsidy given expected profits.

The key difference seems to be the proposed route[128]. Whitney himself identified several of the competing proposals in his 1849 booklet: the Panama Canal route; the railroad route from Memphis or Fort Smith (Arkansas) to Santa Fe, the Gila River and then to San Diego (route 2 in figure 6); the railroad route that starts at Galveston (close to what is today Houston), then goes into Mexican territory, and then to San Diego; and another railroad route started in St Louis, into Missouri, Kansas, and then to the "south pass" of the Oregon Trail, to finish in either Puget's Sound or San Francisco (route 3 in figure 6)[129]. He focused on discussing the advantages and disadvantages of each of the different routes.

[128] Whitney (1849) discussed carefully and extensively the advantages and disadvantages of different routes, but little attention was paid to the form of subsidy.
[129] Whitney (1849) pp. 16-33

The key dimension determining the advantages of the route for merchants was distance. The longer the travel distance the longer the transport time and cost for merchants. Whitney included in the main text of the project detailed calculations of the estimated travel distance and time between Europe and the countries on the Pacific Ocean (Chile, Australia, China) through each of the different routes. These calculations showed how the Panama Canal would not really help to substantially reduce travel distance or time. The Panama Canal route implied going around the tropics, where more distance needs to be covered to go from one longitude to another[130].

Whitney also argued route 2 was longer than his preferred route (see figure 6). The railroad distance between Galveston (Houston) and San Diego, although shorter than the northern route, implied longer connection distances to Atlantic cities, making the full route longer in practice. Additionally, neither Galveston nor San Diego were natural ports comparable to Puget's Sound. Routes 2 and the Galveston-San Diego both also imply crossing longer distances over dessert and with major grades, making construction more difficult and making it impossible to sell the land. And most important, even if it was possible to reach San Diego, starting the route to the Asian ports from San Diego meant travelling 1,200 miles more through the long routes of the equator, and losing the advantages provided by the more northern globe's curvature[131].

Route 3, through St Louis, was less convenient because the prairies without timber are much longer and the rivers much more difficult to traverse (see figure 3.1). Additionally, taking the "south pass" implied taking a less direct route to the Columbia River and a longer distance than Whitney's preferred route. The San Francisco route also had an unfavourable warmer climate, contributing to damage of the vegetable and animal commodities. The great difficulties imposed by the elevations and snow of the Sierra Nevada and a slightly longer distance to Asia

[130] Whitney (1849) pp. 16-23.
[131] Whitney (1849) pp. 23-26.

compared to Puget's Sound's route also played a role[132]. Whitney, thus, felt it was crucial to defend his project's route from competition and devoted almost half of the booklet to this defence.

In the late 1840s and early 1850s several projects appeared and at least three other projects deserve to be mentioned. The first project improves our understanding of the nature of competition to gain control over the Pacific Railroad and how expressions of opposition to a specific project should be interpreted. The other two projects highlight the nature of knowledge about the business case for building a Railway to the Pacific and indicate the potential profitability of the project[133].

The Pacific Railroad and political deadlock

Senator Benton's project illustrates clearly some of the difficulties of using the Congressional debates to improve our understanding of who was opposed to the Pacific Railroad and why. Since 1848, Senator Thomas Benton, democrat for Missouri, proposed and promoted a project for a Railroad to the Pacific from St. Louis to San Francisco following roughly the 38th parallel and crossing the Rockies through the south pass (similar to route 3 in figure 6)[134]. Benton's project is important for two reasons. First, Senator Benton was one of the most aggressive opponents of the Whitney project[135]. Second, the fact that Benton was both opposing a specific railroad route and promoting an alternative route is suggestive of the nature of the conflict for control over the Pacific Railroad. It was not the feasibility or (private or social) convenience of the project that was under

---

[132] Whitney (1849) pp. 26-33.
[133] The progress made in understanding the potential profitability of the project focused on identifying trade costs connected to travel time, as explained below. The advances are advances in the sense that these travel time costs are acknowledged publicly. Whitney (1849) p. 80 had already acknowledged the importance of insurance and working capital costs on the last page of his market research for his plan for a Railroad to the Pacific. However, for some reason, perhaps the fact that Whitney did not want to signal any incentive for exercise of market power, he preferred not to mentions these trade costs in his main texts.
[134] Russel (1948) p. 43.
[135] See Haney (1910) p. 50, Coterill (1919) p. 402.

discussion, but rather the location of the route and the allocation of benefits and costs associated with the project between regions within the United States.

The conflict over the allocation of benefits and costs generated by the Pacific Railroad between regions in the United States may be characterised by several issues. Consider Whitney's northern route. First, note that any transcontinental railroad route would need to cross long lengths of federal territories. Therefore, any project of a Railroad to the Pacific had to be discussed in Congress to acquire, at the very least, the right of way.

Second, direct economic benefits derived from the transport project would accrue to the regions over which the railroad would cross and to Puget Sound and Chicago, as the two key economic centres at both ends of the railroad. Direct economic benefits include profits, wages and derived demand by the railroad itself and the rest of the transport system developed to connect to the railroad, plus the profits, wages and derived demand by merchant activities involved in trading at the cities on the railroad route. The regions experiencing the direct benefits were expected to grow faster. Additionally, the regions between Chicago and the Atlantic seaboard (Boston or New York) would also benefit directly from the project.

Third, the direct cost of building the railroad would be paid by the settlers acquiring the granted land. Land sales in turn would provide the funds to pay for construction of the road. Indirect costs would also be generated. Trade diversion would affect negatively the rich city-ports of the south, particularly New Orleans. Exports and imports of the Midwest to and from Asia and California would take the railroad rather than the route through Mississippi-New Orleans and then sailing ship. Moreover, since New Orleans had recently experienced the consequences of trade diversion as the Erie Canal diverted most Midwest traffic to the Atlantic seaboard from the Mississippi river to the Great Lakes, New Orleans was well aware of the consequences of trade diversion.

Fourth, the direct and indirect economic benefits and costs also had political implications. The expected faster growth of the northern regions crossed by the railroad implied that these territories would rapidly transform from federal territories (without right to vote in Congress) to States (with right to vote), and change the balance of power between east and west and north and south in Congress. Additionally, the project would also imply a shift in resources and political power from regions and groups active in shipping around the Cape Horn to the groups in the northern regions.

Fifth, the imbalance in the geographical distribution of benefits and costs derived from the project also neatly coincided with the growing sectional differences between North and South that eventually led to the Civil War. Any northern route was opposed by southern states. A southern route, in turn, was strongly opposed by the northern states. Moreover, the fact that the project had to be discussed in Congress implied that issues regarding changes in inter-regional distribution of wealth and political power as a consequence of the project became crucial for the project to be accepted by Congress and to continue into the construction stage.

In short, any project for a Railroad to the Pacific had to be discussed in Congress. It would also have been expected to create important changes in the distribution of economic resources and political power between existing states. Therefore it would have faced a very difficult environment in Congress to be approved. Under these circumstances it is easy to understand why the project was consistently experiencing a political deadlock. And it is easy to understand why Benton opposed so fiercely other Pacific Railroad projects and supported so intensively his own one. The political deadlock hypothesis is not a new one and has been supported by many before[136].

[136] For support to the conflict for the economic interest and sectionalism see Putnam's Magazine, Vol. II, July-December 1853, p. 506, Southern Literary Messenger, Vol. XX, September 1854, p. 553, American railroad Journal Saturday July 21 1855, Judah (1857) p. 4, Judah (1859) pp. 5-7, Hinton (1877) p. 38, Hittell (1898) p. 450, Cotterill (1919) p. 412, Haney (1910) Chapter 4, Sabin (1919) p. 21, Russel (1925) p. 192, Russel (1928) p. 350-51, Fogel (1960) p. 22, Griswold (1962) p. 7, Trottman (1966) p. 6-8, Maury Klein (1987) pp. 10-11, Williams (1988) p. 18-19, Bain (1999) pp.

The Pacific Railroad and the value of time

The second project that deserves highlighting is that promoted for the first time in 1849 by P. Degrand (jointly with Robert Fisk and E. H. Derby), who were important China trade merchants and railroad men[137]. Essentially the project proposed to survey a railroad route from St. Louis to San Francisco (similar to route 3 in figure 6). It was expected the survey would indicate the route was practicable and construction costs below $100 million. Once technical feasibility had been established, the project indicated that construction should be funded with private capital through a bond issue in London at 6% interest (essentially the market rate) and guaranteed by the United States government[138]. Thus, the project was to build a railroad for profits and to pay interest on capital to build the road.

Additionally, the project also included information on market research, indicating that the railroad could be expected to be profitable and suggesting a reduction in the cost of travelling for passengers and freight. Most importantly, the project report explicitly accounted for the value of time. The market research compared the cost of travelling between Boston and San Francisco via the sea route to the cost via the proposed railroad route. Passenger traffic was stated to be 150,000 first class passengers and 50,000 second class passengers. Travel time and cost via the sea route was 100 days and $150 for first class and $50 for second class passengers[139]. The expected travel time and cost via rail was 5 days, $60 for first class passengers

43-44, 47-48, 52-53, 67-69, 72-73, and 76-77. Russel (1948) provides a detailed historical presentation of the different specific conflicts arising from the basic issue of conflict regarding the allocation of benefits and costs derived from transportation projects to the Pacific Ocean.

137 The American Railroad Journal published a letter from a reader in St. Louis that argued Degrand and Derby were experienced railroad men and that the Degrand project was favoured by railroad men while the Whitney project was favoured by politicians (American Railroad Journal 1850 p. 787). Johnson and Supple (1967) p. 21 and p. 57 indicate Degrand and Derby were important Boston China trade merchants and railroad entrepreneurs.

138 Degrand (1849) p. 6.

139 Degrand (1849) p. 12.

and $30 for second class passengers[140]. Note the entrepreneurs promised to set rail prices at a level lower than observed sea prices. On top of this, travellers would gain because of the shorter time spent travelling. Entrepreneurs explicitly included in the accounts a value of $5 to $1 per day per passenger attributed to losses and food consumption during the time spent on the trip. The aggregate savings were $10.5 million for passenger fares and $53.2 million for time and food (see summary of Degrand's proposal presented in table 1)[141].

In 1854 senator McDougall of California reported on a project including some interesting market research[142]. The project compared the cost of travelling between San Francisco and the Atlantic ports via the sea route and a proposed rail route. The important issue in this calculation is that entrepreneurs continued highlighting travel costs associated with time. Focusing on freight, Senator McDougall indicated average sea freight rate was $30 per ton for the trip between the Atlantic seaboard and San Francisco. Additionally, merchants had to pay insurance at 4%. The innovative feature in Senator McDougall's market research was to point out that while at sea merchants had to pay working capital interest at 5%. Moreover, losses not covered by insurance are also connected to time and the nature of the trip between the eastern and western United States. "Trade (from New York) is affected by passing through the tropics twice ... flour, pork, beef, sugar, molasses, cotton, and woollens arrive in less quantity or quality to San Francisco. This loss has been averaged ... by merchants at 7% (of the total value of merchandise)"[143].

Senator McDougall continued by computing the profits for the railroad. He started indicating that 423,231 tons total traffic entered San Francisco in 1853 and he estimated the total value of entered merchandise to be $100 million. The aggregate value of freight was $12.7 million and the value of the time connected costs was

[140] Degrand (1849) p. 11. The project approximated the distance between Boston and San Francisco to 3,000 miles and promised to charge 2 cents per passenger mile to first class passengers and 1 cent per passenger mile to second class passengers.
[141] Degrand (1849) pp. 11-3. The entrepreneurs used a higher value of time when using rail than when using sail. Thus, they preferred to underestimate the value of savings.
[142] McDougall (1854) pp. 862-6
[143] McDougall (1854), pp. 865

$16 million. Additionally, Senator McDougall indicated rail operation costs were lower than the sail freight observed in the market (implying positive expected operational profits)[144]. The merchants would not incur any insurance expenses. The time connected travel costs would be reduced as travel time was expected to decline from 5 months to 10 days, the interest on working capital from $5 million to $333,000 and the trip would not involve crossing the tropics at all. Next, McDougall performed an analogous calculation for passenger, mail and gold traffic and concluded that the railroad should be expected to be very profitable, as net earnings would be more than $19 million per year and transport cost savings to the nation more than $48.7 million per year. Finally, he assumed construction costs would be less than $100 million (based on previous experiences in the United States and debates on the Pacific Railroad as illustrated by the American Railroad Journal). Thus, he noted, following his calculations, the nation's savings in travel connected costs would pay for the whole project in just two years (see summary of McDougall's proposal presented in table 1)[145].

The Pacific Railroad and technical uncertainty

The projects by Degrand and McDougall show that entrepreneurs were interested in the business opportunity of transporting trade to and from the Pacific Ocean. They were also rapidly identifying and quantifying the different costs associated with transportation from the eastern United States to the Pacific Ocean via shipping, as a way of developing a sense of the market size for a project such as the Pacific Railroad. The magnitude of resources spent by merchants in trade-related expenses to the Pacific Ocean allowed them to be optimistic about future profits for the railroad and savings for society.

---

[144] McDougall (1854), pp. 865 indicates these operation costs by rail using information drawn from Hunt's Magazine article on reports by the Railroad Times Magazine, the Baltimore and Ohio Railroad, and the Reading railroad.
[145] McDougall (1854), pp. 865

An editorial of the American Railroad Journal in 1853 stated clearly the two main points to be drawn from the description and analysis of the three projects above. First, the editorial questioned "the expediency of having general government directly connect itself with such a work, for the reason that it (the Pacific Railroad) can be built without aid, and having *purely a commercial* character, it should be left entirely to the private enterprise"[146]. Second, the editorial did not only view the intervention of government in a project to build and operate a railroad to the Pacific as unnecessary, but also inconvenient as "its action would undoubtedly create great dissatisfaction in other parts of the country not equally favoured (triggering conflicts of interests between regions)"[147]. The editorial did not address explicitly the way to solve the political conflict, but signalled that it was unfortunate the right of way was in the hands of federal government and a political conflict over the road existed, as they both contributed to delaying such an important project.

Even though the American Railroad Journal indicated the case for a profitable Pacific Railroad was clear, it is fair to say that there was an important piece of information still missing. None of the projects described above contained detailed technical information about grades, curves, tunnels, or bridges.[148] Thus, it was simply impossible to provide a construction cost estimate with reasonable certainty. Moreover, the next two chapters will highlight the fact that a technical description of the railroad was already a standard piece of information in any railroad project by 1850. The lack of technical information represents, in addition to the political deadlock described above, the two main reasons preventing construction of the Pacific Railroad at this time.

[146] American Railroad Journal, Saturday August 27 1853 p. 546. Italics are from the source. It is interesting to note that as with Whitney's project and most other projects for a Railroad to the Pacific, the American Railroad Journal argued strongly that government intervention was unnecessary because the railroad would be profitable (as argued in this quote), and a couple of sentences down in the same editorial it argued that construction could be financed by the sales of land granted by government to the railroad company.
[147] American Railroad Journal, Saturday August 27 1853 p. 546. Italics are from the source.
[148] The closest to a technical survey found while examining these projects is a preliminary and superficial survey of the whole route provided in an annex to Degrand's project. The survey does not provide information about grades, curves, or construction costs.

In 1853 Congress was optimistic about solving both the lack of technical information and the political deadlock. Congress requested the Army to perform a survey of several alternative routes for the Pacific Railroad and set aside $150,000 for that purpose. The results of the survey were published in 1855. These results indicated that some routes were technically feasible but others were not. Additionally, the reports also provided a detailed description of each of the feasible routes. Rough measured average grades for different sections of each of the feasible routes were also included in the report. The shorter, less expensive and technically less challenging route was the one following the 32nd parallel (the most southern route). It was expected to be 1,618 miles long and to cost $69 million[149]. Note the construction cost estimate was higher than the initial estimate provided by Whitney ($40 million), but lower than the prevailing estimate for a central route in the early 1850s (Degrand, McDougall, American Railroad Journal all indicated it was possible to build the road for less than $100 million).

The survey also provided very useful information for the various routes[150]. In 1855, the American Railroad Journal indicated that "government should have built the Pacific Railroad just after California was acquired, but contemptible jealously about routes have prevented the accomplishment of anything. We shall now see who within the men of action and capital will seize upon the greatest opportunity ever offered for gigantic financial and commercial speculation. ... The fact is that the Panama and the Nicaragua routes prove conclusively that the Pacific railway will pay well, if it does not cost much over $100 million, and it can certainly be constructed for that"[151].

Unfortunately, the Journal's editorial prediction proved to be an optimistic one. The Army survey did not provide sufficiently detailed information compared to a standard engineer survey. It was not possible to determine with precision the

---

[149] Davis (1855)

[150] The Army surveys actually set the routes for most of the transcontinental railroads built in the United States.

[151] American Railroad Journal, Saturday July 21 1855 p. 451.

expected cost of a railroad over each of the routes. The survey did not resolve the political nature of the project either and the political struggle continued. Entrepreneurs continued developing further the business case for the Pacific Railroad and discussions in Congress increasingly became more and more polarised. The competition for the allocation of benefits and costs derived from the project was neatly complemented by the increasingly important political differences between the North and South sections in Congress. The national politics of the Pacific Railroad were already very complicated, but these projects were immersed in an even more complicated international context. Another layer of competition to the Pacific Railroad also existed: international competition to build a project to communicate with the Pacific Ocean.

3.4. Competition to profit from transporting trade to and from the Pacific Ocean

The proliferation of projects for a Railroad to the Pacific indicates interest from various different individuals and regions in the profits potentially derived from the construction of the road. Moreover, entrepreneurs were exploring not only a railroad route across the United States to profit from transporting international trade to the Pacific Ocean. Entrepreneurs were also considering other technologies and regions to develop their projects: Clipper ships, canals and railroads across Central America, railroads across Canada and canals and railroads through the Suez Isthmus.

The Clipper ships

The development of the Clipper ships was the first event signalling entrepreneurial interest in transporting trade to the Pacific Ocean faster and charging merchants for the time reductions provided. The 1840s were characterised by several events that created a massive expansion of demand for shipping. The reduction of trade barriers in Asia (Opium wars), the war with Mexico and the consequent American territorial expansion, and the Gold Rushes in California and Australia all contributed to the expansion of transport demand, particularly to and from the Pacific Ocean[152]. In response, the American shipping industry grew rapidly and developed faster ships for communication with the Pacific Ocean. In New York and Boston, experiments to modify the conventional ship design (East-Indiamen and Packet ships) to increase ship speed took place. The result was the development of the Clipper ship[153].

Clipper ships were faster than other sailing ships and competed to reduce passage time for different routes. The Clipper ships also used improvements in knowledge of winds and currents achieved during the late 1840s. Travel time from New York to San Francisco declined from 130-180 days in a normal ship in the late 1840s to a median of 100 days in a Clipper ship during the early 1850s[154].

The speed achieved by the American Clipper ships allowed them to compete successfully with the British merchant marine and gain market share in the Pacific Ocean trade. Speed was their distinctive competitive advantage and the way for these ships to build their reputation, and it was also the key to understanding their pricing of transport services. As each Clipper ship competed with other Clipper ships to set the record passage time for a certain route they also built their reputation. In turn, reputation signalled information about expected travel time reductions to merchants requiring transport services. The Clipper pricing strategy was to charge a premium for expected transport time reductions. For instance, in 1849 the Oriental Clipper ship made very fast passage times from New York to Canton, and back to New York. In 1850 it also made a very fast passage time from New York to Hong Kong, and was then contracted to sail to London fully loaded with tea. The "... Russell and Co. chartered the Oriental at £6 per ton of 40 cubic

---

[152] Evans (1964) p. 33.
[153] Lubbock (1916) pp. 36-102 and Hutchins (1941) pp. 287-96.
[154] Randier (1968) pp. 161-3. The knowledge improvements refer to "Wind and Current Charts" and the "Sailing Directions" developed by the American Navy Lieutenant Maury and providing information on the best passages at different points on the route at different times of the year. For speed of shipping see Berry (1984) p. 117 and p. 119 and Evans (1964) p. 34.

feet, whilst British ships lay waiting for tea at £3 10s per ton of 50 cubic feet"[155]. It arrived in London 97 days later, "causing great excitement in English shipping circles and all kinds of gloomy notices appeared on the papers, predicting the extinction of the British Mercantile marine ... "[156]. Thus, merchants indicated implicitly that (at the very least) 20 days of tea "freshness", insurance and working capital interest savings were worth more than 114% of the alternative transport cost in the London tea market[157].

Evans conducted a more systematic analysis of the Clipper ships business during the 1850s. He concluded that merchants were willing to pay "fancy freights" for fast ships. The Clipper ships frequently charged 77% higher freights than normal ships and the medium sized Clipper ships were very profitable[158]. The importance of the Clipper ship events lies in the fact that they were actually being observed precisely at the same time the different projects for a Railroad to the Pacific were being developed. The Clipper ships provided a clear signal to entrepreneurs that it was possible to derive profits from providing transport time reductions and charging a time savings premium.

Transport across Central America

---

[155] Lubbock (1916) p. 107.

[156] Lubbock (1916) p. 108.

[157] The calculation of the Clipper ship premium over a normal ship freight rate is as follows. A Clipper ship £6 carried 40 cubic feet of tea, thus £0.15 per cubic feet. A normal ship (£3.10=3.5) carried 50 cubic feet, thus £0.07 per cubic feet. The premium is 114% = (0.15/0.07)-1.

[158] Evans (1964) concluded that clipper ships, as a class of ship, were profitable, earning on average 10% per year of the actual value of their capital and reaching even 50% in the best years. The returns were driven by merchants willing to pay fancy freights for fast transport. The impression that Clipper ships were not profitable was driven by anecdotal evidence of a couple of very large Clippers (almost 2,000 tons) that experienced losses. Unger (2000) has suggested that increasing ship size implies a trade-off between scale economies and longer waiting times for departure from a given port. Increasing ship size is associated with scale economies during the trip, as the fixed loading and unloading costs get spread over longer distances. However, longer waiting times to fill the ship discourage merchants, making the process of filling the ship even longer. In addition to relatively high pecuniary returns, at least some of the Clipper ships also reaped non-pecuniary returns derived from prestige for the ship builders and the captains.

The effects of the Mexican war and the Gold Rush were not limited to the development of the Clipper ships. The Pacific Mail Steamship Company and the Panama railroad Company were also created in response to these events. In 1846, during the United States-Mexico war, the United States government reached an agreement with New Granada to build a canal or a railroad through the Panama Isthmus.

Congress authorised the Secretary of War to contract the mail service between the Atlantic ports and Oregon, through the Panama Isthmus. The contract was assigned to William Aspinwall and associates, who organised the Pacific Mail Steamship Company[159]. The contract implied a subsidy. The Pacific Mail initially used steamships to go from New York to Chagres (eastern port of Panama) and from Panama City (western port of Panama) to San Francisco. The Isthmus was crossed via a wagon road. The company began operation just in time to capture the benefits derived from transporting migrants and freight in connection to the Gold Rush. A trip between New York and San Francisco would take at least five weeks.

In 1855 Aspinwall inaugurated a separate company: the Panama Railroad Company. The railroad was built through the Isthmus (to substitute for the wagon road) and reduced travel time of the New York-San Francisco trip by one week[160]. Both the Pacific Mail Steamship Company and the Panama Railroad Company were very profitable by charging high passenger and freight rates. The opening passenger rates ranged between $350 and $200[161].

---

159 Russel (1948) pp. 54-56 and Chandler and Potash (2007) p. 1.

160 Russel (1948) pp. 56-61. Rusell p. 46 mentions that a French company tried to build a railroad through Panama. The American Railroad Journal indicated the British had been performing informal surveys for a railroad through the Isthmus (Thursday January 30 1845 p. 84).

161 Chandler and Potash (2007) p. 10. American Railroad Journal Saturday July 21 1855 p. 451 indicated that both companies were perceived as very profitable. American railroad Journal Saturday September 6 1851 p. 552 indicated that the Pacific Mail Steamship Company also developed strategies to defend its profits from the entry of competition in the form of an alternative canal or railroad through Central America.

The high profit margins implicit in the freight rates charged by the Clipper ships and the Pacific Mail Steamship Company and the Panama Railroad attracted the attention of new entrepreneurs. Cornelius Vanderbilt, the New York entrepreneur, acknowledged the profit opportunity and entered the market. He organised the Accessory Transit Companyto transport to and from California. His route was from New York via steamer to Nicaragua, through Nicaragua via two wagon roads and a ship through Nicaragua Lake, and again onto a steamer to San Francisco. The company began operation in 1851 and competition reduced passenger rates to a $200-$100 range[162]. Vanderbilt also planned to build a canal taking advantage of Lake Nicaragua, but failed to develop it. Finally, another two railroad projects through the Tehuantepec Isthmus in Mexico and through Honduras were launched in the early 1850s[163].

The Suez Canal

The picture of the competition to profit from transporting to and from the Pacific Ocean is certainly not complete without the Canadian transcontinental and the Suez Canal. These two projects turned out to be two important competitors to the American Railroad to the Pacific, as both targeted the market for transportation of international trade to the Pacific Ocean and they were also massive projects.

The Suez Canal re-constructed the ancient canal during the late 1850s and 1860s. The purpose was to reduce travel distance and time from Europe to the Indian and Pacific Oceans. The British had already indicated the potential gains as regular steamer line services between Calcutta and the Suez were developed connecting the Red Sea overland to the Mediterranean. In the 1840s the project across the Suez was characterised by several layers of competition.

---

[162] Russel (1948) p. 76

[163] Russel (1948) chapters 5 and 6.

First, the entrepreneurs intending to build the Suez project were competing, within their home country, with entrepreneurs proposing projects through Central America, and through the Euphrates river exiting in the Persian Gulf. Projects competed to win the favour of their national government, as diplomatic means and influence were indispensable to achieving the right to develop a given project abroad.

Second, the different projects competing to build transportation infrastructure over the Suez Isthmus were each proposing to use different a technology to achieve communication between the Mediterranean and the Red Sea. Some entrepreneurs proposed a sea level canal. Others promoted a long canal with several locks. And still others pressed for a railroad.

Third, British, French and Austrian entrepreneurs with the support of their home countries were competing to build a transport project on the Suez. The entrepreneurs approached the Egyptian government to gain the right to build the project. Ferdinand de Lesseps, an ex-French consul in Cairo, won the diplomatic battle. A concession to build a canal was granted to his company in 1858. The canal was inaugurated in November 1869, just 6 months after the Pacific Railroad. The estimated cost was 230 million francs ($44.2 million) and the final cost was almost double (in large part as a consequence of the diplomatic battles between Britain and France). The majority of resources came from private investors in capital markets. About 40% came from private investors, 15% from private investors in a lottery issue secured by the French government in 1868, and the rest from the Egyptian Emperor government (that in turn collected a substantial share of its funds in the international market)[164].

While American competition was perceived as only indirect in the case of the Suez Canal (via a Central American Canal or the Pacific Railroad), in the case of Canada the issue was perceived more directly. In fact, the development of a plan to build a

[164] Price (n.d.), Lesseps (1857), Fitzgeral (1876) chapter 16, particularly maps, Hallberg (1974) pp. 73-79, 93-136, and 217-19, Marlowe (1964) p. chapters 2 and 3, especially p. 43, Farnie (1969).

railroad across Canada by the British was very much affected by the timing of events in the United States. In 1851, the British discussed a plan for their own Railroad to the Pacific. One of the aims of the railroad was "to retain the most important of our colonies, to keep a pace with the designs of the United States, ... the opening of reciprocal trade with Northeast China and with Japan, ... to extend the broad belt of England in the temperate zone round the world"[165]. Additionally, the plan included the immediate commencement of surveys of the first 400 miles of the route. The influence went further than the perceived source of competition, as the scheme borrowed heavily from Whitney's one[166].

3.5. Conclusions

Several project reports by the entrepreneurs were identified, collected and analysed to determine what entrepreneurs actually expected from the Pacific Railroad. The first project for a Railroad to the Pacific was proposed by Asa Whitney. He performed expensive efforts to develop the project and communicate its importance and practicability. The project was to build a railroad from Lake Michigan to Oregon. The purpose was to transport international trade, particularly Chinese trade. Since the North American continent provided a natural overland bridge between Europe and Asia, the idea was to displace the British in the transportation of Asian trade. Whitney believed that for the railroad to fully divert traffic from the British and promote the development of an American empire it must be priced close to marginal cost. However, he acknowledged the railroad could easily be profitable by charging higher prices. Moreover, Whitney identified the key competitive advantage of the Pacific Railroad as the substantial reduction of transport distance and time when compared to ship routes around the Cape Horn or the Cape of Good

[165] Reported extracts of the proposal in the American Railroad Journal, Saturday January 18 1851, p. 35

[166] Innis (1971) p.68, 102 and chapters 1, 2 and 3. During the 1850s Whitney visited the British parliament promoting his project, but using a route through Canada. Later on the Canadian government also set standards for the Canadian Pacific Railway by imitating those set by the United States government to the Union Pacific Railway Company. The Canadian Pacific Railway took until 1880 to find its way to be built, and when finished it in fact did compete with the American transcontinental for transporting the trade with the Pacific Ocean, particularly for tea.

Hope. During the late 1840s, Whitney developed substantial promotional activities. He presented the project three times to Congress and developed a publicity campaign. By 1850, entrepreneurs, Congress, and the public were seriously considering projects to build a Railroad to the Pacific.

The United States expansion to the west and the California gold rush represented a large positive shock of demand for transportation to and from the Pacific Ocean. Additionally, since after these events the United States actually possessed an exit to the Pacific Ocean, the favourable perception of the project by the public, Congress and the entrepreneurial community was strengthened. However, with increasing legitimacy also came competition. Whitney's chosen route had to compete by the early 1850s with at least four other routes for a Railroad to the Pacific in America and many other projects outside the United States' borders. Different entrepreneurs were identifying and calculating the different costs of travel to and from the Pacific Ocean. The results of these calculations were published in booklets, newspapers, specialised press and Congress debates, and in all of these entrepreneurs were increasingly indicating the potential for profits and social savings.

Moreover, not only railroad projects across the United States were proposed to reach the Pacific Ocean. American shipbuilders developed the Clipper ship. A ship faster than any other existing sail design, the Clipper ships rapidly gained market share from the British in the Chinese trades. And even more interesting, the Clipper ships gained market share even though they charged higher prices – a time savings premium. The distance to the Pacific Ocean from Europe and the Atlantic United States took so long to be covered by ship that merchants were willing to pay higher freights to reduce transport time. The events revealed that savings in insurance and working capital due to travel time reductions could be substantial and signalled clearly to the entrepreneurs where profits may come from. The experience of the Californian trade paralleled the Chinese trade and confirmed the profit signals.

American entrepreneurs also explored and developed projects in Central America to build canals and railroads. British and French entrepreneurs also explored and developed projects in Central America, Canada, and the Suez Isthmus. All of them were targeting the potential profits signalled by the Clipper ships and derived from trade with the Pacific Ocean. And all of them competed with the Pacific Railroad.

The proliferation of projects promoting and competing to build a railroad or a canal to provide communication with the Pacific Ocean indirectly indicates the entrepreneurs' belief in profits. Entrepreneurs had to perform expensive efforts to collect and analyse the relevant information, and then to communicate to others and convince them about the importance and practicability of the railroad.

But if profits were expected, why was the railroad not built during the 1850s? The two main limitations to the development of a Railroad to the Pacific were the lack of detailed technical information about the routes and the political deadlock.

The projects did not describe the route in detail. Whitney, Benton, Degrand, and McDougall had a strong belief that construction and operation of the railroad were practicable. But it was not until the Army surveys that the issue of construction practicability and operation feasibility was addressed in some detail for the first time. The Army surveys identified some routes that were technically feasible and others that were not. However, none of the projects examined above contained a detailed description of the route in terms of grades, curves, number and difficulty of tunnels and bridges. It was simply not possible to develop reasonable construction cost estimates without this information. Additionally, it was not possible either to determine whether it was possible to operate the railroad unless detailed information about grades and curves were available. As the next two chapters illustrate, engineering surveys were already the norm for the development of railroad projects. The lack of this information must have been noted by contemporary entrepreneurs and investors.

Any project for a Pacific Railroad implied crossing federal territories and had to be debated in Congress. Additionally, since the railroad was expected to generate benefits to some regions and costs to others it triggered intense regional conflicts over the allocation of the route (and the associated benefits and costs). The conflict became even more acute as the geography of the railroad very much matched that of slavery. Both southern or northern routes were promoted, but in Congress these were simply politically unfeasible.

The next chapter explains how entrepreneurs in the late 1850s and early 1860s overcame these two limitations and managed to organise construction of the Pacific Railroad. The gold rush in Nevada and Colorado allowed entrepreneurs to divide the project into stages and the technical surveys were performed for the initial stages. Additionally, the Civil War came with secession of the Southern states and facilitated the decision to choose a route to build the Pacific Railroad for the Northern states.

CHAPTER 4. EX-ANTE ENTREPRENEURIAL ACTIVITY AND THE PACIFIC RAILROAD AS A TWO STAGE PROJECT

4.1. Introduction

The previous chapter discussed several projects proposed by entrepreneurs to build a railroad between the Mississippi Valley and the Pacific Ocean. The purpose of these projects was to profit from transporting trade and people between the eastern and western United States. Entrepreneurs declared an expectation that the project would be profitable and identified the two key competitive advantages of the railroad route were reduced travel distance and time.

The technical information provided by entrepreneurs to demonstrate the practicability of a Railroad to the Pacific was initially slim, 1845-1853. In 1853 Congress requested the Army to develop a survey. The information included in the Army surveys was useful as it provided a rough guide to assess the practicability. No contemporary seemed to have doubted the practicability of a least a couple of railroad routes across the United States after the surveys were published. But the survey was not detailed enough to identify the maximum grades and curves of the route, the number and difficulty of bridges, and the number and difficulty of tunnels required. All these were key issues to estimate the expected cost and time of construction. Any project to build a Railroad to the Pacific would have to perform a new and more detailed survey.

At the end of the 1850s two key events occurred. Nevada and Colorado experienced a gold rush. Under these circumstances entrepreneurs realised that an alternative approach could overcome the difficulties of building a Railroad to the Pacific. The railroad now could be built by stages. For instance, the first stage could be to build a railroad from California to the mining camps in Nevada. The second stage could be to build a railroad from the mining camps in Nevada to the Missouri River Valley, where the railroad would connect to the existing railroad network in the eastern United States. Among the several advantages of approaching the project in this way there were two key opportunities. A two stage Pacific Railroad project, whose first stage was to build a railroad from California to the mining camps in Nevada, would transfer the political jurisdiction of the project from the Federal Government and Congress to the State of California (as the mining camps were close to the border of Nevada with California). Additionally, the expenses of a detailed survey to overcome uncertainty about construction costs would also be reduced to a fraction of those of the single stage project (at least initially). Thus, by dividing the project into two stages it was possible to break the deadlock in Congress, generate the necessary information to make an informed investment decision, and make progress in developing the project in a private manner. The one requisite was a local source of demand to make the first stage of the railroad profitable, and this was transport demand derived from mining.

The approach described in the previous paragraph describes the approach followed by the entrepreneurs behind the Central Pacific Railroad Company, one of the two companies that actually built the first transcontinental railroad. Another project also adopted this approach, but proposed to build by stages from east to west. The project was promoted by the entrepreneurs who actually built the Union Pacific Railway Company.

This chapter examines the efforts by entrepreneurs to evaluate the investment opportunity of the Pacific Railroad when considered as a two stage project. The chapter shows the process followed by entrepreneurs when evaluating the investment opportunity and how they framed the investment problem. Additionally, it shows the information collected and the conclusions reached. In short, the chapter discusses how the entrepreneurs formed their expectations. The next section focuses on the project that led to the Central Pacific Railroad. The third section in this chapter focuses on the project that led to the Union Pacific railway. The fourth section focuses on the information the projects provided about construction between the Sierra Nevada and the Rocky Mountains. Finally, conclusions are put forward.

4.2. The Central Pacific Railroad as a two stage project of the Pacific Railroad

The first of these two projects was the Central Pacific Railroad Company. The project was developed by Theodore Judah, who was born in Connecticut in 1828 and, as an adolescent, studied at what is today the Rensselaer Polytechnic Institute. The Institute was well known and a leading education institution for civil engineering, although it is not clear how much civil engineering training Judah received as an adolescent. Theodore's father died before he finished his studies and the family moved to New York City. He soon joined the staff of S. W. Hall, then engineer of the Troy and Schenectady Railroad Company, and began his career. He also worked for the New Haven, Hartford and Springfield Railway, the Connecticut River Railroad - building the bridge over the Vergennes in Vermont, and as a resident engineer of the Erie Canal. He was chief engineer for a railroad down the gorge of the Niagara River to Lewiston, highly regarded as an engineering masterpiece at the time. On May 10 1847 Theodore Judah married Anna Pierce, the daughter of a rich Massachusetts merchant and nephew of Franklin Pierce, a United States Senator[167].

In 1853 Theodore Judah was working on building the Buffalo and New York Railroad when he received a telegram from New York's Governor Seymour asking him to go to New York City. Judah met with the governor and Colonel Charles L. Wilson, who offered him the position of chief engineer in the Sacramento Valley Railroad Company to build a road from Sacramento, along the American river, into the Yuba County, at the foot-hills of the Sierra Nevada. Judah accepted and moved

[167] Hittell (1863) 1st page, Bain (1999) pp. 58-62, Galloway (1950) p. 54, Ambrose (2000) p. 55, Judah (1889) pp. 1-3.

with his wife to California. His dream was to build the great "Continental Railroad to the Pacific"[168].

In 1854 Judah arrived in California via the Nicaragua Lake route. Between 1854 and 1859, Judah built the Sacramento Valley Railroad and participated in several other railroad projects in California[169].

During the second half of the 1850s Judah also explored the Sierra to collect the necessary information to demonstrate the feasibility and cost of building a railroad across it. He used this information to develop plans to build the complete Railroad to the Pacific and went to Washington to promote the project in Congress, sometimes as an individual and sometimes as a representative of the State of California or the Pacific Railroad Convention[170]. After the petitions of the Pacific Railroad Convention were defeated in Washington in early 1860, Judah returned to San Francisco determined to look for private investors to build the railroad. He needed to locate exactly the route to survey[171]. Additionally, in 1859 silver was discovered in Comstock, Nevada, and a new "gold rush" was experienced[172]. Judah received indications of a pass through Dutch flat and leading to Donner Pass. He explored it informally, found it ideal for a railroad to the Nevada silver mines, and wrote a letter of association to organise the Central Pacific Railroad Company[173].

[168] Hittell (1863) 1st and 2nd pages, Ambrose (2000) p. 56, Williams (1988) p. 30; Judah (1889) pp. 3-4.
[169] Hittell (1898) Vol. 4, p. 453.
[170] Judah (1857). In this plan Judah continued the tradition of previous entrepreneurs. Bain (1999) pp. 72-4 and Ambrose (2000) pp. 63-4 indicate that although conflicts between regions on the Pacific coast were visible, while the memorial Theodore Judah introduced to Congress, as a representative of the Pacific Railroad Convention, indicated the chosen route had been the central one, close to San Francisco and Sacramento. He argued further that the main motivation for the railroad was inter-regional trade and development of California and the whole United States, developed a market research exercise (although less detailed than those performed by previous entrepreneurs) indicating the railroad was expected to be profitable, and then suggested a complicated funding mechanism. Finally, and surprisingly, the document requested subsidies from Congress.
[171] On Judah's trips to Washington see Galloway (1941) p. 587, Galloway (1950) p. 57, Ambrose (2000) p. 63-4, Williams (1988) p. 31, Bain (1999) pp. 72-4.
[172] Clay (2003), p. 440.
[173] Bain (1999) p. 81, Judah (1889) pp. 6-7, Galloway (1950) pp. 58-9, Ambrose (2000) p. 67-70, Williams (1988) p. 33.

He returned to Sacramento and published on November 1st 1860 a note entitled "Central Pacific Railroad of California"[174].

In the note Judah indicated the new findings and a plan to build a California stage of the Pacific Railroad. It is important to highlight this change in approach to assessing the investment opportunity as a reaction to the gold rush in Nevada. Rather than continuing promoting the Pacific Railroad as a single stage project, as all the previous entrepreneurs had done, including Judah, it was now possible to argue a profitable railroad could be built to Nevada to transport the mining trade. The railroad to the Nevada mining camps, in turn, could also serve as the first stage of a multistage Pacific Railroad project. Judah decided to take this approach and focused on making the case for the first stage.

The note started by providing details of the route. Additionally, Judah stated the route would follow grades not greater than 250 feet per mile. Moreover, he provided evidence of a railroad operating on the Alleghany Mountains and used it to argue it was perfectly possible to provide a regular and normal service under even more difficult grades and winter circumstances[175].

Judah also proposed the organisation of the Central Pacific Railroad Company. The road was expected to be 115 miles. California law required a minimum subscription of $1,000 per mile of railroad to be built, making the minimum subscription $115,000 and minimum cash payment at a subscription rate of $11,500. Judah indicated the $11,500 should be used to perform a detailed survey of the route. The project had already received bona fida subscription from private investors in Dutch

[174] Judah (1860) p. 1.
[175] Judah indicated that the Virginia railroad was operating on grades of between 250 and 300 feet per mile, that it was stopping and starting even on the higher grades, that it was performing at a speed lower than it was capable of and that snow storms were severe. The railroad in Virginia was successfully providing a regular and normal service, even under these more dramatic circumstances than those proposed for the Central Pacific Railroad. Judah (1860) pp. 7-9.

Flat, Illinoistown, Grass Valley, and Nevada for $46,500; Judah was now looking for private capitalists to participate in subscribing for the remaining $68,500[176].

The document continued, indicating that once the minimum capital required by law was met and the company organised, since the capital market in California was underdeveloped, it was possible to collect the remaining capital through two alternative ways. First, it was possible that discussions in Congress could lead to the allocation of subsidies to the construction of the road[177]. Alternatively, Judah continued, if federal government did not provide subsidies, it was also possible to request aid from Nevada, Placer, and Sacramento counties and the California State[178].

The construction plan was also described. Judah indicated a temporary wagon road should be built first and it would take about 12 months. The wagon road was indispensable as it was necessary to move construction supplies in both directions. Additionally, the wagon road was also key in allowing building from both sides and reducing construction time of the permanent railroad track. Finally, and very importantly, the earnings derived from wagon road traffic to the Washoe, Carson Valley and Salt Lake business (silver mining and settlement in Salt Lake City) would provide resources for construction. Under these circumstances Judah expected to complete grading in 2 to 2.5 years.

Unfortunately Judah did not include an estimate of total construction cost[179]. Judah provided indications on the costs of grading. He also indicated there were "erroneous impressions as to the actual cost of railroads in this (California) State"[180].

---

[176] Judah (1860) pp. 4-5.
[177] Judah (1860) pp. 4-6.
[178] Judah (1860) pp. 11-12.
[179] Judah (1860) pp 9-11.
[180] Judah (1860) p. 11.

Finally, Judah provided some simple estimates of expected earnings. Alternative transport was ox teams and their rates were $120 per ton. Traffic was about 75 tons per day. He expected to reduce transport prices and traffic to double. A simple estimate of expected traffic and earnings per day was presented: 50 tons eastward at $50, 100 tons westward at $25 per ton, and 25 passengers each way at $25, making expected earnings per day equal to $6,250 dollars[181].

Judah held several meetings in San Francisco and had no success in collecting the necessary funds. He then went to Sacramento. It seems that Judah decided to change his strategy to approach the merchants in Sacramento. Rather than requesting them to participate in the construction of a railroad from California to eastern United States, Judah would offer just to build a railroad (or at worst a wagon road) to the Nevada mining regions that they already supplied[182]. He was able to convince a group of merchants of the value of the project. After an introductory meeting, Collis Potter Huntington invited Judah and some other friends to discuss the project above the hardware store he owned in Sacramento. Daniel Strong and Huntington's friends Leland Stanford, Mark Hopkins, Charles Crocker, Cornelius Cole, Lucius Booth, James Baily, Charles Marsh, and James Peel were

[181] Judah (1860) pp. 12-15.

[182] Anna Judah in her biography of Theodore writes: "The wire Mr Judah could pull on these "far-seeing wise men" – was this, it was purely local, "you tradesmen here in Sacramento city, your property and your business is here – help me make the survey, I will make you the company and with the bills passed, you have the control of business which make your fortunes in trades etc etc if nothing more, why, you can own a wagon road if not a railroad" Judah (1889) p. 8. One should be careful to attribute too much weight to a statement from Judah's wife. However, other incidents suggest that she might have been right about the change in strategy and the myopic attitude of the Associates. For instance, the "Dutch Flat swindle" also indicates that at least part of the population had doubts about the intentions of the Associates. The Dutch Flat swindle was a scandal that developed when Judah realised that the Associates had incorporated a different company to manage the wagon road. Judah feared he had been excluded from part of the business and, most importantly, also feared the Associates would not be interested in the railroad but only wanted the wagon road. The information leaked to the press and there was public anger. Additionally, secondary literature has also chosen to accept the view that i) Judah did change his strategy to offer the project between the San Francisco meetings and the Sacramento meetings and ii) the Associates were initially myopic about the great future for the Central Pacific and it was only during the alleged meetings with Vanderbilt after Judah's death or during the last years of constructions that they realised its potential. Thus, although it is not possible to demonstrate that Judah did consciously and explicitly change his strategy to pitch and develop the Railroad to the Pacific, it is fair to say at least it is believed by many that he did change his strategy. See Lewis (1938) pp.20-5, McCague (1964) p. 20, Ambrose (2000) p. 72.

also present. Huntington agreed to give Judah $35,000 to perform a thorough survey of the route[183].

Note that in the document "Central Pacific Railroad of California" Judah indicated that the $11,500 initially collected should be used to perform the technical survey, while in the Sacramento meeting he argued that $35,000 would be needed to perform the survey. The two numbers are not necessarily contradictory. The first one was connected to the funds in cash available by law by subscription date, and simply states that these funds should be put forward for the survey. It does not imply $11,500 was enough to perform the survey. The accounts of the Sacramento meeting indicate Judah referred to $35,000 as the total cost of the preliminary surveys.

Judah organised a team of engineers and performed a survey exploring three routes to cross the Sierra Nevada, all three departing close to Sacramento. The first route was through El Dorado county by way of Georgetown, the second through Illinoistown and the Dutch flat, and the third by way of Nevada and Henner pass. The Dutch flat was likely to be the most practicable as it could reach Donner pass with lower grades. The Sierra could also be descended from Donner pass following the Truckee River and using two ravines south of Lake Donner[184]. Judah spent all spring and summer of 1861 on the Sierra Nevada, and Huntington, Crocker and Stanford at several times joined him to look personally at the route.

On June 28th the Central Pacific Railroad of California Company was incorporated and came into formal existence. By then, the Civil War had started a couple of months before and its conclusion and the consequences for government subsidies to the Pacific Railroad were unpredictable.

[183] Williams (1988) pp. 36-7.
[184] Hittell (1863) 3rd page.

Judah wrote the report on his activities surveying the route and handed it to the board of the Central Pacific Railroad of California on October 1 1861. The report explicitly divided the Pacific Railroad into two stages. The first stage of the railroad connected Sacramento and Virginia City, Nevada. The second stage of the road connected Virginia City to the Missouri River. The report presented very detailed information for the first stage of the project. The information was new and had been collected during the surveys on the Sierra Nevada for the first stage. The report included information for the second stage that was less detailed and based on processing information originally collected during the 1853 Army surveys.

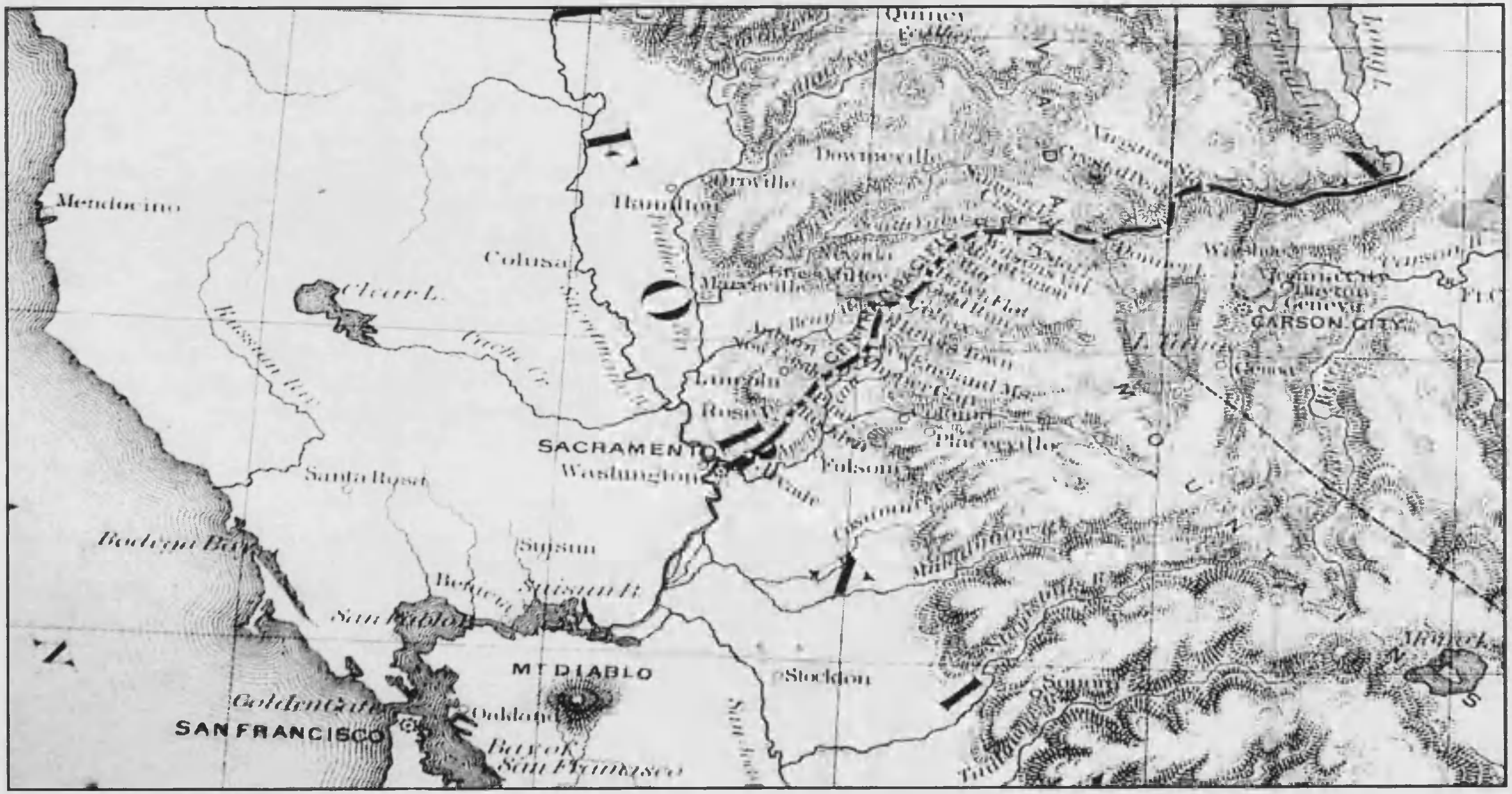
The report presented a detailed geographical description of the most appropriate route surveyed (see figure 9), information on the route's grades, curves, tunnels, and expected costs, and the expected travel time for passenger and freight traffic. It constituted the technical feasibility part of the typical preliminary survey report any eastern railroad company would perform before issuing stock and bonds in the market. Here a brief summary is presented.

