JOHANNES BOEHM

ESSAYS ON INSTITUTIONS AND PRODUCTIVITY

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DECLARATION

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

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

I declare that my thesis consists of 29,090 words.

STATEMENT OF CONJOINT WORK

Chapter 2 is the result of joint work with Professor Francesco Caselli and Professor Nicola Gennaioli. The model is based on the work by Caselli and Gennaioli (2013). I contributed to the changes to their model, performed the calibration and simulations, and wrote the chapter.

Chapter 3 was jointly co-authored with Dr Swati Dhingra and Dr John Morrow. I cleaned and prepared the data, contributed the econometric specifications, ran the regressions, and wrote the text (except the Introduction, Section 3.1, which was written jointly).

ABSTRACT

The thesis contains three essays on the determinants of productivity. The first essay studies how costly supplier contract enforcement shapes firm boundaries, and quantifies the impact of this transaction cost on aggregate productivity and welfare. Contract enforcement costs lead suppliers to underproduce. Thus, firms will perform more of the production process in-house instead of outsourcing it. In countries with slow and costly courts, firms should buy relatively less inputs from sectors whose products are more specific to the buyer-seller relationship. I first present reduced-form evidence for this hypothesis using cross-country regressions. I use microdata on case law from the United States to construct a new measure of relationship-specificity by sector-pairs. This allows me to control for productivity differences across countries and sectors and to causally identify the effect of contracting frictions on industry structure. I estimate a model and conduct a series of counterfactual experiments. Setting enforcement costs to US levels would increase real income by an average of 3.6 percent across all countries, and by an average of 10 percent across low-income countries.

The second essay investigates the role of bureaucratic startup costs and credit market imperfections in shaping selection, misallocation, and aggregate productivity. We study a dynamic model of misallocation. Limited access to external financing and entry costs mean that firms are not necessarily operated by the most talented managers. We calibrate our model to the United States. Our findings suggest that the reduction of startup costs would only have a small impact on aggregate productivity and welfare. Financial frictions, on the other hand, seem to have a much larger impact.

The third essay returns to the role of intermediate inputs for economic performance. Using panel data on manufacturing firms in India, we study the role of input complementarities in shaping the firm's choice of products. We find that firms are more likely to add products to their portfolio if these products require intermediate inputs that the firm is already using in their production activities. Our findings shed light on the source of firm's core competencies. We also provide the first study of supply linkages within multiproduct firms in developing countries. We find product turnover rates in India that are comparable to US levels.

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To dedicate this work to my parents would not do justice to my debt to them. I owe them everything.

Paris, August 2014

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ACRONYMS

BRS Bernard, Redding, and Schott (2010)

GKPT Goldberg, Khandelwal, Pavcnik, and Topalova (2009)

GTAP Global Trade Analysis Project

TFP Total Factor Productivity

Part I

INSTITUTIONS AND ECONOMIC PERFORMANCE

1

THE IMPACT OF CONTRACT ENFORCEMENT COSTS ON OUTSOURCING AND AGGREGATE PRODUCTIVITY

> "A good deal of literature on transaction costs takes enforcement as a given, assuming either that it is perfect or that it is constantly imperfect. In fact, enforcement is seldom either, and the structure of enforcement mechanisms and the frequency and severity of imperfection play a major role in the costs of transacting and in the forms that contracts take."
> — Douglass C. North, (North, 1990)

1.1 INTRODUCTION

A prominent and growing literature has established that legal institutions matter for economic development. Most of this literature has either studied these mechanisms at the microeconomic level, or documented their macroeconomic relevance via reduced-form regressions at the industry or country level.[1] Despite their contributions, this literature has not resolved a central question: just *how* important are legal institutions for aggregate outcomes?