Distance and grade: Total distance from Sacramento to the state line was 140 miles[185]. Maximum inclination was a grade of 116 feet per mile for 2.8 miles (see distance and grade chart in figure 10)[186]. Moreover, using data from Lieutenant Beckwith, Judah also inferred it should be possible to continue the railroad from the California state border to Salt Lake City without going over ascents or descents of more than 90 feet per mile[187].

[185] Judah (1861) p. 27.
[186] Judah (1861) pp. 16-18.
[187] Judah (1861) p. 22.

Figure 9

Map of proposed route for first stage of Pacific Railroad



Source: Judah (1862)

Figure 10.

Distance and grade by route stage

Table of grades.

Length of plane, feet.	Grade ascends per mile.	Grade descends per mile.	Length of plane, feet.	Grade ascends per mile.	Grade descends per mile.	Length of plane, feet.	Grade ascends per mile.	Grade descends per mile.
3,000	9	---------	11,000	105	---------	10,500	105	---------
3,000	53	---------	4,000	53	---------	1,000	53	---------
1,000	Level.	---------	6,750	105	---------	500	Level.	---------
3,000	45	---------	18,250	Level.	---------	5,000	79	---------
4,500	Level.	---------	3,000	105	---------	3,000	105	---------
6,500	45	---------	1,000	Level	---------	3,000	79	---------
4,000	36	---------	6,000	36	---------	38,000	105	---------
4,300	53	---------	13,500	Level.	---------	2,000	Level.	---------
6,300	79	---------	17,500	105	---------	1,000	53	---------
3,200	Level.	---------	1,000	Level.	---------	25,000	79	---------
500	53	---------	3,500	105	---------	2,750	26	---------
12,700	84	---------	1,000	Level.	---------	3,500	105	---------
3,300	Level.	---------	3,500	105	---------	2,000	Level.	---------
5,000	84	---------	1,000	53	---------	57,500	105	---------
6,000	65	---------	2,500	105	---------	1,750	53	---------
7,100	84	---------	2,000	Level.	---------	2,600	Level.	---------
1,300	53	---------	13,000	105	---------	13,750	105	Summit.
2,500	105	---------	1,000	Level.	---------	45,000	---------	105
1,800	26	---------	1,000	53	---------	1,750	---------	Level.
4,000	75	---------	4,000	Level.	---------	15,250	---------	105
1,000	53	---------	172,500	105	---------	2,500	---------	Level.
1,000	75	---------	1,250	Level.	---------	6,500	---------	53
1,700	105	---------	1,000	79	---------	3,200	---------	39
2,500	75	---------	1,000	Level.	---------	2,750	---------	Level.
2,000	105	---------	4,000	53	---------	3,500	---------	39
2,000	65	---------	14,000	105	---------	1,000	---------	53
3,000	105	---------	3,000	53	---------	2,000	---------	39
15,000	116	---------	4,000	79	---------	---------	---------	---------

Source: Judah (1862) p. 23

Additionally, Judah showed the grades necessary to complete the Pacific Railroad were within the range of those used by eastern railroads. The Army surveys had used the Pennsylvania Central and the Baltimore-Ohio as the appropriate technical benchmarks for the Pacific Railroad. Judah continued the use of this benchmark. The Pennsylvania Central had a maximum grade of 95 feet per mile for 10 miles, the Baltimore Ohio had 116 for 11.5 miles, and the Virginia Central had 300 for 2 miles. Judah also inferred from the experience of these railroads that it should be possible for locomotives to ascend pulling an ordinary passenger train at 20 miles per hour or a 150 tons freight train at 13 miles per hour[188].

Alignment (maximum curve): The route maximum curve was 573 feet radius and it compared positively to the curves observed on existing railroads. Eastern railroads had 500 feet curves and allowed for safe transit at speeds of 30 miles per hour. Some eastern railroads had even sharper curves, like the Baltimore Ohio that had

[188] Judah (1861) pp. 18-22.

curves of 400 feet and the Virginia Central that had curves of 300 feet and even 237 feet[189].

Tunnels and cuts: The survey identified 18 tunnels with a total length of 17,410 feet on rock, generally granite walls. The expected minimum construction speed was 2 feet per day. The longest tunnel was 1,370 feet and was expected to take more than one year to be completed. The expected average cost per feet of tunnel was $50, giving a total cost of $870,500[190]. Judah also compared the proposed tunnels to other tunnels built previously in France, England, and several tunnels in the United States. He remarked his estimated excavation speed and costs were conservative given these experiences[191].

Travel time: Judah carefully estimated travel speed and time per route stage, depending on grade, and arrived at a total travel time of 8:30 hours for passengers and 13:00 for freight[192].

Construction cost: The logistic strategy was to build a wagon road first and then use the wagon road to transport supplies for construction of the Central Pacific railroad. The wagon road would also generate traffic earnings supporting funding of construction[193]. Estimated construction cost per route stage, depending on grade and tunnels, and including heavier rails, high costs of transportation of supplies from the eastern states to California and high labour costs in California resulted in an average

[189] Judah (1861) pp. 22-23.
[190] Judah (1861) p. 25. Note that a 1,370 feet tunnel excavated at a rate of 2 feet per day would take 685 days to be completed. Judah indicated it would take about 13 months indicating he probably though about excavating from both ends.
[191] Judah (1861) pp. 24-26.
[192] Judah (1861) p. 26.
[193] The strategy also allowed entrepreneurs, once the wagon railroad was built, to consider if they wanted to continue into building the railroad or not. Thus, what had been a single decision was now divided into three parts: i) wagon road, ii) railroad to Virginia Station, and iii) railroad from Virginia Station to Omaha. The Sacramento merchants revealed these decisions were valuable options when they incorporated in 1861 a different company to build the wagon road and secretly excluded Judah from this company (as Judah was very committed to build the whole project).

cost per mile of $88,000 per mile[194]. Also note this construction cost estimate included rolling stock (locomotives, cars, ...)[195]. Judah then compared the average cost of building the Pacific Railroad stage across the Sierra Nevada to the average cost per mile of constructing several eastern roads. The Boston and Providence, the Boston and Lowell, the New York and Erie, and the Hudson River railroads had cost $81,273, $78,636, $80,000 and $80,000 respectively, and Judah argued that given the comparative difficulties of building the Central Pacific Railroad of California, it was not possible to consider $88,000 as expensive.

Next Judah highlighted the proposed route allowed reducing construction cost of the railroad, compared to the cost indicated in the 1855 army surveys. The total construction cost of the route proposed by Judah from Sacramento to state border railroad was $12.4 million, while the cost to Virginia Station (in the Washoe Region) was $13.3. The construction cost estimated by the army surveys for a railroad crossing the Sierra Nevada and connecting California to western Nevada on the central route was $26.8 million. Judah's route allowed saving almost 180 miles and more than 50% construction costs. Additionally, Judah also used Lieutenant Beckwith's information to infer that the total cost to Council Bluffs, next to the Missouri river in Iowa (i.e. the full Pacific Railroad route), was $99.9 million[196].

Business and revenue: Inclusion of business and revenue estimates was deferred until information on the Washoe trade had been collected, and consequently was not included in the 1861 version of the report[197]. In October 22nd 1862 Judah presented the complete version of the preliminary surveys report, including a detailed economic feasibility section. The main body of the document was exactly the same as the 1861 report, but it now also included a section on revenues, a section on the advantages of the 1862 Pacific Railroad Act passed by Congress in June 1862, and

[194] Compared to the Sacramento Valley Railroad survey report, the Central Pacific Railroad of California survey report devotes more attention to the calculation of costs on each stage of the route, depending on the grade and the number of tunnels, than on the details of the inputs.
[195] Judah (1863) p. 18 includes a different dis-aggregation of costs that allows identifying the rolling cost within the total cost.
[196] Judah (1861) pp. 26-29.
[197] Judah (1861) p. 32.

another section on the value of the lands granted in that Act to the Central Pacific Railroad of California Company (see below for the 1862 Act). The information regarding business and revenue included in the 1862 report is presented here, in connection to the 1861 report, as it was declared by Judah to be an integral part of the report and it facilitates the flow of the presentation of the information to the reader. However, since it was also information generated after the subsidies were offered by government, it was analysed very cautiously to identify the effects subsidies may have had on Judah's calculations of expected revenues and costs. Except for expected operation costs, it was possible to adjust all Judah's other estimates directly affected by subsidies and control for any effects subsidies had over his calculations[198].

Judah defined the market for transportation east to Sacramento as composed of several submarkets. First, transport of freight and passenger traffic connected with agricultural and mining activity between the different points on the western slopes of the Sierra Nevada. Second, transport of freight and passenger traffic between the western and eastern slopes of the Sierra Nevada, in particular the Washoe trade. Third, gold and silver from Nevada was express traffic. Fourth, United States inter-regional and international freight and passenger traffic connected to the Asia-Europe and the eastern-western United States trades. Note the fourth submarket was only implicitly considered in Judah's Central Pacific 1861 and 1862 reports. He provided the costs of extending the railroad's first stage (California-Nevada stage) into the full Railroad to the Pacific (California-Missouri River valley), but he did not include the profits derived from this extension[199].

[198] The subsidies were integrated into Judah's earnings and costs calculations by including the wood in the granted land as fuel for the operation of the railroad and as an additional source of revenue. Note this implies underestimating potential revenues, as wood and timber resources from the land grant territories still needed to be transported to be taken to their markets. Since Judah preferred to present the data for this source of revenue as if the Central Pacific Railroad Company of California was only selling the wood and timber, it is not possible to disentangle what part of revenue would come from transporting the wood and timber and what part of revenue would come from exploiting the land grants. Therefore all sources of revenue associated with the land grants have been excluded from the information reported below.
[199] Judah (1862) p. 48.

Judah estimated earnings for the two submarkets he explicitly considered in the following way. First, information on observed transport prices was collected. In fact, the process of exploring the Sierra Nevada provided part of the information on the existing prices for transport over the Sierra Nevada. Engineers had to move themselves and equipment to different places to perform the survey, and used the existing transport infrastructure. Thus, they were familiar with the transport prices over the Sierra. Second, information on observed traffic was collected by performing a traffic survey on one of the existing wagon roads. Observed earnings were then estimated. Third, entrepreneurs promised a price for transportation when the railroad was in operation – a pricing policy. Fourth, an implicit price-elasticity of demand was assumed. Using the pricing policy and the implicit elasticity it was possible to deduce expected traffic, and expected earnings.

Figure 11.

Measured traffic on the Placerville Wagon Road connecting Sacramento and the Washoe region

ACTUAL COUNT OF TRAVEL ON THE PLACERVILLE WAGON ROAD TO WASHOE AND NEVADA TERRITORY FOR EIGHT WEEKS, ENDING OCTOBER 10, 1862.

Number of Stages bound up	169
Number of Stages bound down	171
Number of Buggies bound up	61
Number of Buggies bound down	46
Number of Stage Passengers up	1,287
Number of Stage Passengers down	785
Number of Travelers, other than Stage passengers, up—riders, footmen and in buggies, (including emigrants)	1,288
Number of Travelers, etc., down	2,508
Loose stock, of all kinds, up	573
Loose stock of all kinds, down	434
Number of Teams bound up	4,142
Number of teams bound down	4,464
Number of Animals in teams, up	22,728
Number of Animals in teams, down	22,803
Number of pounds of Freight, up	19,386,200
Number of pounds of Freight, down	——

Teamsters are not included in the above return.

RECAPITULATION.

	For eight weeks.			For one day.		
	Up.	Down.	Total.	Up.	Down.	Total.
No. of Stages	169	171	340	3	3	6
No. of Buggies	61	46	107	1	1	2
No. of Stage Passengers	1,287	785	2,072	23	14	37
No. Travelers, Footmen, and in Buggies	1,287	2,508	3,79[illegible]	23	45	68
No. loose stock, all kinds	573	434	1,00[illegible]	10	8	18
No. of Teams	4,142	4,464	8,60[illegible]	74	80	154
No. of animals in teams.	22,788	22,003	45,591	407	407	814
No. pounds of Freight	19,286,200		20,000,000	346,185		357,000
No. tons of 2,000 lbs	9,683		10,000	173		178

Source: Judah (1862) p. 50

For instance, the second submarket earnings estimate (Sacramento-Washoe trade) was performed as follows. First, observed prices: freight rate was close to $120 per ton, while passengers paid $30. Second, observed traffic: Judah collected directly information on the traffic to Washoe over the Placerville Wagon Road during a period of 8 weeks. Average traffic of passengers was 37 per day and of freight was 178 tons (see figure 11, last column of lower table). Judah then estimated yearly revenues. As he decided to use a conservative 120 tons per day freight traffic estimate, observed revenues were $5.3 million for freight and $405,150 for passenger[200]. Additionally, traffic also had to pay toll charges and these were estimated as close to $700,000[201]. Total transport earnings in 1862 were therefore close to $6.4 million per year derived from the Placerville Wagon Road, just one of four different roads used to reach Washoe[202].

Judah then moved to produce the estimated earnings for the railroad and continued "a reduction in price (freight rate per ton) from $120 (used above) to $40, and saving in time from nine travel days to one day, would give satisfaction to both merchants and consumers, and secure every pound of the Washoe freight over your road"[203]. Applying a similar logic he also reduced passenger rates from $30 to $15. The next step was to derive the effect of transport price reductions on transport demand. He assumed half of the Sacramento-Washoe travellers not using wagon (number of travellers walking and using buggies was 68) would indeed use the railroad if it offered lower transport costs. Additionally, he also assumed passenger and freight traffic from the other three wagon roads to the Washoe would divert to

[200] Judah (1862) p. 51 preferred to use a conservative estimate of freight traffic. Instead of 178 tons per day he used 120.
[201] Judah (1862) p. 51.
[202] Judah also provided separately the expected revenues derived from timber to be exploited from the Central Pacific Railroad of California land grants. Revenues coming from land grants have been excluded from the information presented above. Judah (1862) p. 51.
[203] Judah (1862) p. 53.

the railroad in a magnitude equivalent to 25% of observed traffic for the Placerville Wagon Road. Expected yearly earnings for the Washoe trade were $3.4 million[204].

Judah performed an analogous calculation for the other submarkets he considered (freight and passenger traffic for Sacramento-points on the western slope of the Sierra Nevada and gold and silver express traffic). Summing up revenue from the submarkets Judah analysed in the report (Sacramento-points on the western slope of the Sierra Nevada; Sacramento-Washoe; and express) would give an expected total yearly revenue of $4.2 million for the railroad[205].

Note Judah underestimated expected earnings. First, he promised a substantial transport price reduction that led to a proportionally smaller increase in traffic. It is clear that the railroad did not have to reduce prices by 66% (from $120 to $40) to compete with wagon transport. Rail provided higher safety and speed than wagon. Therefore, Judah promised to reduce transport price more than it was optimal to do so, given the implicit elasticity of demand he had in mind. Second, he also chose not to include toll earnings in his earnings estimate (toll earnings were close to $700,000).

Operating costs: Judah indicated the expenses of operating road, repairs, taxes and others were $1 million[206]. It is likely this figure underestimates true operational costs. Judah included benefits derived from the land grants and indicated that "the cost of fuel (wood and timber), upon the line of your road will be simply the cost of

[204] The information above comes from a table on page 53, in which Judah summarised revenue information, including revenue from wood resources exploited from the land grants, and gave a total of $4.7 million. The information reported above, $3.4 million results after re-calculation of the total by excluding revenues coming from the land grants (wood and lumber sales equal to $432,500) to control for the effects of subsidies in Judah's calculations. Additionally, express and mail, and the local Californian trade were also subtracted to continue with the illustration of the Washoe trade submarket. Also note Judah added 30,000 tons of traffic down from Washoe to Sacramento without providing an explanation. Judah (1862) p. 53.

[205] Judah estimated revenues for $4,654,240, but included $432,500 derived from sales of wood and lumber in the land granted to the railroad. After excluding revenue from wood and lumber, expected earnings were approximately $4.2 million. See Judah (1862) p. 53.

[206] Judah (1862) p. 53.

cutting it"[207]. Since timber and wood were produced in the land granted by government in the 1862 Act (see below), the cost of fuel was actually the cost of cutting the timber and wood from the forest. Unfortunately, Judah did not provide any quantity measure indicating the magnitude of fuel consumption to perform an appropriate adjustment. Therefore, the operation costs without subsidies must be higher than $1 million dollars.

Profit rate: Judah estimated profits based on a rough estimate of construction cost of $13.3 million ($12.4 from Sacramento to state line + $0.9 from state line to Virginia station), $1 million operating costs, and a revenue estimate of $4.2 million. Operational yearly profits were expected to be $3.2 million or 24% of construction costs (see column 1 table 2).

Above it was noted that Judah reduced transport prices more than it was optimal to do so. It is also possible to calculate a simple adjustment to Judah's forecasted business. Estimated earnings on the Placerville Wagon Road were $6.4 million (see above). That is, estimated earnings for the Central Pacific Railroad would be $6.4 million if price was identical to that of wagon roads and assuming full diversion from the wagon road to the railroad. Assuming full diversion is not a strong assumption in this case, as rail transport offers higher safety and speed to passengers and merchants. Replacing Judah's business forecast of $4.2 million with the estimated earnings of the Placerville Wagon Road of $6.4 million in the profit calculation gives profits assuming full trade diversion, and results in $5.4 million profits or 40% of construction costs (column 2 table 2)[208].

[207] Judah (1862) p. 54.

[208] Note Judah reported all market segments' earnings estimates (i.e. passengers, freight, express, Washoe and California) including land grants. However, he did not report a total earnings estimate including revenues from land grants. He probably did not include this estimate as the relevant estimate for the railroad company was the earnings estimate using lower prices to generate trade diversion from the wagon road. Judah only considered the case when substantial reductions in transport costs generate trade diversion and ignored the case when marginal reductions in transport cots do generate trade diversion.

Table 2.

Expected revenue, operating and construction costs, and profit rate for the Central Pacific Railroad Company of California

	(1) Revenues assume substantial transport price reduction	(2) Revenues assume marginal transport price reduction
Revenue	4.2	6.4
Operating costs	1.0	1.0
Net revenue	3.2	5.4
Construction costs	13.3	13.3
Profit rate	24.1%	40.0%

Source: Own calculations based on revenues reported in Judah (1862) p. 53 adjusted to exclude land grants (see text above and footnote 38).

Finally, the report also explained why the information included in the survey allowed the overcoming of objections about the practicability of the railroad. The four most important objections to the project were the Sierra Nevada's elevation, the depth of its river crossings, its characteristic double summit, and the depth of its snow falls. Judah argued that the important issue was not elevation itself, but the grade implied, and indicated that the proposed route implied grades within the range of eastern railroads routes[209]. Additionally, he also acknowledged that river crossings were extremely difficult in the Sierra Nevada as they flow through gorges that are frequently more than 1,000 feet deep, and indicated that the proposed route only required one relatively simple river crossing with a 50 foot long bridge[210]. The route proposed by Judah went through one of the few places on the Sierra Nevada where a single summit was observed[211]. The snow fall patterns were studied by Judah and he concluded that the maximum depth of snow accumulated over winter was 13 feet. It was also possible to keep the road free of snow by starting an engine with snow-ploughs from the summit each way at the commencement of a storm, as the railroad route was a side hill one, and it was easier to remove snow on a side hill route than when the terrain was level. Finally, Judah indicated that the Placerville wagon road going through the Sierra Nevada was open all winter[212].

[209] Judah (1861) p. 3.
[210] Judah (1861) pp. 3-4.
[211] Judah (1861) pp. 5-6.
[212] Judah (1861) pp. 23-24.

Once the 1861 report was finished, Judah went to Washington to search for subsidies from federal government to build the railroad. The election of Abraham Lincoln as President was a good reason to be optimistic about the possibility of subsidies since he had represented several Midwest railroad companies during the 1850s and he had explicitly declared himself a supporter of the Pacific Railroad. The project figured as a main issue in his electoral platform. Secession of the southern States was also a promising sign, as competition to capture the benefits of the Pacific Railroad was dramatically reduced. However, the Civil War had just started, and it was not going well for the Union. Judah actively collaborated with Senator McDougall and Representative Sargent, and in December 1861 Sargent introduced a bill. The House discussed the bill on May 6th 1862 and passed it by 79 to 49. The Senate discussed the bill on June 20th and passed the bill by 35 to 5. On June 24th the Senate amendments were included in the House and on July 1st 1862 the bill, the Pacific Railroad Act, was approved by President Lincoln[213].

Several key features of the Pacific Railroad Act of 1862 may be highlighted[214]. First, the Act also created the Union Pacific Railway Company. The Secretary of the Interior would appoint a Committee of Commissioners who would promote the road and organise the meeting to designate directors of the company. The organisation of the Union Pacific Railway Company would be authorised when a group of entrepreneurs subscribed and paid at least 10% of the first 2,000 shares. The broad route of the Union Pacific followed roughly the one suggest by Judah in his 1861 report. The President of the United States, after evaluating information based on actual surveys, would decide the precise starting location for the Union Pacific Railway Company, and the route would follow the most direct, central and practicable route indicated by the actual survey within the broadly established route.

[213] Hittell (1898) Vol. 4. pp. 459-61.

[214] The following paragraphs describing the 1862 and 1864 Acts draw on Government Printing Office (1897) Acts and Joint Resolutions of Congress and Decisions of the Supreme Court of the United States Relating to the Union Pacific, Central Pacific and Western Pacific Railroads. pp. 1-33.

Second, two kinds of subsidies were provided. The land grants rights and titles, arranged in alternate sections of 1 square mile for 10 miles on each side of the road, would be issued every time 40 miles of road were completed, and a government commissioner had examined and approved their good condition. The land grants rights and titles were initially limited to lands without mineral resources and sold within the period of construction and up to 3 years after construction finished. In addition to the land grants, the railroad companies would also receive 16 bonds of $1,000 dollars of the United States payable in 30 years and bearing 6% per annum interest for every mile of road built. The bonds would be issued to the company after every 40 miles completed and accepted by the government commissioner. Additionally, the issue of these bonds would immediately constitute a first mortgage on the whole line of the railroad, the telegraph, and the rolling stock. Moreover, it was also established that value of bonds issued to the railroad companies would double for construction between the Rocky Mountains and the Sierra Nevada and would treble for construction on the Rocky Mountains and the Sierra Nevada.

The influence of Judah on the Act is clearly observed in at least two facts. The Central Pacific Railroad Company of California was authorised to build the road from San Francisco or Sacramento to the eastern border of the State of California under the conditions established above. The Act indicated the Central Pacific Railroad Company could request permission to continue building into the United States territories following the route established, but permission was not automatic. Note that the Act in fact divided the Pacific Railroad project into two companies[215]. Second, the technical standards for the Pacific Railroad included in the Act were exactly those presented in the preliminary survey of the Central Pacific in 1861. This suggests that the argument initially put forward by the Army engineers and supported by Judah, that the Baltimore and Ohio Railroad was an appropriate technical benchmark for the Pacific Railroad, was a reasonable and convincing one.

[215] In fact, as will be discussed below, the Act actually divided the Pacific Railroad into at least three companies.

The Act was subject to several amendments during the next decade. The July 12th 1862 amendment established the first meeting of commissioners to be held in Chicago on the first Tuesday in September.

On July 2nd 1864, after intense lobbying by the entrepreneurs of the Central Pacific Railroad and the Union Pacific Railway Company, the Pacific Railroad Act of 1862 was amended. Many of the restrictions included in the 1862 Act were lifted and the amount and frequency of subsidies were increased. In particular, land grants were doubled to 20 miles each side of the road, limitations over use and exploitation of coal and iron mineral resources in land grants were lifted, and the issue of land grants and bonds was now to be authorised every 20 miles instead of 40. Additionally, and importantly, the 1864 amendment allowed the two railroad companies to issue their own first mortgage bonds (effectively accepting that government ceded the first right to claim the assets of the companies if the companies defaulted the payments on the government bond loans). The companies' first mortgage bonds sales should not exceed the value of the government bonds issued to each company. This was an important change in the Act because it opened the door for the two companies to fund privately in the capital markets. Investors would feel more at ease buying bonds that, if defaulted, had the first right to claim the assets of the company. On March 3rd 1865 the Act was amended again and another restriction was lifted. First mortgage bonds sales in advance of up to 100 miles of construction were now allowed, relaxing the financing of the venture.

On July 3rd 1866, the Central Pacific Railroad Company received authorisation to continue building to the east until meeting the Union Pacific Railway Company. The amendment implied that both companies were in fact competing to build the longest route and capture the largest share of subsidies and traffic revenues.

The Act was amended about 11 other times between 1864 and 1870. Generally, the modifications were small changes in rules to allow the companies to work more freely, and included changes like extensions of time to hand in documents or to finish road parts.

4.3. The Mississippi and Missouri Railroad as a two stage project of the Pacific Railroad

The first transcontinental railroad was built by two companies: the Central Pacific Railroad Company and the Union Pacific Railway Company. The story of the Central Pacific Railroad was presented above. In this section the story of the Union Pacific Railway Company is discussed. The antecedents to the creation of the Union Pacific Railway Company have been less well documented as the company was actually created in Congress. However, most of the key people involved in its subscription, management and construction had all been working together in the construction and extension of the Mississippi and Missouri Railroad Company. In particular, the engineers behind the Mississippi and Missouri Railroad provided the first two surveys for the Union Pacific Railway. The first survey was performed by Grenville Dodge during the 1850s, before the Pacific Railroad Act had created the Union Pacific Railway and granted subsidies. The second survey was performed by Peter Dey in 1862 before Thomas Durant organised subscription for the Union Pacific Railway Company in 1863.

Peter Dey was born in 1825 in New York. He studied maths and law before starting to work at the New York and Erie railroad as a resident engineer. Next he worked on the Erie Canal enlargement. In 1850 he moved west to build the Michigan Southern Railroad, where he met Henry Farnam. In 1852 the Michigan Southern was completed, the first railroad into Chicago from the east. Farnam then created the Chicago and Rock Island to go west from Chicago to the Mississippi River, at Davenport. The Chicago and Rock Island reached the Mississippi in 1854 and built the first bridge to cross the river. In short, Farnam and Dey had been building the railroad network to west, following the westward expansion of agriculture to the Midwest.

A brief note is important at this stage. Farnam and Dey were the archetypal entrepreneurs building the Midwest railroads that Fishlow studied. The entrepreneurs built a sequence of railroads connecting the east seaboard to the Chicago and the Illinois western border. The Erie and Lake Shore were already built, and then Farnam and Dey continued the network expansion west by building the Michigan Southern, and then the Chicago Rock Island. Recall Fishlow's conclusion: railroads were built sequentially from east to west, and following demand – as opposed to ahead of demand. And it is precisely this building strategy (after demand) that they tried to implement after reaching Illinois and planning to continue into Missouri. The next paragraphs explain how the strategy led to the development of an informal project to continue building to the Pacific Ocean, and build the Pacific Railroad by stages, from east to west.

It was during the construction of the Chicago and Rock Island that the four key figures promoting a Railroad to the Pacific from the east met. Grenville Dodge was contracted as assistant engineer for Peter Dey[216]. Additionally, Farnam partnered with Thomas Durant to organise the construction company that actually built the Chicago and Rock Island. And it was during this period that the plan became more explicit: continue building west into the Rockies and beyond, and develop the Railroad to the Pacific. In 1853 Farnam and Durant organised the Mississippi and Missouri Railroad to cross Iowa, from the Mississippi to the Missouri Rivers, and then continue to the west. John Dix was named president, Dey chief engineer, and Dodge engineer[217]. Recall at precisely the same time the popularity of the projects to build a Railroad to the Pacific was at its pinnacle, and the Army was starting its own explorations.

[216] Grenville Dodge was born on 1831 in Massachusetts. He was 14 when he first worked in the construction of a railroad. He then went to Norwich University in Vermont to become and engineer, and then joined the Chicago and Rock Island Railroad. Peter Dey recognised the young engineer's talent and they began a long friendship.

[217] Johnson (1939) chapters 1-8.

Durant asked Dey to complete the Iowa surveys and Dodge to survey to the west of Iowa, through the Platte River and the Rockies. Construction of the Mississippi and Missouri in Iowa moved very slowly. Cash faltered. The conflicts between the members of the board were intense as each one speculated with land purchases in different parts of the State and wanted the route of the railroad to go through towns nearby. Obviously, no single route could please all of the board members. And the 1857 panic severely constrained funding for the road. In 1858 Dodge wrote a report and handed it to Thomas Durant and Henry Farnam. Unfortunately, the only evidence connected to this survey that seems to have survived is contemporary letters and the minutes of a meeting in New York. The letters and minutes suggest both Durant and Farnam were attempting to collect capital in the east to continue building over Iowa, into Nebraska, and then further west following Dodge's survey. Although the Mississippi and Missouri Railroad did not progress rapidly, the partnership between Thomas Durant, Henry Farnam, Peter Dey and Grenville Dodge continued. Grenville Dodge also strived in politics and became influential within the Union Army during the first years of the Civil War[218].

The Mississippi and Missouri Railroad was not the only project building a railroad planning to continue west into the Rocky Mountains. Competition from at least two other projects existed during the 1850s. The Lyons Iowa Central had similar plans using a more southern route in Iowa, while the Pacific Railroad of Missouri planned to use a route though the state of Missouri. The three companies had engineers of reputation, performed surveys and approached counties and towns to acquire the right of way. But the fate of all three companies was sealed by the 1857 financial panic and construction faded away[219].

[218] Ambrose (2000) pp. 31-39 and 88-92, Williams (1988) pp. 49-56, Bain (1999) pp. 152-4, Klein (1987) pp. 18-21.

[219] American Railroad Journal, Saturday February 16 1850 p. 103 and Saturday February 23 1850 p. 120, American Railroad Journal, Saturday May 18 1850 p. 313, Saturday September 21 1850 p. 593, Saturday August 23 1851 p. 538, Saturday September 6 1851 p. 552, and Russel (1948) chapter 9 and 10. Some contemporaries disputed whether the Pacific Railroad of Missouri really planned to build the Pacific Railroad. A subscriber to the American Railroad Journal wrote a letter to Henry V. Poor, editor of the Journal, on Saturday 21st September 1850. In this letter he intended to clarify several issues regarding some information previously published by the Journal in several notes about the Pacific Railroad of Missouri. One of the issues was the ambition of the company, and the

The early and mid 1850s had seen railroad companies building west. The companies intended to build the Pacific Railroad by stages, from east to west. The first stage was characterised by competition to develop first mover advantages and anchor the location of the eastern terminus of the Pacific Railroad. In turn, the companies expected the terminus would provide informal priority rights to continue building the next stages of the Pacific Railroad and access land grants. However, the intensity of the railroad construction was tempered and faded away during the late 1850s. Railroad building in general was growing only slowly in the United States and the 1857 panic did not help. The early 1860s were to bring even worse conditions for the western expansion of these railroads as the Civil War broke.

Intense competition to build into the Rocky Mountains returned as a consequence of the Pacific Railroad Act of 1862 and the creation of the Union Pacific Railway Company. Recall government commissioners were in charge of the Union Pacific Railway until 10% of the value of the first 2,000 shares subscribed had been paid. At least two groups were interested in the Union Pacific Railway Company. One group was led by John Fremont, the military officer and explorer. He bought a controlling share in the Leavenworth, Pawnee and Western Railroad. The Leavenworth had received the right to connect to the Pacific Railroad of Missouri and continue west through Kansas. If it reached the 100th meridian before the Union Pacific Railway Company was organised, the Leavenworth was eligible to develop the Pacific Railroad Unfortunately, for Fremont, the Union Pacific was organised. The Leavenworth was built and bought by the Union Pacific during the late 1870s and became the Union Pacific Kansas branch[220].

---

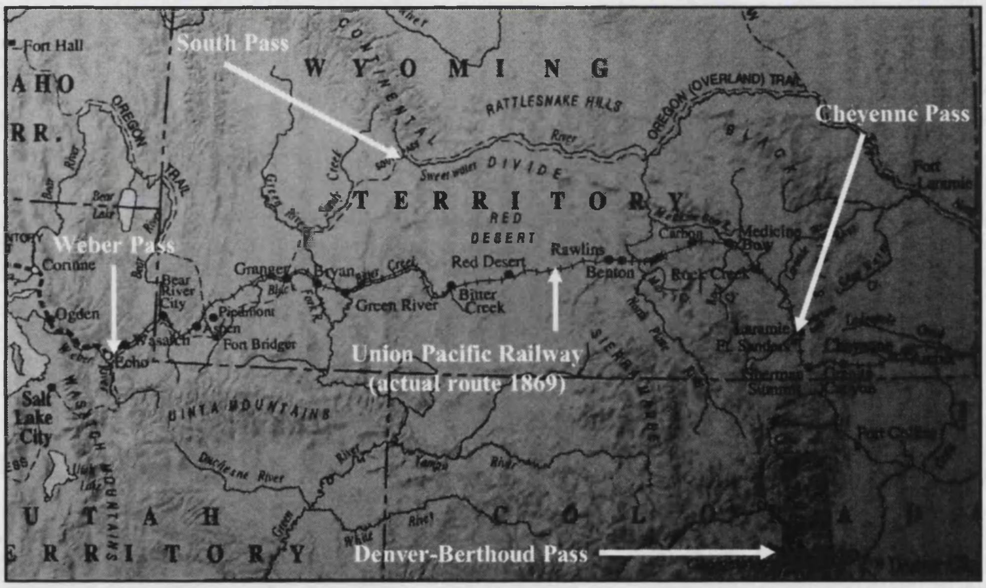
subscriber indicated that these ambitions were more modest than described by the Journal's reports. The subscriber argued it was only a Missouri State railroad. However, since it is not possible to establish the ulterior intentions of the report or the position of the subscriber regarding the railroad, it may be fair to give the benefit of the doubt to the initial reports in the American Railroad Journal (see Saturday September 6 1851 p. 552).

[220] Williams (1988) p. 69 and Bain (1999) pp. 161-2.

Thomas Durant led the second group and had his own plans for the Union Pacific Railway Company. In September 1862 Thomas Durant and Henry Farnam sent Peter Dey to explore the Pacific Railroad route. His report described three possible routes. The first part of any of the three routes followed the Platte River Valley and no major obstacle to construction of a railroad existed up to the base of the Rocky Mountains. The maximum grade was 64 feet per mile and 11 bridges were required[221].

Figure 12.

Map of the possible crossing for the Union Pacific Railway over the Rocky Mountains and the Wasatch Mountains



Source: Bain (1999) p. 477.

On the Rockies he explored three crossings: through Cheyenne Pass (where the Rocky Mountains turn into the Black Hills), Cache la Poudre-South Pass-Laramie (following roughly the Oregon trail), and Berthoud Pass (close to Denver) (see figure 12). He found the Berthoud crossing impracticable and favoured the Cheyenne Pass over the South Pass. The grade on the ascent to the Rocky Mountains was 105 feet per mile for the Cheyenne Pass route. The estimated

[221] Durant (1864) Apeendix No. 1, pp. 1-2. Appendix 1(a) pp. 2-3.

construction cost of crossing the Rockies through Cheyenne was estimated as $3.5 million. The Cache la Poudre-South Pass-Laramie route experienced higher grades on the ascent, comparatively lighter grades on the descent, and was longer. Overall Dey calculated the effects of the higher ascending grades and the longer distance of the route would imply doubling construction costs. The road to Denver was impracticable. The ascending grades were more than 110 feet per mile and would require a tunnel about 3.5 miles long excavating mostly granite walls. The descent from the Rockies to the west was not surveyed, but information collected from the constructors of the wagon roads in the regions indicated it was even more difficult than the ascent[222].

After discussing the most appropriate route over the Rocky Mountains, the rest of the route is described next. The major natural obstacle to overcome was the Wasatch Mountains. However, Dey identified a simple crossing through Bridger Pass, into the Weber River Canyon and leading to Salt Lake City (see figure 12)[223]. The maximum grade was 70 feet per mile and the cost of the crossing was $1.5 million. The route passed at several stages next to abundant sources of wood, an important input for construction. The total distance of the route was estimated as less than 900 miles between Omaha and Salt Lake City[224]. Essentially the route identified by Dey, through Cheyenne Pass, was the route actually built by the Union Pacific[225]. Finally, and important, Dey predicted the road would cost less "than its

[222] Durant (1864) Appendix No. 1, pp. 2-5. Appendix 1 (b) pp. ii, vi-vii.
[223] Actually, two passes were identified. The Weber Canyon and the Timpanagos River were both equally convenient.
[224] Durant (1864) Appendix No. 1, pp. 5-6.
[225] The precise location of the route actually followed by the Union Pacific and the names connected to its key geographical obstacles has generated some overlooked confusion. Fogel (1960) argued that the finding of Evans Pass was the key to finally overcoming any uncertainty over the rail route as it provided an easy grade through the Black Hills (p. 86-7). Klein (1987) argued that the route on which Evans Pass was located was different than the Cheyenne Pass route, on which the railroad was actually built (see p. 62). Bain (1999) indicates that the route follows both Cheyenne Pass and Sherman Summit, and clearly distinguishes the two as two different locations (see p. 477). Ambrose (2000) argued that Lone Tree Pass, Evans Pass, Sherman Pass and Sherman Summit were all different names to Cheyenne Pass (p. 128). Additionally, Ambrose also presents a map in which the rail route takes a slightly southern detour to descend on the western slope of the Black Hills/Laramie Mountains, avoiding Cheyenne Pass/Sherman Pass (see p. 251). It is out of the scope of this thesis to clarify this confusion (actually pointing it out is in itself a contribution as all the previous authors do not seem to have realised the different contradictions here indicated). It is sufficient to argue that

most sanguine friends anticipate" and that with extended surveys the grades may be reduced further.[226]

The survey of existing sources for local traffic identified Salt Lake City trade and the mining of gold in Denver, iron in the Medicine Bow Mountains and the Platte River and coal in the Green River. Additionally, a geological survey indicated two other large and very good quality coal mines were along the route.

The major source of local demand was undoubtedly gold in Denver. The Union Pacific entrepreneurs were posed an important question. The technically most practicable route passed about 100 miles from Denver, but the largest source of local business was in Denver, where the route was impracticable[227]. Dey indicated that a detailed technical and market survey may provide information to assess more carefully the difficulty of the Berthoud Pass, its implications over construction cost and the size of the Denver business. However, he expressed little optimism about the practicability of the road. Instead, Dey preferred to offer optimistic expectations about alternative sources of business on the practicable route (over Cheyenne Pass). First, the miners in Denver expected the main mining region to shift north and closer to the technically practicable routes. Second, Dey expected fast settlement of the Platte River Valley, possibly based on his experience building the Midwest railroads – recall he built the railroads that Fishlow described as built after demand through anticipatory settlement. Third, Dey pointed out even if the railroad did not reach Denver, it would carry most of the traffic to and from Denver, together with the California, Salt Lake City and Salmon River (the gold rush in Idaho) trades. He concluded "the cost of the road will be less and the business far greater than its most sanguine friends anticipate"[228].

---

the route over which the Union Pacific Railway was originally built in 1869 was originally roughly located by Peter Dey in 1862, then accurately located in September 1865 by Grenville Dodge, and finally quantitatively measured by Grenville Dodge in his 1866 surveys (see Dodge (1867)).

[226] Durant (1864) appendix 1, p. 8 and appendix 1A p. 4.

[227] Durant (1864) Appendix 1, pp. 6-7.

[228] Durant (1864) Appendix 1, pp. 6-8.

Peter Dey's preliminary survey was comparable to that provided by Judah in 1860. The approximate grades of the most difficult parts of the road, crossing the Rockies and the Wasatch, did allow the estimation of construction costs for these two sections of the road. But the detailed tables of grades and curvatures had not been developed yet. The information indicated clearly that business was large, but the detailed market survey had not been performed yet, and only impressions of the magnitude of the existing local traffic existed.

In 1863, after receiving Peter Dey's report, Thomas Durant sold several of his assets and invested more than $200,000 to buy the 10% subscription of 2,000 shares required to organise the Union Pacific Railway Company[229]. A stockholder meeting was called in October 29th and John Dix was named president of the company, Thomas Durant vice-president and general manager, and John Cisco treasurer, among others. Initially, Farnam also participated in the venture, but he retired early. Peter Dey was named chief engineer, until he resigned in December 1864. Grenville Dodge was named chief engineer in 1866, after he finished his duties with the Union Army[230].

In October 1863, when the stockholder's meeting was held, the route was still to be decided. In particular, two issues were critical. First, the eastern terminus and the route from the eastern terminus into the Platte river valley had not been chosen. Second, it was not definitive from the information provided by Dey's report that the railroad should opt to bypass Denver.

The choice of eastern terminus and the route between it and the Platte river valley has been characterised by the secondary literature as more of an event driven by economic and political conflict of interests than technical difficulty. Omaha, De Soto (to the North of Omaha) and Bellevue (to the south of Omaha) competed for the eastern terminus. Obviously, the cities were very interested in the eastern

[229] Bain (1999) p. 155. Durant bought the shares using the names of friends, as the Pacific Railroad Act had strick limits on how much could be owned by each individual.
[230] Klein (1987) chapter 2, Bain (1999) chapter 14, and Ambrose (2000) chapter 6.

terminus of such a railroad, and Durant seems to have used this interest to promote competition to his benefit. Additionally, Durant still had interests in several railroads in Iowa and allegedly planned to connect one of these railroads to the Union Pacific. The question was which one and to which of the three cities. Dodge and Lincoln, although not part of the Union Pacific Railway Company, were influential within the company affairs and had their interests close to Omaha. The conflict of interests was never completely resolved. Durant built a line that started at Omaha, then headed south and then north towards the Platte river valley. Bellevue or De Soto were not directly connected. Some rail track was left built but unconnected, the track that was built was made much longer to reap more subsidies, and, although it was out of the legally established route, it was accepted by the government commissioners. In 1908 the main line of the Union Pacific line was rectified to follow a straight line, pretty much following Dey and Dodge's initial surveys[231]. In practice, the choice of the route to the eastern terminus was made in such a way as to reap large subsidies and low land prices for the Union Pacific sites.

The second choice, the crossing over the Rockies, was underlined by technical issues and the influence of economic forces on the main line. The crossing over the Rocky Mountains was clearly a technical issue. The crossing was to use the landscape provided by nature, tunnels and bridges to find a route with characteristics allowing construction and operation of a railroad (as specified by the Pacific Railroad Act). However, as explained above, the crossing of the Rocky Mountains was also an economic issue. The 1859 Pike's Peak gold rush led to the foundation and development of Denver, Colorado. An important source of local earnings for the railroad should not be simply bypassed. Additionally, Denver was growing and pressing to get connected to the Pacific Railroad.

The three courses crossing the Rocky Mountains explored by Peter Dey in 1862 were still being considered in the mid 1860s. Early in 1864 Peter Dey organised

[231] See below on other projects for how competition from Freemont's Leavenworth, Pawnee and Western Railroad pressed Durant. Williams (1988) p. 70-71, McCague (1964) 62-67, Bain (1999) pp. 155-64, Griswold (1962) pp. 42-51, Klein (1987) pp. 22-33.

engineering parties to explore the three routes and the territories between Salt Lake City and the Rocky Mountains. Dey resigned in December 1864. In late December 1864 and January 1865 the engineering reports of the exploration parties were submitted to Thomas Durant. The report for the first route, Cheyenne Pass, presented the tables of grades, curves, the materials and quantities to be excavated to build tunnels, and the number of bridges on the route. Additionally, it indicated the route could be performed under the grade limits provided by the Pacific Railroad Act (i.e. 116 feet per mile) by tunnelling Cheyenne Pass, and that timber and coal were abundant along the route. The only difficulty was descending from Cheyenne Pass, as it had not been possible to find a route with acceptable grades yet. The report on the Denver route was much less positive and indicated the great difficulties of building a railroad to cross the Rockies through this region. The third report indicated a crossing for the Wasatch Mountains via Weber River Canyon was practicable and well within the government specifications. Durant's interpretation of the reports indicated that certainly it was possible to build a railroad within the Government's specifications, but more information was required to locate the appropriate route through the Rocky Mountains[232].

In 1865 the engineering parties continued exploring the region. The difficulty of the Denver route was confirmed. Not only was the route a difficult one to build ascending from the Platte River to Denver, but it was also difficult ascending from Salt Lake City to Denver. Additionally, the reports indicated that from Salt Lake City to 300 miles to the west the road had no obstacles. An alternative and promising pass through the Rockies was also reported, via Antelope and Evans Passes[233].

The key finding was made, however, by Grenville Dodge who in September 1865 was campaigning against the Indians and found a way to descend from Cheyenne

[232] See Durant (1865) p. 7-8 and appendices A, B, and C, especially p. 14 in appendix A. Also see Klein (1987) chapter 4 especially p. 54-6, Bain (1999) chapter 15 especially pp. 91-92, and Ambrose (2000) chapter 6.
[233] See Durant (1866) including appendices B and C. Also see Klein (1987) chapter 4 especially p. 62-64, Bain (1999) chapter 17 especially pp. 231-233 and Ambrose (2000) chapter 6.

Pass to the plains within the grades established by government. On November 1866 Dodge, now chief engineer of the Union Pacific Railway, submitted a report on his own personal surveys during 1866. He compared the route through Denver to that through Cheyenne Pass. The conclusion was that no line through Denver (or any other pass) could "compare in cost, grades, distance, direction, and obstructions from snow with any of the lines crossing the Black Hills range of the Rocky Mountains"[234]. Doge predicted the Cheyenne Pass route was 30% to 50% cheaper than any other alternative route.[235] Dodge suggested Denver could be connected to the main Union Pacific Railway line via a branch.

The route identified by Dodge followed that initially identified by Dey except on the rapid and short descent of the Rockies. It also confirmed Dey's predictions regarding grades and construction costs. The route was expected to experience maximum grades of 90 feet per mile on the crossing of the Rocky Mountains and 40 on the approach the pass. Average cost per mile was expected to be between one third and one half lower than any other alternative route or existing predicted cost.[236] Surveying had thus allowed the Union Pacific entrepreneurs to improve the location of the route such that grades and construction costs were dramatically reduced, as initially expected.

The board of the Union Pacific discussed the report and made the decision to build the main line through Cheyenne pass and a branch to Denver. The route had been finally established and accepted by all those interested[237].

The surveys on the Union Pacific indicate that from the beginning the route had been identified. The best possible crossing was through Cheyenne Pass. The other crossings were technically more complicated and implied breaking the technical

234 Dodge (1867) p. 6.
235 Dodge (1867) p. 12, p. 13, p. 17, p. 21.
236 Dodge (1867) p. 12, 13, 17 and 21.
237 See Durant (1866) including appendices B and C. Also see Klein (1987) chapter 4 especially p. 62-64, Bain (1999) chapter 17 especially pp. 231-233 and Ambrose (2000) chapter 6. Fogel (1960) pp.117-119 a similar story with similar dates using government sources .

standards set by the Pacific Railroad Act and higher construction costs. However, Denver, the main source of local traffic was on a different crossing of the Rockies, about 100 miles south. The difficult decision to bypass Denver and build a branch railroad to connect it took the best of four years to be made. Most probably, it was lack of authority from the engineer within the company rather than lack of information that led to such a delay.

4.4. The second stage of the Pacific Railroad: the connection of the Central Pacific Railroad and the Union Pacific Railway and through traffic expectations

The second section of this chapter showed how the Central Pacific Railroad had developed a detailed technical survey for the first and critical stage of the route before organisation of the company in 1862[238]. In 1862 it completed a detailed market research detailing expected business[239]. The company then completed the detailed surveys for the rest of the route in the next years and updated its local business forecasts[240]. In 1865 the company was already transporting local traffic and the audacious extension of the Central Pacific line to the Great Salt Lake was performed[241].

The third section of this chapter showed that the Union Pacific Railway had taken substantial time to settle the route. The delay was mostly the consequence of a difficult decision. The main source of local traffic existing by 1862 was Denver, but it was 100 miles south of the most practicable route. The entrepreneurs took four years searching unsuccessfully for a route to cross the Rocky Mountains close to

[238] Judah (1861)
[239] Judah (1862)
[240] Judah (1863), Montague (1864), and Montague (1865).
[241] Remember the Central Pacific initially was entitled to build up to the California State line. The entrepreneurs always were explicit in their plans to build at least to Virginia Station in Nevada. In the 1864 Pacific Railroad Act Amendment, the Central Pacific received the right to build 150 miles into Nevada. Additionally, taking advantage of the confusion after Lincoln's assassination, Huntington slipped in a route map for the Central Pacific, including a map of the Central Pacific with a straight line from Sacramento, and Secretary Usher had signed it. The right of way for the Central Pacific had been extended more than 500 miles in the event. Bain (1999) p. 219.

Denver before deciding to build the main line over Cheyenne pass (the most practicable route) and a branch to Denver. Additionally, internal and external economic and political conflicts of interests reinforced the delay.

By 1867 the two railroad companies building the Pacific Railroad had settled the route and many of the restrictions initially included in the Pacific Railroad Act of 1862 had been lifted. The two companies now competed to build the longest track to capture the largest share of subsidies and future earnings possible. Both companies were also looking to connect together and derive earnings from through traffic. At this stage the entrepreneurs began to focus again on the through traffic derived from the California and Chinese trades.

The Union Pacific requested E. D. Mansfield, the commissioner of statistics of Ohio, and a "gentleman believed to be more familiar with railroad enterprises in their relation to the development of the country than any other", to investigate the anticipated business and profits of the company[242]. The two companies then used the same market research to estimate the expected business from through traffic. Both companies published for the first time their through traffic expectations in bond prospectuses in 1867 and used exactly the same observed demand for transportation information.

The observed demand was identified by following the idea that the Pacific Railroad would substitute sail shipping via Cape Horn, steamships through the Panama railroad, and the overland traffic. Trade from Atlantic ports to the Pacific ports (also including the China trade) going through the Cape Horn route was 80,000 tons, trade through Panama was 120,000 tons, and trade overland was 30,000. Assuming traffic was similar in both directions, total observed trade was about 460,000 tons of freight a year. Steamships through Panama carried 50,000 passengers, vessels though Cape Horn carried 4,000, and overland wagons carried 100,000, or a total of 154,000 passengers per year. The entrepreneurs then indicated the average transport

[242] Cisco (1867) p. 5.

price from New York to San Francisco as equal to half of the prices for steamships via Panama, $100 for passengers and $34 per ton. Total transportation expenditure by merchants and migrants was $31 million[243].

However, the two companies were making radically different business forecasts. The Central Pacific bond prospectuses indicated the entrepreneurs promised to reduce prices by 50% and expected earnings to increase three-fold, reaching $90 million. Assuming the Central Pacific captured 50% of earnings and operation expenses were 50% of earnings gives $22.5 million dollars profits per year[244].

The Union Pacific bond prospectuses indicated the entrepreneurs promised to set prices at 50% of the Panama route prices (and higher than the Cape Horn freight prices) and increase average passenger prices by 50%. Freight traffic would partially divert to the Pacific Railroad, and 300,000 tons out of 460,000 would take the rail route. The road would take "all the very light and valuable goods which would be greatly increased by the China trade ... and excepting for some bulky articles, shortness of time (will divert traffic to the railroad)"[245]. Passenger traffic would increase from 154,000 to 300,000. The entrepreneurs argued that this was reasonable because mining in the west (California, Nevada, Montana, and Idaho) was booming and transport safety would be greatly increased with the railroad. Safety, in turn, was valued by all men. Additionally, they noted that investment in California was growing fast and the Pacific Mail Steamship Company was also developing regular services to the Pacific (China, Japan, Sandwich Islands). The entrepreneurs argued these were symptoms of growth connected to the forthcoming inauguration of the railroad. Growth in the west, they argued, would increase future transport demand[246]. Expected total business was more than $55 million. Assuming

[243] Cisco, J. (1868) The Union Pacific Railway Across the Continent West from Omaha Nebraska. (First Mortgage Bonds Sale Prospectus). April 2. pp. 22-23.
[244] Fisk & Hatch (1867) p. 23-4 and Fisk and Hatch (1868) pp. 25-26.
[245] Cisco (1868) p. 23.
[246] Cisco (1867) and Cisco (1868)

the Union Pacific captured $30 million and operating expenses were 50% of earnings, then profits were expected to be close to $15 million[247].

There are two issues that merit a comment. First, note that these business forecasts include only the cost of transportation. Insurance and working capital, two sources of trade costs that had been identified as substantial during the 1850s were not mentioned in the bond prospectuses. Second, the business forecasts proposed are not directly comparable because they assume two almost opposite demand scenarios. The Central Pacific entrepreneurs assumed demand to be elastic while the Union Pacific entrepreneurs assumed demand to be inelastic. Chapter 6 shows that, whatever caused the entrepreneurs to write different forecasts, they both, ex-post, behaved similarly once the railroad opened. The comparison of the prices and traffic used by the entrepreneurs considering the Pacific Railroad as a single stage investment and as a two stage investment is presented in the next chapter.

4.5. Conclusions

The previous chapter documented intense interest to build a Railroad to the Pacific during the second half of the 1840s and the whole of the 1850s. The purpose of this railroad was to profit from transporting goods and people to and from the Pacific Ocean. The railroad was seen as a single stage project. Additionally, there was intense competition between American, British and French entrepreneurs to develop transportation projects targeting this market. The key idea common to all these projects was to identify a shortcut in the route to the Pacific Ocean, reducing transport distance and time. In turn, merchants and passengers were willing to pay higher freights than those typical for all sea voyages. As travel time was reduced, merchants and passengers saved on trade costs as they did on insurance, working capital and foregone earnings. The intensity of competition to develop these projects suggests the profit incentive was strong.

[247] Cisco, J. (1868) The Union Pacific Railway Across the Continent West from Omaha Nebraska. (First Mortgage Bonds Sale Prospectus). April 2. pp. 23-25.

However, the railroad faced two major obstacles and was not built until the 1860s. The first obstacle was that during the 1850s it had not been confirmed yet that a railroad over the North American continent was the most convenient solution to reduce transport distance and time. The market information suggested the market was large and the potential profits high. Additionally, the general impression was that it was technically possible to build a road. But the detailed technical information allowing calculation of construction and operation costs had not been collected. Thus, although the notion that the railroad could be built for about $100 million was strong, a detailed technical confirmation was lacking.

The second obstacle was that the Pacific Railroad generated benefits and costs to different groups in different regions. Since several different routes were feasible, the project generated a political conflict over the allocation of the benefits and costs it generated. And this did not help either to induce construction of the railroad.

The projects examined in this section overcame these two difficulties faced by the project to build the Pacific Railroad in a single stage. The idea of the project for a full Railroad to the Pacific to be built as a single stage and to profit mainly from the Californian and Asian trade shifted into a more pragmatic approach. Initially, the pragmatic approach was very much based on the inertia of the anticipatory settlement process experienced in the Midwest and described by Fishlow. The agricultural frontier moved west as farmers moved west anticipating the very rapid westward expansion of the railroad network. When railroads were built, demand for transportation was already there. The construction strategy performed by Henry Farnam, Thomas Durant, Peter Dey and Grenville Dodge to the Midwest was exactly this one. The extension they planned to Iowa and Nebraska was founded on the same intuition and belief: agriculture would soon settle this region.

The gold rush experienced in Colorado and in Nevada in 1859 provided the key trigger. Mining represents a very important transport demand. It generally takes place in inhospitable regions, where everything must be brought for mining to be performed. And the value of the activity is so high that it actually makes it worth bringing everything. Thus, local traffic appeared with strength at the end of the 1850s and represented substantial local traffic for a railroad over the central route.

Entrepreneurs reacted to the new setting. Theodore Judah, after five years of entrepreneurial effort exploring the Sierra Nevada and pressing for the construction of a Railroad to the Pacific in California and Washington, identified the new opportunities. He identified a pass over the Sierra leading to the silver mines in Nevada and collected enough preliminary information to convince investors a railroad was practicable in 1860 and expected to be good business. The investors, Sacramento hardware and dry goods merchants, knew the market in Nevada, as they supplied it. A detailed survey for a railroad between Sacramento and the Washoe was performed in 1861. For the first time, detailed technical information about the route through the Sierra Nevada had been collected. The grades, curves, number and difficulty of tunnels and bridges were now known. The information revealed that the route did not impose greater technological difficulties than those imposed by some of the most successful eastern railroads, and it was expected to cost less than half of the estimated cost originally believed in the 1850s. Practicability was demonstrated. Additionally, a market survey revealed the market was massive and the potential for profits very high. The survey demonstrated at least a first stage of the Pacific Railroad was already entirely feasible and expected to be highly profitable. The entrepreneurs in California invested privately to identify the route, communicate the findings, organise a detailed survey, incorporate the company and set out to lobby Washington for funding.

Breaking the Pacific Railroad project into two stages had some advantages. The first stage would also cross over the most difficult natural barrier for construction of the Pacific Railroad, facilitating the undertaking of the second stage and completion of the full road. The first stage would also supply funding for the next stage, facilitating its funding. Additionally, the first stage faced less fierce political conflicts as it was entirely a state level decision and it could be performed as any other California railroad, as a private enterprise. Economic activity would also grow in Nevada and soon it would turn into a State. Thus, building the first stage of the Pacific Railroad allowed entrepreneurs to delay facing the political deadlock in Congress.

Intriguingly, entrepreneurs preferred not to avoid Congress. Immediately after the survey was performed they set out for Washington to lobby Congress for subsidies. And the California entrepreneurs achieved it for the first time in 17 years. The influence of the California entrepreneurs in the Pacific Railroad Act can be identified as the Central Pacific Railroad Company was acknowledged as the western part of the Pacific Railroad, and the technical standards were set following those of the Central Pacific.

On the eastern side, entrepreneurial activity promoting the first stage of the Pacific Railroad slowed down following the downturn of general railroad construction during the second half of the 1850s. The creation of the Union Pacific revived entrepreneurial interest to build the Pacific Railroad. A survey was performed in 1862 and the most practicable route identified. The survey confirmed information previously collected by the entrepreneurs in the mid 1850s, was optimistic about reducing construction cost substantially, but still allowed for some doubts. The most practicable route was to bypass the most important source of local traffic, Denver. Still, the Union Pacific was organised in 1863. The search over three different routes continued until 1866, when technical information about the Cheyenne Pass route offered no doubts and the authority of Grenville Dodge allowed the Union Pacific to make the decision to build the most practicable route and a branch railroad to Denver.

In sum, this chapter has documented an important effort by entrepreneurs to search and collect information to demonstrate the positive economic prospects of building a first stage of the Pacific Railroad. The effort took place in the east first, based on the inertia of the railroad expansion to the Midwest following the extension of the agricultural frontier. But after the mid 1850s it slowed down, as did most railroad construction in the United States. In California, the efforts to build a Pacific Railroad had been building during the second half of the 1850s. The discovery of silver in Nevada allowed entrepreneurs to break the project into two stages, and to demonstrate the technical practicability of construction and operation of a railroad, and the massive profits to be derived from the first stage of the Pacific Railroad.

CHAPTER 5. EX-ANTE ENTREPRENEURIAL BEHAVIOUR

5.1. Introduction

The previous two chapters documented entrepreneurial activity evaluating and promoting the Pacific Railroad as an investment opportunity. Chapter 3 focused on entrepreneurial activity promoting a single stage project to profit from the California and China trades. The activities documented in chapter 4 focused on a two stage investment decision to profit from local mining traffic first and then, in a second stage, from the California and China trades. These two chapters' demonstrated entrepreneurs were performing activities suggestive of their interest in the investment opportunity and they declared an expectation that there would be profits from investing in and operating the Pacific Railroad. However, an important issue was not addressed. What is the appropriate benchmark to compare these activities with to determine that in fact these activities do suggest real and serious entrepreneurial interest? Were entrepreneurs behaving to the standard of entrepreneurial behaviour of their time? How do we know these activities and reports were not just cheap talk?

In this thesis it is argued that it is possible to perform two analyses that provide an answer to these questions. First, it is possible to analyse entrepreneurial activities to determine if these were within the realm of activities that i) had been performed during the pre-market stage in successful railroad projects by 1860 and ii) that economic theory predicts them as rational (in the procedural sense of the concept)[248]. Second, it is also possible to analyse entrepreneurial activities to

[248] The idea is that entrepreneurs were behaving rationally but may or may not have considered the outcomes of their actions with perfect foresight. The point is that entrepreneurs had an objective (profits) and they assessed their possible actions to achieve this objective. What is important is that entrepreneurs assessed their possible actions. Whether they actually achieved to attain the predicted outcome depends on many things, including biases in key information and in the framing of the problem, computational limitations, and inherent risk or uncertainty of the situation, among others. The idea follows Simon (1978).

determine if the information used and the forecasts produced were within the range of feasible values given the information publicly available by 1862 (when the Pacific Railroad Acts created the Union Pacific Railway and provided subsidies to both the Central Pacific and the Union Pacific, changing the incentive structure for entrepreneurs). It is helpful to think about the first analysis as an assessment of the processes followed by entrepreneurs to evaluate and promote the investment opportunity. The second analysis corresponds to an evaluation of the outcomes forecasted by the entrepreneurs. The first analysis is performed in this chapter, while the second one is in the next chapter.

The purpose of this chapter is to compare the activities performed by the Pacific Railroad entrepreneurs with the activities performed by entrepreneurs of successful projects and with the predictions of economic theory. Note that transportation markets did not provide information (prices and quantities traded, profits, market share) about these projects as they were not in the market yet and it was indispensable to achieve Congressional approval before any of these projects could even be taken to the capital market. Thus, there is need for a different benchmark. The idea proposed here is that at least we can know if the entrepreneurs of the Pacific Railroad were doing the same things as entrepreneurs of projects that had been successful already by 1860 and if these actions make sense from the point of view of economic behaviour.

The approach is to use the descriptions provided in the two previous chapters to develop a taxonomy of entrepreneurial activities. Next, each of the categories of activity in the taxonomy is examined by asking two questions: were other successful entrepreneurs performing this activity when they promoted their own project? And does it make sense from the point of view of economic theory? Unfortunately the limitation of this method is that it is possible that successful projects performed some other activities not executed by the Pacific Railroad entrepreneurs, and that these activities were important to their success. That is, the taxonomy may help to identify activities that are necessary but not sufficient to determine success. Luckily, there is at least one successful project in the sample of projects described in the two previous chapters: the Central Pacific Railroad. The project was successful in the sense that it received funding during the pre-market stage and it should ameliorate the problem pointed out above and allow identification of the necessary and sufficient activities for success.

A clarification is also necessary before proceeding. As far as the author is aware, no primary or secondary source has described and analysed 1850s entrepreneurial activity evaluating and promoting railroad projects during the pre-market stage[249]. Additionally, it is generally difficult to find good descriptions of the pre-market stage of successful projects (and unsuccessful ones normally leave little trace). Moreover, economic theory on entrepreneurship is scant. Thus, a clear benchmark to guide the comparison of the activities described in the previous two chapters does not exist in the literature. The material presented in this chapter should be seen as a practical approach to compensate for the lack of a well defined benchmark. More precisely, the taxonomy proposed here is in itself a contribution of this thesis, and has been derived from the analysis of the previous two chapters. The information determining the benchmark within each activity was the result of extensive research.

The present chapter also provides the methodological foundations for the model developed in the next chapter. In particular, section 5.4 in this chapter deduces the structure of the typical preliminary railroad survey. The preliminary survey was a relatively standard one and its structure provides the foundational principles to

[249] The two classic sources in railroad finance at the early 20th century were Cleveland and Powell (1909) and Ripley (1915). Cleveland and Powell describe the key information used to promote a railroad. First, a reconnaissance is performed, results are diffused through pamphlets, and sometimes this is enough for a railroad companies to be chartered. Next, a full instrumental survey is performed, and is frequently repeated until the route is located accurately. They also note some of the difficulties to collect accurately the relevant data for the survey and the efforts performed to overcome these difficulties. However, they do not indicate the standards of what is considered accurate or the existence of market research. Ripley (1915), does not indicate the information or method used to evaluate investment opportunities. Modern secondary literature on railroad finance like Currie (1960), Johnson and Supple (1967) and Baskin and Miranti (1997).

derive the model in next chapter. And it is in this sense that it is claimed the model is anchored on the entrepreneur's historical setting.

A brief final warning for the some readers is necessary before proceeding into the substance of the chapter. The results of the section are indispensable to show that the entrepreneurs of the Pacific Railroad were behaving like other successful entrepreneurs and therefore their profit expectations may be trusted (and were likely to receive the support of the capital market, as the successful entrepreneurs did). The essential result of this chapter is that the entrepreneurs of the Pacific Railroad were doing pretty much what other successful railroad entrepreneurs had done when pursuing their own venture. Additionally, what they were doing was very reasonable, in the sense that it is justified by a procedural notion of economic rationality (economic theory). Some of the readers may find this result not too surprising. If the reader is inclined to believe that entrepreneurs behave roughly like rational economic agents independently of the period, the advice is then to rapidly go through this short chapter. If the reader tends to think that economic rationality is mostly a specific feature of the twentieth century, please accept my invitation to consider carefully the evidence put forward.

The next section presents the taxonomy of entrepreneurial activities. Then each of the categories in the taxonomy is described and evaluated. Finally, some conclusions are put forward.

5.2. Taxonomy of entrepreneurial activity to evaluate and promote railroad projects

The previous two chapters have described entrepreneurial activity in a broad way and without assuming any particular definition of what entrepreneurial activities are. At this stage it is convenient to define more precisely what entrepreneurial activities were performed and propose a classification of these activities and their function. The approach here presented proposes a simple framework guided purely by pragmatism and seeks to avoid debates (unnecessary for our purposes) on what is it that entrepreneurs do. The idea is simply to identify a set of activities that were performed by the Pacific Railroad entrepreneurs and would be generally accepted to be typically performed by serious railroad entrepreneurs.

1) Risk bearing: entrepreneurs were exposed to some kind of capital risk

2) Framing of investment opportunity: entrepreneurs were looking for new ways to combine the old technologies (sail) with new technologies (railroads or steamships) and different routes to produce travel distance or time reductions. Additionally, they also provided a framework to think about the economics of the project, to identify the necessary information and produce forecasts of the project's performance.

3) Search as a response to risk and uncertainty: entrepreneurs dealt with risk by identifying the key information items required to perform evaluation of the investment opportunity, searching for these items, and, when unsuccessful in the search, by assuming conservative estimates for the information item.

4) Reaction to new information: entrepreneurs changed different components of the project or business idea when new information arrived.

5) Coordination of key suppliers: entrepreneurs engaged in activities that introduced the project to several different social groups and attempted to coordinate all the necessary inputs for a successful development of the project.

The next sections in this chapter each explore one of the categories of the taxonomy.

5.3. Risk bearing

All the entrepreneurial activity reported in the previous two chapters indicates every entrepreneur was bearing some kind of capital risk while performing the search processes and pursuing profits. All of the actors in chapter 3 performed investments to collect information and promote the project. All of the actors in chapter 4 were stockholders of the Central Pacific or Union Pacific and put work, financial resources, and valuable ideas at stake. All of them invested sunk costs in the form of financial resources for preliminary surveys, lobbying, foregone earnings, or knowledge that could be copied – and all of them faced an opportunity cost (as none was unemployed).

One of the main activities performed by entrepreneurs during the pre-market stage were the preliminary surveys. The content of these surveys is discussed below, but at this point it is important to highlight two issues. First, a survey seems to have been established as a necessary activity in a railroad project since the 1840s (see more below). Second, performing surveys was a relatively expensive and non-negligible activity compared to other economic activity in the 1850s. Surveys were performed by engineers, and railroad engineer wages ($1,800-$7,500) were high compared to average wage in manufacturing ($293 in New York, $330 in Illinois, and $576 in inflation prone California)[250]. Railroad surveys cost $30,000-$35,000[251]. In comparison the average annual revenue per manufacturing establishment was $13,500, $17,700 and $8,000 in Illinois, New York and California respectively[252]. Preliminary survey investment costs were small compared to the $100 million dollars the full Pacific Railroad was expected to cost. But $30,000-$35,000 upfront and sunk investment, when the average sales per

[250] Bain (1999) pp. 182-3 and US Census Browser http://fisher.lib.virginia.edu/collections/stats/histcensus/php/start.php?year=V1860 retrieved 17/05/2008.
[251] The Army surveys were $30,000 per route on average; Judah (1857) pp. 9-10 indicated a cost of $32,150; the the Central Pacific Railroad of California survey was $35,000.
[252] Manufacturing number of establishments, sales, wage, and employment data comes from US Census Browser http://fisher.lib.virginia.edu/collections/stats/histcensus/php/start.php?year=V1860 retrieved 17/05/2008.

manufacturing establishment were just over $10,000, is not negligible or a minor decision either. Entrepreneurs were certainly exposing themselves to relatively high levels of financial risk when performing these surveys.

Entrepreneurs did not only invest in surveys. The entrepreneurs behind the Central Pacific and the Union Pacific sold their assets or used their assets as collateral to get loans and provide cash for construction during the initial years. Whitney and Judah invested substantial effort, time, and foregone earnings in lobbying. Probably the most visible lobbying effort was Whitney's publicity campaign that allegedly cost $23,000[253]. Judah also disclosed knowledge on the location of the route (and all the knowledge accumulated during 5 years of experience building railroads in California), and this could be easily copied by another railroad engineer or other individuals contracting a railroad engineer. Thus, entrepreneurs exposed themselves to different kinds of capital risk.

Economic theory on entrepreneurship is scant and frequently involves opposing views. However, there seems to be general agreement that one of the defining characteristics of entrepreneurial activities is that they imply for the individual performing them exposure to some kind of capital risk (including ideas within capital assets). This is probably the activity most commonly accepted as entrepreneurial[254].

In sum, all the entrepreneurs in chapters 3 and 4 were exposed to capital risk and the magnitude of capital exposure was non-negligible. Additionally, they were exposing themselves to risk by performing activities that railroad entrepreneurs in the 1850s always performed (like the surveys). Finally, exposure to risk is one of the key defining characteristics of entrepreneurship from the point of view of economic theory.

---

[253] Probably the most visible lobbying activity was Whitney's publicity campaign. Bancroft indicates Whitney spend $23,000 of his own savings promoting the project (see Bancroft (1890) p. 498).
[254] Knight (1921), Lucas (1978), Kihlstrom and Laffont (1979), Aghion and Tirole (1994), Hellman and Perotti (2006). Evans and Leighton (1989), Fairlie (1999), Evans and Jovanovic (1989). Some of these references also indicate that entrepreneurial activity is constrained by capital.

5.4. Framing the investment opportunity

The entrepreneurs framed the investment opportunity in a two stage process. Initially the business idea was identified. Once the business idea had been identified, the entrepreneurs used the structure of the preliminary survey to evaluate it.

The key to identifying a business idea in this context was to identify a combination of technology and route providing travel distance or time advantage. Entrepreneurs searched for combinations of technology (ship/canal/railroad) and route (sea/overland) through the Suez Isthmus, Canada, Northern/Central/Southern United States, and Central America that would allow them to reap the profits from transporting trade to and from the Pacific Ocean. When comparing the different business ideas, some entrepreneurs emphasised the travel distance reductions of the overland route, while others emphasised the smaller infrastructure investments of canals (or railroads across the Isthmus) and low transport costs of sea transport.

Next entrepreneurs considered the structure of the preliminary survey in order to identify the key information required to evaluate the business idea. A preliminary survey was a document composed of the following sections:

I. Technical survey

1. Identify and describe qualitatively the route
2. Divide the route into similar segments (divisions)
3. Calculate distance for each division
4. Calculate grades for each division (in feet per mile)
5. Identify the number of curves and measure in degrees for each curve for each division

6. Identify the number of tunnels required, the distance and the material to be excavated for each tunnel, and the cost coefficient connecting volume of excavation of a certain material to the cost of excavation in previous tunnels. Consider additional challenges. Calculate cost of tunnels.
7. Identify the number of bridges, distance and kind of structure required for each bridge. Calculate cost of bridges.
8. Use previous projects of relevant transport mode to calculate the cost of superstructure (grading, rails, ...) and of rolling stock (locomotives, cars, ...)
9. Calculate total construction cost

II. Economic survey

1. Define the potential market for transportation.
2. Identify the level of observed traffic and transport prices for the different origin-destination points, the different routes, and the different transport modes involved.
3. Assume a certain pricing policy for the transport mode to be introduced
4. Implicitly assume a certain price-elasticity of demand.
5. Use observed traffic, the pricing policy and the elasticity of demand to derive expected traffic and earnings.
6. Assume operational costs are connected to those observed in previous projects for the relevant transport mode.
7. Use expected earnings and assumed operational costs to deduce operational profits.
8. Compare construction costs to the flow of operational profits.

The chain of thought implicit in the preliminary survey is as follows: 1) identify a feasible route, 2) describe the key technical characteristics of the route, 3) identify the market the railroad is targeting and describe the existing equilibrium, 4) consider the expected market equilibrium when the railroad enters, and 5) evaluate results and decide whether to invest or not.

The Pacific Railroad entrepreneurs were not innovating when proceeding in this way. When a railroad project was proposed in the United States in the 1850s, a preliminary survey was performed either before the company was organised or immediately after the company was organised.

Technical surveys were well understood by the 1850s and even manuals had been published by at least 1845. For instance, William Gillespie, professor of Civil Engineering at Union College, published a "Manual of the Principles and Practice of Road Making" in 1845[255]. The purpose of the manual was to provide a college text book for the introductory study of civil engineering covering the construction of different kinds of roads (wagon, turnpikes, railroads ...)[256]. The manual described in detail the different activities to collect the necessary information, how to analyse the information, and how to interpret the results of the analysis.

The second part of the textbook described the issues to be considered in the technical survey part of the preliminary survey. It went into the details of locating and describing the road: reconnaissance, survey, mapping, direction, slope, cross-section, surface material, establishing grades, calculating excavations and embankments, costs and final location. In this part the manual also described the logic used to calculate construction costs. The idea was to identify the different activities involved, then use previous projects to derive coefficients describing labour productivity and consumption of other inputs. The quantity of labour and other inputs consumed per mile of road built or cubic feet of tunnel excavated was then connected to the costs of labour and inputs. Next it was possible to deduce the expected cost per activity and, in turn, by aggregating expected costs for all activities it was possible to deduce expected total construction cost. The manual also indicated the tables to be produced from the survey activities, and these very

[255] Gillespie (1855). The first edition had been published in 1845.
[256] In 1845, when Gillespie published the first edition, he indicated the ulterior motive for development and publication of such a manual was to improve the United States road infrastructure that he deemed as "inferior to that of any civilised country" (see preface).

much coincide with the tables described in chapter 4 when discussing the contents of the Judah and Dodge reports.

The first part of the textbook provided guidance on how to perform the economic survey included in the preliminary survey. The manual describes how to perform a traffic survey, calculate earnings and profits (including capital costs). Also interestingly, the manual explains how to estimate the amount of increase in traffic as a consequence of the reduction in transport price for the users. The intuition is simple. First, identify the area next to the road that demands transportation at the existing price. The railroad will provide lower transport price. It is then possible to use geometry to deduce a formula to calculate the area next to the road from which the road will derive transport demand: the area previously identified plus a new area further away but now within reach due to lower transport costs. Once the area next to the road has been identified it is possible to estimate the increase in demand for transport. The procedure allows determining (implicitly) the value of what we today call the price-elasticity of demand. The third part of the manual goes into the details of the technical performance of the operation of a railroad in different terrains (ascent and grade of ascent) and its costs.

The road making manual reveals that both the technical and market research included in the preliminary survey reports were well understood by 1845 or even earlier. The practice of the engineering profession indicates the structure of the report was not only well known but also frequently applied.

The chief engineer preliminary survey reports for the Baltimore and Ohio published in 1830 are an excellent example of a technical survey[257]. In fact, this report actually includes some technical calculations explaining some decisions about the technical standards of the road. No section like this, involving proper engineering calculations, was included in any of the reports examined for railroad projects in the 1850s (including the Pacific Railroad projects). This may indicate that by the 1850s

[257] Thomas (1830). See also the report for the New York and New Haven railroad in 1845.

the knowledge of railroad making had become more standard - an example of standardisation being Gillespie's Manual. Another interesting issue is that already by 1845 it was standard to think of grades of 80 feet per mile as normal for a railroad[258].

The chief engineer reports for New York and Boston in 1847, Pacific Railroad of Missouri in 1852, and the Hannibal and St. Joseph in 1858 provide examples of market research[259]. These reports followed the procedure described above. The market was defined first, observed price and traffic were identified next and, assuming implicitly a price-elasticity of demand and a pricing policy, expected earnings were predicted. Operational costs from other railroads were used to infer the ones on New England and the Midwest. Expected profits were then calculated.

The Northern Indiana in 1847, the Cleveland and Pittsburgh in 1849, and the Chicago, Rock Island and La Salle engineer reports published in 1851 are good examples of a preliminary survey report including both the technical and market research parts[260]. Again, the structure and information provided by these reports is similar to the structure and information described above for the table of contents of the typical preliminary survey report. Also, note that the fact that not all of the reports mentioned here include both the technical and the market research parts of a preliminary survey does not mean that the missing part was not performed for a given railroad. It only means that at the archival collection visited it was not possible to find an example of a report including both parts.

Also indicative that the structure described above was considered a standard practice by the 1850s is Judah's reaction to the Army surveys. In 1857 Judah published a booklet named "Plan for the Pacific Railroad". In this document Judah complained the Army surveys had collected information irrelevant for engineering decisions, while they had left out key information to estimate construction costs.

[258] Chicago, St. Paul and Fond-du-Lac Railroad Company (1847) p.13
[259] Allen (1853) and Hayward (1858).
[260] Jerven (1852).

The number of tunnels and bridges, for instance, had not been collected. He also indicated the minimum information that a preliminary survey ought to contain in order to provide private investors with a reasonable level of confidence on the practicability or non practicability of the railroad[261]. And the structure he described is very similar to the one proposed above.

So far it has been shown that using a preliminary survey to structure the evaluation of a railroad investment opportunity was standard by the 1850s and the entrepreneurs of the Railroad to the Pacific followed this standard. Moreover, the preliminary survey was well grounded in economic intuition and provided a reasonable approach to evaluate the investment opportunity.

Before moving to the next section it is convenient to highlight three examples where the Pacific Railroad entrepreneurs demonstrated an intuition that resembles closely some key insights of modern economic theory. The point is important because it reinforces the impression that entrepreneurs were behaving rationally, at least in the procedural sense of the concept. Additionally, it also illustrates a relatively high level of development in the techniques used to evaluate complex investment decisions during the 1850s.

The first example addresses the key relationships characterising a demand function for transportation. Entrepreneurs, particularly those proposing projects for the whole Railroad to the Pacific, emphasised the importance of travel time and distance reductions and the size of the regions to be connected as determinants of transport demand. In particular, recall that Whitney went to some length to demonstrate with calculations that travel time and distance were expected to be reduced substantially. And travel time and distance, in turn, would induce merchants to use the railroad route rather than shipping around Cape Horn.

[261] Judah (1857) p. 5-10.

Also recall that Whitney pointed out that two very large continents (Asia and Europe) were to be connected via the Railroad to the Pacific. Implicitly Whitney argued that size was connected to trade level. The Union Pacific bond prospectuses indicated it more explicitly: expected trade was large because "this road connects two Oceans and the vast populations of western Europe and eastern Asia"[262]. In short, the entrepreneur emphasised distance and (economic) size as determinants of trade.

The modern-day gravity equation follows exactly the same intuition. The gravity equation is the solution to several different trade models and suggests the two key determinants of trade between two regions are the distance between the two regions and their economic size (even though empirical work has also found some other effects are also important)[263]. Thus, the entrepreneur's intuition in the 1850s was very much in line with modern thinking about transport demand.

The second example addresses the relationship between price-elasticity of demand and business revenue levels. Recall the bond prospectuses revealed that the Central Pacific entrepreneurs promised a price reduction, while the Union Pacific entrepreneurs a price increase. As striking as it is that each group was promising an opposite pricing policy, the fact is that both, as promises, were reasonable and to an extent credible.

The Central Pacific entrepreneurs used an implicit elasticity of 6 when promising a price reduction. This makes sense and is credible in that a price reduction of 50% facing a demand with a price-elasticity of 6 renders higher revenue. Whether reducing price by 50% is optimal is a more complicated issue that requires knowledge of the operational costs to be answered. But it is still safe to indicate that the direction of the policy was potentially reasonable and credible given the assumptions on transport demand used by the Central Pacific entrepreneurs.

[262] Cisco (1867) p. 23.
[263] See Bergstran (1989), Anderson and van Wincoop (2004), Ruijgrok and Bus (1996) and Trujillo, Quinet and Estache (2000).

Entrepreneurs, thus, had a clear understanding of the relationship between the price-elasticity of demand and the business revenue.

The third example addresses the valuation of new goods benefits. Probably the main difference between the Pacific Railroad surveys and other surveys was that the railroad was not competing for through traffic with canals or wagon roads, but with ocean shipping. Ocean shipping to the Pacific implied much longer travel time and distance than any alternative transport mode included in any of the engineer reports described in the previous paragraphs. The efforts to identify the different costs associated with trade to the Pacific have been highlighted above (insurance, working capital and other losses – chapter 3).

But the efforts went further. Entrepreneurs considered carefully the implications of such dramatic transport time and distance reductions. The Union Pacific entrepreneurs indicated that they were not expecting full freight trade diversion and that they were pricing to divert only the group of goods that benefited from transport distance and time reductions. The entrepreneurs realised the price-elasticity of demand of some goods would be low because they highly valued time reductions. Under these circumstances it is feasible and reasonable for entrepreneurs to increase prices. The goods valuing time reductions will pay high freights, while the other goods simply go by ship. The combination of the two approaches (identifying all trade costs - full diversion effects - and assuming a low elasticity of demand for a certain group of goods e.g. partial trade diversion effects) is pretty much what modern market research for new technology-based products performs when developing market research for new goods[264].

In sum, the assessment of a railroad investment opportunity using preliminary surveys was essentially standard by the 1850s. The structure of these surveys was already there when the Pacific Railroad entrepreneurs arrived and it guided their efforts in assessing the investment option and in communicating with the rest of

[264] Bardoe, Duran and Trejo-Tinoco (2000)

society. Moreover, the entrepreneurs also demonstrated a sophisticated understanding of the determinants of transport demand, the intuition behind the concept of elasticity, and the pricing of new goods. Thus, the evidence above supports further the idea that entrepreneurs were very interested in the project, performed activities that were the standard of their time to evaluate the investment opportunity, and made promises that were rational, at least in the procedural sense.

5.5. Search as a response to risk and uncertainty

The framework presented above provides a simple and aggregate measure of profitability, the key variable for entrepreneurs to decide whether to invest or not. If all the information required to use the framework was easily available and certain, the entrepreneurial problem was relatively simple. Once the business idea has been identified, simply collect the information and perform the relevant calculations. However, the information required by the framework was neither easy to collect nor certain. It was necessary to search for the key information.

Entrepreneurs engaged in search processes to collect different types of information. Information to determine the technical feasibility of each project was indispensable. When searching for this information, entrepreneurs' collected and assessed information regarding natural highways as identified by river valleys and the migrations of the wild beasts. They also used the reports by the great explorers over the continent. The Army provided a wealth of information about the feasible overland railroad routes. Some entrepreneurs went further and decided to invest in generating their own information by conducting preliminary engineer surveys to assess the technical feasibility of the construction and operation of a proposed technology/route combination[265].

[265] For examples see Whitney (1849) using reports of the explorers, Davis (1855) Volume 1 for the information provided in the Army reports, Dearborn (1849) reports reconnaissance survey for the Pacific Railroad route proposed by Degrand and associates, and Cornelius Vanderbilt developed detailed studies of the viability of connecting the Nicaragua Lake to the two Oceans.

Market information was also required to perform the evaluation. The entrepreneurs collected and used information from merchants to identify the different trade costs associated with commerce with the Pacific Ocean countries. The information regarding traffic, freight, insurance and working capital expenses was assembled using public sources like commerce statistics reports by governments and specialised press. The entrepreneurs also performed their own surveys if the information had not been publicly released previously.

Entrepreneurs, thus, invested time, effort and financial resources searching for the information required by the preliminary survey. The preliminary survey reports mentioned in the previous section of this chapter (written by successful railroad entrepreneurs) indicate that they also implied search processes to be completed. This is not surprising as there is no reason to assume that information was easily available and certain for these projects. In fact, some of these projects encountered important technical difficulties that were settled by searching for appropriate information. For instance, the Baltimore-Ohio had to search for a satisfactory technical solution to set certain standards for the road. The results of this search process were described and highlighted in the preliminary survey report.

Since the Pacific Railroad entrepreneurs performed search processes, as well as other successful railroad entrepreneurs of the first half of the 19th century, a key question arises. Why is it reasonable to invest in searching for information to complete the preliminary survey and evaluate the project? Given that entrepreneurs know one of the possible results of the preliminary survey is that the project is not a profitable one, why invest in collecting information (if the investment may be lost)? One of the most popular explanations for this behaviour within the frame of mainstream economics is provided by the real options approach. Investing to search and collect information to overcome technical uncertainty in an investment decision may be an economically rational decision. Consider an investment opportunity in which there are two outcomes, good and bad. Next assume it is possible to engage in a costly search process to identify if the outcome will actually be good or bad.

Roughly, engaging in the search process is reasonable if the expected losses involved in the bad outcome are high, and the cost of the search process is lower than the expected benefits generated by the good outcome[266].

The final point discussed in this section is on the behaviour of the Pacific Railroad entrepreneurs when the search efforts were not successful. When it was not possible to collect definitive information on a certain issue required by the preliminary survey, entrepreneurs used conservative estimates to deal with the uncertainty. Using conservative estimates is a rudimentary strategy to deal with uncertainty in assessing the investment opportunity.

When estimating the observed traffic for the Sacramento Valley Railroad, and using information of a traffic survey he performed, Judah argued "passengers are found to be 500 per day, or 3,500 per week. From this I deduct 100 per day, or 700 per week, although assured this past week has been an extraordinary dull one for passengers"[267]. In this way Judah expected to achieve a conservative estimate of traffic over the railroad and, if anything, underestimated profits.

Probably the most convincing example of a conservative estimation was the one performed initially by the Army surveys and then used by Judah to argue that a grade of 116 feet per mile allowed for operation of a railroad over the Sierra Nevada. The Army survey indicated the Baltimore and Ohio Railroad used grades of 116 feet per mile for two segments of the road, one of 11 miles and another of 8. Judah highlighted this information. He also added that the Virginia Central Railroad crossed an average grade of 257 feet per mile, a maximum grade of 296 feet per mile and had been operating for five years. In this way Judah argued it was demonstrated a grade of 116 feet per mile for 2.84 miles made the Central Pacific operationally practicable. A similar argument also using the Baltimore and Ohio as

[266] The example above is a very simplified version of the logic behind the real options approach applied to R&D projects. Expected losses means the probability of the bad outcome times the value of the losses in the bad outcome. Expected benefits means the probability of the good outcome times the value of the benefits of the good outcome. See for example Dixit and Pindyck (1994).
[267] Judah (1854) p. 17.

the technical benchmark had been used in the Army surveys to demonstrate practicability of a railroad[268]. The argument was so successful that a maximum of 116 feet per mile was established as the maximum grade in the Pacific Railroad Act of 1862 and maintained over the whole construction period, even though so many other things in the Act were changed during the period[269].

However, it is also necessary to indicate that Judah and other entrepreneurs were not systematic in the application of conservative assumptions to assess the investment opportunity. For instance, when estimating expected tunnelling costs Judah used something closer to an average rather than an upper bound. He expected the Sierra Nevada tunnels to be excavated at a cost of $50 per linear foot. He compared this to different tunnel excavations in the United States and Europe (some actually reported in the Army reports), and he showed that the tunnels within the sample he used had been excavated at a cost of $40-$77 per linear foot.

The Pacific Railroad entrepreneurs used assumptions to fill the information that could not be collected from the market or the landscape itself. Since the accuracy of these assumptions was not necessarily high, because they had been drawn from a possibly different existing project, entrepreneurs sometimes opted to use a conservative estimate. Some other times they preferred to use a central tendency measure based on a sample of existing projects. The procedure is certainly not the most sophisticated one to deal with uncertainty the reader will ever see. However, one can think of the sample of observed costs per linear foot identified by Judah as the set of possible values for the expected cost of tunnelling. Averaging between observations gives an expected value where each observation has the same chance of occurring. A similar argument may be developed for using the experience of operation of existing railroads to set the standards for the Pacific Railroad route. In this sense the entrepreneurs were dealing with uncertainty in a reasonable way given their knowledge and tools. Even today we use conservative assumptions to

[268] Davis (1855) Vol. 1.
[269] Judah (1861) pp. 24-7.

deal with uncertainty in investment decisions. For instance, the Department of Transport of the UK suggests the use of an optimism bias adjustment of between 1-1.6% of the value of the assumed information[270].

In sum, this section has shown that railroad entrepreneurs during the first half of the 19th century searched for information to complete the preliminary survey and use it to evaluate a railroad investment opportunity. The Pacific Railroad entrepreneurs also performed these search processes. Moreover, economic theory suggests these search processes are rational actions in the face of technical uncertainty. If information is not easily available or certain it is, under some conditions, reasonable to invest in searching for the information to make an informed investment decision. Finally, when it was not possible, even after a search process, to obtain definitive information, entrepreneurs used conservative or "best guess" estimates. Although, these estimates are not the optimal solution, sometimes even today it is unavoidable to use them.

5.6. Reaction to new information

The entrepreneurs showed substantial rationality in the way they reacted to new information. There is a key example. Since the early 1850s it was very clear for entrepreneurs that the project faced a political deadlock. Sectional differences due to conflicts over the allocation of benefits and costs associated with the railroad project and the slavery question made it highly improbable that any project of a Railroad to the Pacific would pass all the way through Congress. Nevertheless, the entrepreneurs kept on trying and promoting projects for a railroad to the pacific.

In 1859 a gold rush was experienced in Colorado and Nevada. Local traffic for a segment of the route was suddenly there. Particularly in California, the entrepreneurs developed rapidly a new approach to the Pacific Railroad. The focus was now on local traffic, and the idea was to build the Pacific Railroad by stages. In

[270] Department for Transport (2007) Transport Analysis Guidance, Unit 3-13-1, p. 8-9

this way, the project was now put within the legislature of a single state. The Pacific Railroad (in its first stage) then became an investment like any other railroad: a private investment and subject to standard regulations within the state. Although the political conflict was not over, the scale of it decreased and the arena changed from congress to state markets. The railroad would also generate earnings from very early in its life, and improve profitability expectations. And building the next stage was an option over which the company had an advantage.

Moreover, the profits would provide a source of funding to continue into the second stage of the Railroad to the Pacific, easing the capital constraints for the project. And hopefully, the political deadlock at Congress would disappear. The political and economic feasibility of the project radically changed. In being alert to new information and using it to improve the strategy for building, the railroad entrepreneurs demonstrated high rationality.

When new and valuable information appeared, entrepreneurs rapidly incorporated and modified their business idea and preliminary survey. The entrepreneurs realised the importance of the new information and the new preliminary survey report portrayed a more attractive investment opportunity.

5.7. Conclusions

In chapters 3 and 4 it was shown that entrepreneurs performed efforts, indicating they considered seriously the investment opportunity in the Pacific Railroad. In this chapter it was shown that entrepreneurs performed activities typically executed by successful railroad entrepreneurs. Additionally, these activities were also rational in a procedural sense. Thus, this chapter provides additional evidence of the interest entrepreneurs had in the Pacific Railroad as an investment opportunity, reinforcing the conclusion from chapters 3 and 4.

The evidence provided in this chapter indicates the Pacific Railroad entrepreneurs bore capital risk, as they invested time, effort, financial resources and ideas when evaluating and promoting the investment opportunity. The magnitude of the resources invested was small, probably in order of $10,000-$30,000, compared to the construction cost of the railroad. However, entrepreneurs did invest in the pre-market stage of the Pacific Railroad substantially more resources than those managed by the typical active manufacturing firms at the time.

The Pacific Railroad entrepreneurs also performed a preliminary survey. The preliminary survey was the standard tool to evaluate a railroad project during the first half of the 19th century, was performed by all railroad projects before or after incorporation, and provides a rational way to evaluate the project's returns to investment. The preliminary survey also provides a simple way to communicate the project's evaluation to the rest of society. Moreover, entrepreneurs also evidenced their own relative high degree of economic sophistication and that of their time by identifying clearly the demand for transportation and applying the relationship between price-elasticity of demand and business revenue to forecast expected revenues for the railroad.

The preliminary survey provided the backbone for evaluating a railroad investment project, but the information providing the detail still had to be searched for. The Pacific Railroad entrepreneurs searched intensively for the appropriate information and when it was not possible to acquire it they used conservative estimates to reduce the effects of risk and uncertainty over the surveys results. Additionally, the entrepreneur's behaviour is justified as economic theory indicates it may be rational to invest in searching for information about an investment project in order to reduce its uncertainty.

The Pacific Railroad entrepreneurs also demonstrated their attentive and rational behaviour when using new information. When new and valuable information was revealed, entrepreneurs changed their business idea and included it in their surveys.

The portrait of the entrepreneur provided by the previous paragraph is substantially different than the irrational or determined entrepreneurs as described by Jenks. The picture does not fit either the idea that entrepreneurs were mistaken because they were not expecting to derive profits from the Pacific Railroad, as Fogel suggests. The picture in fact reveals direct evidence of rationality and profit expectations. Recall Fishlow found that railroads in the Midwest were built after demand, and he inferred that entrepreneurs had been rational in pursuing the expansion of the railroad network. Harley also found evidence indirectly supporting the idea that the entrepreneurs were rational. The picture portrayed above provides direct evidence of rationality, at least in the procedural sense, for railroad entrepreneurs during the 1840s and 1850s.

In sum, the evidence collected in this chapter confirms the significance of the activities reported in chapter 3 and 4. The evidence reinforces the impression that entrepreneurs were, at the very least, trying to do their best to provide evidence of expected profitability in a way similar to that used by successful active railroads. Moreover, these activities were also economically rational, in the procedural sense. But can we take entrepreneurial declarations at face value? Recall that almost every single project examined was predicted to be privately profitable, but subsidies were also requested. Were entrepreneurs really expecting to profit from operation of the railroad, or did they have their eyes on the subsidies? Or put another way, was there a case for the entrepreneurs to expect operational profits from a Railroad to the Pacific? The next chapter uses the structure of the preliminary survey to develop a historically grounded simulation model and discusses in detail whether the expectations declared by the entrepreneurs were reasonable or not.

CHAPTER 6. ENTREPRENEURIAL EXPECTATIONS AND PLAUSIBLE PROFITABILITY

6.1. Introduction

The Pacific Railroad entrepreneurs declared to expect profits. Additionally, they did what other successful railroad entrepreneurs of the 1850s had done when promoting their own projects. The fact that these activities were relatively standard for successful projects and expensive provides some sense of reliability to their declared expectations. In this chapter an alternative gauge to the declared expected profits is proposed. An empirical model of the entry decision is developed to test if the expectations declared by entrepreneurs were plausible. The idea is to model the decision an entrepreneur would face when deciding whether to enter into the transport market by building a railroad following the route of the Pacific Railroad as it was actually built.

The model follows some simple principles. First, it adopts an *ex-ante* approach using the methods and information sources entrepreneurs used to build their declared expectations. The model follows the logic of the entrepreneurs' calculations (as presented in their project reports) and compares expected operational profits against expected construction costs. The demand and cost functions in the model follow the intuition behind the entrepreneurs' arguments and calculations. The parameters of the demand and cost functions are estimated using information publicly available before construction started. The information used here was generated by sources similar to those used by entrepreneurs in the 1850s. Special consideration is given to any reason to expect observed behaviours and prices to change due to the introduction of the Pacific Railroad. Thus, the model maintains clearly and explicitly the distinction between observed and expected information.

A comment is necessary at this stage. The purpose of the model is to follow an *ex-ante* approach that replicates as closely as possible the methods and information used by 1850s railroad entrepreneurs. Alternatively, the estimates of expected profits could have been drawn using the models to assess infrastructure investment and methods to infer parameter values used by modern academic or business economists.[271] However, the approach developed here hinges on acknowledging that what is important is what profit expectation 1850s railroad entrepreneurs could have held. It is only what they could have expected in the 1850s that may answer our question whether entrepreneurs expected the Pacific Railroad to be profitable or not. The point is not to say that entrepreneurs in the 1850s were irrational, and therefore non-optimal solutions are acceptable. Neither is it right to assume that capabilities and information not available in the 1850s would have influenced a decision in the 1850s. Rather, the point is simply to accept that the way entrepreneurs built expectations in the 1850s was rational but bounded by specific methods and information.

Second, the model assumes the road may be built in two sequential stages (following the project reports reviewed in chapter 4). The first one is a railroad between Sacramento and Nevada focusing on local traffic. The second stage extends the road to Omaha and earnings come from both local and through traffic.

Third, the purpose of the model is to improve our understanding of the market the railroad was to enter. Therefore the model abstracts from any perverse incentives derived from the political economy of the project or the capital markets. The model assumes that if entrepreneurs wanted to build the railroad they could simply buy the right of way for a fixed fee, without going to Congress to discuss the project, having to convince different regional groups of the general benefits of the railroad, and

[271] The main difference between the two approaches is connected to the modern emphasis on the probability of an outcome. Entrepreneurs in the 1850s were just observing the beginning of the adoption of probabilistic and statistical analysis to business decisions in the insurance business. Outside the insurance industry entrepreneurs tried to use conservative estimates for the underlying variables in their models to compensate for their inability to allocate probabilities to events. The approach developed here follows the 1850s approach but also performs robustness checks on the probability of occurrence of the events studied.

facing the "temptation" of lobbying to get subsidies. Moreover, once the right of way is bought there is no risk of future expropriation by government. The fixed fee is calculated based on the cost of land in an average eastern railroad project.

The model also assumes that if the project is shown to expect profits then enough capital is available at the market rate to finance construction (recall entrepreneurs expected construction cost of the first stage to be \$13.3 million and of the second stage \$86.7 million). The assumption actually implies two different conditions: i) capital market size was large enough to fund a project of the magnitude of the Pacific Railroad, and ii) if the project is shown to be expected to be profitable, then it is likely to receive funding.

Capital market size was large enough to fund a project of this magnitude once it was divided into two stages. Railroads built privately in the United States had already been within the \$10-\$22 million range of construction cost.[272] Railroad investment during the 1850s indicates the domestic and international capital markets provided substantial capital. More than \$70 million per annum was invested in American railroads, roughly \$30-\$40 million came from European countries, and American railroad stock floated in European stock markets already by late 1850s.[273] Moreover, precisely during the second half of the 1850s and the 1860s the Suez Canal, a project of comparable scale, was funded using substantial capital provided by small French private investors.[274] Precedents indicate it was

[272] The Pennsylvania railroad collected more than \$13 million in stock and almost \$9 million in bond issues to build the railroad during the first half of the 1850s (Poor (1860) p. 472). The cost of major western railroads built during the 1850s (Michigan Central and Michigan Southern) were \$10-\$17 million (Chandler (1977) p. 90). The New York and Erie, already in operation during the 1850s, issued bonds five different times during the decade and collected more than \$16 million (Poor (1860) p. 282).

[273] Total investment from Fishlow (1965) nominal grass capital formation p. 389. European investment from Davis and Cull (2000) p. 751. Engerman (1972) also supports the view that capital market size was not a major limitation for developing the transcontinental.

[274] Austrian, British, and French entrepreneurs with the support of their home countries competed to build a transport project on the Suez. Ferdinand de Lesseps, an ex-French consul in Cairo, was granted a concession by the Egyptian government in 1858. The canal finished in November 1869, just 6 months after the first transcontinental. Lesseps rejected the services of established investment banks, like the Rothschild, and organized an international issue of shares of the canal collecting \$21.5 million from small investors, mostly French, and \$17.5 from the Egyptian government.

certainly feasible to fund the first stage of the transcontinental using capital external to the firm coming from local and/or foreign capital markets. The second stage was a larger investment, but well within the range of capital already devoted to railroad construction in the United States and of comparable size to the investment in the Suez Canal. Moreover, the potential use of profits from the first stage to partially finance construction of the second stage also reduce reliance on external capital and signals information reducing or ameliorating any perceptions of moral hazard the capital markets may have.