In this paper, I am concerned with one particular dimension of legal institutions: the cost of enforcing a supplier contract in court. Countries differ vastly in the speed and cost of enforcement procedures: while Icelandic courts often resolve commercial disputes within a few months, cases in India that are decades old are commonplace.[2] This constitutes a transaction cost between firms (North, 1990). If enforcement of supplier contracts is costly, firms will perform a larger part of the production process within the firm, instead of outsourcing it, thereby avoiding having to contract with an external supplier. This increases the cost of production (Khanna and Palepu, 2000).[3,4] Higher production cost feeds into higher input prices in

1 See, among others, Besley and Ghatak (2010) on the microeconomic level, and La Porta et al. (1997), Djankov et al. (2003), Acemoglu and Johnson (2005), and many papers that follow Rajan and Zingales (1998).
2 Council of Europe (2005), Supreme Court of India (2009)
3 In a case study on the TV broadcasting industry in India, Anand and Khanna (2003) give the example of the cable network firm Zee Telefilms Limited (ZTL), which was faced with a multitude of local cable operator firms that grossly understated the number of subscribers and underpaid fees. Litigation was slow and costly, thus ZTL was forced to expand into the cable operator's business. The resulting distribution subsidiary was not profitable for the first five years after its inception, a long time in an industry that consisted mostly of small young firms.
4 See also the surveys by Bresnahan and Levin (2013), and Syverson (2011).

downstream sectors, thus amplifying the distortions on the macroeconomic scale.[5]

This paper exploits cross-country variation in enforcement costs and input expenditure shares to study the importance of enforcement costs for productivity and income per capita. I make three contributions to our understanding of the role of institutions for economic outcomes. First, I construct a general-equilibrium model that reveals how contract enforcement costs, together with asset specificity, shape the firm's domestic outsourcing decision and the economy's industry structure. To describe contracting frictions, I extend the literature on hold-up in a bilateral buyer-seller relationship to a setting of enforceable contracts, where enforcement is subject to a cost and goods are relationship-specific. Contracts may alleviate hold-up problems only if enforcement costs are sufficiently low. Second, I find evidence for my model's qualitative predictions on external input use using cross-country reduced-form regressions. Using microdata on case law from the United States I construct a new measure of relationship-specificity. By counting the number of court cases between two sectors, and normalizing it, I obtain the relative prevalence of litigation between these two sectors, which is informative about the degree of relationship-specificity. The fact that this is a bilateral measure means that I can control for cross-country heterogeneity in the upstream sectors, and causally identify the effect of costly enforcement on outsourcing. Third, I show that this has large consequences for aggregate productivity and welfare. I do this by structurally estimating my model and simulating the aggregate variables in the absence of enforcement costs. Hence, transaction costs and the boundaries of the firm are issues of macroeconomic importance.

The analysis proceeds in several steps. I first propose a general-equilibrium model where firms face a binary decision between in-house production and domestic outsourcing for each activity in the production process.[6] Firms and suppliers draw independent productivity realizations for each activity. In-house production uses labor, which is provided on a frictionless market. Outsourcing, however, is subject to contracting frictions that increase its effective cost. To understand what drives the magnitude of the distortion I explicitly model the interaction of the buyer and seller. The produced goods are relationship-specific, i.e. they are worth more within the buyer-seller relationship than to an outside party. Contracts specify a quantity to be delivered and a fee, and are enforceable at a cost which is proportional to the value of the claim.[7] Courts do not enforce penal clauses in the contract, and award damages only to *compensate* the innocent party. This places strong limitations on the ability to punish the underperforming party, and may give rise to the seller breaching

5 This idea of a 'multiplier effect' goes back to Hirschman (1958). See also Ciccone (2002), Jones (2011a, 2011b), and Acemoglu et al. (2012).

6 I use the term 'activity' to refer to both physical inputs and tasks in the production process.

7 Enforcement costs include time costs, court fees, and fees for legal representation and expert witnesses.

the contract in equilibrium. When the buyer holds up the seller, the seller could recover his fee net of damages by going to court. In the presence of enforcement costs, the amount the seller could recover is lower, leading him to ex-ante produce less than the efficient quantity. On the other hand, if enforcement costs are high and the resulting inefficiency is large, it may be preferable to write an unenforceable (incomplete) contract, where the inefficiency depends on the degree of relationship-specificity (Klein, Crawford, and Alchian, 1979). This can be replicated through an enforceable contract where the specified quantity is zero.[8] Thus, the overall distortion when using an optimal contract is the minimum of the distortions implied by enforcement costs (in the case of a formal contract, and breach) and relationship-specificity (in the case of an informal contract).