The second condition, that if the project is shown by entrepreneurs to be likely to be profitable, then the capital market will fund the project, is more subtle. The main difficulty is that since the railroad was to cross federal territories, the project had to be approved first by Congress. Consequently, no issues of stock or bonds were performed during the project phase of the railroad, the *ex-ante* period, making difficult to evaluate the likelihood of the capital market funding the project. Moreover, since the companies involved were not operating yet or floating in the stock market, it is not possible to observe the capital market's reaction to the project on the value of these companies. The available information is the entrepreneurial projects described in the previous chapters and expressions of support to these

---

Initially Lesseps expected French investors to buy 20% of the stock, other Europeans and Americans 54%, Egyptian government 16%, and African investors 10% (Schonfield (1939) p. 86). However, Britain's political opposition to the Lesseps project and the intent of assassination of Napoleon III led to low European subscription. Lesseps continued ignoring the French investment bankers, issued and sold more stock to small French investors and convinced the Egyptian government to increase its participation to complete the initial capital to $39 million (Farnie (1969) pp. 49-54, Fitzgerald (1876) pp. 119-125, and Kinross (1968) pp. 115-17). Further participation of French small investors and the Egyptian government completed the capital to pay for construction process. In total French small investors bought more than $20 in stock and $6 million in bonds without government aid. French small investors also bought in 1868 an additional $13 million in lottery bonds guaranteed by government. The Egyptian government invested about $41 million. Small European investors completed the total costs that had grown to $87.9 million (nominal value at 1858 US dollar-GBP exchange rate) (Marlowe (1964) pp. 241-3 for sources of funding after initial stock issue, Farnie (1969) pp. 83-84 and Wilson (1977) pp. 44-45 for total construction cost). In short, more than $26 million was collected in the French capital market without government aid, an additional $13 million were also provided by French investors assured by government. Private investment could have been substantially higher had Lesseps not excluded French investment bankers from funding the project and the international political conditions been less tense. Finally, the Egyptian government also collected a substantial share of the funds it provided to the project by issuing bonds in the international capital market.

projects.[275] Note the difficulty is not one inherent to the research strategy chosen or specific to the Pacific Railroad. Any large scale infrastructure project that generates large externalities will lead to political conflicts, and hence, will require political approval before the project can be scrutinized credibly by the capital market. Thus, it is an unavoidable assumption.

Fourth, the model deals with uncertainty in various ways. In particular, the model deals with two types of uncertainty.[276] i) The model, implicitly, considers uncertainty about identifying correctly the observed equilibrium and the baseline expected equilibrium. Recall the entrepreneurs performed technical and market research to reduce uncertainty and published the results of these efforts in the form of reports of the preliminary survey. Since the approach to the model is based on these reports and comparing them to available public information, the model already, implicitly, considered this form of uncertainty. Additionally, the

[275] The information available includes expressions of support to the transcontinental railroad by several influential people during the 1850s. The most knowledgeable source, the American Railroad Journal expressed support for the project several times (see above). The newspapers maintained close track of the proposals but it is not easy to calculate the likelihood of capital market funding the project only based on these reports. Inspection of the Pacific Mail Steamship Company (PMSC), the Panama Railroad (PR), the New York and Erie Railroad and the Chicago Rock Island Railroad market value quotations compared to an index of transportation companies in the NYSE does not reveal any significant information before 1862. Once the Pacific Railroad Act was passed the data reveals The PMSC and PR quotations increase 1862 to 1866-9 and a sharp decline 1867-69 relative to an index of transportation companies in the NYSE. These companies should have expected increasing demand for transportation as the first transcontinental railroad transports inputs for construction from eastern United States to San Francisco, explaining the rise in market value. Additionally, after completion of the transcontinental these companies competed with it, and were likely to loose business and profits, explaining the decline in market value. The NYER and the CRIR reveal no clear pattern compared to the transportation index.

[276] A note on the likelihood of a third type of uncertainty, technical uncertainty, is important at this stage. The impression one develops after reviewing the project reports of different railroads and comparing them to those produced to evaluate the first transcontinental railroad is that there were no engineering challenges requiring important technical innovations to overcome these challenges. The chief engineer reports written by Judah or Montague include no proposed innovation or improvement of any of the building or operating techniques. The chief engineer reports of the Baltimore and Ohio published in 1830 are an excellent example of a report that identified the challenge implied by the terrain (see Thomas (1830) and the New York and New Haven Railroad report (1845)). The report presents the high grades and the expected difficulties in building and running railroads under these high grades. Next the report performs the necessary calculations to predict the impact of these difficulties on technical operation, construction cost and operation cost. No such an issue is discussed in the reports for the first transcontinental. Rather, the approach is simply to demonstrate the technical standards of the proposed route for the Central Pacific are within the range of those of the Baltimore and Ohio. The logic is: if the Baltimore and Ohio is profitable under grades of up to 116 feet per mile, the Central Pacific can also be profitable under these grades.

entrepreneurs used conservative assumptions when no specific data was available for a particular parameter. Following the entrepreneurs the model will produce a downward biased estimate of expected profits. Another reason to adopt a downward bias is that we are looking to understand better the circumstances under which the road should have been expected to be profitable. If it is shown that the Pacific Railroad should have been expected to be profitable under circumstances adverse to profits, there should be little room for discussion of results. ii) Robustness checks identifying the probability of occurrence of the baseline results and determining the effects of random shocks to the baseline results are also performed and provide information about the sensitivity of the results to specific parameter values and therefore to different forms of uncertainty.

6.2. An entry decision model

An entrepreneur considers whether to build a railroad to enter the market for transportation between N origin i and destination j pairs. The process to make the decision is simple. The entrepreneur first locates the most appropriate route and estimates the flow of construction cost. Next, he estimates the flow of expected operational profits. The flow of expected construction costs are compared to the flow operational profits next. The entrepreneur decides to build the road if the flow of operational profits is higher than the flow of construction cost.

Construction costs

The entrepreneur first locates the most appropriate route between origin i and destination j pair and develops an estimate of construction cost. Expected total construction costs, $\tilde{TC}$, are then given by the sum of the stream of expected construction costs, $\tilde{C}_t$, and the right of way fixed fee, L:

$$\tilde{TC} = L + \sum_{t=1}^{T} \tilde{C}_t$$

Expected operational profits

Next the entrepreneur collects information to evaluate expected operational profits. The entrepreneur starts with the observed demand. Next he considers how demand may change due to the characteristics of the road. An expected operational cost function is assumed next. A pricing policy is derived, and it is then possible to deduce expected operational profits.

Observed transport demand

Consider the demand for freight transportation between location i and j. Transport demand in tons per year depends on transport price and is given by:

$$q_{ij} = h_{ij} - a_{ij}P_{ij}$$

where q_{ij} is traffic between origin location i and destination j; h_{ij} is a constant specific to each ij pair and associated with the economic size and other relevant origin-destination pair specific effects of the trade partners; P_{ij} is the freight price; a_{ij} is a coefficient determining the sensitivity of output q to changes in prices P specific to each ij. The price is defined as $P_{ij}=f^m d_{ij}^m$, where f^m is the average freight rate per ton-mile for existing transport mode m and d^m_{ij} is the distance covered on transport mode m between origin location i and destination j.

The intuition behind the demand function is simple: as distance or freight rates per ton-mile decline (and, thus, freight price between the two trading partner's falls), transport demand increases. A linear functional is chosen for simplicity.[277]

[277] Other functional forms are possible. For instance, the constant elasticity form allows for demand to have a similar functional form to demand equations used in empirical transport economics and

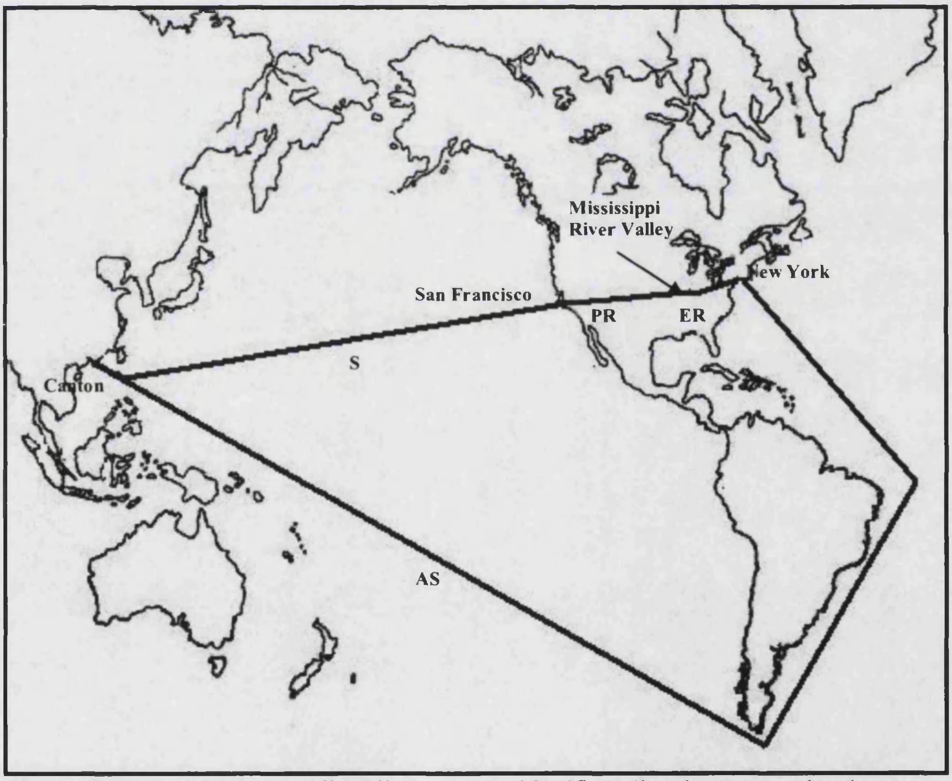
In the case of transportation between Canton and New York, for example, entrepreneurs *observed* the demand for transport when the only transportation mode available is sail ship around the Cape Horn, route AS in figure 13. Hence,

$$(1) \qquad q_{ij} = h_{ij} - a_{ij}(f^{S} d_{ij}^{AS})$$

with f^S the average freight rate per ton mile and $d^{AS}{}_{ij}$ the distance of the all sea trip around Cape Horn.

Figure 13.

Trip Canton-New York City via all sea and rail routes



Source: Whitney (1849) Appendix. All sea route and Pacific Railroad route own drawing.

---

international trade analysis estimating transport demand. The analysis below has also been performed with a constant elasticity demand function. Results are qualitatively similar, but there is potentially an upward bias on expected profits when the demand approaches its asymptotic limit at high prices. The linear demand function is preferred to avoid the upward bias.

Next entrepreneurs used the *observed* demand to derive the *expected* demand for transport if the Pacific Railroad is built. The latter is the demand function relevant to calculate expected transport demand and operational profits.

Expected transport demand

The entrepreneur considers next the scenario when the railroad is built, consisting of transport from Asia to San Francisco (S), then by the Pacific Railroad to the Mississippi Valley (PR), and finally by the eastern railroad network to the east coast (ER).[278] The expected demand of the new route is given by the trade that merchants are willing to take over the new route given the expected freight price of the new route. Let us define expected demand for transport over the new route for a given origin-destination pair *ij*, $\tilde{q}_{ij}$, as:

$$(2) \quad \tilde{q}_{ij} \begin{cases} \tilde{q}_{ij} = \tilde{h}_{ij} - \tilde{a}_{ij}\tilde{P}_{ij} & \text{if} \quad \tilde{P}_{ij} \leq P_{ij} + B_{ij} \\ \\ \tilde{q}_{ij} = \tilde{u}_{ij} - \tilde{b}_{ij}\tilde{P}_{ij} & \text{if} \quad \tilde{P}_{ij} > P_{ij} + B_{ij} \end{cases}$$

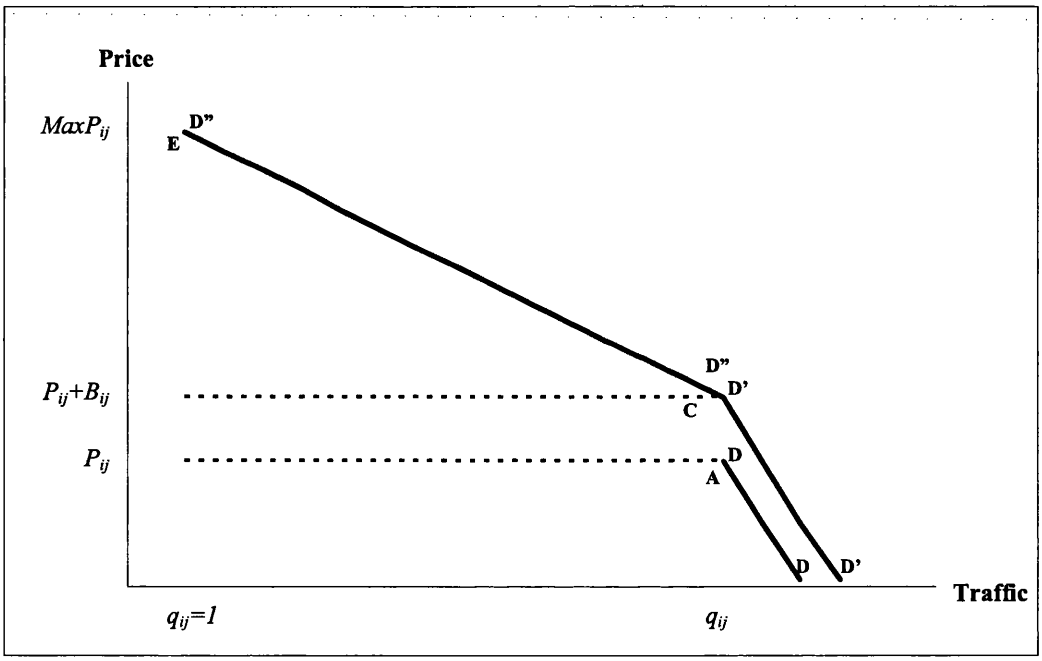
where ~ denotes expectation. $\tilde{P}_{ij}$ is the expected price of transportation on the Pacific Railroad route. In turn $\tilde{P}_{ij}$ is defined as $\tilde{P}_{ij} = (f^S d_{ij}^S + f^{PR} d_{ij}^{PR} + f^{ER} d_{ij}^{ER})$ where f^{PR} is the expected average freight rate per ton-mile that the entrepreneur sets for the Pacific Railroad (e.g. the entrepreneur's decision variable); f^S and f^{ER} are the expected average freight rate for the *S* and *ER* segments of the route; and d^S_{ij}, d^{PR}_{ij},

[278] Note that the PR segment here includes what was actually built by two different railroad companies, the Central Pacific Railroad and the Union Pacific Railroad.

d^{ER}_{ij} are the distances over the *S*, *PR*, and *ER* transport modes, respectively.[279] At this stage it is also convenient to note that d^{PR}_{ij} and d^{ER}_{ij} are constant across origin-destination pairs, and therefore their *ij* sub-indices may be dropped, facilitating notation.[280] Parameters $\tilde{a}_{ij}$ and $\tilde{b}_{ij}$ give the sensitivity of traffic to observed price, while parameter B_{ij} is the value in dollars of the minimum insurance and working capital costs saved by the rail route's reduction on transport time (see more below).

Figure 14.

Expected demand function



The intuition behind the expected demand function is simple. The idea is that the Pacific Railroad entrepreneurs formed their expectation on future demand based

[279] The first transcontinental railroad route may imply transhipments not necessary by the all sea route. In the example of trade between Canton and New York the transhipments would take place in San Francisco and in the Mississippi region. The transhipment costs may be easily included, but for simplicity have been excluded from the analysis at this stage. They will be considered below in the sensitivity analysis section.

[280] See appendix for explanation why d^{PR} and d^{ER} are constant across origin-destination pairs.

only on the observed market information for the all sea route. The entrepreneurs observed the aggregate all sea route price (P_{ij}) and traffic (q_{ij}), point A in figure 14. Since the Pacific Railroad offered faster transportation to merchants, this means that if the entrepreneurs set the Pacific Railroad segment price so that the expected price of the rail route ($\tilde{P}_{ij}$) is less or equal than the all sea route price (P_{ij}), the Pacific Railroad will capture the whole market. If the expected rail route price is lower than the observed price, then the entrepreneur faces a demand schedule denoted D-D. Note that if entrepreneurs form their demand expectations in this way they only use the observed aggregate market equilibrium information; that is they build strictly backward looking expectations (the world will look in the future as it looks today). Most entrepreneurs formed their demand expectations for the first stage of the Pacific Railroad (Sacramento-Washoe) in this way (see more in section 6.3.1). Also note the expected demand function is identical to the observed demand when evaluated at the observed price; hence $\tilde{h}_{ij} = q_{ij} + \tilde{a}_{ij} P_{ij}$.

Entrepreneurs formed their expectations in a more elaborate way when considering the second stage of the Pacific Railroad (Sacramento-Omaha). The rail route was expected to provide transportation characterized by attributes not ever supplied before – the Pacific Railroad route was a new good. The rail route would be faster, dryer, and with cooler and more stable climate compared to the all sea route crossing the equator twice. The entrepreneurs expected the new good attributes of the rail route to have two different effects over expected demand: i) raise the price every single merchant is willing to pay to transport every single ton over the rail route and ii) raise (even higher) the price some merchants are willing to pay to transport commodities that benefit more from the new good attributes of the Pacific Railroad route.

i) Raise in the price every single merchant is willing to pay for every single ton

The intuition behind the expected demand function if $\tilde{P}_{ij} \leq P_{ij} + B_{ij}$ is simple. The Pacific Railroad route was expected to be faster than the all sea route, allowing railroad entrepreneurs not only to capture the whole market (as in the case of expected demand schedule D-D), but also to charge higher transport prices. As the rail route reduces transport time, it also saves at least part of any merchants' insurance and working capital expenses, B_{ij}. This means that if the entrepreneurs set the Pacific Railroad segment price so that $\tilde{P}_{ij} \leq P_{ij} + B_{ij}$, the rail route will capture the whole market. The expected demand for the new route is then given by point C in figure 14. If the expected price of the rail route is lower than $(P_{ij}+B_{ij})$ then the Pacific Railroad faces demand schedule D'-D'. Expected demand forecasted in this way uses observed aggregate market equilibrium information and observed non-transport trade costs; entrepreneurs still form their demand expectations in a backward looking way.

ii) Raise in the price some merchants are willing to pay

The intuition behind the expected demand function if $\tilde{P}_{ij} > P_{ij} + B_{ij}$ is slightly more complex.[281] It is based on the idea that the Pacific Railroad route enjoys some attributes that are not offered by any other transport route and are relatively novel. The combination of rapid, dry, and relatively stable climate transportation makes the Pacific Railroad particularly suited to transport goods like fresh, green, and dried commodities. In turn, as the Pacific Railroad raises its segment price and the rail route price increases over $(P_{ij}+B_{ij})$, the rail route will begin to lose traffic to the all sea route. Still the rail route will maintain some positive market share because it offers more advantageous transport services to some specific goods. In order to determine the most appropriate Pacific Railroad segment price entrepreneurs need to develop a forward looking inference of how sensitive is traffic on the Pacific

[281] The author is unaware of any models considering the problem of defining an expected demand function for a new good emphasizing on the use of only information available ex-ante.

Railroad to the expected rail-route price. More precisely, the entrepreneur needs to develop an estimate for $\tilde{b}_{ij}$.

The entrepreneurs declared *ex-ante* the market equilibrium (price and traffic) they expected when the rail route was in operation, but did not explain how they formed the demand expectation.[282] A simple method to infer $\tilde{b}_{ij}$ using the information available to entrepreneurs is proposed here. The idea is to infer the value of $\tilde{b}_{ij}$ and derive expected demand based on information observed by the entrepreneurs: observed aggregate equilibrium and the maximum observed price.

The value of $\tilde{b}_{ij}$ is computed by using two points on the expected demand schedule. The first point is the one denoted by C in figure 14 and discussed above. This point represents the observed aggregate equilibrium adjusted for the savings in insurance and working capital expenses the rail route may provide to any merchant.

The second point is denoted by E in figure 14, the maximum observed price. After identifying points C and E, it is possible to identify a $\tilde{b}_{ij}$ that allows expected demand to be equal to q_{ij} (traffic observed in 1860) when $\tilde{P}_{ij} = (P_{ij} + B_{ij})$ and equal to 1 when $\tilde{P}_{ij} = \max P_{ij}$. If the expected price of the rail route is higher than $(P_{ij}+B_{ij})$ then the Pacific Railroad faces a demand schedule D"-D".

Expected demand forecasted in this way uses only information observed by entrepreneurs and one conservative assumption. The assumption is that when $\tilde{P}_{ij} = \max P_{ij}$ expected traffic $\tilde{q}_{ij} = 1$. The assumption is conservative in two ways. The assumption implies that at the maximum observed price traffic is only one ton

[282] The Union Pacific entrepreneurs expected to set prices 50% higher than the observed price and resulting traffic to be about 66% of all traffic observed in the California and China trades, once the railroad was operating (Cisco (1868) p. 23).

or one passenger per year. The information about traffic paying the maximum price is not available, but it is very likely it is substantially higher than 1. For instance, the number of passengers who paid the maximum observed price (first cabin rate on steamers between New York and San Francisco) was very likely higher than 1 since the average capacity of cabin accommodations was more than 40% of total passenger capacity for a sample of 15 steamships operating on the route.[283] The assumption also implies that the maximum observed price is the maximum customers may have paid for the Pacific Railroad. The maximum observed price is likely to be lower than the maximum price customers may have paid for the new good attributes provided by the Pacific Railroad. Because these new good attributes are not available when using any other transport mode, they were simply never observed before entry of the railroad. Consequently, the maximum observed price must have been lower than the maximum price customers were willing to pay for the Pacific Railroad. Thus, assuming that when $\tilde{P}_{ij} = \max \tilde{P}_{ij}$ traffic $q_{ij} = 1$ leads to underestimating expected revenue for the Pacific Railroad and is a conservative assumption.

The expected demand identified if $\tilde{P}_{ij} > P_{ij} + B_{ij}$ is faced only by the rail route (as the all sea route cannot offer the kind of specific new good attributes the rail route offers). Note that by construction any $\tilde{b}_{ij}$ implies that for $\tilde{P}_{ij} > (P_{ij} + B_{ij})$ expected traffic must also be lower than observed traffic.[284] Thus, there is a residual demand for transportation that may be supplied by the all sea route at the observed price. More formally, residual demand is given by ($q_{ij} - \tilde{q}_{ij}$). The full market expected

[283] Kemble (1943) appendix.

[284] Implicitly it is assumed that price discrimination between commodities is not possible. Price discrimination was frequently practiced by transport entrepreneurs during the 19th century already. However, the entrepreneur proposals did not consider this possibility. Additionally, the bias caused to the expected profit estimate by not considering the potential additional profits derived from price discrimination is in line with other biases leading to a downward biased profit estimate. As explained above this is the empirical strategy adopted in this study, thus excluding potential profits derived from price discrimination does not affect the nature of the exercise performed here.

demand function is given by the expected demand for the rail route given the profit maximizing $\tilde{P}_{ij}$ plus the residual demand.

The expected demand for the Pacific Railroad route (for the second stage) is given by the schedule D'-D'-D"-D", a kinked demand curve. The schedule below $(P_{ij}+B_{ij})$ is formed using backward looking expectations, while the schedule above $(P_{ij}+B_{ij})$ is formed using forward looking expectations about the value of new good attributes of the Pacific Railroad route.

Alternative methods to infer the demand function also exist. The literature on the identification of the welfare effects of new goods offers a different approach. Loosely speaking, and assuming perfect competition to keep matters simple, this approach uses data revealed after the new good has been introduced and a certain functional form for preferences to identify the price elasticity of demand for the new good. It is then possible to calculate the integral of the demand function to estimate the area below the demand curve and above the old good's price, which represents the welfare gains made by consumers. Robustness of this approach rests on the researcher demonstrating that the estimated elasticity estimated and functional form do not generate an upward bias on the demand function. The litmus test is that the virtual price at which the estimated demand function predicts demand is 0 is not unreasonably high[285].

It is, however, difficult to use this approach in the case of the first transcontinental. Estimating the price elasticity of demand for a good before it appears in the market place is not feasible because no data about its market price exist. That said, it is feasible to use a particular functional form and to find the necessary elasticity values that would have allowed the entrepreneur to expect the project to be profitable. I undertook this assessment, but the results were highly sensitive to the

[285] See Tratjtenberg (1989), Hausman (1996), Hausman (1997), Hausman (1999), Petril (2002) and Greenwood and Kopecki (2009).

choice of functional form and, most importantly, it is not possible to connect them to the information that entrepreneurs had available in the 1850s.[286]

The approach proposed here is theoretically less elegant than that proposed in the new goods literature, but it has two advantages in the context of evaluating ex-ante willingness to pay. First, it relies on price information only; entrepreneurs had those prices available, and are known to have taken note of them when making their decisions. Second, note that at the maximum observed price the expected demand is $\tilde{q}_{ij} = 1$, that is, the maximum price the railroad route may charge is the maximum price observed *ex-ante*. This implies the maximum price the railroad route may charge is the maximum price observed ex-ante. Thus, this assumption guarantees any solution identified using this method will generate a demand curve that is broadly speaking plausible.

Operational costs

The entrepreneurs used the eastern railroads experience to derive expected operational costs. Constant average cost per passenger-mile or per ton-mile was frequently used in the 1850s to describe operational costs, similar to a constant marginal cost incurred in the provision of the transport service, c:

$$\tilde{O} = \tilde{c}\, d^{PR}\, \tilde{q}_{ij}$$

[286] A constant elasticity demand function was assumed and results indicate that if the price elasticity of demand is within the range 1-1.17 expected profits are positive. Two difficulties arise with this result. First, it is difficult to argue these elasticity values were the ones the entrepreneurs actually expected. Entrepreneurs did implicitly think in terms of elasticity, but simply did not write using this language. Second, the results indicate the asymptotic nature of the constant elasticity demand function leads the virtual price to be unrealistically high when quantity is 0. Consequently, the profit maximization solution is at unrealistically high prices and very low quantities. However, examination of other points on the demand curve that are not profit maximizing solutions but do involve positive expected profits reveals many of these points involve realistic price and quantity solutions. Thus, the use of a constant elasticity demand function leads to the disturbing finding that profit maximizing solutions are not realistic while non-profit maximizing solutions are realistic. Detailed results are available upon request.

The expected operational cost, $\tilde{O}$, is, then, given by the expected constant marginal cost, $\tilde{c}$, the distance over the Pacific Railroad segment, d^{PR}, and total expected passenger or freight traffic, $\tilde{q}_{ij}$.[287]

Operational profits

The expected operational profits, $\tilde{\pi}_{ij}$, are given by:

(3) $$\tilde{\pi}_{ij} = (f^{PR} - \tilde{c})d^{PR}\tilde{q}_{ij}$$

The intuition behind the profit function is simple. The first part of the function is the profit per passenger-mile or ton-mile transported. The second part is distance times the number of passengers or freight transported (passengers/tons moved one-mile), or quantity transported.

Maximization problem

The problem faced by the entrepreneurs may be framed in two different ways depending on whether they form backward or forward looking expectations. First, if the entrepreneur for backward looking expectations, the problem is to maximize profits subject to a price ceiling. The entrepreneur chooses an optimal expected freight rate, f^{PR*}, maximising expected operational profits subject to expected transport price being equal or less than $(P_{ij}+B_{ij})$. Note that $(P_{ij}+B_{ij})$ acts as a strict price ceiling imposed by competition with sail. More formally, the entrepreneur's problem is:

[287] Note the operation cost function does not allow for economies of scale, scope or density. These are important characteristics of the operation cost function in many transport industries. However, the reports do not indicate entrepreneurs considered these issues when developing their expected outcomes. Additionally, since these economies lead to lower operation costs and higher profits, the profits estimated by the model will be downward biased and consistent with the research strategy.

$$(4) \qquad \underset{f^{PR}}{Max}\,\tilde{\pi}_{ij} = (f_{ij}^{PR} - \tilde{c})d^{PR}(\tilde{h}_{ij} - \tilde{a}_{ij}\tilde{P}) \qquad \text{st} \qquad \tilde{P}_{ij} \le P_{ij} + B_{ij}$$

If the implied elasticity of demand is lower or equal to 1, the solution to the profit maximization problem is given by the Pacific Railroad freight rate that makes the expected price of the rail route equal to the price of the all sea route plus extra insurance and working capital expenses, (P_{ij}+B_{ij}). The expected equilibrium quantity is then identical to observed quantity. The railroad route will capture the whole market as it offers better quality service than sail. Under an expected inelastic demand schedule, the entrepreneur cannot increase profits by reducing prices, as quantity reacts less than proportionally to price changes.

If the expected elasticity of demand is higher than 1 the solution takes into account the sensitivity of traffic to changes in the expected rail route price, $\tilde{P}_{ij}$. The profit maximizing expected freight rate is given by:

$$(5) \qquad f_{ij}^{PR*} = \frac{1}{2}\frac{q_{ij} + \tilde{a}E_{ij} + \tilde{a}cd^{PR}}{\tilde{a}d^{PR}} \quad \text{with} \quad E_{ij} = P_{ij} - (f^S d_{ij}^S + f^{ER}d^{ER})$$

The optimal freight rate is an increasing function of observed traffic, the difference between the price ceiling and the price of transport over the two other segments on the rail route (Canton-San Francisco via sail and Omaha-New York via eastern railroad), and the marginal cost. For the relevant parameter values, the optimal freight rate per ton mile is a decreasing function of the Pacific Railroad distance and the parameter $\tilde{a}_{ij}$ that determines the sensitivity of demand to price changes. The higher the value of $\tilde{a}_{ij}$, the higher the elasticity of demand (ceteris paribus the observed price and traffic), and the lower the profit maximizing freight rate is.

The maximum profit function is given by:

$$(6) \qquad \pi_{ij}^{*} = \frac{1}{4}\frac{(q_{ij} + \tilde{a}_{ij} E_{ij} - \tilde{a}_{ij} cd^{PR})^2}{\tilde{a}}$$

The maximum profit is an increasing function of observed traffic, the difference between the price ceiling and the price of the other two segments of the rail route, and parameter $\tilde{a}_{ij}$. The optimal profit function is a decreasing function of the marginal cost.

Second, if the entrepreneurs form forward looking expectations, they face the following problem:

$$(7) \qquad \underset{f^{PR}}{Max}\, \tilde{\pi}_{ij} = (f_{ij}^{PR} - \tilde{c})d^{PR}(\tilde{u}_{ij} - \tilde{b}_{ij} \tilde{P}_{ij})$$

The profit maximizing expected freight rate is given by:

$$(8) \qquad f_{ij}^{PR*} = \frac{1}{2}\frac{q_{ij} + \tilde{b} E_{ij} + \tilde{b} cd^{PR}}{\tilde{b} d^{PR}}$$

The optimal freight rate is similar to that in equation (5), but the sensitivity parameter is b_{ij} instead of a_{ij}. By construction b_{ij} leads to inelastic demand schedules while a_{ij} must lead to elastic ones.

Maximum profits are given by:

$$(9) \qquad \pi^*_{ij} = \frac{1}{4}\frac{(q_{ij} + \tilde{b}_{ij}\,E_{ij} - \tilde{b}_{ij}\,cd^{PR})^2}{\tilde{b}}$$

Again the solution of the problem is similar to that when the entrepreneur forms backward looking expectations, the difference being the term on the expected sensitivity of traffic to price changes, b_{ij}.

Once the entrepreneur calculates the maximum expected operational profits for each of the N origin-destination pairs considered, total operational profits for period t, $\tilde{\eta}_t$, is calculated as:

$$\tilde{\eta}_t = \sum_{ij}^{N} \tilde{\pi}_{ij}$$

Entry decision

The model presented identifies the flow of expected construction costs and a lower bound of the flow of expected operational profits. The next step is to compare the flow of expected construction cost with the flow of expected operational profits and derive the entry condition for the entrepreneur to decide whether to build the road or not. The entry condition compares the present value of the flow of $\tilde{\eta}_t$ to that of $\tilde{TC}$ and is defined as:[288]

$$(7) \qquad \sum_{t}^{T} \frac{\tilde{\eta}_t}{(1+r)^t} \geq L + \sum_{t}^{T} \frac{\tilde{C}_t}{(1+r)^t}$$

[288] The entrepreneurs did not use the present value to sum a cash flow. The precise entry conditions they specified are introduced and discussed in the model solution section below.

where T is the total life time of the project and r is the discount rate. The intuition is simple. The sum of expected discounted stream of total operational profits must be higher than the sum of expected discounted stream of construction costs for the entrepreneur to decide to build the railroad.

6.3. Results

In this section the structure provided by the model presented above is anchored to the historical context by using information publicly available before construction to calculate expected profits. The purpose of using information publicly available before construction is to continue with the *ex-ante* spirit of the exercise. Subsection 1 discusses results for the first stage while subsection 2 presents results for the second stage.

6.3.1. Decision to build the first stage of the Pacific Railroad

The first stage of the railroad, as proposed by the entrepreneurs of the Central Pacific, is a railroad from Sacramento to Virginia Station, in the Washoe mining region of Nevada (see map in figure 15). The market for transportation consists of two submarkets: passenger and freight traffic both ways between Sacramento and Virginia Station.

Construction was expected to take five years and cost $13.3 million, spread evenly over the five years. Earnings from the two submarkets start arriving in the sixth year and continue until the project's life is finished in year twenty five.[289] The parameters characterizing construction costs, observed demand, expected demand and operational costs are drawn from public sources (like specialized press,

[289] The period of construction and operation is taken to be 25 years. For the ex-post social saving evaluations Fogel (1960) used a 10 years period after inauguration and Mercer (1982) 20 years. See more details in the appendix.

shipping lists, or government reports), sources frequently used by entrepreneurs in the 1850s (see table 3).[290]

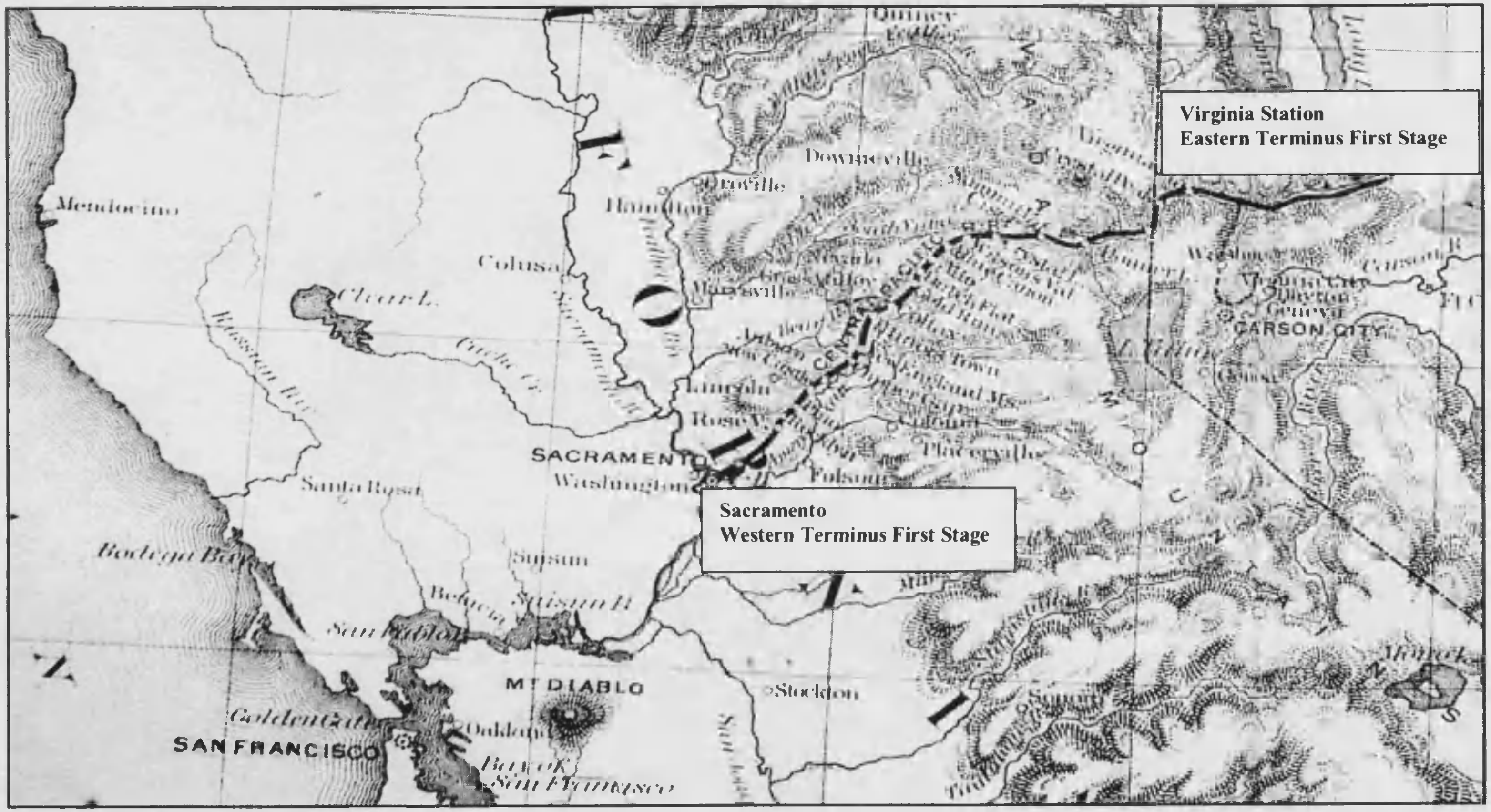
The entrepreneurs framed the entry decision with a ceiling price equal to observed price. Although the railroad would certainly offer shorter travel time and more convenience than wagon, there is no evidence entrepreneurs considered these potential transport quality improvements to form the profit expectations of the first stage. That is, the entrepreneurs did not use information on the value of the new good attributes to form their expectations for the first stage.[291]

[290] A detailed description of the data and sources included in table 3 is included in appendix.

[291] Note the first stage implies no need for sea or eastern railroad transport (as opposed to the second stage), and therefore the $f^{S}d^{S}_{ij}$ and $f^{ER}d^{ER}_{ij}$ are equal to 0.

Figure 15.

Map of the first stage of the Pacific Railroad



Source: Judah (1861)

Table 3.

Summary parameter values, sources and comments for first stage

Parameter/Variable	Value	Source & comment
Expected construction cost	$13.3 million	Judah (1861)
Expected railroad distance	155 statute miles	Judah (1862) Close to distance of railroad when it was actually built
Construction period	5 years	Construction of Sacramento-Virginia Station segment took 4 years and 9 months (09/1863-06/1868)
Land fixed fee	1% construction cost	Fishlow (1965) and land prices in 1850
Project's life	25 years	Average of Fogel (1960) and Mercer (1982)
Discount rate	9%	Mercer (1982) Higher than 5-8% typically offered by railroad bonds
Observed freight traffic	43,800 tons/year	Judah (1862) 15%-39% lower than alternative info
Observed passenger traffic	13,505 passenger/year	Judah (1862) In line with alternative info
Observed freight price	$120	Judah (1862) Lower than alternative info as it excludes tolls
Observed passenger price	$30	Judah (1862) In line with alternative info
$\tilde{a}_{ij}$ (expected sensitivity of traffic to price)	Calibrated (see text)	
$\tilde{h}_{ij}$ (trading partners characteristics)	Calibrated (see text)	
Expected freight operational cost	1.18 cents ton-mile	Poor (1860) 136% higher than entrepreneur info
Expected passenger operational cost	0.88 cents per pass-mile	Poor (1860)

The baseline equilibrium is calculated under a range of values for $\tilde{a}_{ij}$, the sensitivity of traffic to changes in expected transport price. For values of $\tilde{a}_{ij}$ rendering a price elasticity of demand equal or lower than 1 the profit maximizing solution to the model is trivial: the entrepreneur should set a rate of the Pacific Railroad such that the expected price is equal to the observed price. The entrepreneur gains nothing from reducing expected price because traffic will grow less than proportionally to the expected price reduction. Freight profits should have been expected to be close to \$5.2 million per annum and passenger profits close to \$387,000 (see table 4 baseline scenario).

Once expected operational profits for the first stage are calculated it is possible to compute the entry condition. The expected net present value (NPV) of the project is \$24.5 million dollars (see table 4 baseline scenario). As discussed in chapters 4 and 5 the entrepreneurs used two measures of expected profitability in the 1850s. The ratio of operational costs to revenue is an inverse indicator of the average margin per unit. A satisfactory ratio was expected to be lower than 50%. The results indicate the expected ratio for the Pacific Railroad was less than 5%. The ratio of total operational profits over total construction costs indicates the time in years it takes the entrepreneurs to repay the initial fixed investment. The minimum satisfactory level for this ratio was 15%-20%. The results indicate the ratio was over 40%. The railroad was expected to generate higher average margins and to repay initial investment faster than the standard 1850s railroad investment opportunity. The baseline scenario (using the information available to the entrepreneurs by 1862) indicates the first stage of the Pacific Railroad should have been expected to be profitable.

In order to complement the analysis in the previous paragraph focusing on inelastic values of the price-elasticity of demand, the model was also solved assuming an elastic demand. The range of the price-elasticity of demand considered is between 1 and 3. Given that transport demand tends to be inelastic, the range is wide enough to consider all relevant scenarios.[292] The results indicate profits increase as the price-elasticity of demand increases. For instance, operational profits should have been expected to be more than \$7 million and the NPV higher than \$35 million with an elasticity of 3 (see table 5).

[292]The range is wide enough to consider all values considered by Oum and Waters (1990 and 2000) in their reviews of the literature on transport price-elasticity of demand.

Table 4.

Comparative statics first stage and inelastic price elasticity of demand

		P $	Q Tons	P*Q $	C $	Profit $	NPV $ mlls	C/P*Q	Profit/CC
Baseline scenario	**Freight**	120	43,800	5,256,000	80,110	5,175,890	24.5	0.02	0.42
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Construction cost up 3.15 times	**Freight**	120	43,800	5,256,000	80,110	5,175,890	0	0.02	0.13
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Traffic & prices down by 43.2%	**Freight**	68	24,878	1,695,712	45,503	1,650,209	0	0.03	0.13
	Passenger	17	7,671	130,711	10,463	120,248		0.08	
Operational cost freight up 43.6 times and passenger up 21.9 times	**Freight**	120	43,800	5,256,000	3,492,805	1,763,195	0	0.66	0.13
	Passenger	30	13,505	405,150	405,150	0		1.00	
Discount rate up by 2.76 times	**Freight**	120	43,800	5,256,000	80,110	5,175,890	0	0.02	0.42
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Project's life down to 8.5 years	**Freight**	120	43,800	5,256,000	80,110	5,175,890	0	0.02	0.42
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Earnings delayed 9.6 years	**Freight**	120	43,800	5,256,000	80,110	5,175,890	0	0.02	0.42
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Combination of negative events 1	**Freight**	90	32,850	2,956,500	75,103	2,881,397	2.1	0.03	0.23
	Passenger	23	10,129	227,897	17,270	210,627		0.08	
Combination of negative events 2	**Freight**	96	35,040	3,363,840	76,906	3,286,934	2.3	0.02	0.27
	Passenger	24	10,804	259,296	17,684	241,612		0.07	
Combination of negative events 3	**Freight**	120	43,800	5,256,000	120,165	5,135,835	1.1	0.02	0.41
	Passenger	30	13,505	405,150	27,631	377,519		0.07	
Combination of negative events 4	**Freight**	96	35,040	3,363,840	76,906	3,286,934	0	0.02	0.27
	Passenger	24	10,804	259,296	17,684	241,612		0.07	

Note: P: Profit maximizing price; Q: Total quantity of output in tons; P*Q: Revenue; C: Operational cost; Profit: Operational profit; NPV: Net Present Value of first stage project; NPV%: % of NPV compared to baseline NPV; C/P*Q: Operational cost over revenue; Profit/const: Operational profit over construction cost. Combination 1: Construction cost, operational cost and discount rate up by 25%, and traffic & prices down by 25%. Combination 2: Construction cost and operational cost up by 20%, traffic & prices down by 20% and project's life down to 15 years. Combination 3: Construction cost and operational cost up by 50%, earnings delayed by 2 years and project's life down to 15 years. Combination 4: Construction cost and operational cost up by 20%, traffic & prices down by 20%, earnings delayed 1 year, and project's life down to 15 years.

Table 5.

First stage profits for elastic price elasticity of demand

		P	Q	P*Q	C	Profit	NPV	C/P*Q	Profit/CC
Elasticity <=1	**Freight**	120	43,800	5,256,000	80,110	5,175,890	24.5	0.02	0.42
	Passenger	30	13,505	405,150	18,421	386,729		0.05	
Elasticity=1.1	**Freight**	116	45,593	5,267,300	83,390	5,183,909	24.6	0.02	0.42
	Passenger	29	13,840	405,833	18,878	386,956		0.05	
Elasticity=1.5	**Freight**	101	54,102	5,469,563	98,952	5,370,611	25.9	0.02	0.43
	Passenger	26	16,417	421,686	22,393	399,293		0.05	
Elasticity=2	**Freight**	91	64,737	5,898,925	118,404	5,780,521	28.7	0.02	0.47
	Passenger	23	19,639	455,319	26,787	428,532		0.06	
Elasticity=3	**Freight**	81	86,008	6,975,129	157,308	6,817,821	35.9	0.02	0.55
	Passenger	21	26,082	539,472	35,576	503,897		0.07	

Note: P: Profit maximizing price; Q: Total quantity of output in tons; P*Q: Revenue; C: Operational cost; Profit: Operational profit; NPV: Net Present Value of first stage project; C/P*Q: Operational cost over revenue; Profit/CC: Operational profit over construction cost

In order to determine more precisely the robustness of the finding above additional analysis is performed. First, the sensitivity of the baseline results to changes in the underlying parameters is examined. Second, the threat of potential competition to the road's assumed monopoly is considered.

The sensitivity analysis is performed in three different ways. i) The minimum change to each single parameter making the project's expected NPV equal to 0 is identified, ii) the effects of a series of combinations of negative events over the project's NPV are evaluated, and iii) a Monte Carlo experiment identifying the effects of pseudo-random negative events on the project's NPV is performed.

The minimum change to any single parameter necessary to make the expected NPV equal to 0 is very large (see table 4). The project is still profitable even after total construction cost increases 3.15 times, or observed traffic and prices for both freight and passenger submarkets go down by 43% for the whole project's life, or operational cost increase 43 times for freight and 21 times for passengers, or the discount rate goes up 2.76 times, or the project's life is reduced from 25 to 8.5 years, or earnings are delayed entirely by 9.6 years.

The project's expected profitability is still positive even after a wide combination of negative events (see table 4). For example, construction costs, operational costs and the discount rate can go up by 25% and traffic and prices for freight and passengers can go down by 25%, all at the same time, and the project still renders a NPV of more than $2 million. Or construction costs and operational costs may increase up to 20%, passenger and freight traffic and price can go down by 20% and the project's lifetime reduced to 15 years and the NPV will still be higher than $2 million. The project may also be subject to other combinations of negative events and still render a positive NPV (see combinations 3 and 4 in table 4).

The Monte Carlo experiment allows testing the sensitivity of the baseline results described above and identifying their probability of occurrence. The experiment is as follows. The price elasticity of demand is assumed to be inelastic; therefore the profit maximizing price is equal to the observed price.[293] The parameters of the model (construction cost, observed traffic, observed price, operational cost and discount rate) experience a pseudo-random shock in the direction against profits up to a given percentage of the historical value. For example, if the parameters vary by 10%, it means that the freight traffic value used to calculate the optimal expected profits in a given replication is a pseudo-random number between 43,800 tons a year (the historic value reported in table 3) and 39,420 (0.9 X 43,800) drawn from a uniform probability distribution.[294] The experiment allows every parameter to vary pseudo-randomly and independently at the same time, and is replicated 2,000 times for any given percentage level of negative shock. The procedure is then repeated for negative shocks of 10%, 20%, 30%, 40% and 50%. The Monte Carlo experiment gives a sample of 2,000 observations of estimated NPV for each given level of negative shock that may then be used to proxy the probability distribution of NPV given the parameters' historical values and a specific level of negative shock. The Monte Carlo method applied in this way allows identifying the probability of the project attaining a certain level of profits, given the assumptions of the model.

The summary results are presented in figure 16.[295] The qualitative findings presented above still hold. Since the Monte Carlo experiment allows each parameter to vary independently and each replication is also generated independently of each other, the average NPV for each sample is a statistic consistent with the concept of expected utility (payoff). The average NPV declines as the shock increases and reaches roughly $5 million when the negative shock on each parameter is increased to up to 50%. An alternative and more conservative statistic for expected profits is

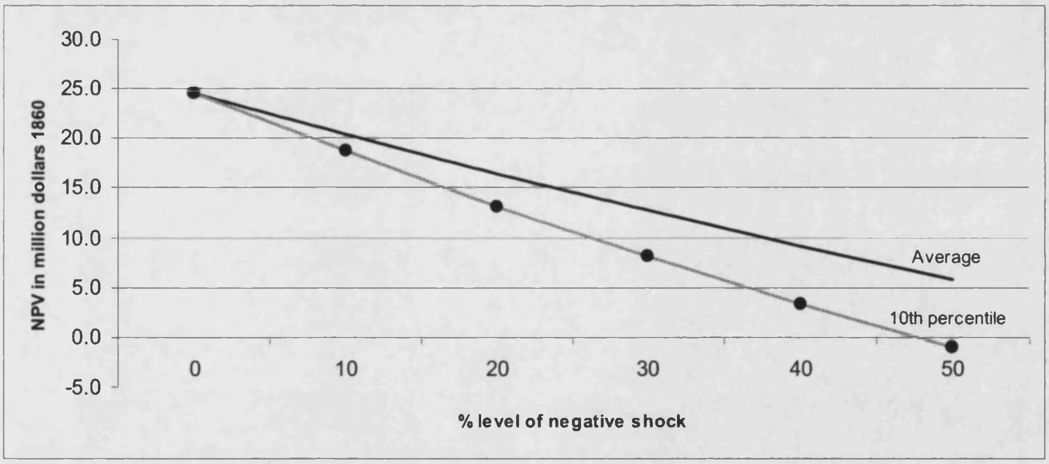
[293] The case when the price elasticity of demand is elastic indicates NPV is increasing in the elasticity of demand. Results are thus qualitatively identical.
[294] The uniform probability distribution is used because there is no prior about whether a certain outcome for each variable is more likely than another. Additionally, the uniform probability distribution weights heavier the extremely bad outcomes than other probability distributions, a pattern in line with the approach to develop a minimum profit estimate.
[295] Summary statistics for each of the five samples of NPV are presented in table 16 appendix. Table 17 in appendix presents summary statistics for each of the five samples of NPV in the case of an elastic demand schedule.

the minimum level of profits expected for a given probability of occurrence. The 10th percentile of each NPV sample indicates approximately the level of profits to be expected with 90% probability. The NPV of the 10th percentile declines as the negative shock increases reaching 0 when the random negative shock on each parameter increases up to 46%. Thus, many things may go wrong to a significant extent and it is still overwhelmingly likely the project will be profitable.

The baseline scenario is also robust to changes in the underlying probability distribution generating the negative shock. If the uniform probability distribution is replaced by the normal distribution results are even strengthened. Even if an asymmetric distribution is used, like the gamma distribution, the qualitative results still hold without any caveats (see appendix 6.4.7 for details).

Figure 16.

First stage average and 10th percentile expected NPV in Monte Carlo experiment



Note: Negative shock on construction cost, observed traffic and prices, and operational costs. Each variable experienced a shock on the direction affecting negatively profits. The shock is defined as a random reduction between 0% and the % level of negative shock indicated in the X axis. The average and the 10th percentile are from a sample of 2,000 replications of the Monte Carlo experiment.

The first stage of the Pacific Railroad should have been expected to be highly profitable, and therefore might induce competition for its profits. A rational entrepreneur will consider the threat of entry when performing the *ex-ante* calculations of expected profitability of the project. Were profits high enough to induce additional entry and, if yes, what effects would entry have on profits per firm?

Potential competition to the Pacific Railroad may come from another railroad or from wagon roads. The case for an alternative railroad hinges on the availability of an alternative route over the Sierra Nevada. As explained in chapters 3 and 4, the 1855 army surveys indentified a route over the Sierra Nevada, but estimated construction costs were twice as high as the route identified by Judah to build the Pacific Railroad first stage.[296] Thus, the alternative route available by 1862 experienced clear disadvantages.

However, the possibility of another route crossing the Sierra nearby the Pacific Railroad route being discovered in the next decade or so could not have been entirely ruled out by 1862. It is possible to analyze the effects of threat of entry on the expected profits of the Pacific Railroad by assuming the potential entrant experiences identical construction and operational costs to the Pacific Railroad, it builds simultaneously, and the railroads engage in Cournot competition.[297] The assumptions, particularly the idea of simultaneous entry, are biased against profitability of the Pacific Railroad, as the purpose here is to develop a downward biased estimate of expected profitability.

The highest number of potential entrants the market could have supported profitably is given by the collusion equilibrium where profits are 0. The analysis of this scenario indicates that given 1862's market size a second railroad could have entered the market profitably. A third entrant reduced profit per firm to almost 0 (see collusion solution in table 6). Collusion equilibrium tends to be unstable, and it is more likely the potential entrants considered a more competitive equilibrium to

[296] Judah (1861) p. 36.

[297] Note Bertrand competition is excluded because if the potential entrant expects to play Bertrand it will expect equilibrium market price to be equal to marginal cost and profits to 0. Thus, there will be no incentives to enter.

form their expectations. The Cournot equilibrium indicates only one more firm may find it profitable to enter, and both the Pacific Railroad and the entrant will earn approximately $4.5 million (see Cournot duopoly solution table 6). Thus, even assuming the Pacific Railroad enjoys no construction cost advantage, nor first mover advantage, and cannot develop entry deterrence strategies, the indivisibility of construction cost implies that few potential entrants may be supported by 1862s market size, and allows the Pacific Railroad first stage to remain profitable even if entry was to be experienced.[298]

Table 6.

First stage profits under threat of entry

	Freight		Passenger		NPV
	P	**Q per firm**	**P**	**Q per firm**	
Monopoly – baseline scenario	120	43,800	30	13,505	24.5
Collusion - 2 firms	120	21,900	30	6,753	6.5
Collusion - 3 firms	120	14,600	30	4,502	0.4
Cournot - 2 firms	81	28,977	21	8,797	4.5
Cournot - 3 firms	61	21,733	16	6,598	-2.4

Note: P: Profit maximizing price; Q per firm: Quantity per firm; NPV: Net Present Value of first stage project.
Monopoly scenario: Identical to baseline scenario above
Collusion scenario: Assumes incumbent and entrant organize a cartel. Monopoly solution gives maximum profits for cartel as elasticity is assumed to be 1. Monopoly output is divided by the number of firms in the market. Market shares are identical because entrants are assumed identical to the incumbent (Pacific Railroad).
Cournot scenario: Cournot competition market outcome assuming entrants and incumbent (Pacific Railroad) enter simultaneously, entrants are identical to incumbent and the price-elasticity of demand is equal to 1.

The case for competition from a wagon road rests on the observed price in 1862 being substantially higher than the marginal cost of wagon transport. If this was the case, wagons may have been able to compete with rail transport by reducing prices.

[298] Ex-post information indicates that technological constraints were probably an important entry barrier. No alternative route seems to have been available, given that the first stage of the first transcontinental railroad had been built and its pricing strategy. The other three railroads ever built crossing the Sierra were the other transcontinental railroads. Built during the 1870s and 1880s, these three roads cross the Sierra far away from the first transcontinental route, in Southern California, Oregon and Washington states. Given that i) market size grew substantially during the 1870s and 1880s, ii) entry for new state level railroads was legally available, and iii) entry of new railroads into the Sacramento-Washoe market was never observed, it is unlikely competition from other railroads ever represented a real threat.

Although the marginal cost of wagon freighting across the Sierra Nevada is not available, it is unlikely it was substantially lower than the observed price. The observed prices were lower or in line with other relevant transport prices in 1850s California, as explained in table 3 in this chapter. The lower the prices the less likely a high difference exists between price and marginal cost.

Additionally, transportation over toll roads, as the Placerville Wagon Road connecting Sacramento and the Washoe region, implied low entry barriers. The available evidence indicates that, at least for Mid Atlantic and New England, toll roads entry barriers were low and evading paying tolls was easy. In fact these roads actually faced important free-riding and collective action problems typical of public goods.[299] Scattered evidence for the Washoe region indicates some resemblance to the Mid Atlantic experience. The number of teams involved in freighting over the Placerville Road increased rapidly during the early 1860s from 400 to roughly 1,400. Approximately 2,000 people were employed in the industry, and a significant company in the market would have employed 50-60 people.[300] Although an association of teamsters existed, the absolute numbers indicate the relatively ease of entry and the consequent difficulty to coordinate collusion.[301] Increasing competition in this market should have maintained profit margins relatively low. The Pacific Railroad profits should not have been threatened by competition from wagon roads.

Finally, it is also possible to learn about the *ex-ante* scenario and the nature of the decision to enter by examining *ex-post* information. Construction activity is briefly examined next. Transport market outcomes cannot be examined as the relevant information is not available.[302]

[299] See Klein (1990) pp. 789-91.
[300] Lord (1959) pp. 194-95.
[301] Additionally, there are theoretical arguments that suggest organizing collective action even within a small group of players is very hard when demand booms, as it was booming in the Washoe trade (see Rotemberg and Saloner (1986)).
[302] The average freight rate and the aggregate tons carried for years 1868 to 1869, when the railroad opened to Washoe, are available. The order of magnitude of the numbers indicates the equilibrium that prevailed in the Sacramento-Washoe submarket was probably one with a price lower than that

The best *ex-post* construction cost estimate available indicates the first stage construction cost is $14.1 million, implying a cost over-run of 6% (see table 7). Construction was also achieved within the grade limit of 116 feet per mile emphasized by entrepreneurs, although the distance over which the grade stretched was more than three times longer (up from 2.8 to 9.5 miles) – but still shorter than the Baltimore and Ohio (11 miles), the technical benchmark of the Pacific Railroad.[303]

Table 7.

Comparison of ex-ante and ex-post construction activity of first stage

	Unit	Ex-ante	Ex-post
Construction cost	Millions	13.3	14.1
Completion time	Years	More than 2.5[(a)]	4 years 9 months
Maximum grade	Feet per mile	116	116
Miles of max grade	Miles	2.84	9.5
Number of tunnels	Number	18 12[(b)]	15
Length of tunnels	Feet	17,410 5,655	6,245
Cost of tunnels	Dollars	870,500	312,250[(c)] 473,355[(d)]
Length of longest tunnel	Feet	1,370 1,700[(b)]	1,659
Time to excavate longest tunnel	Months	13 18[(b)]	13
Cost of longest tunnel	Dollars	68,500	109,474[(d)]

Source: Ex-ante information comes from Judah (1861), except (a) that comes from Judah (1860) and (b) that comes from Montague (1865) p. 15. Ex-post construction costs comes from Mercer (1982) p. 154 and 164, completion time, maximum grade and length of maximum grade comes from Report of the Board of Railroad Commissioners (1877) p. 313, number and length of tunnels and time to excavate of longest tunnel comes from Central Pacific (1869) Report of the Engineer's Office to the President and Directors, pp. 32-5. Tunnel construction cost (c) is calculated using the cost per linear feet of excavation in Judah (1861) and (d) is calculated using the cost per linear foot of excavation of the Summit tunnel (the most difficult and expensive of the tunnels) using black powder and nitro-glycerine in Gilliss (1870) p. 170.

---

observed in 1861 and with moderately higher quantities. Given this data and the growth of the Sacramento and Washoe regions it is likely that transport demand was inelastic. If this was the case, entrepreneurs engaged in behavior (reducing prices under an inelastic demand function) that was different from profit maximizing. The information is not detailed enough to determine if this was the case. No passenger rate or traffic information is available as it was aggregated with mails, express, and other services and reported only as aggregate revenue.

[303] Judah (1861) p. 25.

The information in table 7 reveals substantial learning about the terrain during the first two years of construction helped to reduce the length of required tunnels.[304] The savings in construction cost and time derived from less tunnelling are not available. An estimate indicates savings in excavation (the lion's share cost in tunnelling) were between $0.5 and $0.9 million dollars.[305] Also recall the route originally proposed by Judah already saved more than 50% construction cost compared to the route proposed in the army surveys. The evidence indicates it was feasible to rapidly learn about the topography of the region, improve the location of the route and reduce construction costs compared to those estimated by the army surveys.

The *ex-post* evidence suggests the longest tunnel (Summit tunnel) took as long as expected to be excavated, although it was actually longer and more expensive than expected. The entrepreneurs initially did not expect to use nitro-glycerine, but it was actually used to excavate about half of the tunnel, saving about 100 days of excavation work and $22,000 1860 dollars.[306] Thus, nitro-glycerine allowed traffic to run between Sacramento and the Washoe region just over three months earlier but had a very modest effect on total construction costs.

Construction was performed roughly along the lines of the proposed project with the help of additional surveying to reduce the length of tunnelling and the use nitro-glycerine. But even if entrepreneurs had not performed the surveys leading to

[304] See Montague (1865) report for evidence of learning and improvement on the route originally proposed by Judah.
[305] Assuming the ex-ante cost of tunnelling from Judah (1861) the savings are $558,250. Assuming the *ex-post* cost of tunnelling the Summit tunnel (the most difficult and expensive one) from Gilliss (1870) savings are $908,058.
[306] Nitro-glycerine had been recently invented in 1847. At the same time nitro was introduced to mining in California, the Pacific Railroad entrepreneurs explored the possibility of using nitro to excavate the transcontinental railroad tunnels, in 1866. It was actually used in excavation activities after February 9th 1867 (Bain (1999) pp. 272-3, Griswold (1962) pp. 146-8, and Gilliss (1870) p. 162). The savings are computed as the difference between the cost of a 1,659 tunnel at the average cost using no nitro and the estimated actual cost of Summit tunnel (using nitro) as reported by Gilliss (1870).

reduction of tunnelling length or used nitro, the project's baseline expected profits would have been reduced only modestly.[307]

In sum, the first stage of the Pacific Railroad should have been expected to be profitable. The investment should have been perceived as an attractive investment opportunity given the methods to evaluate railroad investments in the 1850s and the information publicly available by 1862. Evidence indicates the technological challenge of building the road was relatively well predicted by the entrepreneurs and no innovation in construction techniques was required to build the road roughly within the plan proposed by the entrepreneurs. If anything, the experience of the entrepreneurs seems to suggest the technology of construction exhibits important learning economies, particularly in surveying activities. As knowledge of the region's topography is accumulated, the route is improved and construction cost reduced. The entrepreneurs predicted improving the location of the line compared to the army surveys, predicted substantially lower construction costs, and achieved them. The project based its competitive advantage on its technological advantage over wagon transportation and booming demand.

[307] The Sierra Nevada tunnels and the Summit one, especially, have been indicated as the key technological difficulty to build the Central Pacific (and more generally the first transcontinental) because of the harsh weather and the hardness of granite in the Sierra. The histories of the first transcontinental railroad have highlighted entrepreneurs devised creative solutions to overcome these difficulties, as snow tunnels, a shaft in the middle of the Summit tunnel in order to allow excavation of four faces instead of only the two external ones, and the use of nitro-glycerine. However, a report by civil engineer John Gilliss for the American Society of Civil Engineers casts doubt about the level of creativity or innovativeness of these solutions. Gillis introduced the paper "the track has been completed … much sooner than thought possible, that the difficulties overcome are apt to be underrated" (p. 153). Next he describes the harsh winter conditions. The solutions to building under these circumstances are identified as snow tunnels and the shaft, as the secondary literature reports. But these solutions are not indicated to be new techniques in railroad construction. No adjectives synonymous of creativity were used. The only novelty highlighted by Gilliss is regarding the use of nitro-glycerine. The novelty, Gilliss points out, is not the manufacture or use of nitro, but the information on performance of nitro in excavating hard rock tunnels (Gilliss (1870) p. 163). The Van Nostrand's Eclectic Engineering Magazine report on Gilliss article and does not include any mention of a novel technique or idea (Van Nostrand's (1870)). The 1855 army reports in fact indicate that the challenge to build railroad tunnels is not so much technology to excavate or the length of the tunnel, but costs (citing the experience of the Baltimore-Ohio with sixteen tunnels) (McClelland (1855) pp. 111-12). Once one considers that the only person involved with the Central Pacific that had experience with railroad construction prior to the project, Theodore Judah, died in 1863 while travelling to New York and before construction into the Sierra started, it is not surprising the project did not advance railroad technology. In short, the evidence indicates that entrepreneurs performed an immense work and investment under harsh climate but did not advance railroad construction or tunneling technology.

6.3.2. Decision to build the second stage of the Pacific Railroad

The second stage of the railroad, as proposed by the entrepreneurs of the Central Pacific, is a railroad going from Virginia Station, Nevada, to Omaha, Nebraska. Recall the first and second stages were proposed as sequential projects. The exercise performed here assumes the first stage has been successfully completed and takes as given the technical information and construction cost estimates for the second stage included in the engineering survey part of the reports by the Central Pacific and the Union Pacific. The exercise focuses on performing again the market research part of the reports using the model presented above and publicly available information. The purpose is to use the model as a counterfactual scenario focusing only on operational profits to obtain a less biased estimate of expected profits. The market research baseline results are then subject to sensitivity analysis. Finally, the ex-ante and ex-post information is compared.

The route of the project follows that proposed by Judah in the Central Pacific preliminary survey reports and built by the first transcontinental railroad (see figure 17).[308] Expected construction cost is drawn from the Central Pacific project report. Construction of the full project was expected to cost almost $100 million and take about 10 years.[309] Since $13.3 million and 5 years are allocated to construction of the first stage, the remaining $86.7 million and 5 years are allocated to construction of the second stage (see table 8).[310] Entrepreneurs also expected to reduce construction cost by 33% to 50%.[311] Note construction of the second stage was simpler than that of the first stage. Grades were generally smoother and less and shorter tunnels were required (compared to crossing the Sierra). Not only the second stage was simpler but the credibility of expected construction cost reduction

[308] Judah (1861) pp. 1-30.
[309] Judah (1861) p. 29. The observed cost was $58.2 million.
[310] Construction cost and time also includes the track segment between Sacramento and San Francisco completing the full railroad to the Pacific Ocean and connecting directly with ships to and from China.
[311] See section 3.C. above.

must have also increased. Construction of the second stage may only be initiated after the first stage had been completed successfully (because the first and second stages were sequential). Additionally, completion of the first stage also reveals that construction cost has been predicted relatively well. Thus, technical uncertainty about building the simpler second stage must have decreased substantially.

The second stage project's life starts in year 6 of the full project (including the first stage) and ends in year twenty five. Costs are evenly spread over the five years. The market for transportation is composed of three submarkets: freight traffic in both directions between California and eastern United States (California trade), freight traffic in both directions between China and eastern United States (China trade), and passenger traffic in both directions between California and eastern United States (California passenger). Earnings arrive in year 11 and continue doing so for the rest of the project's life. The parameters characterizing construction costs, land values, observed demand, expected demand and operational costs are drawn, as for the first stage, from public sources like specialized press or government reports (see table 8).[312]

The model assumes that capital supply is elastic. As for the first stage, the discount rate is assumed to be 9% to account for the premium investors may charge in the face of market failure. The second stage was a substantially larger project than the first stage or any other infrastructure project undertaken in the United States at the time. About $70 million per annum was invested in railroad construction and the project would consume the equivalent of 12%-25% this capital (depending on the construction cost estimate used).[313] However, precisely during the second half of the 1850s and the 1860s the international market allocated substantial resources to the construction of the Suez Canal, a project of comparable scale. The Canal was funded using substantial capital provided mostly by small French private investors, while French investment bankers were excluded from the project and British and

[312] A detailed description of the data and sources included in table 4 is included in appendix 3.
[313] Fishlow (1965) p. 389 and Davis and Cull (2000) p. 751. Engerman (1972) also supports the view that capital market size was not a major limitation for developing the transcontinental.

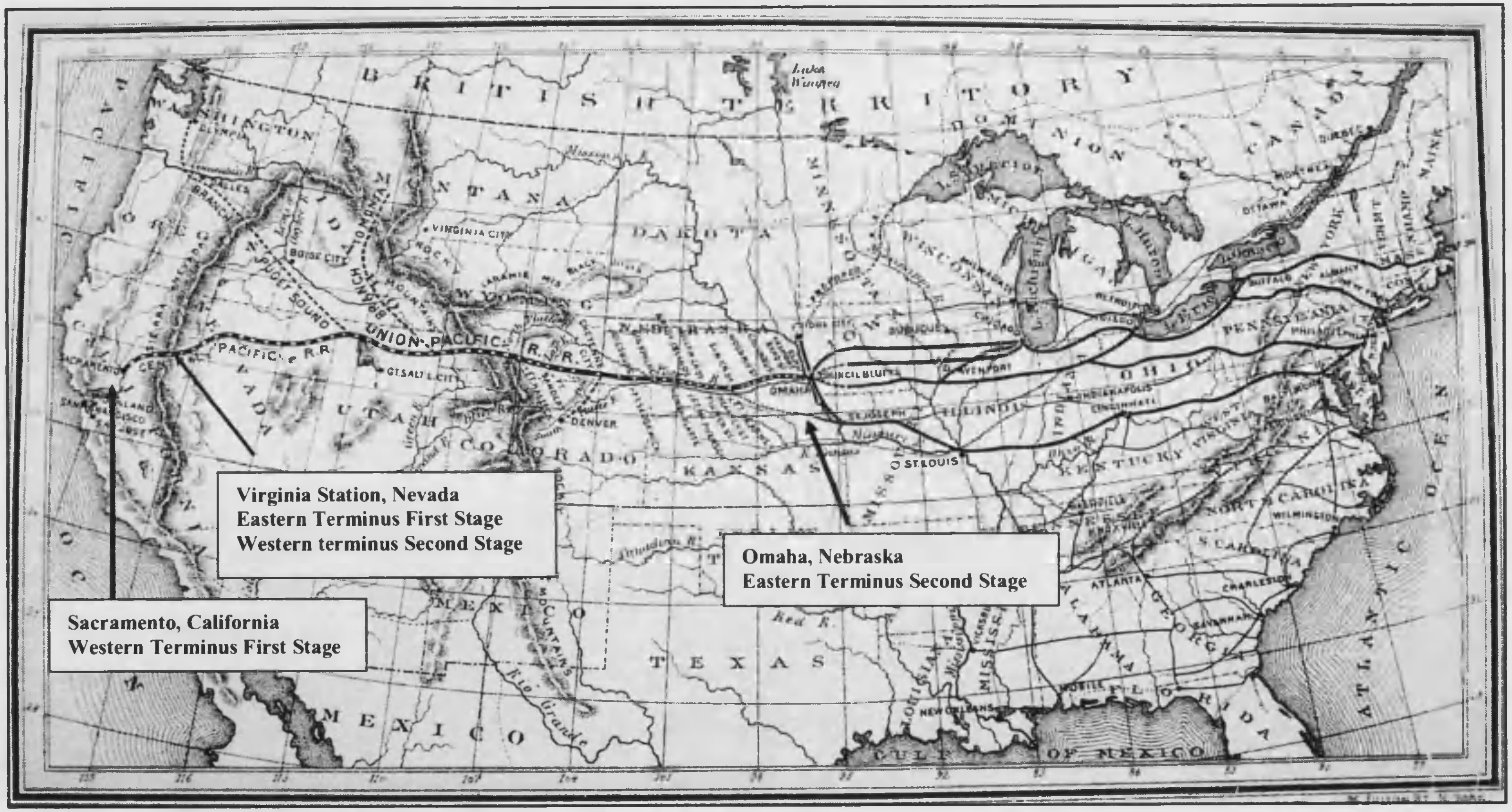
German investors boycotted it for political reasons.[314] Additionally, the first stage should have been capable of generating resources to transfer into the second stage and reducing the need for external financing. Thus, although funding the second stage must have been a tighter affair than financing the first stage, the international capital markets revealed to be large enough to accommodate it.

A brief discussion summarising the main differences between the data provided by the entrepreneurs in their reports and the data presented in tables 3 and 8 is important. First, the data in tables 3 and 8 indicates entrepreneurs reported similar observed prices to those reported by public or secondary sources. Thus, entrepreneurs seem to have identified correctly observed prices.

[314] Initially Lesseps expected French investors to buy 20% of the stock, other Europeans and Americans 54%, Egyptian government 16%, and African investors 10% (Schonfield (1939) p. 86). However, Britain's political opposition to the Lesseps project and the intent of assassination of Napoleon III led to low European subscription. Lesseps continued ignoring the French investment bankers, issued and sold more stock to small French investors and convinced the Egyptian government to increase its participation to complete the initial capital to $39 million (Farnie (1969) pp. 49-54, Fitzgerald (1876) pp. 119-125, and Kinross (1968) pp. 115-17). Further participation of French small investors and the Egyptian government completed the capital to pay for construction over-runs. In total French small investors bought more than $20 in stock and $6 million in bonds without government aid. French small investors also bought in 1868 an additional $13 million in lottery bonds guaranteed by government. The Egyptian government invested about $41 million. Small European investors completed the total costs that had grown to $87.9 million (nominal value at 1858 US dollar-GBP exchange rate) (Marlowe (1964) pp. 241-3 for sources of funding after initial stock issue, Farnie (1969) pp. 83-84 and Wilson (1977) pp. 44-45 for total construction cost). In short, more than $26 million was collected in the French capital market without government aid, an additional $13 million were also provided by French investors assured by government. Private investment could have been substantially higher had Lesseps not excluded French investment bankers from funding the project and the international political conditions been less tense. Finally, the Egyptian government also collected a substantial share of the funds it provided to the project by issuing bonds in the international capital market.

Figure 17.

Map of second stage of the Pacific Railroad



Source: Cisco (1868)

Table 8.

Summary of parameters, values, and comments for second stage

Parameter/Variable	Value	Source & comment
Expected construction cost	$86.7	Judah (1861) p. 29.[315]
Expected railroad distance	1,845 statute mile	Judah (1861) p. 29 expected In line with entrepreneurs.[316]
Construction time	5 years (starting in year 6)	Construction of Virginia City to Promontory Summit (Central Pacific 06/1868-05/1869) and Omaha-Promontory Summit (Union Pacific 07/1865-05/1869) took 4 years and 9 months.
Land fixed fee	1% construction cost	Fishlow (1965) and land prices in 1850
Project's life	25 years	Average of Fogel (1960) and Mercer (1982)
Discount rate	9%	Mercer (1982) Higher than 5-8% typically offered by railroad bonds
Observed traffic freight – NY-SF	147,392 tons/year	Berry (1984), Nimmo (1885) 50%-65% lower than entrepreneur info
Observed traffic freight – NY-Shanghai	79,849 tons/year	Report on Commerce and Navigation (1856-6) 50%-65 lower than entrepreneur info
Observed traffic passenger – NY-SF	44,102 passengers/year	Nimmo (1885) 60%-78% lower than entrepreneur info
Observed sail ship freight price – NY-SF	$16.83	SF Press (1856-60) In line with entrepreneur info
Observed sail ship freight price – NY-Shanghai	$17.49	SF Press (1856-60) In line with entrepreneur info
Observed sail ship passenger fare – NY-SF	$50.00	Chandler (2007) In line with entrepreneur info
Maximum observed freight price – NY-SF	$140.00	Otis (1860)
Maximum observed freight price – NY-Shanghai	$140.00	Otis (1860)
Maximum observed passenger fare –NY-SF	$252.64	Kemble (1943)
$\tilde{b}_{ij}$ (expected sensitivity of traffic to price)	Calibrated (see text)	
$\tilde{u}_{ij}$ (trading partners characteristics)	Calibrated (see text)	
Expected eastern railroad distance	850 statute miles	Distance between Omaha and 16 large eastern cities
Expected eastern railroad freight price – Omaha-average eastern city	$20.50	Poor (1860) 140% higher than entrepreneur info

[315] Bancroft (1890) p. 504 reviews various estimates and suggests $100 million with a lower bound of $70. The observed cost was $58.2 million.
[316] See Bancroft (1890) p. 504.

Expected eastern railroad passenger fare - Omaha-average eastern city	$14.96	Poor (1860)
Expected sea distance – Shanghai-SF	6,210 statute miles	
Expected sea freight price	$6.83	SF Press
Expected freight operational cost	$0.0118 ton-mile	Poor (1860) 136% higher than entrepreneur info
Expected passenger operational cost	$0.0088 per pass-mile	Poor (1860)

Second, entrepreneurs tended to report observed traffic as more than 50% higher than that identified through the use of public sources. The railroad operational cost reported by entrepreneurs was lower than that identified through the use of public sources. The pattern is stronger for the second stage than the first stage. It is not possible to know if entrepreneurs were making mistakes or deliberately overstated traffic and understated operational costs to predict higher social benefits and profits. However, that the mistakes always favoured higher profits and related to variables difficult to observe raises suspicions that the entrepreneurs overstated/understated these variables to predict higher profits and social benefits.

Using the model presented in the previous section and the information in table 8 allows solving the entry model for the second stage. The empirical results indicate the project should not have been expected to be profitable if expectations are based on the aggregate observed equilibrium. The observed all sea freight price per ton between San Francisco and New York is $16.83 while the expected eastern railroad freight price is $20.50. Thus, there is simply no room for the Pacific Railroad to charge a positive rate per ton-mile for the provision of transportation over its route segment. More intuitively, sail cost is about one tenth the cost of rail (0.11 cents to 1.18 cents), while the railroad route is expected to reduce distance to one fifth of the sail route distance (from 15,300 to 2,850).[317] The shorter distance of the rail route is not short enough to allow rail to compensate its cost disadvantage.

[317] The results for the China trade are analogous. The road does enjoy a small cost advantage for passenger traffic. The advantage is not enough to render the project profitable. Maximum operation profits are $700,000 dollars, but are not enough to generate a positive net present value.

The use of observed information on trade costs does not allow expecting the railroad to be profitable either. An estimate of the trade cost savings generated by the project and measured by savings in insurance, interest charges on working capital and foregone income is presented in table 9.

Table 9.

Value of time per ton or passenger in real dollars (1860=100)

	Freight		Passenger
	China	**California**	**California**
Time trade costs - via all sea			
Insurance ($ per ton/trip)	2.21		
Working capital interest ($ per ton/trip)	2.36		
Foregone earnings ($ per passenger trip)			25.00
Total costs ($ per ton/trip)	4.58	4.58	25.00
Time trade costs - via Pacific Railroad			
Insurance ($ per ton/trip)	0.34	0.00	
Working capital interest ($ per ton/trip)	0.65	0.27	
Foregone earnings ($ per passenger trip)			5.00
Total cost ($ per ton/trip)	0.99	0.27	5.00
All sea total cost			
Trade cost savings ($ per ton) (1)	3.58	4.30	20.00
Freight cost (2)	17.49	16.83	50.00
Total cost (3) = (1)+(2)	21.07	21.13	70.00
Maximum Pacific Railroad price			
ER price (4)	20.50	20.50	14.96
Canton-SF via sea (5)	6.83		
Maximum Pacific Railroad price (3)-(4)-(5)	-6.26	0.63	55.04

Sources: Average value per to of trade = (value of exports+value of imports)/(tonnage entered+tonnage cleared). Information for Total US export comes from series Ee533, total US imports from series Ee551, exports to China from series Ee546, imports from China from series Ee554. Value of California trade is not available. The value of China trade is assumed to proxy the value of California trade. The idea is reasonable in so far both regions trade with eastern United States luxury goods, like tea and silk. Information on insurance rates and working capital interest rates comes from Whitney (1849) p. 80, McDougall (1854) p. 865, and Nimmo (1885) p. 71. Information on time length of average trip New York-San Francisco comes from Berry (1984) p. 119. Information on expected time length of PR comes from Whitney (1849) p. 25 and McDougall 91854) p. 865. Information on value of time for passengers comes from Degrand (1849) p. 12 and McDougall (1854) p. 865.

The likely average savings the rail route may offer are not high enough to allow freight services to operate profitably. Insurance and working capital savings on the China trade are on average $4.30 for the typical ton traded. The value of the California trade is not available, and therefore it is not possible to estimate the expenses on insurance and working capital for this trade. The expenses for the China trade are used as a proxy for the California trade. The China trade probably underestimates slightly the total value of the typical ton of California trade, as it included mostly tea and silk, and only a portion of the California gold was exported to China. Thus, insurance and working capital expenses for the California trade may be slightly underestimated. Adding the value of insurance and working capital savings to the all sea route price gives $21.13. The eastern railroad price is $20.5. The difference between $21.13 and $20.5 is 63 cents, and gives the maximum price the Pacific Railroad can charge without making the total price of the rail route higher than the all sea route. The implied freight rate per ton-mile is 0.03 cents, substantially lower than the 1.18 cents per ton-mile operational costs. The Pacific Railroad had no room to enter freight services.[318]

Foregone income savings are high enough for the Pacific Railroad passenger services to be profitable. The Pacific Railroad may charge a fare of up to 2.75 cents per passenger-mile. Profit per passenger-mile is 1.87 cents and total through passenger profit is $1.6 million (assuming an inelastic price elasticity of demand). Passenger profits alone are not high enough to induce entry of the Pacific Railroad into the second stage, as the NPV is -$63 million. In short, if entrepreneurs form backward looking expectations they should not have expected the Pacific Railroad to be profitable.

However, at least some entrepreneurs formed their expectations in a forward looking manner. Specifically, the new good attributes of the rail route to be valued highly by merchants and passengers, they predicted traffic to grow fast, and construction costs to be lower than expected in the 1850s. Recall the entrepreneurs did not explain how they calculated the expected values for these variables. The next three paragraphs explain how some assumptions, the information available to entrepreneurs, and the equilibrium expected by the entrepreneurs is used to generate estimates of expected profitability of the second stage.

[318] The results for the China trade are analogous. See table 9.

First, entrepreneurs expected to charge high prices. The preliminary survey reports, and particularly the Union Pacific bond prospectuses, indicate entrepreneurs also expected the railroad to provide transportation with new good attributes.[319] The entrepreneur's decision problem is given by equation (3). Recall the demand function is inferred using the observed price and the maximum observed price. The observed price corresponds to an average price for transportation. The maximum observed price corresponds to the average for fast steamer price (freight) and for first cabin fares (passenger) on the Panama route (see table 8). The railroad's optimal price when entrepreneurs consider the new good attributes of the railroad is, thus, between the observed price and the maximum observed price.

Second, entrepreneurs expected market size to grow fast. The reports also indicate market size was predicted to grow fast, doubling soon after completion of the road.[320] Expectation on market size growth is implemented by allowing average traffic for the 15 years of operation of the second stage to vary pseudo-randomly between the observed level in 1860 and twice this level following a uniform distribution. The idea is that few investors would have expected market size to decline during the next 15 years as eastern United States and California increasingly integrate and China grows and integrates into the world economy. Some must have also expected the growing Japanese trade to go over the rail route. Thus, the lower bound must have been the observed market size. On the other hand, entrepreneurs may have been optimists and over-estimated expected growth, setting the upper bound on expected market size growth. Consequently, the interval for market size growth indicates the range of expectations investors may have held. Since indication of the distribution or the central tendency of investor's expectations in the range between market size observed in 1860 and market size expected by entrepreneurs does not exist, the uniform distribution is adopted.

[319] Cisco (1868) pp. 23-24.

[320] Entrepreneurs also mentioned the New York and Erie Railroad that originally planned to earn 3 million per annum in the 1830s and by early 1860s earned more than 15 million (Cisco (1868) p. 23-24).

Third, entrepreneurs expected construction cost to be reduced. Expected construction cost is implemented by allowing construction cost to vary pseudo-randomly between the expected value based on the mid 1850s army surveys ($86.7 million) and 50% of that value ($43.4 million) following a uniform distribution. The entrepreneurs declared to expect construction cost of the second stage to be between 33% and 50% lower than expected in the mid 1850s.[321] Again, the construction cost drawn from a uniform distribution represents the range of construction costs the entrepreneurs and investors may have held.

Next a Monte Carlo experiment is performed using the observed information contained in table 8, the intervals for expected traffic and construction cost indicated above, and the entry model to determine the optimal price and traffic. The experiment is repeated 2,000 times.

Results are presented in table 10. The baseline results indicate entrepreneurs should have expected profits from all three submarkets and a positive NPV for the second stage. The profit maximizing average freight price is $70 and average passenger price is $128; and predicted freight traffic is about 134,000 tons and almost 40,000 passengers per annum. Average annual profit for the California trade is $4.2 million, for the China trade $2 million, and for the California passenger submarket $4.3 million. The average NPV (that proxy the expected utility (payoff) criteria) is $3.5 million. Positive NPV is likely with 64.2% probability. Thus, if investor's expectations about future traffic growth and construction cost reductions are distributed uniformly between a very conservative point of no traffic growth or cost reduction and the level of traffic growth and cost reduction expected by the entrepreneurs, 64.2% of investors should have expected the second stage of the Pacific Railroad to be profitable. The operational cost ratio (operational cost/earnings) ranges 14%-35%, well below the maximum 50% suggested by entrepreneurs as acceptable in the 1850s. The annual profit over construction cost

[321] See section 3.C. above.

ratio is 9%, however, below the 15%-20% indicated by entrepreneurs as satisfactory. The sum of the NPV of first and second stage is $34.7 million.

Note that the single stage Pacific Railroad proposed by entrepreneurs during the late 1840s and 1850s could not have been expected to be profitable. The average NPV of the second stage is $3.5 million while the present value of the expected construction cost of the first stage ($13.3 million) is $10.8 million. Dividing the Pacific Railroad line into stages was indispensable for the venture to be expected profitable.

How sensitive are the results to the specific assumptions? The results do not seem too sensitive to specific values imposed on the range of each of the key variables (see table 10). Maximum observed freight prices may go down by 8.3% or passenger maximum observed prices may go down by 23.9% and the NPV is still positive. The expected market size growth interval's upper bound may be reduced to 70% growth of observed market size instead of doubling it and the NPV is still positive. Expected construction cost reduction's interval upper bound may be reduced to a maximum 35.7% construction cost reduction rather than 50% and the NPV is still positive. The shape of the demand curve may also change and the NPV is still positive. The linear demand function was replaced for a non-linear function below the linear function. Note earnings in the non-linear case are strictly lower that in the linear case. For instance, the kinked demand function D'-D'-D"-D" in figure 14 may be transformed into a discontinuous demand function such that if $\tilde{P}_{ij} \leq P_{ij} + B_{ij}$ then D"-D" rotates to the left on a fixed point given by the maximum observed price and traffic equal to 1 ($\tilde{P}_{ij} = \max P_{ij}$, $\tilde{q}_{ij} = 1$). Sensitivity analysis indicates the demand function can rotate to the left such that expected traffic may be reduced by 26.1% and NPV is still positive. Thus, the specific assumptions imposed on the upper bound of expected traffic, construction cost reduction, and maximum price are not only tightly based on the entrepreneurs declared expectations and data on observed willingness to pay revealed in the 1850s, but may also change moderately in the direction against profits and the road should still be expected to be profitable.

The baseline scenario is also robust to moderate changes in the rest of the parameters of the model (see table 11). The Monte Carlo experiment was performed now changing each of the other parameters of the model until the NPV became 0. The new good attributes of the rail route create monopoly power insulating the first transcontinental from competition via the all sea route. The all sea route price may be halved to \$8.40 and the average NPV is still expected to be positive. The complementary price (the price for rail service between the Mississippi and the eastern destination of traffic and the price of the Canton to San Francisco all sea trip) may go up by 26.3% and the average NPV is still positive. An alternative interpretation of the previous result is that the cost of transhipment at Omaha (and San Francisco for the China trade) may go up to \$7 per ton and the first transcontinental should still be expected to be profitable on average. As a benchmark consider in 1859 the cost of transhipment of the Baltimore-Ohio at Benwood, Ohio, was 0.29 cents per ton[322]. The operational costs may go up by 24.8% or the discount rate up by 13.8% and the average NPV is still positive.

Finally, Monte Carlo experiments allow an examination of the effects of a negative random shock on the project's expected profitability (following the same method as the Monte Carlo experiment in subsection 7.A.). The baseline scenario may be subject to a random negative shock of up to 8.3% on construction cost, operational cost, all-sea price, complementary transport price, and discount rate (all at the same time) and the average NPV is still positive with a probability of 50.3%.

The baseline scenario is also robust to some changes in the underlying probability distribution generating the negative shock. If the uniform probability distribution is replaced by the normal distribution results are in fact strengthened. However, if the uniform distribution is replaced with an asymmetric distribution, like the gamma

[322] Fishlow (1965) p. 66.

distribution, the quantitative results are weakened increasingly as the magnitude of the random shock increases. Given these negative random shocks are for all parameters and independently, and that the baseline scenario is a downward biased estimate of expected profits, the qualitative result that entrepreneurs should have expected the two stages of the Pacific Railroad to be profitable after 1859 is still a reasonable finding (see appendix 6.5.7 for details).

Table 10.

Monte Carlo experiment forward looking expectation of profitability

Scenario	Submarket	P $	Q Tons or passengers	PQ $	C $	Profit $	NPV 2^{nd} stage $ mlls	NPV full $ mlls	C/P*Q	Profit/CC
Baseline scenario	California freight	72	89,574	6,409,016	2,113,937	4,295,079			0.33	
	China freight	68	45,124	3,074,518	1,064,917	2,009,602	3.5	28.039	0.35	0.09
	California passenger	128	39,857	5,087,460	701,491	4,385,969			0.14	
Baseline & maximum observed freight down by 8.3%	California freight	66	87,269	5,741,074	2,059,555	3,681,519			0.36	
	China freight	62	43,500	2,713,121	1,026,594	1,686,527	0	24.562	0.38	0.08
	California passenger	128	39,857	5,087,460	701,491	4,385,969			0.14	
Baseline & maximum observed passenger price down by 23.9%	California freight	72	89,574	6,409,016	2,113,937	4,295,079			0.33	
	China freight	68	45,124	3,074,518	1,064,917	2,009,602	0	24.562	0.35	0.08
	California passenger	97	43,210	4,209,776	760,502	3,449,274			0.18	
Baseline & expected market size growth down from 100% to 73.8%	California freight	72	81,701	5,845,731	1,928,144	3,917,587			0.33	
	China freight	68	41,144	2,803,402	971,010	1,832,392	0	24.562	0.35	0.08
	California passenger	128	36,385	4,644,180	640,368	4,003,812			0.14	
Baseline & expected construction cost reduction down from 50% to 35.7%	California freight	72	89,574	6,409,016	2,113,937	4,295,079			0.33	
	China freight	68	45,124	3,074,518	1,064,917	2,009,602	0	24.562	0.35	0.09
	California passenger	128	39,857	5,087,460	701,491	4,385,969			0.14	
Baseline & rotation of demand reducing expected traffic by 26.3%	California freight	72	81,647	5,841,896	1,926,879	3,915,017			0.33	
	China freight	68	41,216	2,808,267	972,695	1,835,572	0	24.562	0.35	0.08
	California passenger	128	36,380	4,643,600	640,288	4,003,312			0.14	

Note: P: Profit maximizing price; Q: Total quantity of output in tons; P*Q: Revenue; C: Operational cost; Profit: Operational profit; NPV 2^{nd} stage: Net Present Value of second stage project; NPV full: Net Present Value of full project; C/P*Q: Operational cost over revenue; Profit/CC: Operational profit over construction cost. Baseline scenario is Monte Carlo experiment for traffic varying pseudo randomly between observed in 1860 and twice that level, expected maximum price varying pseudo randomly between observed maximum price and expected maximum price using observed value per day of transport time reduction in Clipper ships or Panama route and expected transport time reduction by Pacific Railroad , construction costs varying pseudo randomly between expected construction cost using army surveys and 50% that level.

Table 11.

Monte Carlo experiment sensitivity of forward looking expectation of profitability

Scenario	Submarket	P $	Q Tons or passengers	PQ $	C $	Profit $	NPV 2^{nd} stage $ mlls	NPV full $ mlss	C/P*Q	Profit/CC
Baseline scenario	California freight	72	89,574	6,409,016	2,113,937	4,295,079			0.33	
	China freight	68	45,124	3,074,518	1,064,917	2,009,602			0.35	
	California passenger	128	39,857	5,087,460	701,491	4,385,969	3.5	28.039	0.14	0.09
	China freight	68	41,216	2,808,267	972,695	1,835,572			0.35	
	California passenger	128	36,380	4,643,600	640,288	4,003,312			0.14	
Baseline & observed price down by 49.5%	California freight	72	83,735	5,991,252	1,976,142	4,015,110			0.33	
	China freight	68	42,076	2,866,881	992,997	1,873,884	0	24.562	0.35	0.08
	California passenger	128	35,122	4,483,037	618,149	3,864,888			0.14	
Baseline & observed complementary prices up by 26.3%	California freight	69	84,534	5,820,374	1,995,002	3,825,371			0.34	
	China freight	65	41,479	2,677,038	978,916	1,698,123	0	24.562	0.37	0.08
	California passenger	126	39,144	4,919,376	688,941	4,230,435			0.14	
Baseline & operational costs up by 24.8%	California freight	74	84,103	6,263,875	2,477,452	3,786,423			0.40	
	China freight	71	42,156	2,995,796	1,241,816	1,753,980	0	24.562	0.41	0.08
	California passenger	130	39,066	5,071,808	858,222	4,213,586			0.17	
Baseline & discount rate up by 13.8%	California freight	72	89,574	6,409,016	2,113,937	4,295,079			0.33	
	China freight	68	45,124	3,074,518	1,064,917	2,009,602	0	24.562	0.35	0.09
	California passenger	128	39,857	5,087,460	701,491	4,385,969			0.14	

Note: P: Profit maximizing price; Q: Total quantity of output in tons; P*Q: Revenue; C: Operational cost; Profit: Operational profit; NPV 2^{nd} stage: Net Present Value of second stage project; NPV full: Net Present Value of full project; C/P*Q: Operational cost over revenue; Profit/CC: Operational profit over construction cost. Baseline scenario is Monte Carlo experiment for traffic varying pseudo randomly between observed in 1860 and twice that level, expected maximum price varying pseudo randomly between observed maximum price and expected maximum price using observed value per day of transport time reduction in Clipper ships or Panama route and expected transport time reduction by Pacific Railroad, construction costs varying pseudo randomly between expected construction cost using army surveys and 50% that level.

It is also possible to learn about the nature of the results presented above by comparing the forecasted scenario to what was actually observed during the operation of the railroad. The best construction cost estimate available indicates total cost of the second stage was \$50.5 millions and of the full road \$64.6 million.[323] Construction cost was actually substantially lower than that expected by the army surveys, \$86.7 million. It is remarkable that such an important difference has not been pointed out by the existing literature. Part of the explanation possibly lies in that no previous work on the Pacific Railroad has identified carefully what the entrepreneurs expected at different times, and therefore cannot identify the surprisingly low cost of construction. The entrepreneurs invested intensively in surveying and learning about the topography over which the road was to be built. They expected the investment to pay-off in the form of substantially lower construction costs. A route with grades lower than 90 feet per mile and substantially lower construction cost was found. Construction cost was actually reduced to 58% of the army survey's estimate. Note the cost reduction came from all over the route, including the Central Pacific part, not only the pass over the Rockies, as indicated by Fogel.[324]

The information in table 12 compares the baseline scenario and the average observed market outcomes during operation 1870-84. The baseline scenario predicts the weighted average freight price is \$70 and traffic close to 134,000 tons for the first transcontinental railroad. Predicted passenger price is \$128 and about 39,000 passengers per year. The observed market outcomes indicate an average freight price of \$41 and almost 247,000 tons traffic per annum for the first transcontinental and more than 528,000 tons traffic for the total California and China trades. The passenger fare was \$52 and traffic over 89,000 passengers per year. The baseline scenario predicts higher prices and lower traffic than the observed market outcomes.

[323] Construction cost from Mercer (1982) plus necessary repairs for \$6.5 million demanded by government commissioner Snow after evaluating the road to grant last batch of subsidies is 1869 (Snow (1869)).
[324] See Durant (1866) and Dodge (1867) for a description of the advantages of the improved route.

Table 12.

Comparison of baseline scenario and average observed market outcomes 1870-84

Scenario	Submarket	P	Q	Market share	Profits	NPV 2nd stage
Simulation - baseline scenario						
	Freight California	72	89,574		4,295,079	
	Freight China	68	45,124		2,009,602	
	Freight total	70	134,697	26	6,304,680	
	Passenger California	128	39,857	41	4,385,969	3,477,113
Simulation - using *ex-post* traffic, maximum price, and construction cost						
	Freight California	45	109,471		2,292,768	
	Freight China	41	49,590		869,266	
	Freight total	43	159,061	30	3,162,034	
	Passenger California	92	64,500	67	4,804,893	1,378,596
Observed outcome						
	Freight total	41	246,645	47	n.a.	
	Passenger total	52	89,463	93	n.a.	

Source: Rail route freight price and traffic from Mercer (1982)

There are two main reasons why the baseline scenario predicts higher price and lower traffic. First, when the observed outcomes are compared to the baseline scenario it appears the baseline uses a conservative range for expected traffic and construction cost, while it uses a higher range for expected maximum price. The baseline scenario used an expectation of traffic varying on a range between the level of observed traffic in 1860 and a maximum of twice that level, with a mean expected average traffic of 1.5. The average traffic 1870-84 for the California and China trades was actually 2.3 times the traffic observed in 1860 and 2.19 for California passenger traffic. Construction cost in the baseline scenario varies between the figure suggested in the army surveys and 50% of it, with a mean expected construction cost of 75% of the army surveys. The observed outcome was 58% of the army surveys.

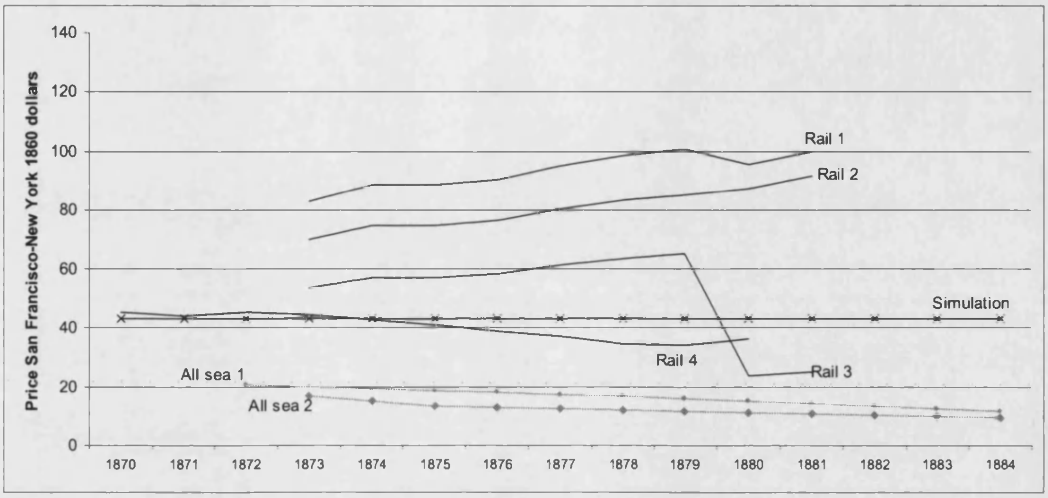
Once the average 1870-84 traffic, the actual construction cost are used, and the observed average price on the Panama route in the 1850s are input the model's predictions come closer to the observed outcomes (see table 12 simulation using observed traffic growth, maximum price and construction cost). The predicted profit maximizing price for freight declines to $43, and relatively close to the $41 observed outcome. Predicted freight traffic via rail increases to more than 159,000 tons a year. The profit maximizing passenger price declines to $92, still higher than the observed average price 1870-84, $52. Predicted passenger traffic increases to 64,000. The NPV of the second stage under these assumptions is $1.3 million. In short, the baseline scenario is off the observed outcome partly because it is based on very conservative assumptions about growth of market size and construction cost reductions. The entrepreneurs' expectations happened to be not that far from the actual outcome and our efforts to control for any potential optimism or intent to lie in their stated expectations led to using too conservative a set of assumptions, leading to forecasting too high prices and too low traffic.

Second, the reports written by the entrepreneurs performed a simplified analysis of the investment opportunity. The framing of the problem abstracted differences between commodities. But once the railroad was built, the entrepreneurs did consider these differences and set different prices for different commodities. Figures 19 and 20 show some of the different prices set by the first transcontinental route San Francisco-New York for different commodities. The price predicted by the model is in between the low and high rail route prices. Thus, the entry decision model seems to capture relatively well the aggregate pricing problem the entrepreneurs faced in the 1850s, but its predictions are weakened because it does not consider price discrimination between commodities. An important characteristic of price discrimination pricing is that it may lead to increasing total output.[325] Thus, price discrimination may also explain why the model predicts a relatively lower level of traffic compared to observed traffic 1870-84.

[325] Varian (1985)

Figure 18.