Next, I provide empirical evidence for my model's key qualitative prediction using cross-country reduced-form regressions. The model predicts that in countries where enforcement costs are high, firms spend less on inputs that are very relationship-specific. I thus regress intermediate input expenditure shares by sector-pair on an interaction of country-wide enforcement costs and relationship-specificity at the sector-pair level. Regarding relationship-specificity, I exploit my contracting game's prediction that high relationship-specificity is linked to higher prevalence of breach on behalf of the seller. Using case law from the United States for 1990-2012, I construct a measure of relationship-specificity of an upstream-downstream sector pair that is the number of court cases with a firm from the upstream sector, per firm in the downstream sector. On the sector-pair-country level this measure, interacted with enforcement costs in the country, is negatively correlated with the downstream sector's expenditure share on inputs from the upstream sector: in countries with high enforcement costs, intermediate input shares are lower for sector-pairs where litigation is common in the United States. Since this relationship-specificity measure varies across sector-pairs, I can include country-upstream sector fixed effects and thus control for unobserved heterogeneity, such as differences in productivity and access to external financing, across sectors and countries. To the extent of my knowledge, my paper is the first to use this identification strategy in cross-country regressions. [9]

Finally, I quantify the impact of enforcement costs on aggregate variables by structurally estimating the key parameters of my model and performing a set of counterfactual exercises. This is possible because my model exploits the tractability of multi-country Ricardian trade models, most notably the one of Eaton and Kortum (2002), even though these papers study an entirely different question. I obtain a relatively simple expression for intermediate input use between sec-

8 My model thus provides a new economic rationale for preferring informal contracts over formal ones, where the threat of litigation and its associated costs may lead the seller to ex-ante underinvest.

9 Existing industry-level measures of relationship-specificity (Nunn 2007, Levchenko 2007, Bernard et al. 2010) are constructed using data on input-output relationships, which are endogenous in my analysis, and/or are only available for physical goods.

tors, where contracting frictions distort input prices and lower intermediate input expenditure shares in the same way iceberg trade costs lower trade shares in the Eaton-Kortum model. I structurally estimate the key elasticities, along with country-specific parameters such as sectoral productivity levels, from data on intermediate input shares and enforcement costs. This allows me to perform welfare counterfactuals, and highlight the macroeconomic significance of transaction costs: reducing enforcement costs to zero would increase real income per capita by an average of 7 percent across all countries (13.3 percent across low-income countries), and decrease consumer prices by an average of 8.5 percent. For countries with very high enforcement costs, such as Indonesia, Mozambique, and Cambodia, the welfare benefits would be around 30 to 50 percent of real income. For many countries the welfare impact exceeds the gains from international trade that the literature has estimated. Since zero enforcement costs may be impossible to achieve in practice, I also calculate the counterfactual welfare gains when enforcement costs are set to US levels. The corresponding increase in real income would still be on average 3.6 percent across all countries, and on average 10 percent across low-income countries.

The paper contributes to the literature on legal institutions and their macroeconomic effects.[10] The challenges in this literature are twofold. First, institutions are hard to quantify. I therefore guide my empirical analysis using a micro-founded model. The empirical counterpart for the enforcement cost maps exactly into the theoretical concept. Second, it is hard to empirically identify the effect of institutions on macro-outcomes due to the presence of many unobserved factors that correlate with institutions and development. The literature on cross-country regressions in macroeconomics typically deals with this by trying to proxy for these unobserved factors. This introduces measurement error and other problems. By exploiting variation across countries and sector-*pairs*, I can include country-upstream-sector fixed effects and thus control for unobserved heterogeneity in country-industry pairs in a much cleaner way.