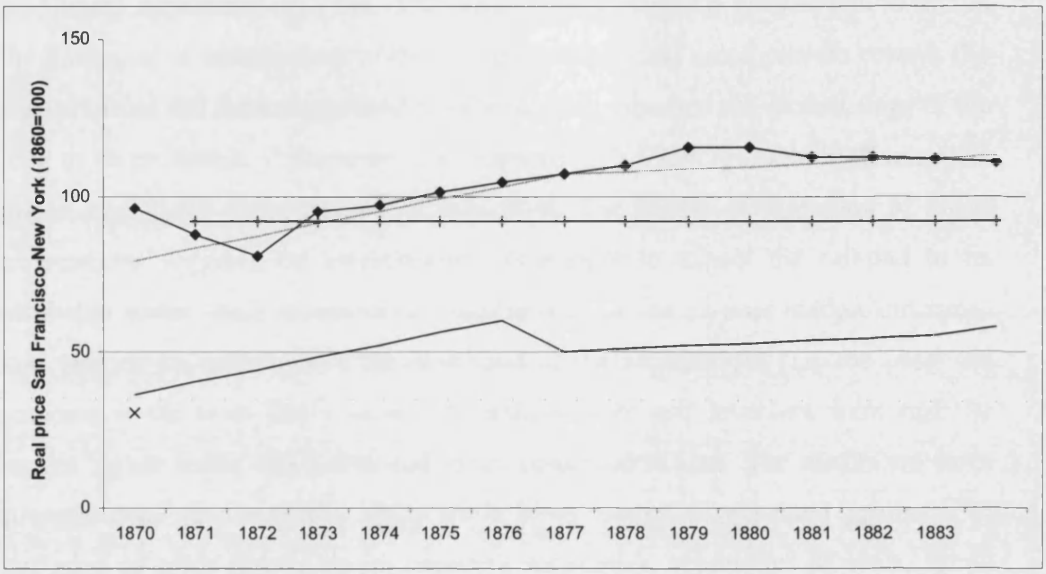
Freight price for all sea, Clipper ships, Panama route, simulation and Pacific Railroad



Source: All sea 1: Kaukianen (n.d.) p. 3 of statistical annex for 1873, 1880, and 1885; the series was completed by interpolation. All sea 2: Harley (1988) p. 864 for 1873, 1875, and 1890; the series was completed by interpolation. Rail 1: Aldrich (1893) pp. 593 Dry goods & glass ware. Rail 2: Aldrich (1893) pp. 593 Cotton goods, hides, leather. Rail 3: Aldrich (1893) pp. 593 Canned goods and starch. Rail 4: Mercer (1982) implicit average freight rate.

Figure 19.

Passenger price for all sea, Panama route, simulation and Pacific Railroad



Source: All sea 1: Degrand (1849) p. 12, 2nd class average for Panama, Cape Horn and Magellan Straight routes. All sea 2: Degrand (1849) p. 12, 1st class average for Panama, Cape Horn and Magellan Straight routes. All sea 3: McDougall (1854) p. 865, average for sea and overland routes. Panama 1: Chandler and Potash (2007) p. 12, 1st cabin. Panama 2: Chandler and Potash (2007) p. 12, 2nd cabin. Panama 3: Chandler and Potash (2007) p. 12, steerage. Panama 4: Fisk and Hatch (1867) p. 24, Fisk and Hatch (1868) p. 26, and Cisco (1868) p. 23. Panama 5: Nimmo (1885) p. 126, cabin. Panama 6: Nimmo (1885) p. 126, steerage. Rail 1: Nimmo (1885) p. 132, 1st class. Rail 2: Appleton's Railway and Steamship Guide of the United States and Canada (1869), emigrant class. Deflator: CPI index David (1977).

Another important abstraction performed by entrepreneurs when developing their market research before building the railroad is that other potential sources of traffic were not included in the quantitative forecast. Trade on sugar from Sandwich Islands and tea and silk from Japan diverted completely and permanently from the Clipper ships to the rail route once the Pacific Railroad was operating, after 1869.[326] If these important additional sources of traffic are included the model's predicted price will reduce still further and traffic on the Pacific Railroad increase further, helping to explain better the observed market outcome.[327]

[326] San Francisco Chamber of Commerce Annual Report 1873-1885.

[327] Note the average traffic growth of 2.3 times the traffic observed in 1860 is only for traffic on rail through traffic plus commerce transported via shipping between eastern United States and California and eastern United States and China

Summing up, utilizing the conventional way entrepreneurs used to frame railroad investment opportunities in the 1850s and publicly available information to model the formation of expectations of the first transcontinental entrepreneurs reveals the entrepreneurs and the average investor should have expected the second stage of the road to be profitable. Entrepreneurs anticipated high traffic growth, high transport prices, and likely construction cost reductions. The model of formation of profit expectations suggests the entrepreneurs were right to expect the railroad to be profitable under these assumptions. Additionally, if the *ex-post* market outcomes also provide an indication of the likelihood of the expectations (i.e. the observed outcome is the most likely to occur), entrepreneurs and investors were right to expect higher traffic and prices and lower construction cost. The results are even stronger once one considers these are a lower bound of expected profits. The inclusion of price discrimination, network economies, economies of scale, scope and density or other sources of earnings not included in the analysis should lead to even higher expected profits.

6.4. Implications: The land grant debates and the Credit Mobilier Scandal

The evidence presented earlier in chapters 3 and 4 and in this one has important implications for our understanding of some other important events in American economic history. The evidence allows a reinterpretation of the land grant debates and suggests a new hypothesis on the origins of the Credit Mobilier scandal.

In the late 1840s and 1850s trade to and from the Pacific Ocean boomed. Additionally, entrepreneurs learned that merchants and passengers value transport time reductions highly. Rapid demand growth and high prices indicated profit opportunities from transporting trade to and from the Pacific Ocean. Once silver was found in the Washoe region and entrepreneurs divided the project into two stages, the project's profitability became more certain. The evidence indicates that when the Pacific Railroad Act was passed in Congress in 1862, entrepreneurs had already performed the private surveys necessary to take the first stage of the project to the capital market. The project's size and expected profits were comparable or better than those of the typical 1850s project. Thus, the evidence strongly suggests the first stage of the Pacific Railroad could have been built privately, without recourse to government subsidy of any sort.

The engineering survey for the second stage had not been completed in detail by 1862. It is likely entrepreneurs would learn about construction cost of the first stage and explore the terrain for the second stage while building the first stage (as it actually happened with the Central Pacific entrepreneurs). Thus, entrepreneurs should have gained enough information to realize that the construction cost had been overestimated by the army surveys. Once entrepreneurs expected i) rapid traffic growth in the California and China trades, ii) rail users to value time savings highly, and iii) reduced construction costs, the second stage should have been expected to be profitable.

These results have important implications for the land grant debates. For a normative cost-benefit analysis to evaluating government intervention in the construction of the Pacific Railroad (as proposed implicitly by Fogel and explicitly by Fishlow and Mercer) the first criteria to evaluate whether a project should receive public aid to promote its private construction is its ex-ante expectations of profit. If ex-ante profits are lower than the opportunity cost, public aid is appropriate, so long as the net social benefits are higher than the opportunity costs. If ex-ante profits are higher than the opportunity cost, public aid is not necessary to promote private construction of the railroad[328]. The results presented in this thesis indicate market incentives to build the Pacific Railroad were expected to be high enough to render ex-ante profits higher than the opportunity cost and so to induce entry of entrepreneurs to build the railroad privately. The entrepreneurs stated that they expected the Pacific Railroad to be profitable. The empirical entry model indicates entrepreneurs were right to expect profits from building and operating the

[328] See Fogel (1960), Fishlow (1965) and Mercer (1982), and chapter 2 of this thesis.

railroad. Contrary to what Fogel and Mercer conclude, the results presented in this thesis indicate that from a normative point of view public aid was not necessary to promote private construction of the first transcontinental railroad.

The evidence analyzed in this study, however, also highlights the importance of considering other factors to improve our understanding of the Pacific Railroad Act and the land grant subsidies. It is interesting to discuss not only whether the Pacific Railroad Act and the railroad land grants were efficient subsidies, as much of the existing literature discusses, but also why we observe government intervention and subsidies at all given the evidence that indicates the railroad was expected to be profitable[329]. Three different arguments may explain why we observe subsidies.

First, the positive profit expectations identified in the declared expectations and the entry decision model refer to a project building the two proposed stages of Pacific Railroad sequentially. The Pacific Railroad Act of July 1 1862 allocated the right of way to two companies, the Central Pacific and the Union Pacific, promoting simultaneous construction from both[330]. The July 3 1866 amendment of the Act allowed the Central Pacific to continue building east of Nevada, promoting competition between both companies for the loan resources, land grants, and future earnings[331]. By promoting simultaneous construction and competition the Pacific Railroad Act possibly accelerated the arrival of the social benefits associated to the full Pacific Railroad. The point is important for several reasons. The projected two stages of the railroad may have not been built immediately one after the other. Moreover, even if the gold rush in Colorado and the California and Asian trades were expected grow rapidly, providing strong inducement to private investment building the second stage, it is still possible that construction of the second stage

[329] For the debates on the efficiency of the loan subsidy and the land grants or the efficiency of alternative policies see Carstensen (1963), Engerman (1972), Fleisig (1974 and 1975), Fogel (1960), Lebergott (1966), McClelland (1972), Mercer (1982) and chapter 2 this thesis. The debates reflect even in the major textbooks in American economic history, as each of the major textbooks has a different position regarding the efficiency of the land grants - see Atack and Passell (1994), Hughes and Cain (2003) Walton and Rockoff (2005).
[330] Government Printing Office (1897).
[331] Government Printing Office (1897).

may have been divided into more stages, delaying the arrival of the social benefits. Construction costs of the second stage was still high (even though it was comparable to large transport projects funded in the international capital market in the 1850s and 1860s); and it may have strengthened any incentives the entrepreneurs faced to divide the second stage into more stages. Thus, dividing ownership and setting a construction race seems to have been a virtue of the Pacific Railroad Act overlooked by most of the existing literature on the subject.

Second, the Pacific Railroad was actually built between 1863 and 1869. Construction during this period coincided with the Civil War and reconstruction. The Civil War crowded out private investment in the local capital market and effectively closed access for American entrepreneurs to the international capital market. Under these circumstances subsidies may have been a substitute for a highly distorted capital market. Note, however, that the argument here is that because of the Civil War coincided with actual construction subsidies may have been necessary. But the timing of the Civil War and that of construction are not necessarily connected, it is only a coincidence both occurred at the same time. This argument provides only a circumstantial basis for subsidies.

Third, the political economy of the project had two important implications for the private investment decision. i) The entrepreneur's decision to invest to produce a preliminary survey was affected by the political deadlock experienced in Congress. Incentives to invest in a survey are by definition risky (the outcome of the survey may be that a good route to build the railroad exists or may be the reverse). However, if the project requires Congress to agree and grant the right of way (as it did), and experience indicates there is an intense political conflict in Congress over the distribution of benefits and costs derived from the project leading to a political deadlock (as there was), then the political deadlock will have an important negative effect on incentives for private investment. Thus, even if we do not observe the entrepreneurs investing in the preliminary survey, it does not necessarily mean that market incentives are not high enough to induce entry (and subsidies are necessary to promote private construction of the railroad).

ii) The entrepreneur's decision to invest in performing the preliminary survey and building the railroad may be affected by the risk of expropriation. If an entrepreneur has to reveal the results of an expensive survey to pass the project through Congress, but may risk Congress allocating the project to another entrepreneur for political reasons, in practice the entrepreneur faces the risk of expropriation of the returns to its investment. The geographical specificity of the survey probably protected the Pacific Railroad entrepreneurs, as a southern entrepreneur could not use the results of a survey of a northern route to build a southern route. If an entrepreneur faces the possibility of a change in the political equilibrium affecting its possibilities to appropriate future profits derived from operation of the project, in practice entrepreneurs face the risk of expropriation. This was probably a key issue as entrepreneurs knew the right to profit from operation of the railroad during two decades after construction finished was indispensable for the project's profitability. In turn, it is possible that even if a Pacific Railroad project passed through Congress, as the political equilibrium changed in the next three decades, the railroad entrepreneurs would be exposed to expropriation of future profits through regulation or actual expropriation. The clearest example of this is the situation for the Central Pacific entrepreneurs when lobbying to pass the Pacific Railroad Act of 1862. If the right of way was granted to the Central Pacific (as it actually was), the entrepreneurs faced the risk that the Union lost the Civil War and the South would expropriate them from their future profits either through regulation or actual expropriation of their property rights.

The effects of political risk on reducing the incentives for private investment are not a new insight[332]. However, the evidence presented in this thesis does highlight a new insight: under circumstances of political risk entrepreneurs have incentives to

[332] The identification of these effects come from different fields in economics, ranging from economic history (North (1981)) to growth empirics (Barro (1991) or Alesina (1992))

lobby for subsidies to profit as highly and as rapidly as possibly to reduce the risk of expropriation. All of the preliminary surveys examined in chapters 3 and 4 indicate entrepreneurs expected the railroad to be profitable and also i) highlighted the risks the political conflict implied over the project and ii) requested subsidies. The Central Pacific entrepreneurs stated the railroad was expected to be profitable and lobbied to pass the Pacific Railroad Act of 1862, emphasizing as much on the right of way as on subsidies.

The insight is important for two different reasons. First, it allows a reconciliation of apparently contradictory evidence. On the one hand, entrepreneurs continuously claimed the railroad that they expected the railroad to be profitable by running transportation services (an expectation supported by the empirical entry model presented in this chapter). On the other hand, entrepreneurs requested subsidies (and what is most striking Congress granted them). Recognizing that political risk existed and that entrepreneurs may lobby to get subsidies to insure against this political risk allows us to make sense of the entrepreneur's expectations as stated in the preliminary survey reports, the fact that government actually granted the subsidies, and the results of the empirical entry model presented in this chapter. Thus, the insight makes sense of the Pacific Railroad's history and the railroad land grant legislation.

Second, this insight allows for a different argument for why we observe subsidies in real world. A first argument explaining subsidies is that government provides them based on normative criteria to induce private investment in projects that provide public goods (positive externalities). The idea that political intervention may fix market failures assumes political markets work relatively well[333]. A second argument is that entrepreneurs lobby government to set regulations that allow their businesses to capture monopoly rents (subsidies). The idea is that political failure

[333] The formal analysis of public goods was first provided in Samuelson (1954).

may induce even larger market failures[334]. The nature of the argument proposed here is entirely different: entrepreneurs lobby for subsidies to achieve insurance from political risk. The market works but the political market does not. Entrepreneurs lobby and allow society to overcome the political market's failure. The conditions under which the optimal outcome (markets and government work) is attainable and how much less efficient is the outcome identified here are matters for important further empirical and theoretical analysis.

In sum, although entrepreneurs declared that they expected the Pacific Railroad to be profitable, government intervened. Government granted the necessary right of way. But government also went further, and promoted private construction of the railroad through the Pacific Railroad Act Congress passed in July 1 1862 and its subsequent modifications by dividing ownership of the road into two railroad companies, setting a construction race between the two companies, and allocating a subsidized loan and land grants to each company. Three reasons may explain government's intervention. First, the Pacific Railroad Act facilitated coordination of construction of the whole railroad line by dividing ownership and setting a construction race between the Central Pacific and the Union Pacific, promoting simultaneous and rapid construction of the Pacific Railroad. Second, the capital market was severely affected during the Civil War and reconstruction; subsidies substituted for a well-functioning domestic and international capital markets. Third, the Pacific Railroad generated positive and negative externalities and a political conflict over the distribution of these externalities existed; entrepreneurs lobbied for subsidies to insure against future changes in the political equilibrium and the risk of expropriation.

Finally, the evidence presented in this thesis also allows the formulation of a new hypothesis on the origins of the Credit Mobilier scandal. Recall that the scandal erupted when the press revealed the promoters of the Union Pacific had bribed

[334] The formal analysis of interest groups incentives to influence government actions was first provided by Posner (1975) and Stigler (1971)

congressmen in 1864 to increase the frequency of allocation of the subsidized loan and the rights over natural resources included with the land grants (the July 2 1864 amendment to the Pacific Railroad Act)[335]. Congress organized two investigations. The official verdict was that two congressmen received bribes and the Union Pacific entrepreneurs used the Credit Mobilier to profit from construction of the Union Pacific rail infrastructure in a way that was not legitimate. The Credit Mobilier charged construction prices for the Union Pacific far higher than actual construction cost. Most argue this behaviour was explained by the Union Pacific entrepreneurs' moral traits. Fogel argues that the incentives contained in the Pacific Railroad Act led rational economic agents to behave in the observed manner. He argues this could have been avoided had the government constructed the railroad itself[336]. The political risk argument discussed above provides an alternative explanation for the Union Pacific entrepreneurs' behaviour. Given the political risk it was rational for entrepreneurs to seek to profit from construction rather than from operation. Note that political risk is a different argument from badly designed government interventions. Independently of the instrument(s) used by government to intervene, the risk that government's decisions regarding the railroad would change (as a consequence of the political conflict over the distribution of benefits and costs derived from the project or once the Civil War was finished) remained. Additionally, it is also possible that since entrepreneurs reduced their forecasts of construction costs and actually these cost savings, they also were able to take the "money left on the table". Entrepreneurs must have been tempted to appropriate the results of route improvements and construction cost reductions in an environment where monitoring accountancy was made difficult by the effects of Civil War inflation. In short, entrepreneurs faced incentives to profit from construction (in addition to operation) and appropriate the returns from route improvements, and their response to these incentives may have set the Credit Mobilier scandal in motion.

[335] Klein (1987) pp. 291-4

[336] Klein (1987) pp. 291-4 reviews the literature on greed. Fogel (1960), assuming the Pacific Railroad was not expected to be profitable, proposes that the Pacific Railroad Act should have allocated construction to government and operation also to government until it was clear it was a privately profitable venture.

6.5. Conclusions

The examination of entrepreneur reports and secondary sources on the history of the Pacific Railroad revealed the entrepreneurs expected the road to be profitable. Since the late 1840s entrepreneurs showed interested in investing and developing the Pacific Railroad to profit from transporting the booming trade with the Pacific Ocean and its high valuation for transport time reduction. The development of the Washoe mining trade in the late 1850s strengthened the inducement to private investment in the Pacific Railroad. Next entrepreneurs divided the project into two stages and performed the necessary non-negligible investments to reduce uncertainty of the first stage to a level comparable to that of the typical 1850s railroad investment project. The second stage seemed like a good investment opportunity, and entrepreneurs also showed interest in reducing its technical uncertainties. But can we believe the entrepreneurs?

In this chapter an alternative estimate of the Pacific Railroad's expected profits controlling for the perverse incentives the entrepreneurs faced is developed. The estimate is drawn from an empirical entry decision model based on the methods the 1850s railroad entrepreneurs used to evaluate railroad investment opportunities and information publicly available. The empirical model helps to understand better the incentives the entrepreneurs faced to develop the Pacific Railroad as a private venture.

The model confirms the intuition the entrepreneurs described in their projects. Once it was possible to divide the project into two stages and it was likely both stages turn out to be profitable. If the prices and traffic observed by the entrepreneurs and the secondary sources examined are correct, the first stage of the Pacific Railroad should have been expected to be highly profitable. The prediction is robust to substantial changes in the entry model.

The entrepreneurs that formed their expectations for the second stage in a forward looking manner should have expected the road to be profitable. Entrepreneurs predicted rapidly growing traffic, high willingness to pay for transport time reductions, and construction cost reductions. Given these expectations, the entry model indicates the second stage should have been expected to be profitable. The sensitivity analysis indicates the empirical entry model's predictions have a moderate room for mistakes and some hard luck, and the project should still have been rendered profitable.

The comparison of the entry model predictions and the observed outcomes of the project indicates the entrepreneurs were right: traffic grew fast, merchants and passengers paid higher prices to reduce transport time to the Pacific Ocean, construction cost was substantially lower than expected by the army surveys and the railroad was profitable. The entry decision model indicates that entrepreneurs were indeed right to declare to expect profits.

Interestingly, although entrepreneurs declared to expect the Pacific Railroad to be profitable, the Pacific Railroad Act Congress passed in July 1 1862 included a subsidized loan and land grants to promote private construction of the first transcontinental. There are two reasons why Congress granted these subsidies. First, the capital market was severely affected during the Civil War and reconstruction; subsidies substituted for a well functioning domestic and international capital markets. Second, the Pacific Railroad generated positive and negative externalities and a political conflict over the distribution of these externalities existed; entrepreneurs lobbied for subsidies to insure against future changes in the political equilibrium and the risk of expropriation. Finally, the Pacific Railroad Act also facilitated coordination of construction of the two stages of the railroad line by dividing ownership and setting a construction race between the Central Pacific and the Union Pacific, promoting simultaneous and rapid construction of the Pacific Railroad.

In sum, analysis of *ex-ante* information performed here indicates entrepreneurs did expect the Pacific Railroad to be profitable and they were right to do so after 1859, when the project was divided into two stages. The key sources for profits identified are: i) technological advantage over wagon roads for the first stage, ii) rapid transport demand growth on the back of mining booms, the relatively fast growth of international trade and the fast integration between eastern and western United States, iii) new good attributes of the rail route generating market power and allowing to charge high transport prices to transport to and from the Pacific Ocean, and iv) little initial knowledge of the topography of the West and rapid accumulation of this knowledge, allowing to improve the location of the route and reducing substantially construction cost.

6.5 APPENDIX TO CHAPTER 6

Detailed description of information to input model of formation of expected profitability

6.5.1. Definition of the investment opportunity

The Pacific Railroad project evaluated here is to build a railroad from San Francisco bay east to Omaha. The railroad route to be followed is the one proposed by Judah in 1861. This route was in fact roughly followed by the Central Pacific and the Union Pacific railroads when actually built.

First Stage

The first stage of the Pacific Railroad is performed is to build a road from San Francisco bay to the east to Virginia Station, Nevada. Local traffic is developed when the railroad reaches the Washoe mining camps at Virginia Station. Expected profitability of the first stage is assessed.

Second stage

Construction then may continue to Omaha. Local earnings support construction into the desert, across the Rocky Mountains, and into the prairie to Omaha. When Omaha is reached, the Pacific Railroad connects to the eastern railroads and makes it possible for through traffic to flow over the Pacific Railroad and into the eastern seaboard. After reaching Omaha the railroad enjoys through traffic earnings from the Californian and Chinese trades. The two stages are then put together into a single project and expected profitability of the project is assessed.

The rest of this section presents the specific values of the parameters to be used in the model to predict operational profits and evaluate the investment decision. Each parameter of the model is determined using information publicly available before construction of the railroad started. The purpose of this restriction is to continue with the ex-ante spirit of the exercise. Additionally, when an expectation of a parameter is required it is produced in the following two steps. First, examine the information available before construction and determine the appropriate observed value. Second, consider whether the entry of the Pacific Railroad was likely to change the value of the parameter and in what way. Following this process the resulting expectation is more than a simple adaptive expectation as it is also based, to some extent, on forward looking information.

6.5.2. Route and construction schedule and costs

The precise Pacific Railroad project to be evaluated follows the one proposed by Judah in his 1861 and 1862 reports. The actual route proposed by Judah went from Sacramento to Omaha and roughly coincides roughly with that in figure 17 (included in the main body of this chapter) and actually built by the Central Pacific and Union Pacific railroads.

The data on expected construction costs comes from the entrepreneur's reports. The first stage of the Pacific Railroad, between Sacramento and Virginia Station, was expected to be 155 miles and cost roughly $13.3 million.[337] These two figures for expected distance and construction cost were used in this exercise. Construction to Nevada is assumed to take five years. The only *ex-ante* information available about expected construction time indicates it was higher than two and a half year. Actual construction took about five years to open the railroad to Virginia City, and this expected time is used given not alternative one is available. Construction costs were evenly spread over the five years of construction. Local traffic earnings are assumed to arrive on the sixth year, once construction to Nevada is finished, and continue flowing until the project's life finishes.

---

[337] Judah (1861) p. 34. The observed cost was $14.1 million (Mercer (1982) p. 154 (see details below).

The full Pacific Railroad was expected to be about 2,000 miles, cost around $100 million and to take 10 years.[338] For the purposes of the simulation, the second stage of the Pacific Railroad was assumed to be 1,845 miles (including construction of the San Francisco/Oakland-Sacramento segment of the road) and to cost $86.7 million. Cost is spread evenly over the second set of five years.[339] The most difficult and expensive construction effort, crossing the Sierra Nevada, would take most of the first stage and first five years of construction. Once Nevada was reached the terrain was relatively easy for construction and it was possible to accelerate building speed and expenditure per year. Even though the crossing of the Wasatch and Rocky Mountains was not expected to be an easy task, it was certainly expected to be substantially easier than crossing the Sierra Nevada. The grades were generally smoother and substantially less and shorter tunnels were required than over the Sierra. After crossing the Rocky Mountains, a slow and long descent to the Missouri River valley follows. Construction over this stretch was expected to be relatively easy and cheap. After finishing construction to Omaha (and the Oakland-Sacramento rack) in year 10 the entrepreneur stops construction and simply operates the railroad line between Sacramento and Omaha for a period of time. Actual construction time was four years and nine months.

The Pacific Railroad project is assumed to have a life of 25 years. The first five years would involve construction of the first stage. Local earnings would start at the sixth year. The next stage would be completed by year 10. Through earnings would start at the eleventh year. The railroad then operates for 15 years. Fogel and Mercer used an operation life of 10 and 20 years in their evaluations of the social savings of the Central Pacific and Union Pacific, thus 15 years is a reasonable average of the two.[340] The purpose of this assumption is to simplify the problem by limiting the time period considered and avoiding entering into issues of developing a railroad system, as both the Central Pacific and the Union Pacific actually did. Since this

[338] Judah (1861) p. 29 and Bancroft (1890) p. 504 reviews various estimates and suggests $100 million with a lower bound of $70. The observed cost was $58.2 million.
[339] The extension between Sacramento and Oakland, in the San Francisco Bay, was completed by November 1869 (six months after inauguration of the Sacramento-Omaha railroad).
[340] Fogel (1960) p. 96 and Mercer (1982) p. 236.

assumption biases expected profits downwards by limiting the growth potential for the railroad, it is consistent with the lower bound expected profits proposed.

The costs and earnings experienced are discounted at 9%. Mercer calculated the observed opportunity cost of capital for the two Pacific Railroad railroads as 9%.[341] The typical railroad bond issue would offer a 5%-7% interest and when the railroad bonds of the Central Pacific and the Union Pacific railroads were issued they offered 6%.[342] Thus, 9% is a relatively high opportunity cost for the project. A high discount rate guarantees the estimate of expected profits is a downward biased estimate of the true value of expected profits, and is consistent with the research strategy adopted in this study.

Finally, the right of way, as explained above, is assumed to be available to be bought for a fixed fee. The purpose is to abstract from the difficult political economy of the project. The value of the fixed fee is set considering the market value of land. Recall most of the land between Sierra Nevada and the Rocky Mountains had not been settled and except for the gold rush regions in Nevada and Colorado, and Salt Lake City, little economic activity took place in the region crossed by the railroad. Thus, the value of the land is difficult to assign because of the lack of market activity in the region, but it must be low.

Some observations of land prices do exist. Congress made an offer to Asa Whitney to sell the land he requested in his project at 16 cents per acre.[343] Assuming a price of 16 cents per acre and that the right of way required a land strip of 208 feet wide (the length of one side of an acre) by 2,000 miles long gives $8,095 dollars.[344] A right of way 208 feet wide is ample enough to include the necessary complementary infrastructure like stations, buildings, and repair shops. A price for land of 16 cents

[341] Mercer (1974) p. 499.
[342] See Poor (1960) p. 282 and p. 472 for examples of railroad bond issues in the 1850s.
[343] Whitney (1848) p. 3. He requested a price of 12 cents.
[344] An acre is equal to 208.7 feet squared. A mile is equal to 5,280 feet. Rowlett (2007). Thus, a mile long strip of acres contains 25.29 acres. Cost of land assuming offer to Whitney: 25.29 X 2,000 X 0.16 = 8,095.43. Cost of land assuming offer to price of western land: 25.29 X 2,000 X 1.25 = 63,245.55.

per acre may be too low for a conservative estimate to be obtained. During the 1850s government was selling agricultural land in the Midwest at $1.25 dollars an acre. If this price is used the total fixed fee gives $63,245.

An alternative approach to determine the appropriate fixed fee for the railroad is to focus on the experience of eastern railroads. Existing evidence indicates that railroads in the Mid-Atlantic region were spending about 8% of construction costs on buying land already settled. The antebellum Midwest roads built in Ohio, Indiana, or Illinois, where less valuable land was available at the time, and spent about 3%.[345] The value of land on the territories to be crossed by the Pacific Railroad was substantially lower than in the Mid-Atlantic region or the Midwest as it had not been settled by farmers yet and a good portion of it would never be settled as it was dessert. If a fixed fee of 1% of construction cost is assumed, the absolute value of the fee would be equivalent to $1 million dollars. A fixed fee of 1% of total construction cost or $1 million seems to be a high fee for buying the land given that the land was offered to Whitney for $8,095. However, such a high fixed fee seems reasonable given that the purpose of this exercise is to produce a conservative expected profit estimate and the experience of eastern railroads.

6.5.3. Local traffic submarkets

Once the expected route and construction costs have been identified, the next step is to produce the expected earnings derived from local traffic. The transport problem is as follows. In 1859 Nevada experiences a gold rush and the Washoe region develops. Miners, mining inputs and basic goods flow from California (San Francisco and Sacramento area) to the Washoe, while miners and silver returns back to California. Traffic is transported using four different wagon roads across the Sierra Nevada. The proposed railroad route is presented in the map included in figure 15 above (in main body of this chapter). The question is how much net

[345] Fishlow (1965).

earnings (operational profits) a railroad over the Sierra Nevada can derive from this traffic.

The procedure to estimate expected net earnings or operational profits follows the model presented in the main section of this paper. First observed price and traffic are identified. Second, the expected demand function is identified. Third, operational costs are identified. Fourth, the entrepreneur uses the expected demand and operational costs to deduce the maximum operational profit.

Observed local traffic demand

The market is defined as a single flow aggregating traffic both ways between Sacramento and Virginia Station, north of Carson City, in Nevada, where the Nevada gold and silver mines were located.

Observed traffic and price information was collected by Judah using a survey of traffic over the Placerville wagon road that connected Sacramento to Placerville and then to Virginia Station. The Placerville Wagon Road is one of four different wagon roads leading to the Virginia Station region.

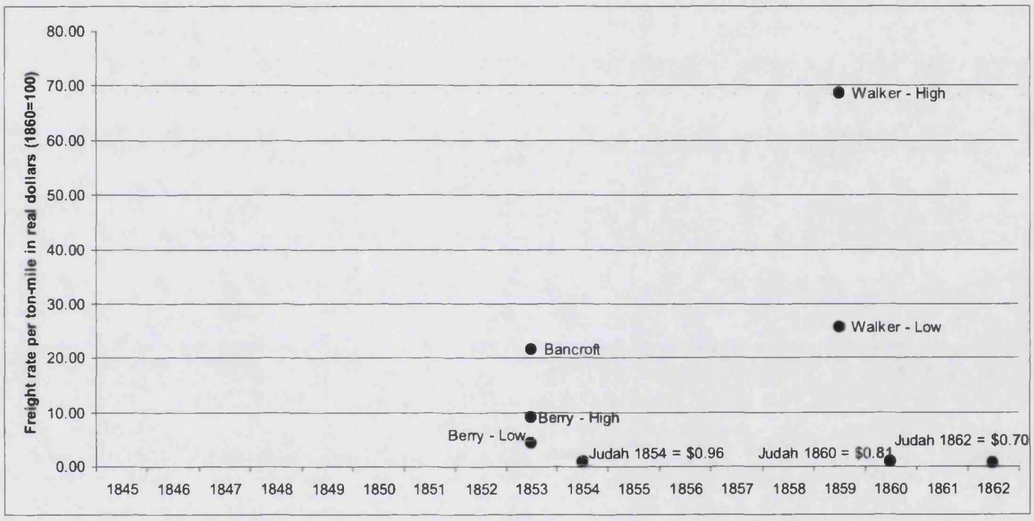
Judah estimated freight traffic was 120 tons per day, freight price was $120 per ton for the whole trip, and on top tolls of between $22.75 and $30 had to be paid. Additionally, estimated passenger traffic on the Placerville Wagon Road was 37 per day using the stage coach at $30 per trip. The entrepreneur assumed a full year of operations and identical traffic levels along the whole year, and annual traffic was estimated to be 43,000 ton and 13,505 passengers.[346]

A contemporary of Judah has written a book on the development of the Comstock mines, allowing verifying the reliability of Judah's information. Eliot Lord indicates

[346] Note that the result of the survey indicated traffic of 178 tons per day. Judah preferred to use 120 instead and did not explain the reason. Thus, the estimation to be performed here is certainly lower biased compared to the information collected in the surveys organised by Judah.

that Judah's data overestimates traffic and transport prices in 1862. Lord also provides the traffic and prices data for 1863-68. For this period freight was 45,000 and 70,000 per year and moved at 5 cents per pound. Passengers on only one of the stage companies were roughly 17,000 per year and moved at $27.[347] Thus Judah provided prices slightly higher than those reported by Lord, while his traffic estimates were lower.

Figure 20. ***Freight rate per ton-mile in Sierra Nevada wagon roads***



Source: Judah (1854) p. 18, Judah (1860) p. 13, Judah (1862) p. 51, Bancroft (1890) p. 153, Berry (1984) p. 141, Walker (1970) p. 294. Note Judah (1860) and (1862) provide identical nominal freight rate estimates, $120. The difference in this graph is caused by the deflation procedure. Deflator: CPI index from David and Solar (1977).

The transport prices indicated by Judah may also be compared to others reported by contemporaries (see figure 21). The freight price does not appear to be high compared to those available in the literature.[348] Berry indicates that wagon freight rate per ton-mile was between $4.30 and $8.96, while the Judah freight rate per ton-mile is 81 cents excluding the tolls. The rest of the sources indicate even higher differences. Berry and Bancroft freight rates are for the eastern slope of the Sierra Nevada, to the east of Sacramento, in the early 1850s. Judah's are for the same

[347] Lord (1959) pp. 193-95.

[348] Mercer (1982) calculated the intraregional external benefits of the Central Pacific by assessing increasing land values, and used no data on transport costs.

region but in the late 1850s. Perhaps the great difference between rates is connected to differences in the development of the roads along the 1850s decade. Passenger transport prices for high mountain routes are not available.[349]

The observed prices relevant for the analysis are taken to be $120 per ton and $30 per passenger. Although these prices are slightly higher than those reported by Lord, they also exclude the tolls and are likely to be lower than the full price reported by Lord. These prices have the advantage of being *ex-ante.*

The value of the observed price-elasticity of demand is unknown. The entrepreneurs implicitly assumed a certain value, but no values of specific elasticity for wagon transport are available. Since transport demand is a derived demand, it also tends to be inelastic. Therefore, it is assumed the price-elasticity of demand to vary between 0 and 3.

The observed demand equation is completed with the terms a_{ij} and h_{ij}. Term a_{ij} is set to allow the price elasticity of demand to vary between 0 and 3. The term h_{ij} captures determinants of traffic different from distance or freight rate. It includes, for instance, the relationship between economic size of trading partners and trade level. The value of h_{ij} is calibrated to allow the demand function at observed freight price to be identical to observed traffic. Calibrating in this way guarantees that any differences between expected demand and observed demand will only arise due to changes in freight rates and distances due to the introduction of the Pacific Railroad, exactly what entrepreneurs emphasised the most. The following formula describes the calibration procedure:

$$h_{ij} = q_{ij} - aP_{ij}$$

349 Mercer (1982) p. 245, Chandler (2001) p. 2-24 and Chandler (2003) p. 21-33 provide information for stage coach prices, but these are for long routes, as the California trail, that go over long stretches of flat terrain and therefore are not appropriate to compare with the Sierra route of the Placerville road:

Expected traffic demand

The market structure of wagon transport provision over the Sierra Nevada was relatively competitive. The data provided by Lord indicates one of the largest stage companies employed about 2% of the teamsters and hostlers and about 5% of the horses used to provide transport services on the wagon road.[350] The dispersed market structure fits well with the characterization of toll roads as public goods prevalent in the literature on transportation in the 19th century.[351] Thus, it is reasonable to expect the price of transportation to be close to the marginal cost, and therefore not to allow wagon roads to compete with the Pacific Railroad if the rail price is equal or lower than the price of wagon transport, as it actually happened.

Expected operational costs

Recall the cost function proposed by entrepreneurs was a constant marginal one. The average cost per ton-mile and per passenger-mile from the three largest railroads in the east was used to proxy the constant marginal cost. Unfortunately, the cost data available for the 19th century did not distinguish between local and through operational costs. Thus, the proxy does suffer from a minor measurement problem as it is an aggregate measure of expenses in local and through freight transport service provision. The local operational costs are probably underestimated while the through ones are overestimated. Aggregate profits are likely to be reasonably accurate, if the downward bias of local operational costs is cancelled by the upward bias of the through operational cost.

The average of observed costs for the New York, Lake Erie, and Western Railroad, the New York Central and Hudson River Railroad and the Pennsylvania Railroad Company between 1856 and 1860 were used to estimate operational costs. These

[350] Lord (1859) p. 195.
[351] Klein (1990) and Taylor (1951) chapter 2.

were large railroads already during the 1850s, they moved large volumes of traffic and the Pennsylvania Railroad Company also had an important mountainous segment in the route. Unfortunately, data for no other companies is available regularly during the 1850s. The data comes originally from railroad company reports collected by Poor's History of the Railroad and Canals.[352] Poor's Manual of Railroads in the United States, the publication continuing from Poor's History of the Railroad and Canals and the American Railroad Journal, is an information source commonly used in studies on railroads in the United States. It is also identical to that included in the United States Censuses and the Aldrich Report on transportation.

The average expense per ton-mile for the three companies 1856-60 was 1.18 cents per ton-mile, while the coefficient of variation was 21%. The estimated value is also higher than that provided by Judah, 0.78 cents, and Whitney, 0.5 cents.[353] The rate includes the cost of running the trains, the cost of operating the stations, the cost of the repair and maintenance stores (includes depreciation). Finally, and incidentally, the ratio of the average of freight expenses per ton-mile over average freight earnings per ton-mile was 54%, indicating that when the entrepreneurs expected operational costs to be about 50% of earnings, they were very well in line with the eastern railroad's experience.

The average expenses per passenger were not published. Recall that for the freight rates, average expenses per ton-mile were close to 50% of earnings. The rate per passenger-mile for the New York Central and the New York Erie railroads was 1.76 cents.[354] Thus, the average cost per passenger-mile was set to 0.88 cents. The average cost assumed here is also higher than that indicated by Judah, 0.462 cents.[355]

---

[352] Poor (1860)
[353] Judah (1854) p. 10.
[354] The information on passenger rates for the Pennsylvania Railroad Company was not available.
[355] Judah (1854) p. 10.

Table 13.

Summary of parameters, values and comments

Parameter/Variable	Value	Source & comment
Expected construction cost	\$13.3 million	Judah (1861)
Expected railroad distance	155 statute miles	Judah (1862) Close to distance of railroad when it was actually built
Construction period	5 years	Construction of Sacramento-Virginia Station segment took 4 years and 9 months (09/1863-06/1868)
Project's life	25 years	Fogel (1960 and Mercer (1982)
Discount rate	9%	Mercer (1982)
Land fixed fee	1% construction cost	Fishlow (1965) and land prices in 1850
Observed freight traffic	43,800 tons/year	Judah (1862) 13%-38% lower than alternative information
Observed passenger traffic	13,505 passenger/year	Judah (1862) Lower than alternative information
Observed freight price	\$120	Judah (1862) Similar to alternative information
Observed passenger price	\$30	Judah (1862) Similar to alternative information
Expected parameter b_{ij}	Calibrated	
Expected parameter h_{ij}	Calibrated	
Expected freight operational cost	\$0.0118 ton-mile	Poor (1860) Higher than entrepreneur information
Expected passenger operational cost	\$0.0088 per pass-mile	Poor (1860) Higher than entrepreneur information

6.5.4. Through traffic submarkets

Once the expected road has been completed to Virginia Station (focusing on local traffic), the second stage may continue to Omaha, focusing on through traffic. The traffic expected to go through on the Pacific Railroad was international and inter-regional. Initially Whitney ignored potential competition coming from transport projects developed by other countries, like the Suez Canal or a Central American Canal. He focused on total international trade. However, after California's gold rush, entrepreneurs were focusing mostly on United States trade. More precisely, by the mid 1850s the entrepreneurs were focusing on passenger movement and trade between eastern and western United States and on trade between the eastern United States and China. Almost all trade at this time was transported via sail ships around Cape Horn. Passengers travelled more frequently using the steamships to Central America, crossing it via different transport modes, and then connecting to another steamship to take them to the western or eastern United States, depending on the direction travelled.

Entry of the Pacific Railroad was expected to provide a 2,000 mile railroad between San Francisco and Omaha. Passengers and trade were then expected to complete the overland route via the eastern railroads to reach the eastern sea board. Trade between eastern and western United States would entirely avoid all sea transport, while trade with China would use sail between Canton and San Francisco and overland rail.

Observed demand

The market is defined as i) a single flow aggregating freight traffic both ways between the eastern and western United States, ii) a single flow aggregating freight traffic both ways between the eastern United States and China, and iii) a single flow aggregating passenger traffic both ways between the eastern and western United States. Other origin-destination pairs could have been included but they implied smaller traffic (Sandwich Islands), were not open to trade with the US in the 1850s (Japan), was not clear their traffic was to be diverted by the Pacific Railroad (India) or regional trade data simply did not exist (San Francisco-Salt Lake City). Moreover, most entrepreneurs focused on the Californian and Chinese trades.

Observed traffic

i) Freight through traffic between the eastern and western United States

Inter-regional trade was drawn from Berry who used 1850s newspaper and contemporary specialised press information to calculate a series of entrances from the eastern to western United States and produced the only available series of entrances to the western United States.[356] Entrances are used as a proxy for imports. A series of ship clearances (proxy for exports) from the western to eastern United States is not available. However, scattered 1850s data collected and published in the United States Treasury Report on Internal Commerce indicated that in 1853 and in 1858 tonnage exported from the western to eastern United States was about 12% of the tonnage moving from the eastern to western United States.[357] In order to estimate a series of exported tonnage from the western to eastern United States it was, thus, assumed that tonnage moving east was 12% of the tonnage imported from eastern into western United States. Berry's series of exports from the eastern to western United States was then multiplied by 0.12 to compute exported tonnage from the western to eastern United States. The average number of tons traded between the eastern and western United States 1856-1860 was 147,392 tons a year (see table 14).

Table 14.

Inter-regional traffic

	1856	1857	1858	1859	1860	Average
California trade	165,760	123,200	133,280	169,120	145,600	147,392
China trade	75,808	66,040	66,655	87,138	103,603	79,849
Passenger (NY-SF)	52,697	33,468	36,126	60,249	37,970	44,102

Sources: California trade from Berry (1980) p. 112 and Nimmo (1885) p. 59 (see text for calculation of clearances from San Francisco to eastern United States); China trade from Report of Commerce and Navigation of the United States 1856-1860; Passenger (NY-SF) from Kemble (1943) p. 254, Folkman (1972) p. 163, and Unruh (1979) p. 120.

Berry's series measure trade in number of registered tons traded per year. Although registered tonnage is not the most desirable measure for our purposes, it is the only one available. Berry has indicated that traditionally ships would wait to depart until

[356] Berry (1984) p. 112.
[357] See Nimmo (1885) p. 59.

they were full, and tonnage effectively carried was about 1.5 times registered tonnage[358]. In consequence, trade estimated here will underestimate trade and expected transport demand, and therefore complies with the objective of estimating a downward biased level of expected profits for the Pacific Railroad.

ii) Freight through traffic between the eastern United States and China

The Reports on Commerce and Navigation published by the United States Treasury between 1856 and 1860 provide information on the tonnage of ships with United States' exports clearing to China and of ships with United States' imports arriving from China. Traffic between the eastern United States and China was deduced by subtracting traffic between San Francisco (and other western United States minor ports) to total traffic between China and the United States. The average traffic (both ways) between the eastern United States and China was 79,749 tons a year (see table 14). Tonnage is, again, measured in registered tons and therefore is subject to the same measurement problems explained in the previous paragraph, leading the traffic estimate to be underestimated. Again, it is preferred to use an underestimate of traffic as the purpose is to achieve a minimum estimate of expected profits.

iii) Passenger movement between the eastern and western United States

Passenger traffic data were drawn from three different sources: Kemble's book on the Panama route, Folkman's book on the Nicaragua route, and Unruh's book on the overland route.[359] The average traffic between 1856 and 1860 both ways on these three routes was 44,102 passengers per annum. Additionally, the Cape Horn

[358] See Berry (1984) pp. 126-7. In this study we also assume that 1 registered ton is equal to 1 weight ton. It is also very likely that 1 registered ton (volume measure used in trade statistics) is actually equal to more than 1 freight ton (weight measure used by merchants and railroad statistics). Rowlett (2007) indicates 1 registered ton is equal to 2.8 cubic meters and that 1 ton weight may also be converted into a volume measure and it is 1.13 cubic meters. He argues that "In old England, a "tun" was a large cask used to store wine. Because these tuns were of standard size, more or less, the tun came to represent both a volume unit, indicating the capacity of a cask, and also a weight unit, indicating the weight of a cask when it was full". Here we have preferred to assume equality and very likely underestimate trade.
[359] Kemble (1943) p. 254, Folkman (1972) p. 163, and Unruh (1979) p. 120.

route also transported migrants to California. Although by the later 1850s it transported less passengers than the three routes above, it is not known how many.

The entrepreneurs indicated higher levels of observed traffic in their projects. Degrand had indicated observed passenger traffic by 1849 was about 200,000 between first and second class passengers. McDougall's project suggested observed traffic was 423,000 tons and 110,000 passengers. Finally, the Central Pacific and Union Pacific entrepreneurs declared that traffic (in 1866 or before) was 460,000 tons and 154,000 passengers. Thus, both freight and passenger traffic, as estimated by the entrepreneurs tends to be higher than the preferred estimates identified here.

Observed price

i) Average observed price

The price for freight transport between the eastern and western United States and China is the sea freight rate for long haul trips, as both trips were longer than 15,000 statute miles. Sea freight rates per ton-mile were well known in the 1850s and substantial data on them is available from primary sources. However, the data was published in different forms, for different commodities, for different volume and weight units, and in different currencies. In order to develop a simple observed average sea freight rate per ton-mile the 1850s San Francisco specialised press was examined and the most respected secondary sources were also used. Additionally, the entrepreneur market research reports described in the previous chapters also provides some information.

The San Francisco Price Current and Shipping List used to publish information on total freight earnings and offers made by ships arriving and ready to depart, and it has been previously used by Berry in his study on California prices. The San Francisco Shipping List published information on total freight earnings and tonnage per ship arriving in San Francisco, and allows calculation of an *implicit* freight rate.

Dividing total freight earnings by a ship's tonnage and then by distance of the trip gives a weighted average implicit freight rate per ton-mile, where the weights are given by the shares of each commodity in total tonnage (that are implicit in the total freight earnings). Thus, the implicit freight rate is a reasonably good reflection of sea transport prices given the observed commodity structure of trade in 1850s. As noted above, Berry includes in his study of California prices some aggregate freights per ship and its tonnage for ships frequently arriving in San Francisco (Clipper and non-Clipper ships).[360] The same procedure to calculate implicit average freight rates was applied to his data. Evans provides aggregate earnings and tonnage arriving in San Francisco from New York or Boston. An identical method to calculate implicit freight rates was performed to his data.[361]

The freight rate data is presented in figure 22. The graph reveals most of the information before 1860 ranges between 0.13 and 0.11 cents per ton-mile. The information drawn from the San Francisco Press, from Berry, from Evans, from Whitney, and from the Army survey reports is all within this range. Only one observation of observed freight rate collected by Evans and that suggested by McDougall are well above this range. Thus, a freight rate per ton-mile of 0.11 cents is deemed as a reasonable one.

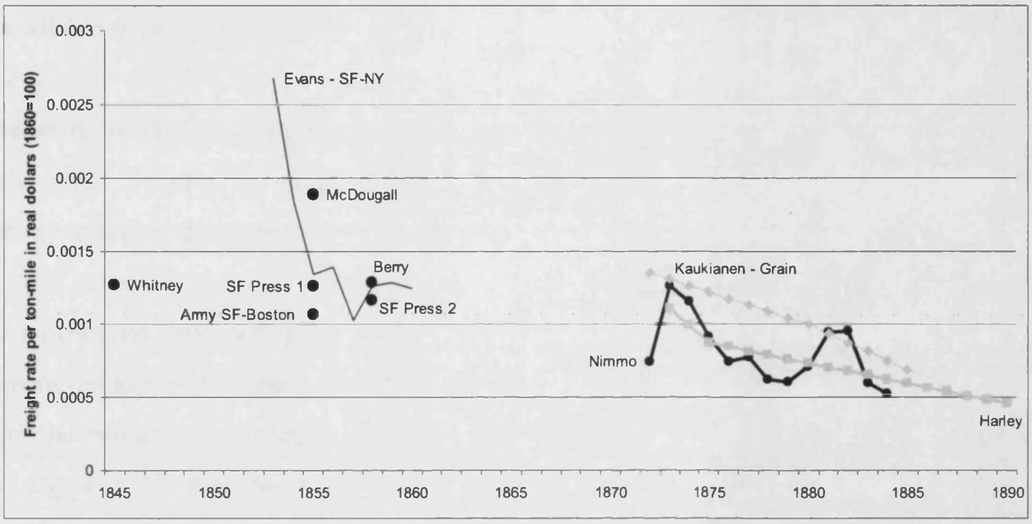
The data described above was also compared to some of the most respected series on freight data for long haul trips. Harley's data for San Francisco-Liverpool grain freights, Kaukianen's grain series for 15,000 statute miles, and Nimmo's series for grain freights San Francisco-Liverpool, all start in 1873 roughly close to 0.11 cents per ton mile.[362] Thus, assuming a freight rate of 0.11 cents per ton-mile or $16.83 for New York-San Francisco is also supported by secondary sources.

---

[360] Berry (1984) p. 117.
[361] Evans (1964) p. 39.
[362] Kaukianen coal series was excluded because most coal was transported to San Francisco from Vancouver, and is the lowest of all the product specific rates.

Figure 21.

Average sea freight rate per ton-mile



Source: Whitney (1849) p. 24. Army: Report of Government Explorations and Surveys (1855) p. 130. McDougall (1854) p. 865, SF Press 1: Samples of 37 New York-San Francisco and 21 Boston-San Francisco trips drawn from the San Francisco Price Current and Shipping List, June 29 1855. In both samples the estimated median was $0.013 and coefficient of variation of 50%. SF Press 2: Sample of 12 international and inter-regional origin ports further than 10,000 statute miles drawn from the San Francisco Price Current and Shipping List, March 3 1858. Estimated median was $0.0014 and the coefficient of variation of 65%. Evans (1964) p. 39. Berry (1984) p. 117. Nimmo (1885) p. 65. Harley (1988) p. 864 for 1873, 1875, and 1890; the series was completed by interpolation. Kaukianen (n.d.) p. 3 of statistical annex for 1873, 1880, and 1885; the series was completed by interpolation. Deflator: CPI index from David and Solar (1977).

ii) Maximum observed price

In addition to the all sea route around Cape Horn discussed in the previous paragraphs, the Pacific Mail Steamship Company and the Panama Railroad Company also provided freight transportation services through the Panama route. Up to the Civil War this route captured a small market share of the California trade traffic, about 10% of total tonnage.[363] The Panama route captured very little, if any,

[363] Berry (1984) p. 113.

China trade traffic. The available information on commodity traffic through Panama indicates no tea or silk was transported by the Panama railroad.[364]

Information on transport price between New York and San Francisco is scarce. The available information includes seven observations and ranges from $140 on the fast service to $80-$58 for the slow service.[365] The observed maximum freight price is taken to be $140 because it reflects the highest level of willingness to pay, precisely the upper bound of the range of prices considered by entrepreneurs in the empirical entry model to determine their pricing policy.

An observed maximum price for through freight of $140 for one ton a year does not seem unlikely given the information reported above, but it is probably the weakest of the model's parameters as information is so scarce. Sensitivity analysis to changes in this parameter is therefore important to determine the robustness of the findings.

iii) Average observed passenger price

Passenger traffic was mostly travelling through the Panama route.[366] The data for passenger fares is presented in figure 5. The fares through Panama were divided into three groups: first cabin, second cabin and steerage (declining in quality of service and price).

The main feature of the passenger rates is the high variance. The main reason for this high variance is price wars. With each price war the three rates decline (not necessarily proportionally), and as collusion is restored, the three rates increase. Cornelius Vanderbilt entered the market for California passenger traffic several times, forcing a price war. Kemble identifies at least five different price wars during

---

364 Otis (1862)

365 Otis (1862) p. 148 and Berry (1984) p. 113 and 249.

366 Nimmo (1885) p. 57 Information for the overland route and the Cape Horn route is scarce (see Unruh (1979) and Chandler (2001) and (2003).

1850-60. The Pacific Mail Steamship Company solved the price war by agreeing with Vanderbilt to pay him to exit the market. The agreement was not credible, Vanderbilt entered the market again, and the Pacific Mail Steamship Company again offered to pay Vanderbilt to exit the market. The cycle was repeated several times.[367]

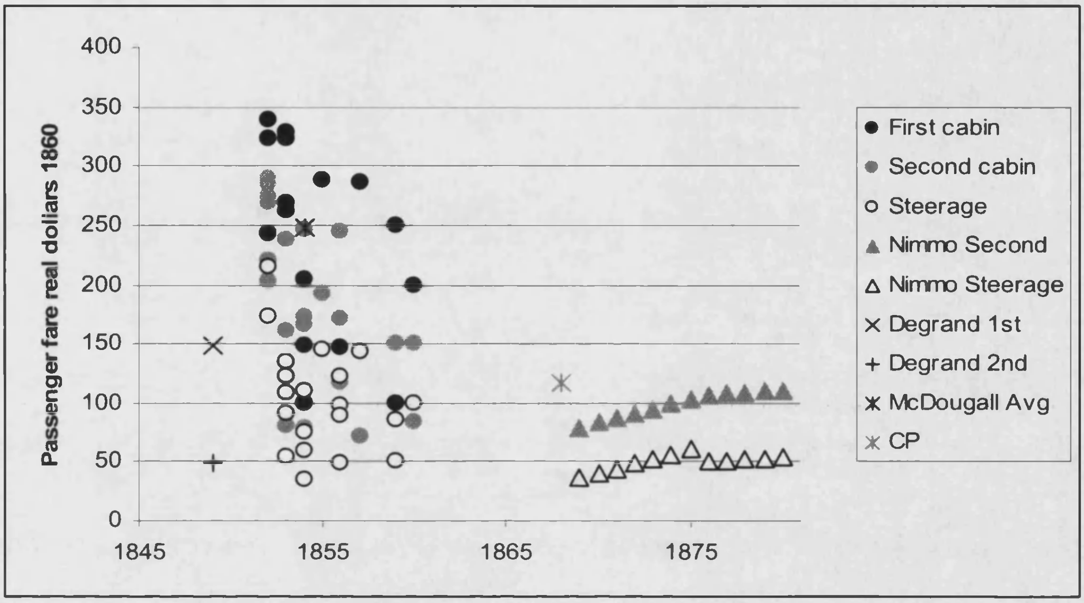
The relevant information for the observed low passenger price is the steerage passenger fare. The information between 1845 and 1860 indicates that most observations for the steerage fare through Panama were within a range of $50-$150 dollars and the fare was unlikely to have been lower than $50 (only one observation during one of the price wars is below $50). Thus, assuming the steerage price is equal to $50 for the Panama route seems to be a relatively conservative estimate of the low transport price for passengers from the eastern to western United States.

The data provided by the entrepreneurs was within the range of observed prices. Degrand was well in line with the observed prices in the market. The data provided by McDougall was within the high range of the market data. Additionally, data from Nimmo for the period 1869-85 reveals that $50 reasonably describes the minimum long term transport costs between the eastern and western United States. Except for the rate wars between 1869 and 1874, just after the transcontinental started operation, the rates were above $50 for steerage and $100 for second cabin.

[367] Kemble (1943).

Figure 22.

Average sea passenger fare for Panama and overland routes



Source: Degrand (1849) p. 12, average for Panama, Cape Horn and Magellan Straight routes. McDougall (1854) p. 865, average for sea and overland routes. Panama first cabin, second cabin, and steerage: 12 observations containing first, second and steerage from New York Times March-June 1852, 22 observations from Kemble (1943) p. 65, p. 66, p. 67, p. 69, p. 70, p. 74, p. 75, p. 77, p. 82, p. 94, p. 107, p. 108 and 2 observations from Chandler and Potash (2007) p. 12. Panama CP and UP: Fisk and Hatch (1867) p. 24, Fisk and Hatch (1868) p. 26, Cisco (1868) p. 23. Nimmo second cabin and steerage Nimmo (1885) p. 126. Deflator: CPI index from David and Solar (1977).

iv) Maximum observed passenger price

The data in figure 5 also reveals the high level of consumers' willingness to pay for faster and more comfortable transportation to and from California. A large group of observations for the price of first cabin are clustered between $250-$350 dollars, the average first cabin price was $252.60 dollars and the fare bounced back after every price war above $250 dollars. The observed maximum price is taken to be $252.60, the average price for first cabin. This price sets the upper bound for the range of prices considered by the entrepreneur in the model of formation of expectations when determining their pricing policy.

A non negligible share of passengers may have used the first cabin. The technical information on each of the steamships used on the New York-San Francisco route sometimes provides data on the capacity of the ship for cabin and steerage classes. The sample disclosing this information is small and does not distinguish between first and second cabin. However, for this sample, steamships were designed to, on average, carry 40% of passengers on first and second cabin.[368]

The data available on passenger traffic suggests that using an observed maximum price of $252.60 for 1 passenger a year seems a conservative assumption. Both price and quantity data indicate this equilibrium could have been sustained by the market any year 1850-60.

Expected demand

The expected demand function for freight and passenger transport between the eastern and western United States is given by:

$$\tilde{q}_{ij} = \tilde{h} - \tilde{a}_{ij} \tilde{P} = \tilde{h} - \tilde{a}_{ij}\left(f^{PR} d^{PR} + f^{ER} d^{ER}\right)$$

The expected demand function for freight between the eastern United States and China is given by:

$$\tilde{q}_{ij} = \tilde{h} - \tilde{a}_{ij} \tilde{P} = \tilde{h} - \tilde{a}_{ij}\left(f^{PR} d^{PR} + f^{ER} d^{ER} + f^{S} d^{S}\right)$$

The necessary information to complete the expected demand functions is the expected distance for the Pacific Railroad, the expected freight rate for the eastern

[368] Additionally, information from the available steam ships designs on this route suggests that traffic on first and second cabins was close to 40% of total traffic. Kemble (1943) presents a list of all steam ships used on the Panama route. For 13 ships out of 108 the distribution between cabin and steerage capacity is available. For these 13 ships the capacity allocated to cabin passengers is between 17% and 76% with an average of 42%.

railroads and the distance to be covered by them, and for the China trade, and the cost of sail ship between Shanghai and San Francisco.

The entrepreneurs expected the Pacific Railroad to be 2,000 statute miles long, between the Pacific coast and where the Missouri river valley connects to the Mississippi river valley.[369] Since the final destination for every ton was the eastern economy, it is assumed every ton was expected to be carried the full Pacific Railroad distance.

The expected eastern railroads freight rate was based on the observed freight rate and considering why it may change because of the Pacific Railroad's entry. The average observed freight rate per ton-mile for the three largest eastern railroads between 1856 and 1860 was 2.412 cents per ton-mile and the coefficient of variation was 19%. The data comes from exactly the same sources used for the eastern railroad operational costs, as discussed above in the local traffic part of this section.

During the 1850s trains from the eastern seaboard were already routinely arriving at Chicago. The New York Central Railroad, the New York and Erie railroad, the Pennsylvania Railroad and the Baltimore and Ohio Railroad, the four trunk railroad, were already competing for the trunk traffic between the Mississippi and Ohio valleys and the eastern seaboard.[370] Although the Baltimore-Ohio's information is not available, the freight rate proposed here is a reasonable measure for the observed average freight rate.

The expected eastern railroads average freight rate per ton-mile should be similar to the one observed from 1856-60 or lower. From 1856-60 many eastern railroads still

[369] Different entrepreneurs were pushing for different routes and therefore expected different first transcontinental railroad distances. However, a rough average estimate of these distances is about 2,000 statute miles. Additionally, when the first transcontinental railroad was inaugurated it went from Sacramento to Omaha for more than 1,900 miles. The distance between Sacramento and San Francisco today is about 80 miles.
[370] See Holbrook (1947) p. 452.

enjoyed substantial market power within their home region. Additionally, the Pacific Railroad would bring a new source of through traffic for many of these railroads and strong incentives to compete to carry through traffic. Thus, as the Pacific Railroad route started operation it was expected that demand for eastern railroads would boom and competition to carry this traffic would also increase (compared to each individual regional monopoly case). Existing research indicates there are good reasons to expect that under these circumstances tacit collusion and cartelisation are more difficult and the observed outcomes tend to be ones of intense competition.[371] Thus, it is unlikely the rail freight rates observed by 1860 would remain at those high levels once the Pacific Railroad was built. Finally, also note that this estimate is substantially higher than that used by Whitney, 1 cent per ton-mile. Whitney underestimated seriously the costs of rail transport.

The expected eastern railroad passenger rate was calculated, following the same procedure as for freight rates above, as 1.76 cents per passenger mile. Again, the observed fare, if anything, overestimates the expected fares and underestimates operational profits.

The expected eastern railroads distance was calculated as 850 statute miles. The eastern terminus of the Pacific Railroad was assumed to be in Omaha, where the terminus of the Union Pacific railroad was actually located. The expected distance for the eastern railroads is the distance between Omaha and the origin or destination locations of the international and inter-regional traffic. Ideally one would use data

[371] A wide array of research supports this idea. Rotenberg and Saloner (1986) developed a super-game to explain why price wars are observed during booms. Casadesus-Masanell, Nalebuff, and Yoffie (2007) developed a model for two complementary goods. Production of good one is under monopoly (PR). Production of good two is under monopoly or duopoly (eastern railroads). The authors show that if the scenario for production of good two is duopoly, competition between the two firms will drive price of good two down. Additionally, if the scenario is monopoly, the firm producing good one will have incentives to strategically promote entry into production of good 2 to induce competition. Empirical evidence for these kinds of ideas in the American railroad industry is illustrated by the price wars between railroads and steamships in the 1850s (Taylor (1951) p. 62). Harley (1982) developed an empirical model to explain 1880s railroad construction booms as a result of railroad cartels breaking after demand booms. Porter (1983) developed a full empirical model and determined that in the 1880s changes in prices and quantities were connected to changes in behaviour of railroad companies reacting to demand changes.

on the location of origins and destinations for international and inter-regional imports and exports to identify these distances, but unfortunately neither the imports nor exports nor the identity of these origin and destination locations is available.

As a simple alternative procedure, the distance between Omaha and 16 major eastern cities was computed and examined. The simple average and median distances were 837 and 894 statute miles respectively.[372] The distance of the eastern railroad network expected to be covered by every ton transported was assumed to be 850 miles and constant across origin-destination pairs, as a number between the two measures of central tendency for the distance between Omaha and the 16 eastern cities. The magnitude of the bias implied by this procedure is probably small. The eastern United States economy during the 1850s was relatively segmented into regional markets, and the regional metropolises were all included in the sample to compute the average distance between Omaha and the eastern United States origin and destination of the import or export activity.

The distance of the sea segment between Shanghai and San Francisco was 6,210 statute miles. The expected sea freight rates are set at 0.11 cents per ton-mile, following the discussion on freight rates above. The discussion on observed demand above has explained why the existing evidence on implicit sea freight rates indicates this is a reasonable proxy for the *observed* average sea freight rate per ton-mile. It is still necessary to go one step further since the information required to build the expected demand function is the *expected* sea freight rate. The entrepreneur's expectation would be based on the changes entrepreneurs thought likely to be experienced by the sea transport industry due to the entry of the Pacific Railroad. Since the sea transport industry was characterised by relatively easy entry and exit into different submarkets (trades), numerous submarkets, very low sunk costs, relatively moderate fixed costs, and large numbers of ships of any type of

[372] The 16 major eastern US cities are Chicago, Cleveland, Cincinnati, St Louis, Pittsburgh, Philadelphia, New York, Boston, Washington, Baltimore, Memphis, New Orleans, Mobile, Savannah, Charleston, and Augusta.

design, many have argued it may be regarded as a competitive industry.[373] Thus, it is unlikely there was much scope for any issue of strategic behaviour to arise and for sea freight rates to change due to the Pacific Railroad's entry.

The price elasticity of demand for transport and the terms a_{ij} and h_{ij}. are not known. The same procedure as for local traffic is used to set h_{ij}. The price elasticity and a_{ij} are calibrated following the procedure discussed in the paper.

Expected operational costs

Recall available operational cost information did not disaggregate between through and local traffic costs. The expected costs are set identical to those discussed for the local traffic submarkets, 1.18 cents per ton-mile and 0.88 cents per passenger mile.

Table 15 summarizes the information for through traffic. A brief discussion summarising the main differences between the data provided by the entrepreneurs in their reports and the data presented in tables 13 and 15 is important.

First, the entrepreneurs identified correctly observed prices. The data in tables 13 and 15 indicates entrepreneurs reported similar observed prices to those reported by public or secondary sources. Second, entrepreneurs tended to report substantially higher observed traffic and lower railroad operational cost than those identified through the use of public sources. The pattern is stronger for the second stage than the first stage. It is not possible to know if entrepreneurs were making mistakes or deliberately overstated/understated traffic/operational costs to predict higher social benefits and profits. However, that the mistake always favoured higher profits and it was on variables difficult to observe raises suspicions that the entrepreneurs overstated/understated these variables to predict higher profits and social benefits.

[373] For instance, North (1968) p. 956 and (1958) p. 539 argued the shipping industry was a competitive industry.

Table 15.

Summary of parameters, values, and comments for second stage

Parameter/Variable	Value	Source & comment
Expected construction cost	$86.7	Judah (1861) p. 29.[374]
Expected railroad distance	1,845 statute mile	Judah (1861) p. 29 expected In line with entrepreneurs.[375]
Construction time	5 years (starting on year 6)	Construction of Virginia City to Promontory Summit (Central Pacific 06/1868-05/1869) and Omaha-Promontory Summit (Union Pacific 07/1865-05/1869) took 4 years and 9 months.
Project's life	25 years	Fogel (1960) and Mercer (1982)
Discount rate	9%	Mercer (1982)
Land fixed fee	1% construction cost	Fishlow (1965) and land prices in 1850
Observed traffic freight – NY-SF	147,392 tons/year	Berry (1984) 50%-65% lower than entrepreneur info
Observed traffic freight – NY-Shanghai	79,849 tons/year	Report on Commerce and Navigation (1856-6) 50%-65 lower than entrepreneur info
Observed traffic passenger – NY-SF	44,102 passengers/year	Nimmo (1885) 60%-78% lower than entrepreneur info
Observed sail ship freight price – NY-SF	$16.83	SF Press (1856-60) In line with entrepreneur info
Observed sail ship freight price – NY-Shanghai	$17.49	SF Press (1856-60) In line with entrepreneur info
Observed sail ship passenger fare – NY-SF	$50.00	Chandler (2007) In line with entrepreneur info
Maximum observed freight price – NY-SF	$140.00	Otis (1860)
Maximum observed freight price – NY-Shanghai	$140.00	Otis (1860)
Maximum observed passenger fare – NY-SF	$252.64	Kemble (1943)
$\tilde{b}_{ij}$ (expected sensitivity of traffic to price)	Calibrated (see text)	
$\tilde{u}_{ij}$ (trading partners characteristics)	Calibrated (see text)	
Expected eastern railroad distance	850 statute miles	Estimated based on distance between Omaha and 16 large eastern cities
Expected eastern railroad freight price – Omaha-average eastern city	$20.50	Poor (1860) 140% higher than entrepreneur info
Expected eastern railroad passenger fare -	$14.96	Poor (1860)

[374] Bancroft (1890) p. 504 reviews various estimates and suggests $100 million with a lower bound of $70. The observed cost was $58.2 million.
[375] See Bancroft (1890) p. 504.

Omaha-average eastern city		
Expected sea distance – Shanghai-SF	6,210 statute miles	
Expected sea freight price	$6.83	SF Press
Expected freight operational cost	$0.0118 ton-mile	Poor (1860) 136% higher than entrepreneur info
Expected passenger operational cost	$0.0088 per pass-mile	Poor (1860)

6.5.6. First stage Monte Carlo experiment – sensitivity to the price-elasticity of demand

The Monte Carlo experiment performed to test the sensitivity of the baseline results for the first stage generate 2,000 observations of NPV for each level of negative random shock. The next two tables present the summary statistics of the NPV samples assuming first an elastic demand and then an inelastic demand.

Table 16.

First stage Monte Carlo experiment NPV summary statistics – inelastic price-elasticity of demand (0-1)

	Level of negative shock					
	0%	**10%**	**20%**	**30%**	**40%**	**50%**
Min	24,562,201	17,035,516	10,176,162	3,984,139	-1,540,553	-6,536,622
Average	24,562,201	20,426,903	16,478,145	12,715,928	9,140,251	5,751,115
Max	24,562,201	23,912,495	23,267,545	22,627,350	21,991,910	21,361,225
Std Dev	0	1,352,015	2,570,899	3,659,788	4,622,528	5,463,868
10th percentile	24,562,201	18,642,426	13,142,442	8,057,356	3,328,519	-1,038,909

Table 17.

First stage Monte Carlo experiment NPV summary statistics – elastic price-elasticity of demand (1-1.5)

	Baseline	Elasticity varies randomly between 1-1.5 Level of random negative shock					
		0%	**10%**	**20%**	**30%**	**40%**	**50%**
Min	24,562,201	24,562,220	17,101,358	10,278,134	4,147,944	-1,414,874	-6,412,522
Average	24,562,201	25,027,520	20,854,009	16,901,590	13,170,263	9,660,028	6,370,886
Max	24,562,201	25,880,589	24,988,890	24,237,786	23,492,535	22,753,137	22,019,592
Std Dev	0	381,365	1,413,882	2,630,920	3,727,619	4,693,754	5,529,262
10th percentile	24,562,201	24,602,000	19,033,710	13,455,259	8,323,643	3,578,234	-689,449

6.5.7. Monte Carlo experiment simulated expected profit probability distribution - Histogram and descriptive statistics

The key outputs of the simulation model after performing the Monte Carlo experiments described above are expected profit probability distributions. The Monte Carlo experiments test the sensitivity of the baseline results to random independent shocks for most parameters in the model (traffic, traffic price, operational cost, costs of complementary transport mode, construction cost and discount rate) in the direction against profits. The Monte Carlo experiment was repeated 2,000 times to generate a sample probability distribution of expected profits.

The Monte Carlo experiment was performed using three different probability distributions generating the negative independent random shock on each parameter. The results described in the main body of the text are mostly regarding the Monte Carlo experiments using a uniform distribution. The uniform distribution is preferred because there is no prior about the appropriate distribution of the negative random shocks. The Monte Carlo experiments were also performed using a normal distribution with mean 0.5 and standard deviation of 0.5/3. To test the effects of random shocks generated from a distribution weighting heavily the most negative shocks, the standard gamma distribution (shape parameter equal to 11.4, range of (0,25), mean of approximately 0.55 and a median ranging from 0.6 to 0.7) was used to perform the Monte Carlo experiments.

The results indicate the baseline scenario simulations using the uniform distribution as the underlying probability distribution generating the negative shocks are not very sensitive to changes in the underlying probability distribution if the new distribution is symmetric. When the normal distribution is used to generate the random shocks on the parameters the central tendency of the results are similar and the dispersion decreases. As the uniform distribution has thinner tails than the uniform distribution, lower maximum values and higher minimum values and lower frequency of both are observed, and variance is reduce. An important difference between the two sets of results is that the probability of positive expected profits increases by about 10% when using the normal distribution, from about 60% to 70% for low random shocks for the second stage.

When the gamma distribution is used to generate negative random shocks on the parameters, the expected profit probability distribution becomes more highly dispersed and less well behaved. While with the uniform and the normal distribution the expected profit probability distributions are characterized by a single mode and are relatively symmetric, the ones with the gamma distribution have multiple modes and are asymmetric. As the random shock increases the variance increases very rapidly. Predicted average profits are generally lower, and the difference increases as the random shock increases. However, although the model is moderately sensitive to using asymmetric distributions (as expected), still the probability of positive expected profits is not substantially different. Quantitative results are weakened but the qualitative results maintain valid.

In sum, the baseline scenario seems to be relatively robust to changes in the probability distribution generating the negative independent random shocks to the parameters of the model. Symmetric probability distributions, like the normal distribution, are unlikely to change substantially results, and they may even strengthen the finding of expected profits. Asymmetric probability distributions, like the gamma distribution, do reduce expected profits. The first stage results are robust to moderate asymmetry. The second stage is more sensitive, but the probability of positive profits is not reduced substantially. Given these random shocks are for all parameters and independently, and that the baseline scenario is a downward biased estimate of expected profits, the general result that entrepreneurs should have expected the two stages of the Pacific Railroad to be profitable after 1859 still holds.

Table 18.

Descriptive statistics of expected profit probability distribution – MC experiment uniform probability distribution

Construction stage	Random negative shock %	Observations	Mean	Standard Deviation	Minimum	Maximum	25th percentile	50th percentile	75th percentile	Probability profit > 0
First	10	2,000	20.42	1.35	17.03	23.91	19.43	20.42	21.40	1.00
	20	2,000	16.47	2.57	10.17	23.26	14.61	16.43	18.32	1.00
	30	2,000	12.71	3.66	3.98	22.62	10.05	12.58	15.28	1.00
	40	2,000	9.14	4.62	-1.54	21.99	5.74	8.88	12.37	0.99
	50	2,000	5.75	5.46	-6.53	21.36	1.63	5.27	9.55	0.85
	60	2,000	2.54	6.19	-10.93	20.73	-2.19	1.85	6.80	0.61
	70	2,000	-0.46	6.80	-14.72	20.11	-5.74	-1.38	4.12	0.43
Second	0	2,000	3.48	8.30	-20.31	24.89	-2.54	3.57	9.62	0.64
	2	2,000	2.64	8.27	-20.69	23.44	-3.35	2.71	8.80	0.61
	4	2,000	1.80	8.25	-21.08	22.48	-4.27	1.86	7.93	0.58
	6	2,000	0.97	8.24	-21.46	21.88	-5.11	1.06	7.07	0.54
	8	2,000	0.14	8.24	-21.84	21.28	-5.94	0.20	6.22	0.51
	10	2,000	-0.69	8.25	-22.80	20.68	-6.76	-0.58	5.39	0.48

Table 19.

Descriptive statistics of expected profit probability distribution – MC experiment normal probability distribution

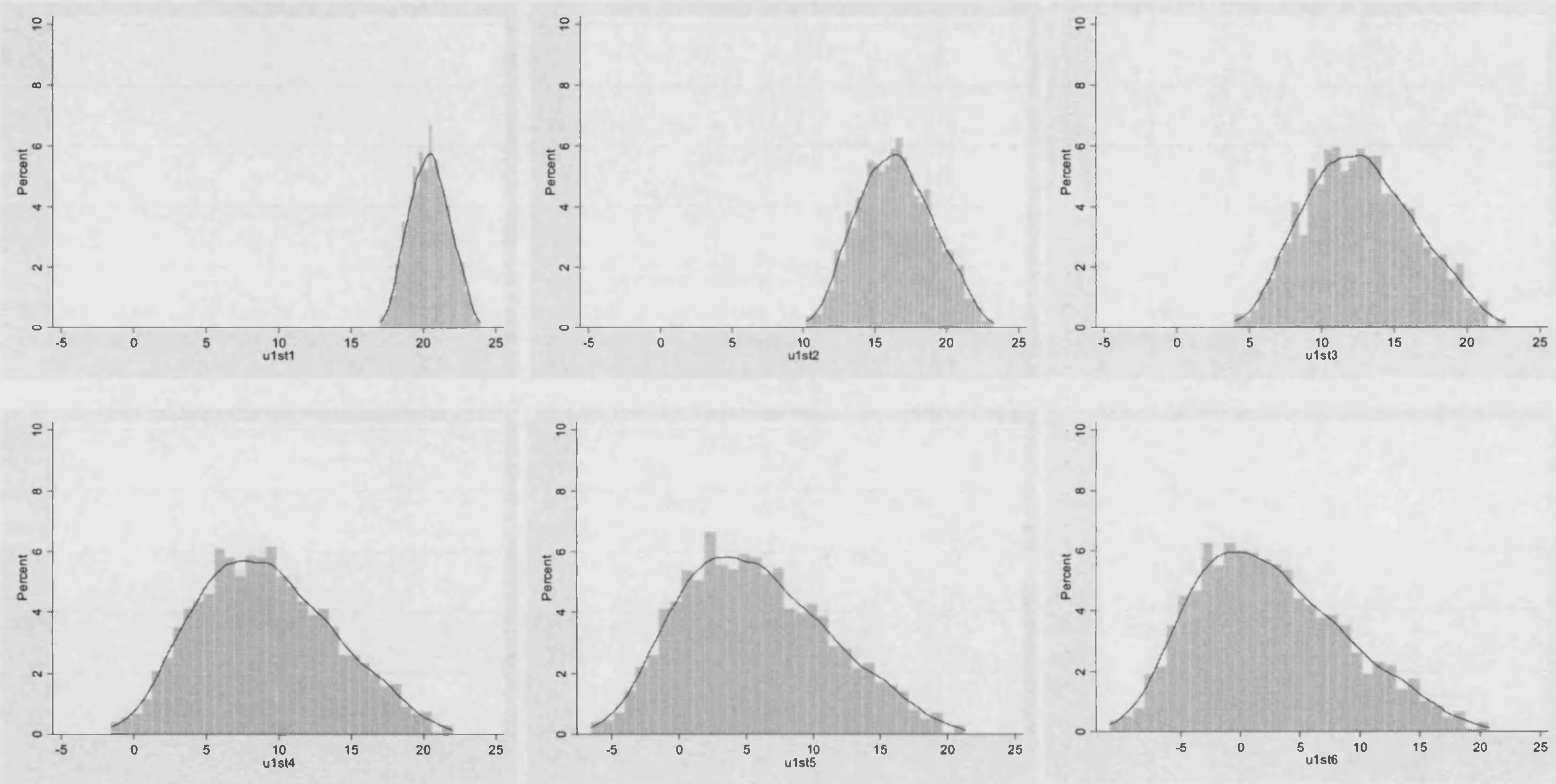
Construction stage	Random negative shock %	Observations	Mean	Standard Deviation	Minimum	Maximum	25th percentile	50th percentile	75th percentile	Probability profit > 0
First	10	2,000	20.40	0.78	17.79	23.23	19.88	20.41	20.92	1.00
	20	2,000	16.43	1.48	11.56	21.86	15.44	16.45	17.42	1.00
	30	2,000	12.65	2.10	5.85	20.45	11.22	12.66	14.06	1.00
	40	2,000	9.05	2.65	0.67	19.00	7.27	9.03	10.81	1.00
	50	2,000	5.65	3.13	-3.97	17.50	3.54	5.58	7.72	0.97
	60	2,000	2.43	3.53	-8.09	15.97	0.02	2.31	4.75	0.75
	70	2,000	-0.59	3.86	-11.67	14.52	-3.21	-0.78	1.92	0.42
Second	0	2,000	3.16	4.70	-15.26	21.91	-0.07	3.18	6.34	0.75
	2	2,000	2.32	4.68	-16.15	21.20	-0.90	2.38	5.45	0.69
	4	2,000	1.47	4.67	-17.04	20.50	-1.76	1.54	4.62	0.63
	6	2,000	0.64	4.67	-17.93	19.80	-2.53	0.72	3.77	0.56
	8	2,000	-0.20	4.68	-18.81	19.10	-3.38	-0.14	2.96	0.49
	10	2,000	-1.03	4.69	-19.69	18.40	-4.21	-0.96	2.17	0.41

Table 20.

Descriptive statistics of expected profit probability distribution – MC experiment gamma probability distribution

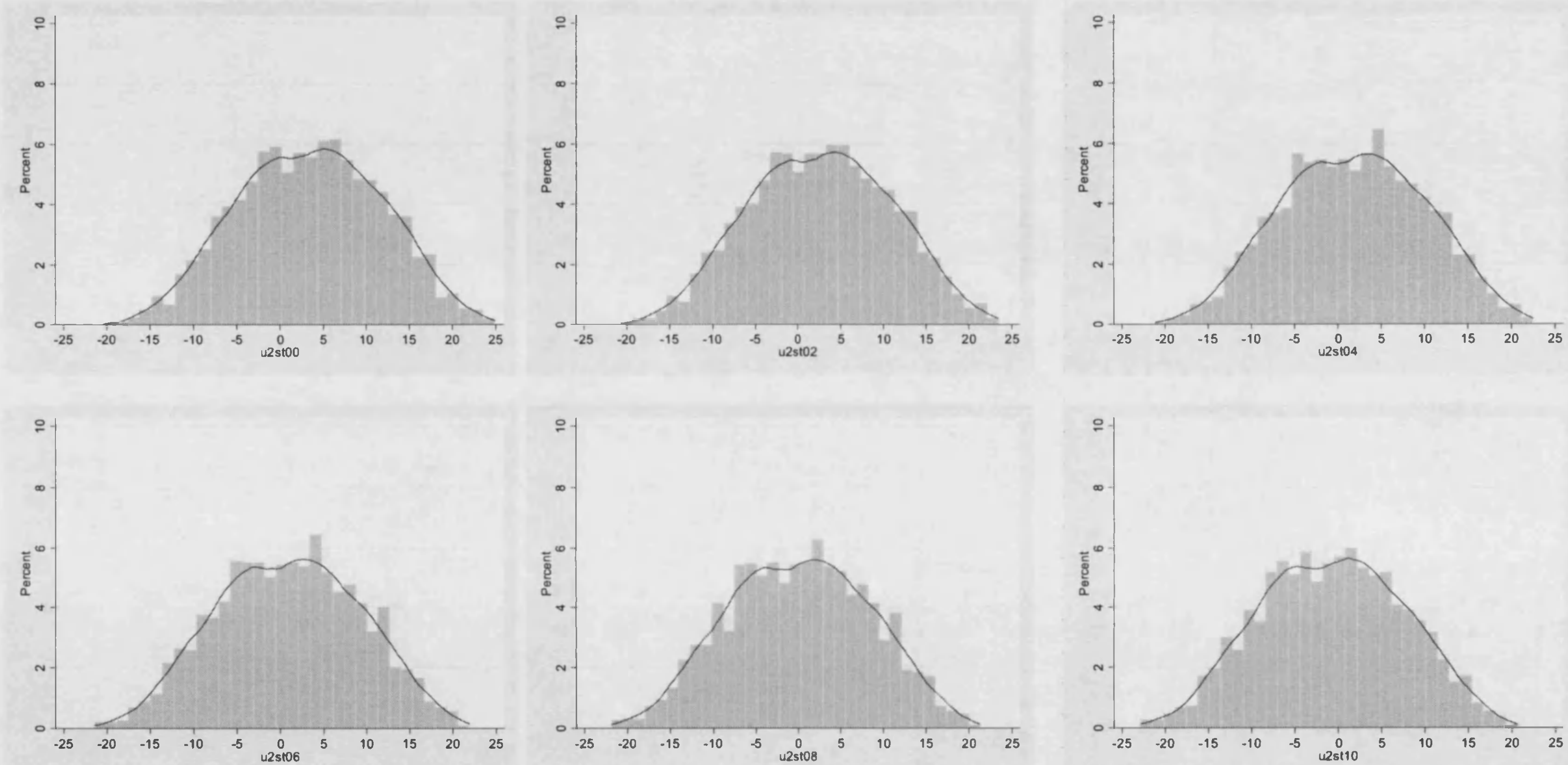
Construction stage	Random negative shock %	Observations	Mean	Standard Deviation	Minimum	Maximum	25th percentile	50th percentile	75th percentile	Probability profit > 0
First	10	2,000	20.07	1.90	16.51	24.53	18.52	20.04	21.15	1.00
	20	2,000	15.79	3.60	9.20	24.50	12.90	15.61	17.78	1.00
	30	2,000	11.74	5.11	2.62	24.48	7.73	11.24	14.43	1.00
	40	2,000	7.89	6.43	-3.22	24.45	3.08	6.95	11.11	0.89
	50	2,000	4.27	7.57	-8.32	24.42	-1.19	2.89	7.80	0.69
	60	2,000	0.86	8.57	-12.69	24.39	-4.93	-0.96	4.63	0.46
	70	2,000	-2.33	9.42	-16.33	24.36	-8.79	-4.55	1.59	0.30
Second	0	2,000	2.66	11.09	-19.33	27.47	-6.86	1.20	12.55	0.53
	2	2,000	1.75	11.08	-20.31	26.43	-7.83	0.29	11.63	0.51
	4	2,000	0.83	11.10	-21.54	25.40	-8.73	-0.60	10.69	0.49
	6	2,000	-0.08	11.13	-22.76	24.36	-9.55	-1.46	9.97	0.47
	8	2,000	-0.98	11.17	-23.98	23.91	-10.60	-2.31	9.06	0.46
	10	2,000	-1.88	11.23	-25.19	23.53	-11.35	-3.00	8.21	0.44

1) Histograms and Kernel density distributions first stage – underlying parameter distribution of random shock: uniform



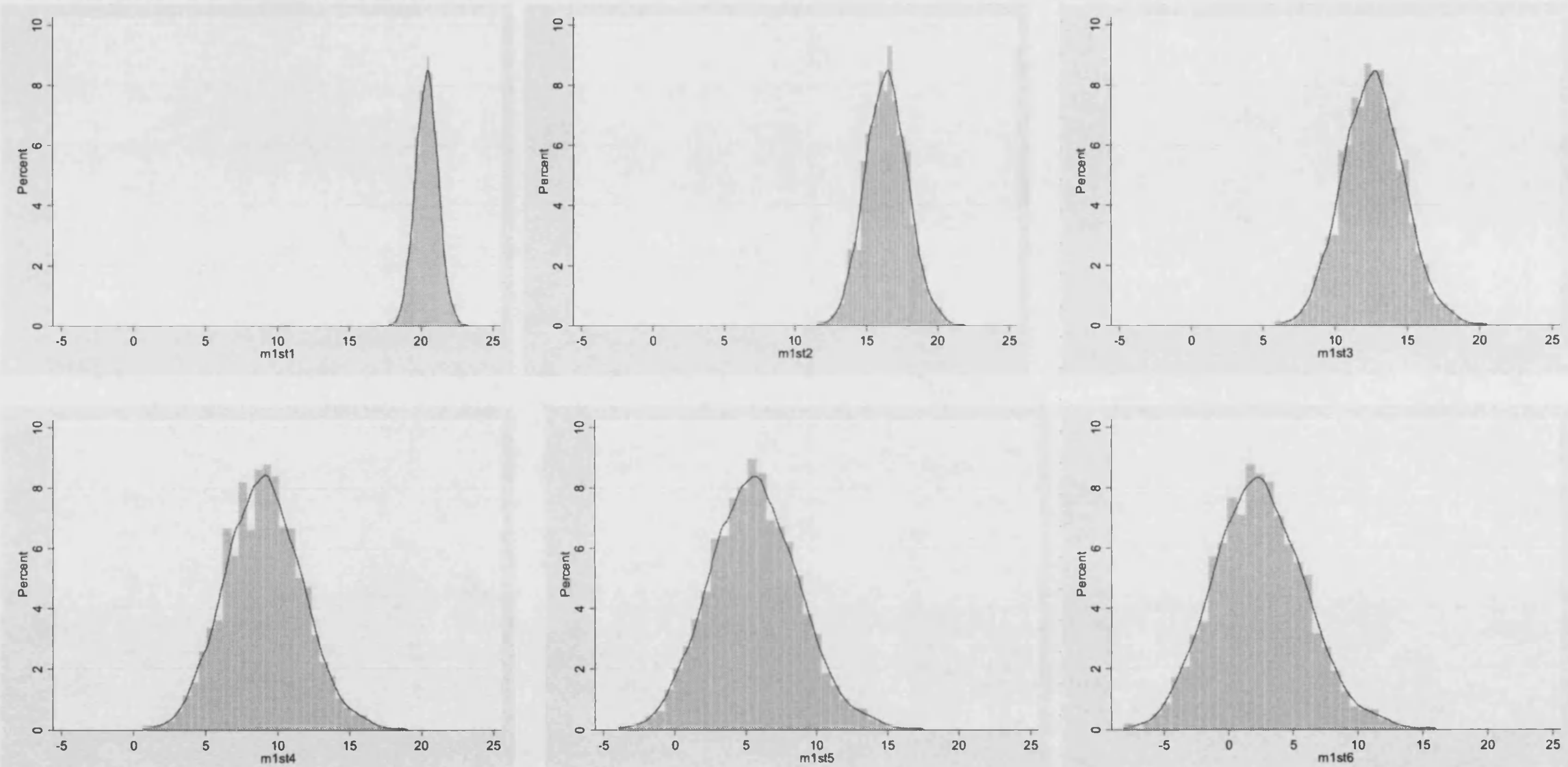
Note: u1st1: Expected profit distribution for 1^{st} stage under negative shock of 10%; u1st2: Expected profit distribution for 1^{st} stage under negative shock of 20%; u1st3: Expected profit distribution for 1^{st} stage under negative shock of 30%; u1st4: Expected profit distribution for 1^{st} stage under negative shock of 40%; u1st5: Expected profit distribution for 1^{st} stage under negative shock of 50%; u1st6: Expected profit distribution for 1^{st} stage under negative shock of 60%. Kernel density distribution estimated using Epanechnikov method.

2) Histograms and Kernel density distributions second stage – underlying parameter distribution of random shock: uniform



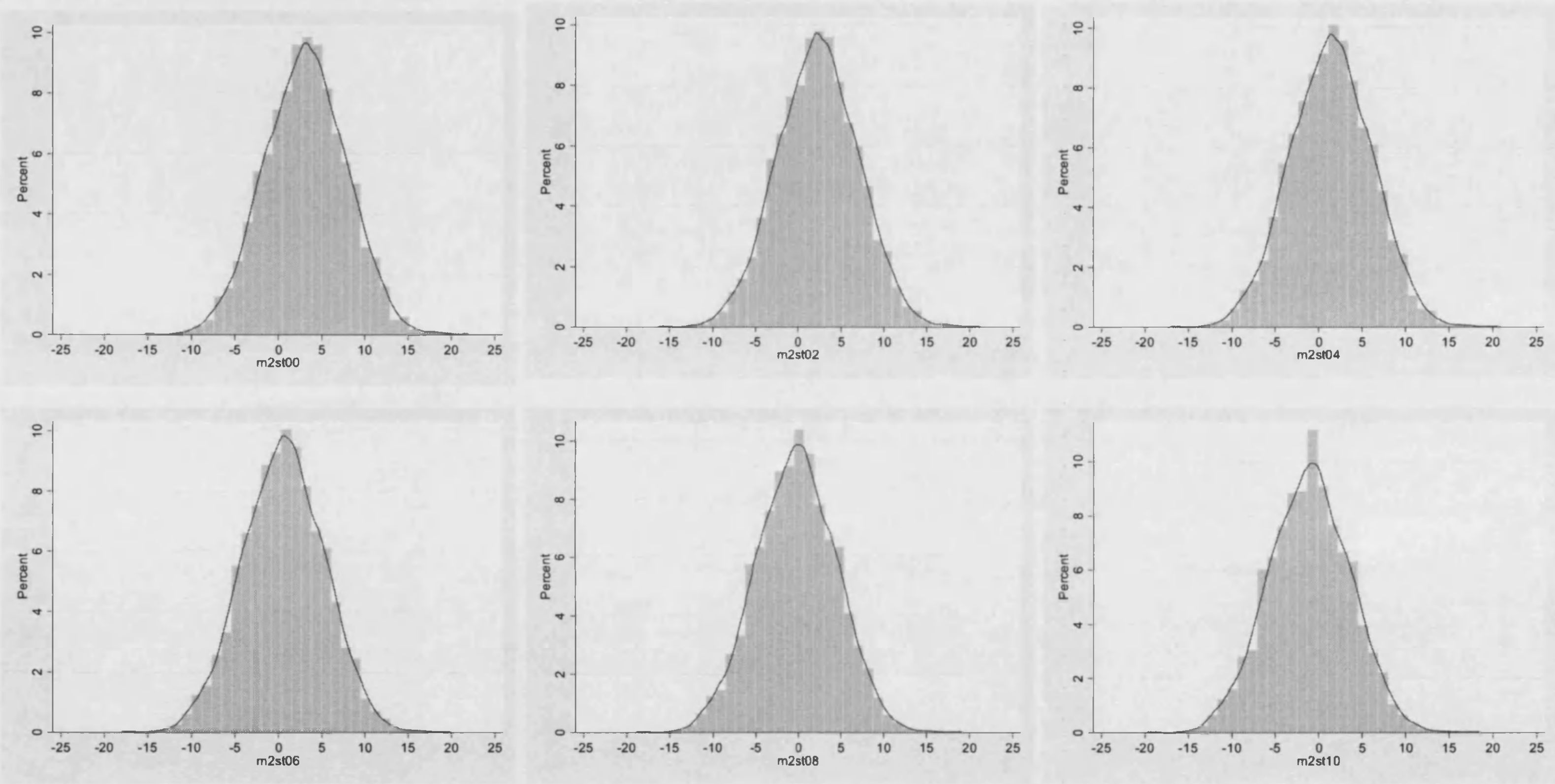
Note: u2st00: Expected profit distribution for 2nd stage under negative shock of 0%; u2st02: Expected profit distribution for 2nd stage under negative shock of 2%; u2st04: Expected profit distribution for 2nd stage under negative shock of 4%; u2st06: Expected profit distribution for 2nd stage under negative shock of 6%; u2st08: Expected profit distribution for 2nd stage under negative shock of 8%; u2st10: Expected profit distribution for 2nd stage under negative shock of 10%. Kernel density distribution estimated using Epanechnikov method.

3) Histograms and Kernel density distributions first stage – underlying parameter distribution of random shock: normal



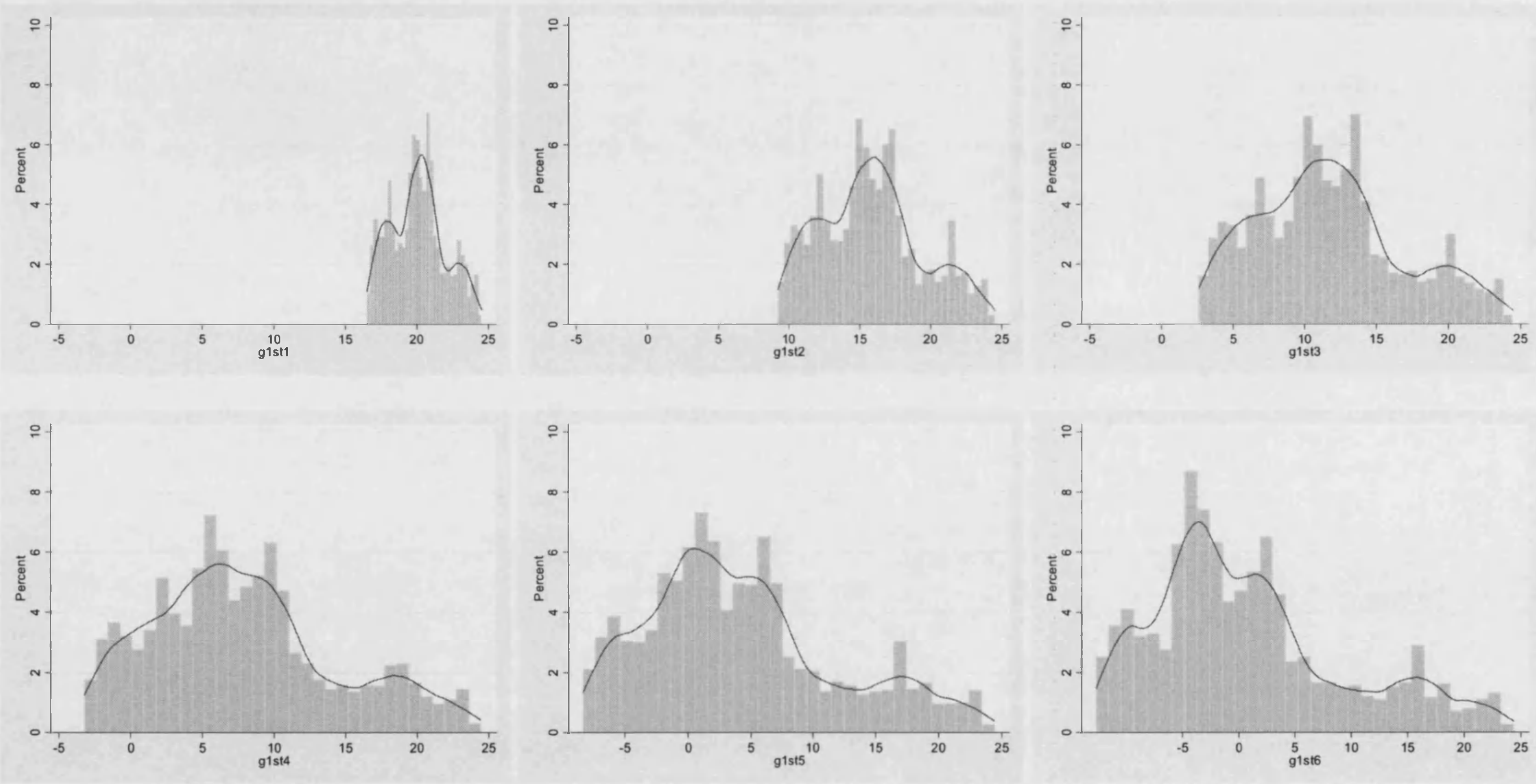
Note: m1st1: Expected profit distribution for 1st stage under negative shock of 10%; m1st2: Expected profit distribution for 1st stage under negative shock of 20%; m1st3: Expected profit distribution for 1st stage under negative shock of 30%; m1st4: Expected profit distribution for 1st stage under negative shock of 40%; m1st5: Expected profit distribution for 1st stage under negative shock of 50%; m1st6: Expected profit distribution for 1st stage under negative shock of 60%. Kernel density distribution estimated using Epanechnikov method.

4) Histograms and Kernel density distributions second stage – underlying parameter distribution of random shock: normal



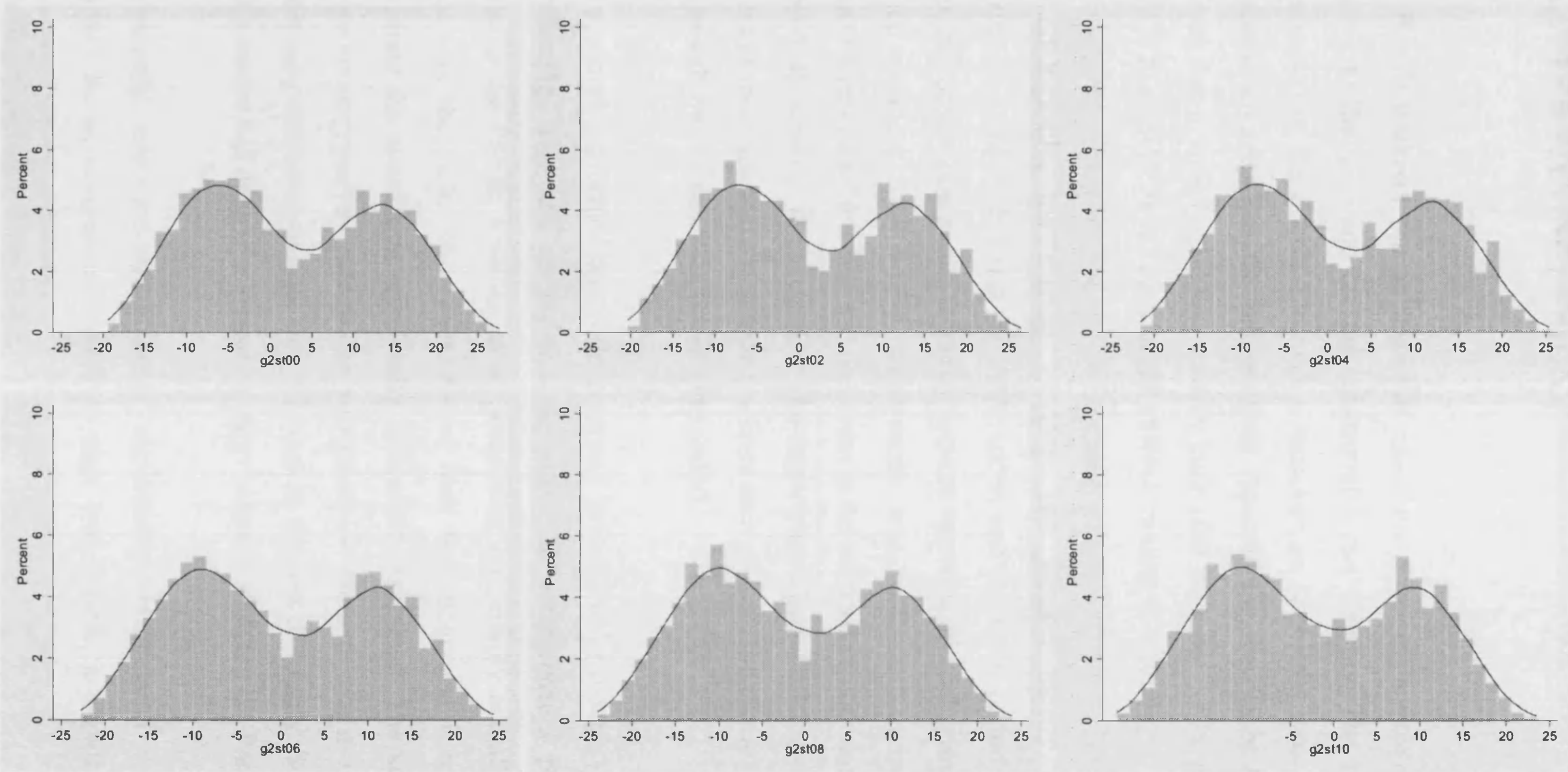
Note: m2st00: Expected profit distribution for 2nd stage under negative shock of 0%; m2st02: Expected profit distribution for 2nd stage under negative shock of 2%; m2st04: Expected profit distribution for 2nd stage under negative shock of 4%; m2st06: Expected profit distribution for 2nd stage under negative shock of 6%; m2st08: Expected profit distribution for 2nd stage under negative shock of 8%; m2st10: Expected profit distribution for 2nd stage under negative shock of 10%. Kernel density distribution estimated using Epanechnikov method.

5) Histograms and Kernel density distributions first stage – underlying parameter distribution of random shock: gamma



Note: g1st1: Expected profit distribution for 1st stage under negative shock of 10%; g1st2: Expected profit distribution for 1st stage under negative shock of 20%; g1st3: Expected profit distribution for 1st stage under negative shock of 30%; g1st4: Expected profit distribution for 1st stage under negative shock of 40%; g1st5: Expected profit distribution for 1st stage under negative shock of 50%; g1st6: Expected profit distribution for 1st stage under negative shock of 60%. Kernel density distribution estimated using Epanechnikov method.

6) Histograms and Kernel density distributions first stage – underlying parameter distribution of random shock: gamma



Note: g2st00: Expected profit distribution for 2nd stage under negative shock of 0%; g2st02: Expected profit distribution for 2nd stage under negative shock of 2%; g2st04: Expected profit distribution for 2nd stage under negative shock of 4%; g2st06: Expected profit distribution for 2nd stage under negative shock of 6%; g2st08: Expected profit distribution for 2nd stage under negative shock of 8%; g2st10: Expected profit distribution for 2nd stage under negative shock of 10%. Kernel density distribution estimated using Epanechnikov method.

CHAPTER 7. CONCLUSIONS

The Pacific Railroad was an important milestone in the expansion of the railroad network to the west and created substantial social benefits. The motivation for construction of the Pacific Railroad is therefore an important issue. The existing consensus suggests that the entrepreneurs expected the road to be built ahead of demand, but it turned out it was actually built after demand[376]. The purpose of this thesis is to examine if this paradoxical characterisation is accurate.

Methodologically, the existing literature has focused mostly on analysing information generated during the construction and operation period. Data derived from the construction period is murky because opportunistic behaviour casts doubts on its accuracy. Additionally, construction was performed under the unusual circumstances of a Civil War and no access to the external capital market, making it difficult to identify if data reflect the underlying characteristics of the railroad project or these unusual circumstances. Data derived from the operation period does not provide any evidence on the ex-ante period.

The approach performed here is different and believed to be thought-provoking and illuminating. The idea is to examine what the entrepreneurs promoting and assessing the Pacific Railroad as an investment opportunity actually did and the documents they left. The rationality of their behaviour and their approach to evaluating the investment opportunity is carefully examined. The key sources are the preliminary survey reports the entrepreneurs wrote to assess the investment opportunity and communicate their findings to the rest of society. Several features of this source had been overlooked by many scholars studying the Pacific Railroad.

Additionally, since the entrepreneurs' expectations, as declared in these reports, may not be an accurate reflection of their true beliefs, a simulation model is

[376] See Fogel (1960) and Mercer (1982).

developed to evaluate the plausibility of the declared expectations. The simulation model is founded on the approach prevalent in the 1850s to evaluate railroad investment opportunities and uses information publicly available by 1862, when Congress provided subsidies through the Pacific Railroad Act and changed the incentives faced by entrepreneurs.

Next, the observed performance of the entrepreneurs is examined. A substantial effort collecting price information by submarket for the Pacific Railroad allowed the identification of the competitive strategy adopted by the entrepreneurs in each submarket. Finally the three sets of information (declared expectations, simulated expectations, and observed outcomes) are compared to understand better what the entrepreneurs expected, which events happened in an unexpected manner, and what were the consequences of these events.

The thesis contributes to two literatures. Initially it is discussed if the Pacific Railroad was built ahead of demand. The following part considers the nature and degree of rationality demonstrated by entrepreneurs.

7.1. The Pacific Railroad and building ahead of demand

The evidence collected in this thesis indicates that entrepreneurs had been interested in the Pacific Railroad as an investment opportunity since the mid 1840s. The demand for transportation to the Pacific Ocean boomed at the time. The territorial expansion of the United States, acquiring immense new territories and a long coast on the Pacific Ocean, the gold rush in California, and the opening of the Chinese market to international trade led to a phenomenal expansion of demand for transportation to the Pacific Ocean.

The entrepreneurs perceived the expansion of demand and evaluated the opportunity of profiting by providing transport to and from the Pacific Ocean. First, entrepreneurs performed activities to reduce uncertainty of the project. Market surveys were performed identifying better the nature of trade costs, how the Pacific Railroad would reduce these costs, and its level of expected profits. All entrepreneurs declared to expect the railroad to be profitable. Additionally, some proposed charging a premium to appropriate some of the trade costs savings derived from the reduction in transport time provided by the Pacific Railroad. The entrepreneurs also undertook publicity campaigns to demonstrate to Congress, capital markets and the public the benefits derived from the Pacific Railroad.

Second, entrepreneurs explored different combinations of technologies and routes to determine the most effective one to improve transportation to and from the Pacific Ocean, compared to conventional shipping around Cape Horn or Cape of Good Hope. The Clipper ships were the first technology to appear in the marketplace and were very profitable. The Pacific Mail Steamship Company was second to arrive and was also very profitable. It was initially launched with subsidies to provide communication for the United States Army during the Mexican war, but as the California gold rush developed it became one of the most profitable American companies. Larger infrastructure projects like railroads and canals then began to compete to enter the market. Some entrepreneurs considered the possibility of a railroad across the North American continent, and connecting to shipping to reach Asia. Some others considered the possibility of canals across Central America and the Suez Isthmus. And some others considered a railroad through Central America, the Suez, or the Ottoman Empire. Profit opportunities of transport projects to and from the Pacific Ocean were so evident that American, British and French entrepreneurs competed to identify the most appropriate combination of technology and route.

The project for a Railroad to the Pacific faced two important difficulties during the 1850s. One difficulty was that uncertainty regarding construction costs and the practicability of operation still existed. The Army survey performed during the early 1850s concluded construction of a railroad across the continent was feasible and several routes were available. However, the Army surveys were not detailed enough to reliably determine operational practicability of a given route or to develop construction cost estimates. Detailed technical and market survey techniques were well developed already, but had not been performed for the Army survey and were expensive. Another difficulty is that the project faced a deadlock in Congress. As explained above, there were many entrepreneurs competing to build a large scale project to transport to and from the Pacific Ocean. Each entrepreneur was supported by a specific social group and proposed a specific technology/route combination to provide transportation to the Pacific Ocean. Within the United States at least five different potential transcontinental railroad projects existed. All projects implied building over federal territories, and therefore any project had to be debated in Congress. Additionally, each project implied a different regional allocation of the benefits and costs generated by the railroad. Consequently, some regions promoted a specific project benefiting them and blocked all other projects, particularly those imposing costs on them. The conflict over the allocation of benefits and costs often coincided with the geography of the slavery question. The result was congressional deadlock for the project.

New gold rushes were experienced in Nevada and Colorado during the late 1850s. Mining was an intensive user of transportation. The location of transport demand derived from the mining booms was ideal for the project to build a Pacific Railroad through a central route. On the Pacific coast, San Francisco and Sacramento were the key economic centres of California and the natural western terminus for any Railroad to the Pacific. On the eastern slope of the Sierra Nevada the gold rush in Nevada would provide immediate transport demand once the railroad crossed the Sierra. In the basin between the Sierra Nevada and the Rocky Mountains, the Mormons had been prosperously concentrating in Salt Lake City, and its trade also had to be transported. On the eastern part of the railroad route, the mines in Pikes Peak (near Denver, CO) would provide transport demand up the eastern slope of the Rocky Mountains.

Entrepreneurs realised it was now possible to divide the project of a Pacific Railroad through the central route into two stages. A first stage of the Pacific Railroad from California to Nevada would allow crossing the major obstacle (the Sierra Nevada). After the Nevada gold rush, the railroad could be expected to experience high earnings as soon as the railroad crossed the Sierra, without having to wait for 10 years for the Californian and Chinese trade traffic earnings to come in with the completion of the road. Additionally, there was no need to debate the project in congress, overcoming the political deadlock; at least until the first stage was already running and profitable.

Californian entrepreneurs found a route and invested in developing a detailed survey, assessed the investment opportunity, and incorporated the Central Pacific Railroad in 1861. The investment in producing the survey was small compared to the costs of building the road, but it still was more than twice the average revenue of a typical manufacturing establishment in the eastern industrial states. The survey collected detailed information on the location of the route, the grades, the curves, the number and cost of tunnels and bridges. Using this information the survey report provided an estimated construction cost. The expected cost was about half of the cost the Army surveys indicated in the mid 1850s for their preferred route to cross the Sierra Nevada from San Francisco to Nevada. The practicability of operation of the railroad was assessed by comparing the technical standards of the proposed route to a successful eastern one. Operating the Central Pacific should not be much more difficult than operating the Baltimore and Ohio (that had already operated successfully for more than 20 years). Market research was also performed. The survey collected traffic statistics of several local traffic submarkets and estimated expected revenues and profits. The Central Pacific was expected to be very profitable.

The California entrepreneurs also considered the second stage of the Pacific Railroad. Although technical assessment of the second stage of the project relied on the Army surveys, the entrepreneurs were positive about its operational practicability for two reasons. First, the first stage was technically more complicated than the second stage and it had been shown a railroad over the Sierra Nevada was expected to cost less than originally thought and to be operationally practicable. Second, since the entrepreneurs make the decision to build the second stage after completion of the first stage, by then they already know if the expected operational practicability and construction cost reductions of the first stage have been achieved. Successful completion and operation of the first stage with lower construction costs certainly boosts the expected operational practicability of the simpler second stage. The economic incentives for the second stage were connected to increasing traffic growth and high transport time savings premiums. The development of the Colorado gold rush and growth of the Californian and Chinese trades were expected to generate rapid transport demand growth. Finally, some entrepreneurs indicated to expect to charge high prices to transport goods and passengers faster.

Additionally, eastern entrepreneurs also demonstrated interest in developing what the California entrepreneurs considered the second stage of the Pacific Railroad. The entrepreneurs had been promoting railroad construction in the Mid-west following the expansion of the agricultural frontier in the late 1840s and early 1850s. In the mid 1850s they proposed to continue promoting railroad construction into the Rocky Mountains. After the Pacific Railroad Act created the Union Pacific it was these entrepreneurs who incorporated it. The Union Pacific surveys also indicate the entrepreneurs expected the second stage to be operationally practicable and to cost less than it had been originally indicated by the Army surveys. Thus, there were several plans and substantial interest to develop what the California entrepreneurs considered the second stage of the Pacific Railroad.

The information derived from the simulation exercise indicates the entrepreneurs were right to divide the project into two stages. The first stage should have been expected to be profitable. Local traffic and wagon prices were high enough and rail's technological advantage so great that such a railroad was most likely to be privately profitable. Additionally, the project should have been expected to be profitable under many variations of the situation observed by 1862. The project was solid and deserved interest from entrepreneurs.

The simulation exercise also reveals the extension of the project into the second stage depended critically on the entrepreneurs' forward looking expectations. The cost of sea transport was so low compared to the cost of rail that the Pacific Railroad could not have competed successfully on prices with shipping around Cape Horn. For the Pacific Railroad entrepreneurs to expect profits from the through traffic business they should have expected traffic to grow fast, merchants and passengers to value transport time reduction highly, and construction cost to be substantially lower than what was expected it would be during the 1850s.

The collection of ex-post information confirmed the entrepreneurs formed their expectation generally in the right way. They predicted the road would cost substantially less than it was believed to cost in the 1850s, and it actually cost substantially less. They predicted high traffic growth and high value of time savings, and traffic grew even faster and high prices for transportation were paid.

In short, the paradoxical consensus is wrong. The entrepreneurs expected the Pacific Railroad to be built after demand and it turned out to be built after demand. There is no paradox. The sources of demand were mining for local traffic and the Californian and Chinese trades for through traffic. Expected lower construction costs also played an important role in the project's expected and observed profitability. The existing literature is correct about the absence of widespread settlement by 1862 on the region the railroad was to cross. Additionally, the existing literature is also correct that substantial stretches of the territories crossed by the railroad would never be settled for agriculture, as these were deserts. Economic historians who wrote the existing literature correctly focused on the expansion of the agricultural frontier on the eastern side of the United States, but when they looked for transport demand on the Pacific side they may have simply overlooked that alternative sources of transport demand existed.

Interestingly, although entrepreneurs declared to expect the Pacific Railroad to be profitable, the Pacific Railroad Act Congress passed in July 1 1862 included a subsidized loan and land grants to promote private construction of the first transcontinental. There are two reasons why Congress granted these subsidies. First, the capital market was severely affected during the Civil War and reconstruction; subsidies substituted for a well functioning domestic and international capital markets. Second, the Pacific Railroad generated positive and negative externalities and a political conflict over the distribution of these externalities existed; entrepreneurs lobbied for subsidies to insure against future changes in the political equilibrium and the risk of expropriation. Finally, the Pacific Railroad Act also facilitated coordination of construction of the two stages of the railroad line by dividing ownership and setting a construction race between the Central Pacific and the Union Pacific, promoting simultaneous and rapid construction of the Pacific Railroad.

7.2. Entrepreneurial activity and rationality during the 19th century

The investigation carried out here provided detailed documentation on the different activities performed by entrepreneurs when promoting and assessing an investment opportunity in the 1840s and 50s. The entrepreneurs invested sunk costs to perform research activities which would reduce uncertainty. Research was performed in a manner similar to what we do today. The technical characteristics of the project were identified in detail. The feasibility of the project was based on the similarity between the technical characteristics of the proposed project and those of existing successful experiences. The market research followed a reasonable approach and used intuitions that were later developed into economic theory, like the price-elasticity of demand and the gravity equation.

The evidence provided here complements the findings of Fishlow and Harley on the rationality of the railroad entrepreneurs behind the western expansion of the railroad network. Fishlow provided indirect evidence of rationality as railroads followed settlement of the Midwest in the 1840s and 50s[377]. Harley provided evidence also indirectly indicating similar behaviour for the Midwest in the late 1860s and the north Midwest in the 1880s[378]. The investigation presented here provides *direct* evidence of the entrepreneurs' rationality and illuminates the extent to which these men had performed procedurally rational assessments of the investment opportunity and performed activities to reduce any uncertainties involved.

In sum, this thesis has examined carefully the expectations of entrepreneurs when proposing to build the Pacific Railroad and the market outcomes once they built the road. Focusing explicitly on the entrepreneurial expectations allowed identifying that entrepreneurs had performed activities to evaluate the Pacific Railroad as an investment opportunity and reduce the uncertainty involved in the decision. In 1860 the project was divided into two stages. The evidence discussed above indicates entrepreneurs expected the first stage to be highly profitable and were right to expect so. Entrepreneurs also expected the second stage to be profitable. If they believed traffic would grow rapidly, merchants and passengers would pay high rail prices for fast transportation, and construction cost would be lower than expected in the 1850s, as some of them declared to believe, expected profits were justified. The observed outcomes indicate traffic grew even faster than expected, rail users paid high prices to reduce transport time, and construction costs were lower than originally expected in the 1850s. The findings have highlighted the importance of considering and analysing explicitly entrepreneurial expectations and provided evidence of the high degree of rationality exhibited by entrepreneurs during the 19th century.

[377] Fishlow (1965).
[378] Harley (1980 and 1982).

BIBLIOGRAPHY

ARCHIVAL SOURCES

California State Library, California History Room Collection.

California State Railroad Museum, Central Pacific Company and Southern Pacific Company Collections.

London School of Economics, Special Collections

Newbery Library, Railroad Archives

Northwestern University, Transportation Library

Union Pacific Railroad Company, Union Pacific Railroad Museum, Union Pacific Collection

University of California-Berkeley, Bancroft Library, Bancroft Collection

University of California-Davis, Michael and Margaret B. Harrison Western Research Center Collection

Stanford University, Southern Pacific Records

1. PRIMARY SOURCES

RAILROAD PROJECTS AND RAILROAD COMPANY REPORTS

Central Pacific Railroad Company (1863-1871). Annual Report of the Central Pacific Railroad Company of California to the Secretary of State of California.

Central Pacific Railroad Company (1877-1883). Report of the Central Pacific Railroad Company to the Auditor of railroad Accounts, Department of Interior, Washington D.C. for the Year.

Cisco, J. (1867-68). The Union Pacific Railroad from Omaha, Nebraska, Across the Continent, Making with its Connections an Unbroken Line from the Atlantic to the Pacific Ocean, Various Issues.

Cisco, J. (1868). The Union Pacific Railroad Company, Chartered by the United States, Progress of their Road West from Omaha, Nebraska Across the Continent New York.

Cleveland and Pittsburgh Railroad Company. (1849). Report of the Chief Engineer on the location and estimates of cost of the Cleveland and Pittsburgh Railroad : accompanied by the report of Alexander C. Twining, consulting engineer, and the statement of the President and Directors to the stockholders of the Company. Hudson,: 65p.

Davis (1855). Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean. Washington, Congress.

Degrand, P. (1949). Proceedings of the Friends of a Railroad to San Francisco at their Public Meeting Held at the US Hotel in Boston. Bosotn, Dutton and Wentworth.

Dodge, G. (1867). Report of General G. M. Dodge, Chief Engineer on the Lines Crossing the Rocky Mountains.

Dodge, G. (1868). The Union Pacific Railroad Company. Progress of their road west from Omaha. New York.

Durant, T. (1864). Report of the Organization and proceedings of the Union Pacific Railroad.

Durant, T. (1866). Union Pacific Railroad Report of Thomas Durant to the Board of Directors in Relation to the Surveys Made Up to the Close of the Year 1864.

Fisk and Hatch (1867-68). Railroad communication with the Pacific, with an account of the Central Pacific Railroad of California : the character of the work, its progress, resources, earnings and future prospects, and the advantages of its first mortgage bonds, Various Issues.

Hatch, F. a. (1867). Central Pacific Railroad of California: the Character of the Work, its Progress, Resources, Earnings and Future Prospects, and the Advantages of its First Mortgage Bonds. New York.

Holcomb, F. P. (1847). Report on the preliminary surveys and estimates for the South-Western Railroad, from Macon to Fort Gaines, on the Chattahoochee River, and the Gulf of Mexico : with branches to Columbus and Albany. Macon,: 76p.

Judah, T. (1854). Railroad Report of the Chief Engineer on Preliminary Surveys and Future Business of the Sacramento Valley Railroad

Judah, T. (1857). A Practical Plan for Building the Pacific Railroad.

Judah, T. (1857). A Practical Plan for the Pacific Railroad.

Judah, T. (1860). Central Pacific Railroad of California.

Judah, T. (1861). Memorial of the Central Pacific Railroad of California.

Judah, T. (1862). Report of the Chief Engineer on the Preliminary Survey, Cost of Construction, and Estimated Revenue of the Central Pacific Railroad of California

Judah, T. (1863). Report of the Chief Engineer Upon Recent Surveys, Progress of Construction and an Approximate Estimate of Cost of First Division of Fifty Miles of the Central Pacific Railroad of California.

McDougall (1854). "Speech of Mr J. A. McDougall of California in the House of Representatives." Appendix to the Congressional Globe **33 Congress 1st Session**: 862-866.

Montague, S. (1864). Report of the Chief Engineer upon Recent Surveys, Progress of Construction, and an Approximate Estimate of Receipts of the Central Pacific Railroad of California

Montague, S. (1865). "Report of the Chief Engineer upon Recent Surveys, Progress of Construction of the Central Pacific Railroad of California."

n.a. (1847). Exposition of Advantages of a Railroad between New York and Albany, on the Interior Route. New York.

New York and Boston Railroad Company. (1847). Report of Edwin F. Johnson to the Central Committee, August, 1847. Middletown, Conn.,: 65p.

New York and New Haven Railroad Company. (1845). Engineer's report on the survey and primary location of the New York and New Haven Railroad ... 1845. New Haven,: 39p.

Union Pacific and Central Pacific Railroad Companies (1870, 1873, 1884). Union and Central Pacific Railroad Line, Advestisement Pamphlet Including Passenger Rates and Timetables.

Union Pacific Railway Company (1871-1883). Report to the Stockholders of the Union Pacific Railway Company for the Year.

Whitney, A. (1845). A railroad to the Pacific. Washington, US Congress, Memorial.

Whitney, A. (1848). Railroad to Oregon. H. o. R. US Congress.

Whitney, A. (1849). Project for a railroad to the Pacific. New York.

GOVERNMENT PUBLICATIONS

Aldrich, F. (1893). Wholesale Prices, wages and Transportation.

Board of Railroad Commissioners (1879). Biennial Report of the Commissioner of Transportation of the State of California for the Years Ending December 31, 1877 and 1878. Sacramento.

Census Office (1883). Report on the Agencies of Transportation in the United States, Including Statistics of Railroads, Steam Navigation, Canals, Telegraphs and Telephones.

Census Office (1883). United States Census Report on the Agencies of Transportation in the United States, Vol 4. Washington.

Davis (1855). Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean. Washington, Congress.

Government Printing Office (1897). Acts and joint Resolutions of Congress and Decisions of the Supreme Court of the United States Relating to the Union Pacific, Central Pacific and Western Pacific Railroads.

McClellan (1855). Memoranda on Railways. Report of the Secretary of War Communicating Several Pacific Railroad Explorations. J. Davis. **1:** 96-117.

Nimmo, J. (1885). Report on the Internal Commerce of the United States, Treasury Department.

Snow, C. (1869). Preliminary Report to the President of the United States on the Location, Construction, and Management of the Union Pacific Railroad.

US Department of Treasury (1856-1860). Commerce and Navigation Report.

NEWSPAPERS AND OTHER PRIMARY SOURCES

American Railroad Journal

New York Shipping List and Current Prices

Pacific Mail Steamship Company (1859). Fifth Annual Report. New York.

Pacific Mail Steamship Company (1868). Report of the President to Stockholders.

Putnam's Monthly Magazine

San Francisco Chamber of Commerce (1867-90). Report of the President for the Year. San Francisco.

San Francisco Chamber of Commerce (1873). Report of the Committee Appointed by the Chamber of Commerce of San Francisco to Co-operate with the Select Committeeof the U.S. Senate on the Subject of Routes of Transportation. San Francisco.

San Francisco Chamber of Commerce (1873). Report of the Committee of the Chamber of Commerce of San Francisco to Prepare Bills for Legislative Action on the Subject of Fares and Freight. San Francisco.

San Francisco Journal of Commerce

San Francisco Price Current and Shipping List

2. SECONDARY SOURCES

Aghion, P. and J. Tirole (1994). "The Management of Innovation." The Quarterly Journal of Economics **109**(4): 1185-1209.

Alchian, A. A. (1950). "Uncertainty, Evolution, and Economic Theory." The Journal of Political Economy **58**(3): 211-221.

Alesina, R, Özler, S., N. Roubini and P. Swagel (1992) "Political instability and economic growth" Working Paper No. 4173, NBER, Cambridge, MA

Ambrose, S. (2000). Nothing Like It in the World. The Men Who Built the Transcontinental Railroad 1863-69. New York, Simon and Schuster.

Ames, C. E. (1969). Pioneering the Union Pacific; a reappraisal of the builders of the railroad. New York, Appleton-Century-Crofts.

Anderson, J. E. and E. van Wincoop (2003). "Gravity with Gravitas: A Solution to the Border Puzzle." American Economic Review **93**(1): 170-92.

Anderson, J. E. and E. van Wincoop (2004). "Trade Costs." Journal of Economic Literature **42**(3): 691-751.

Arrow, K. (1962). Economic Welfare and the Allocation of Resources for Invention. The Rate and Direction of Inventive Activity. N. B. o. E. Research. Princeton, Priceton University Press.

Atack, J (1979) "Fact in Fiction? The Relative Costs of Steam and Water Power: A Simulation Approach." Explorations in Economic History, **16** : 409-437.

Atack, J., P. Passell, et al. (1994). A new economic view of American history : from colonial times to 1940. New York, Norton.

Bain, D. (1999). Empire Express. Building the First Transcontinental Railroad. New York, Viking.

Barro, R. (1991) "Economic Growth in a Cross Section of Countries." **Quarterly Journal of Economics 106 :** 407–443.

Bates, J. (2000). History of Demand Modelling. Handbook of transport modelling. D. A. Hensher and K. J. e. Button, Pergamon: 11-34.

Baumol, W. J. (1968). "Entrepreneurship in Economic Theory." The American Economic Review **58**(2): 64-71.

Baumol, W. J. (1990). "Entrepreneurship: Productive, Unproductive, and Destructive." The Journal of Political Economy **98**(5): 893-921.

Bergstrand, J. H. (1985). "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence." The Review of Economics and Statistics **67**(3): 474-481.

Berry, T. (1984). Early California: Gold, Prices, Trade. Richmond, Bostwick.

Blank, L., D. Kaserman, et al. (1998). "Dominant firm pricing with competitive entry and regulation: the case of IntraLATA toll." Journal of Regulatory Economics **14**: 35-53.

Blanquier, A. (1997). Traffic and revenue forecasts for the Channel Tunnel project. The econometrics of major transport infrastructures. E. Quinet and R. Vickerman, MacMillan Press: 83-114.

Borenstein, S. (2002). "The Trouble With Electricity Markets: Understanding California's Restructuring Disaster." The Journal of Economic Perspectives **16**(191-211).

Borenstein, S. and J. Bushnell (1999). "An Empirical Analysis of the Potential for Market Power in California's Electricity Industry " Journal of Industrial Economics **47**(3): 285-323.

Boyd, J. H. and G. Walton (1972). "The social savings from nineteenth-century rail passenger services." Explorations in Economic History **9**: 233-254.

Braeutigam, R. R. (1999). Learning about Transport Costs. Essays in transportation economics and policy: A handbook in honor of John Meyer. J. A. Gomez-Ibanez, W. B. Tye and C. e. Winston, Brookings Institution.

Brown, M. (1933). "Asa Whitney and his Pacific Railroad publicity campaign." The Mississippi Valley Historical Review **20**(2): 209-224.

Bruchey, S. (1967). "Review American Railroads and the Transformation of the Ante-Bellum Economy by Albert Fishlow." The American Historical Review **72**(3): 1097-98.

Buschena, D. and J. Perloff (1991). "The creation of dominant firm market power in the coconut oil export market." American Journal of Agricultural Economics **73**(4): 1000-1008.

Bushnell, J., E. Mansur, et al. (forthcoming). "Vertical Arrangements, Market Structure and Competition: An analysis of Restructured U.S. Electricity Markets." American Economic Review.

Camerer, C. and D. Lovallo (1999). "Overconfidence and Excess Entry: An Experimental Approach." The American Economic Review **89**(1): 306-318.

Carlton, D. and J. Perloff (2005). Modern industrial organization, Pearson.

Carstensen, V. R. (1963). The public lands : studies in the history of the public domain. Madison, University of Wisconsin Press.

Carter, S. B., S. S. Gartner, et al. (2006). Historical statistics of the United States : earliest times to the present. Cambridge, Cambridge University Press.

Casadesus-Masanell, R., B. J. Nalebuff, et al. (2007). Competing Complements. NET Institute Working Paper.

Casson, M. (2003). The entrepreneur : an economic theory. Cheltenham, Edward Elgar.

Chandler, A. D., Jr. (1965). The Railroads : The Nation's First Big Business: Sources and Readings. New York, Harcourt.

Chandler, A. D., Jr. (1969). "Review American Railroads and the Transformation of the Ante-Bellum Economy by Albert Fishlow." The Journal of Economic History **29**(3): 562-6.

Chandler, A. (1977). The visible hand : the managerial revolution in American business. Cambridge, Belknap Press.

Chandler, R. (2001). "California Stagecoaching: the Dusty Reality." Dogtown Territorial Quarterly **47**(Fall): 4-24.

Chandler, R. (2003). "Wells Fargo Stagecoaching: An 1860s Turf War." Journal of the West **42**(Spring): 21-33.

Chandler, R. and S. Potash (2007). Gold, Silk, Pioneers and Mail: The Story of the Pacific Mail Steamship Company. San Francisco, Friends of the San Francisco Maritime Museum Library.

Clark, A. H. (1911). The clipper ship era : an epitome of famous American and British clipper ships, their owners, builders, commanders, and crews, 1843-1869. New York, Knickerbocker Press.

Clay, K. (2003). Entry for San Francisco. The Oxford Encyclopedia of Economic History. J. Mokyr. Oxford, Oxford University Press: 439-440.

Combs (1999). Entry for John Jay. AMERICAN NATIONAL BIOGRAPHY. J. Garraty and M. Carnes. **11:** 891-4.

Conkling, R. and W. D. Shipman (1887). The Central Pacific Railroad Company in equitable account with the United States, growing out of the issue of subsidy bonds in aid of construction : a review of the testimony and exhibits, etc. New-York, [s.n.].

Cotterill, R. (1919). "Early Agitation for a Pacific Railroad 1845-1850." The Mississippi Valley Historical Review **5**(4): 396-414.

Daggett, S. (1966). Chapters on the history of the Southern Pacific. New York,, A. M. Kelley.

David, P. and P. Solar (1977). A bicentenary contribution to the cost of living in America. Research in Economic History. P. Uselding. Greenwich. **2:** 1-80.

Davis, L. and R. Cull (2000). International capital movements, domestic capital markets, and American economic growth, 1820-1914 The Cambridge Economic History of the United States. S. Engerman and R. Gallman. Cambridge, Cambridge University Press. **2**.

Degrand, P. (1949). Proceedings of the Friends of a Railroad to San Francisco at their Public Meeting Held at the US Hotel in Boston. Bosotn, Dutton and Wentworth.

Deverell, W. (1994). Railroad Crossing. Berkeley, University of California Press.

Disdier, A. and K. Head (2006). "The Puzzling Persistence of the Distance Effect on Bilateral Trade." The Review of Economics and Statistics **90**(1): 37-48.

Dixit, A. K. and R. S. Pindyck (1993). Investment under uncertainty. Princeton, N.J., Princeton University Press.

Eaton, J. and S. Kortum (2002). "Technology, Geography, and Trade." Econometrica **70**(5): 1741-79.

Engerman, S. (1972). "Some Economic Issues Relating to Railroad Subsidies and the Evaluation of Land Grants " Journal of Economic History **32**(2): 443-63.

Evans, R. (1964). "Without regard for cost": the returns on Clipper Ships." The Journal of Political Economy **72**(1): 32-43.

Farnie, D. A. (1969). East and west of Suez : the Suez Canal in history, 1854-1956. Oxford, Claredon Press.

Feenstra, R. C. (2004). Advanced international trade : theory and evidence. Princeton, N.J., Princeton University Press.

Fishlow, A. (1965). American railroads and the transformation of the ante-bellum economy Harvard economic studies, Harvard University Press.

Fishlow, A. (1972). Internal transportation. American Economic Growth: An economist's history of the United States. L. Davis, R. Easterlin and W. Parker. New York, Haeper & Row.

Fishlow, A. (2000). Internal transportation in the nineteenth century Cambridge Economic History of the United States. S. Engerman and R. Gallman. Cambridge, Cambridge University Press.

Fitzgerald, P. (1876). The Great Canal at Suez: Its Political, Engineering and Financial History. London.

Fleisig, H. (1974). "The Union Pacific Railroad and the railroad land grant controversy." Explorations in Economic History **11**(2): 155-172.

Fleisig, H. (1975). "The Central Pacific Railroad and the Railroad Land Grant Controversy." The Journal of Economic History **35**(3): 552-566.

Fletcher, M. (1958). "The Suez Canal and World Shipping, 1869-1914." Journal of Economic History **18**(4): 556-573.

Fogel, R. (1960). The Union Pacific: A Case in Premature Enterprise. Baltimore, John Hopkins University Press.

Fogel, R. (1964) Railroad and American Economic Growth: Essays in Econometric History. Baltimore, John Hopkins University Press

Folkman, D. (1972). The Nicaragua route. Salt Lake City, University of Utah Press.

Furtan, W. H., J. G. Nagy, et al. (1983). "The Impact on the Canadian Rapeseed Industry from Changes in Transport and Tariff Rates: Reply." American Journal of Agricultural Economics **65**(3): 618-19.

Galloway, J. D. (1941). "Theodore Dehone Judah - Railroad Pioneer." Civil Engineering.

Galloway, J. D. (1950). The First Transcontinental Railroad: The Central Pacific, the Union Pacific. New York, Simmons Boardman.

Gilliss, J. (1870). "Tunnels of the Pacific Railroad." Transactions of the American Society of Engineers **1**(13): 153-172.

Gomez-Ibanez, J., W. Tye, et al. (1999). Essays in transportation economics and policy: A handbook in honor of John Meyer, Brookings Institution.

Goodrich, C. (1948). "National Planning of Internal Improvements." Political Science Quarterly **63**(1): 16-44.

Goodrich, C. (1950). "The Revulsion Against Internal Improvements." The Journal of Economic History **10**(2): 145-169.

Goodrich, C. (1956). "American Development Policy: The Case of Internal Improvements." The Journal of Economic History **16**(4): 449-460.

Goodrich, C. (1970). "Internal Improvements Reconsidered." The Journal of Economic History **30**(2): 289-311.

Gowrisankaran, G. and T. Holmes (forthcoming). "Mergers and the evolution of industry concentration: results from dominant firm model." Rand Journal of Economics.

Griswold, W. (1962). A Work of Giants. New York, McGraw Hill.

Gunderson, G. (1970). "The Nature of Social Saving." The Economic History Review **23**(2): 207-219.

Hallberg, C. W. (1974). The Suez Canal, its history and diplomatic importance.

Haney, L. H. and University of Wisconsin. (1910). A congressional history of railways in the United States, 1850-1887. Madison, [s.n.].

Harley, C. K. (1978). "Western Settlement and the Price of Wheat, 1872-1913." Journal of Economic History **38**(4): 865-78.

Harley, C. K. (1980). "Transportation, the World Wheat Trade, and the Kuznets Cycle, 1850-1913." Explorations in Economic History **17**(3): 218-50.

Harley, C. K. (1982). "Oligopoly Agreement and the Timing of American Railroad Construction." Journal of Economic History **42**(4): 797-823.

Harley, C. K. (1988). "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed." Journal of Economic History **48**(4): 851-76.

Harley, C. K. (2007). Steers afloat: the North Atlantic meat trade, liner predominance and freight rates, 1870-1913. Working Paper. Oxford University.

Hensher, D. and K. Button (2000). Handbook of transport modelling, Pergamon.

Hinton, W. M. (1877). Theodore Judah The Pioneer Engineer and Successful Projector of the Pacific Railroad. First Annual Meeting of the Territorial Pioneers of California.

Hirshson, S. P. (1967). Grenville M. Dodge : soldier, politician, railroad pioneer. Bloomington, Indiana University Press.

Hittell, T. (1863). "Theodore Dehone Judah member of American society of civil engineers." Transactions of American Society of Civil Engineers.

Hittell, T. (1898). History of California.

Holbrook, S. H. (1948). The story of American railroads. New York,, Crown Publishers.

Hughes, J. R. T. and L. P. Cain (2003). American economic history. Reading, Mass., Addison-Wesley.

Hunt, E. H. (1967). "Railroad Social Saving in Nineteenth Century America." The American Economic Review **57**(4): 909-910.

Hutchins, J. (1941). The American Maritime Industries and Public Policy. Boston, Harvard University Press.

Hutchinson, W. and R. Ungo (2004). The social savings of the Panama Canal. WP 04-W23.

Innis, H. A. (1971). History of the Canadian Pacific Railway. Toronto, University of Toronto Press.

Isserlis, L. (1938). "Tramp Shipping Cargoes, and Freights." Journal of the Royal Statistical Society **101**(1): 53-146.

Jones, M. (1995). The Limits of Liberty: American History 1607-1992. Oxford, Oxford University Press.

Judah, A. (1889). Preparatory Notes for Biography of Theodore Judah.

Jue, J. G. (1999). Inter-regional Trade and Market Integration: California and the Transcontinental Railroad, 1860-1900. Economics. Berkeley, University of California-Berkeley. **PhD**.

Kahai, S., D. Kaserman, et al. (1996). "Is the "Dominant firm" dominant? An emprical analysis of AT&T's market power." Journal of Law and Economics **39**(2): 499-517.

Kaukiainen, Y. (n.d.). How the price of distance declined: Ocean freights for grain and coal from 1870s to 2000. Department of History, University of Helsinki: 1-34.

Kemble, J. H. (1942). A Hundred Years of the Pacific Mail. Side-Wheelers Across the Pacific. J. H. Kemble, San Francisco Museum of Science and Industry.

Kemble, J. H. (1942). Side-Wheelers Across the Pacific. Side-Wheelrs Across the Pacific. J. H. Kemble, San Francisco Museum of Science and Industry

Kemble, J. H., Ed. (1943). The Panama Route 1848-1869. Berkeley, University of California Press.

Kihlstrom, R. E. and J.-J. Laffont (1979). "A General Equilibrium Entrepreneurial Theory of Firm Formation Based on Risk Aversion." The Journal of Political Economy **87**(4): 719-748.

Kinross, P. (1968). Between two seas; the creation of the Suez Canal. New York, Morrow.

Kirzner, I. M. (1973). Competition and entrepreneurship. Chicago ; London, University of Chicago Press.

Kirzner, I. M. (1997). "Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach." Journal of Economic Literature **35**(1): 60-85.

Klein, M. (1987). Union Pacific, Birth of a railroad. Garden City, N.Y, Doubleday.

Knight, F. H. (1921). Risk, uncertainty and profit. Boston, Houghton Mifflin.

Kydland, F. (1979). "A dynamic dominant firm model of industry structure." Scandinavian Journal of Economics **81**: 355-366.

Lavender, D. (1970). The Great Persuader. New York, Doubleday & Co.

Lebergott, S. (1966). "United States Transport Advance and Externalities." The Journal of Economic History **26**(4): 437-461.

Leibenstein, H. (1966). "Allocative Efficiency vs. "X-Efficiency"." The American Economic Review **56**(3): 392-415.

Leland, H. J. (1944). "Railroads as an Economic Force in American Development." The Journal of Economic History **4**(1): 1-20.

Lew, B. and B. Cater (2006). "The Telegraph, Co-ordination of Tramp Shipping, and Growth in World Trade, 1870-1910." European Review of Economic History **10**(2): 147-73.

Lewis, O. (1938). The big four : the story of Huntington, Stanford, Hopkins, and Crocker, and of the building of the Central Pacific. New York, Knopf.

Locklin, P. (1966). "Annals of the American Academy of Political and Social Science." Annals of the American Academy of Political and Social Science **367**(229).

Loomis, N. (1912/13). "Asa Whitney: Father of the Pacific Railroads." Proceedings of the Mississippi Valley Historical Association **6**: 166-175.

Lopez-Cordova, J. E. and C. M. Meissner (2003). "Exchange-Rate Regimes and International Trade: Evidence from the Classical Gold Standard Era." American Economic Review **93**(1): 344-53.

Lopez-Cordova, J. E. and C. M. Meissner (2005). The Globalization of Trade and Democracy, 1870-2000, National Bureau of Economic Research, Inc, NBER Working Papers: 11117.

Lord, E. (1959). Comstock Mining and Miners. Berkeley, Howell-North.

Lotchin, R. (1974). San Francisco 1846-1856: From Hamlet to City. New York.

Lubbock, B. (1916). The China clippers. Glasgow,.

Lubbock, B. (1933). The Opium clippers. Glasgow, Brown, Son & Ferguson.

Lucas, R. (1976). Econometric policy evaluation: A critique. Carnegie-Rochester Conference Series on Public Policy.: 19-46.

Lucas, R. E., Jr. (1978). "On the Size Distribution of Business Firms." The Bell Journal of Economics **9**(2): 508-523.

Marlowe, J. (1964). The Making of the Suez Canal. London, Cresset Press.

Marvin, W. L. (1902). The American merchant marine : its history and romance from 1620 to 1902. London, [s.n.].

McAvoy, P. (1968). "Review American Railroads and the Transformation of the Antebellum Economy by Albert Fishlow." The American Economic Review **58**(1): 214-16.

McCague, J. (1964). Moguls and iron men; the story of the first transcontinental railroad. New York,, Harper & Row.

McClelland, P. D. (1968). "Railroads, American Growth, and the New Economic History: A Critique." The Journal of Economic History **28**(1): 102-123.

McClelland, P. D. (1972). "Social Rates of Return on American Railroads in the Nineteenth Century." The Economic History Review **25**(3): 471-488.

McMaster, J. B. (1932). A history of the people of the United States from the revolution to the civil war. Vols. 1-7, (1784-1850). New York, Appleton.

McNally, M. G. (2000). The Four-Step Model. Handbook of transport modelling. D. A. Hensher and K. J. e. Button, Pergamon: 35-52.

Mercer, L. (1974). "Building Ahead of Demand: Some Evidence for the Land Grant Railroads." Journal of Economic History **34**(2): 492-500.

Mercer, L. (1982). Railroads and Land Grant Policy : A Study in Government Intervention. New York, Academic Press.

Mercer, L. J. (1969). "Land Grants to American Railroads: Social Cost or Social Benefit?" The Business History Review **43**(2): 134-151.

Mercer, L. J. (1970). "Rates of Return for Land-Grant Railroads: The Central Pacific System." The Journal of Economic History **30**(3): 602-626.

Mitchener, K. J. and M. D. Weidenmier (2004). Empire, Public Goods, and the Roosevelt Corollary, National Bureau of Economic Research, Inc, NBER Working Papers: 10729.

Mohammed, S. and J. Williamson (2003). Freight Rates and Productivity Gains in British Tramp Shipping 1869-1950 NBER Working Paper.

Mohring, H. (1994). The economics of transport, Elgar.

Moody, J. (1919). The railroad builders : a chronicle of the welding of the states. New Haven, Yale university press ;

Murphy, K. M., A. Shleifer, et al. (1989). "Industrialization and the Big Push." The Journal of Political Economy **97**(5): 1003-1026.

n.a. (n.a.). Around the World by Steam via the Pacific Railway.

Nelson, R. R. (1959). "The Simple Economics of Basic Scientific Research." The Journal of Political Economy **67**(3): 297-306.

Neu, I. (1966). "Review American Railroads and the Transformation of the Ante-Bellum Economy by Albert Fishlow." The Journal of American History **53**(2): 365-7.

North, D. (1958). "Ocean freight rates and economic development 1750-1913." The Journal of Economic History **18**(4): 537-555.

North, D. (1968). "Sources of productivity change in ocean shipping 1600-1850." The Journal of Political Economy **76**(5): 953-970.

North, D. (1981) Structure and Change in Economic History. Norton, New York

O'Rourke, K. H. and J. G. Williamson (1999). Globalization and history : the evolution of a nineteenth-century Atlantic economy. Cambridge, Mass., MIT Press.

Orsi, R. J. (2005). Sunset limited : the Southern Pacific Railroad and the development of the American West, 1850-1930. Berkeley, University of California Press.

Otis, F. (1861). Illustrated history of the Panama railroad. New York, Harper & Bros.

Oum, T. H. and W. G. Waters, II (2000). Transport Demand Elasticities. Handbook of transport modelling. D. A. Hensher and K. J. e. Button, Pergamon: 197-210.

Oum, T. H., W. G. Waters, II, et al. (1990). A survey of recent estimates of price elasticities of demand for transport. World Bank WPS: 1-34.

Pels, E. and P. Rietveld (2000). Cost Functions in Transport. Handbook of transport modelling. D. A. Hensher and K. J. e. Button, Pergamon: 321-334.

Persson, K. G. (2004). "Mind the gap! Transport costs and price convergence in the nineteenth century Atlantic economy." European Review of Economic History **8**: 125-147.

Poor, H. V. (1860). History of Railroads and Canals in the United States. New York.

Poor, H. V. (1881). "Central Pacific Railroad." Poor's Manual of Railroads of the United States.

Poor, H. V. (1881). Poor's Manual of Railroads in the United States.

Poor, H. V. (1881). "Union Pacific Railway." Poor's Manual of Railroads of the United States.

Porter, R. H. (1983). "A Study of Cartel Stability: The Joint Executive Committee, 1880-1886." The Bell Journal of Economics **14**(2): 301-314.

Posner, R. (1975) "The Social Costs of Monopoly Regulation." Journal of Political Economy **83**(August): 807–827.

Potter, J. (1967). "Review American Railroads and the Transformation of the Ante-bellum Economy by Albert Fishlow." The Economic Journal **77**(308): 904-6.

Prentice, B. E., Z. Wang, et al. (1998). "Derived Demand for Refrigerated Truck Transport: A Gravity Model Analysis of Canadian Pork Exports to the United States." Canadian Journal of Agricultural Economics **46**(3): 317-28.

Price, J. S. (n.d.). The Early History of the Suez Canal. London, Hazell, Watson, and Viney Printers.

Quandt, R. and W. Baumol (1966). "The demand for abstract transport modes: theory and measurement." Journal of Regional Science **6**(2): 13-26.

Quinet, E. and R. Vickerman (1997). The econometrics of major transport infrastructures, MacMillan Press.

Quinet, E. and R. Vickerman (2004). Principles of transport economics, Edward Elgar.

Randier, J. (1968). Men and ships around Cape Horn : 1616-1939. London,.

Ransom, R. (1967). "Review American Railroads and the Transformation of the Ante-Bellum Economy by Albert Fishlow." Southern Economic Journal **34**(1): 178-9.

Redding, S. and A. J. Venables (2004). "Economic Geography and International Inequality." Journal of International Economics **62**(1): 53-82.

Rhode, P. W. (1995). "Learning, Capital Accumulation, and the Transformation of California Agriculture." The Journal of Economic History **55**(4): 773-800.

Rose, A. K. and E. van Wincoop (2001). "National Money as a Barrier to International Trade: The Real Case for Currency Union." American Economic Review **91**(2): 386-90.

Rosenberg, N. (1990). "On Technological Expectations." Economic Journal 86(343): 523-35

Rotemberg, J. J. and G. Saloner (1986). "A Supergame-Theoretic Model of Price Wars during Booms." The American Economic Review **76**(3): 390-407.

Rowlett, R. (2007). "A dictionary of units of measurement http://www.unc.edu/~rowlett/units/." Retrieved Visited 10/06/2007, 2007.

Russel, R. (1925). "The Pacific Railway Issue in Politics Prior to the Civil War." The Mississippi Valley Historical Review **12**(2): 187-201.

Russel, R. (1928). "A Revaluation of the Period Before the Civil War: Railroads." The Mississippi Valley Historical Review **15**(3): 341-354.

Russel, R. R. (1948). Improvement of communication with the Pacific Coast as an issue of American politics, 1783-1864. Cedar Rapids, Iowa, Torch Press.

Sabin, E. (1919). Building the Pacific Railway. Philadelphia, Lippincott Company.

Samuelson, P. (1954) "The Pure Theory of Public Expenditure." Review of Economics and Statistics **36**(4): 387-389.

Santos Silva, J. M. C. and S. Tenreyro (2006). "The Log of Gravity." Review of Economics and Statistics **88**(4): 641-58.

Schaefer, D and T. Weiss (1971) "The Use of Simulation Techniques in Historical Analysis: Railroads Versus Canals." Journal of Economic History, **32**(4) : 854-884.

Schonfield, H. J. (1939). The Suez Canal. Harmondsworth, Middlesex., Penguin

Schumpeter, J. A. (1934). The theory of economic development : an inquiry into profits, capital, credit, interest, and the business cycle. Cambridge, Harvard University Press.

Schumpeter, J. A. (1939). Business cycles : a theoretical, historical and statistical analysis of the capitalist process. New York, McGraw-Hill.

Schumpeter, J. A. (1943). Capitalism, socialism, and democracy. London, G. Allen & Unwin ltd.

Simon, H. A. (1978). "Rationality as Process and as Product of Thought." The American Economic Review **68**(2): 1-16.

Small, K. and C. Winston (1999). Demand for transportation: Models and applications. Essays in Transportation Economics and Policy: A Handbook in Honour of John R. Meyer. J. Gomez-Ibanez, W. Tye and C. Winston, Brookings Institution: 11-56.

Stigler, G. (1950). "Monopoly and oligopoly by merger." American Economic Review **40**: 23-34.

Stigler, G. (1965). "The dominant firm and the inverted umbrella." Journal of Law and Economics **8**: 167-172.

Stigler, G. (1971) "The Economic Theory of Regulation." Bell Journal of Economics **2**(1): 3–21.

Stiglitz, J. E. and A. Weiss (1981). "Credit Rationing in Markets with Imperfect Information." The American Economic Review **71**(3): 393-410.

Stover, J. F. (1997). American railroads. Chicago, Ill., University of Chicago Press.

Supple, B. (1966). "Review American Railroads and the Transformation of the Ante-Bellum Economy by Albert Fishlow " The Business History Review **40**(3): 379-82.

Taylor, G. R. (1951). The transportation revolution, 1815-1860. New York,, Rinehart.

Trottman, N. (1966). History of the Union Pacific : a financial and economic survey.

Trujillo, L., E. Quinet, et al. (2000). Forecasting the demand for privatized transport: What economic regulators should know and why. World Bank Policy Research Working Policy 2446, World Bank: 1-35.

Unger, R. and J. Lucassen (2000). "Labour Productivity in Ocean Shipping, 1500-1850." International Journal of Maritime History **12**(2): 127-141.

Unruh, J. (1979). The Plains Across, University of Illinois Press.

Van Nostrand's Magazine (1870). "Tunnels of the Pacific Railroad." Van Nostrand's Eclectic Engineering Magazine **Vol. 2**: 418-423.

Varian, H. (1985). "Price discrimination and social welfare." American Economic Review(75): 870-875.

Walker, H. P. (1970). "Freighting from Guaymas to Tucson, 1850-1880." The Western Historical Quarterly **1**(3): 291-304.

Walton, G. M. and H. Rockoff (2005). History of the American economy. Mason, Ohio, Thomson/South-Western.

White, H. K. and University of Chicago. (1895). History of the Union Pacific Railway. Chicago, [s.n.].

Williams, J. H. (1988). A Great Shining Road. New York, Times Books.

Williamson, J. (1967). "Review American Railroads and the Transformation of the Ante Bellum Economy by Albert Fishlow." The Economic History Review **20**(1): 194-6.

Wilson, A. (1977). The Suez canal : its past, present, and future. London, Oxford University Press.

Winston, C. (1985). "Conceptual Development in the Economics of Transportation: An Interpretive Survey." Journal of Economic Literature **23**(1): 57-94.

Yamawaki, H. (1985). "Dominant firm pricing and fringe expansion: The case of the U.S. iron and steel industry, 1907-1930 " The Review of Economics and Statistics **67**(3): 429-437.

Index