The paper is also related to the literature on the role of intermediate inputs for aggregate outcomes.[11] These papers typically take the country's input-output structure as exogenous, or even take the US input-output table to describe the industry structure across countries. I show that input-output tables differ substantially and systematically across countries and exploit this variation in my empirical analysis. In

10 For example, theoretical work by Acemoglu, Antràs and Helpman (2007) studies the effects of contracting frictions on the incentives to invest in technology. The empirical literature often employs reduced-form cross-country regressions, see Rajan and Zingales (1998), La Porta et al. (1998), Acemoglu and Johnson (2005), and many others. Recent country studies include Laeven and Woodruff (2007) and Chemin (2010) on judicial efficiency in Mexico and, respectively, India; Ponticelli (2013) on bankruptcy reform in Brazil, and Cole, Greenwood, and Sanchez (2012) on courts and technology adoption in Mexico.

11 Among others, Hirschman (1958), Romer (1980), and Jones (2011a, 2011b) for economic growth, and Dupor (1999), Horvath (2000), Acemoglu et al. (2012) and Carvalho and Gabaix (2013) for fluctuations. See also Oberfield (2013) for how input linkages shape aggregate productivity.

the model I endogenize the sectoral composition of the firm's input baskets.

My paper also draws on the literature on contracting frictions, intermediate inputs, and productivity in international trade.[12] While my analysis is only concerned with domestic transactions, there are reasons to believe that this still captures most of the welfare effects. Contracting frictions are particularly important for service inputs, because these are naturally relationship-specific (i.e., once produced they cannot be 'sold' to an outside party). Services are typically performed within the boundaries of the economy. Furthermore, any distortion to international trade due to contracting frictions cannot cause a welfare loss greater than the overall gains from trade, thus I capture the bulk of the relevant distortions.[13]

Finally, viewed through the lens of industrial organization, my paper is related to the theoretical and empirical literature on transaction costs and vertical integration. In my theory, the firm's make-or-buy decision is influenced both by the presence of non-transferable firm-specific capabilities (Wernerfelt, 1984; Bloom and Van Reenen, 2007), and by its desire to overcome transaction costs (Klein, Crawford and Alchian, 1979; Williamson, 1985). In modeling transaction costs and property rights, I deviate from the usual assumption of incomplete contracts and instead assume that contracts are enforceable at a cost, and that courts award expectation damages.[14] The property rights are then endogenously assigned by an optimal contract, taking into account enforcement costs and relationship-specificity, to maximize the ex-ante investment. The strength of this approach is that there is a direct empirical counterpart for the transaction cost, which allows me to study its quantitative importance.[15] The paper also contributes to the empirical literature on the determinants of the boundaries of the firm.[16]

The paper proceeds as follows. Section 1.2 describes a macromodel of input choice, where contracting frictions distort the firm's make-or-

12 Antràs (2003) pioneered the property rights approach in international trade. Khandelwal and Topalova (2011) show that increased access to intermediate inputs increases firm productivity. Nunn (2007) uses cross-country regressions to show that contracting institutions shape comparative advantage and explains this using a story similar to mine. Compared to his work, I show direct evidence on input use and study the quantitative effects of contracting institutions. To keep my model sufficiently tractable to allow estimation of the parameters, I draw from the literature on quantitative trade models, see Eaton and Kortum (2002), Chor (2010), Costinot, Donaldson, and Komunjer (2012), Caliendo and Parro (2012), and Arkolakis, Costinot, and Rodriguez-Clare (2012).

13 Indeed, Irarrazabal et al. (2013) argue that exporting and multinational production are close substitutes. Garetto (2013) estimates that the gains from intra-firm international trade are roughly 0.23 percent of consumption per capita. For more complex sourcing strategies, see Ramondo and Rodriguez-Clare (2013).

14 The literature in Law and Economics discusses the economics of enforcement costs and remedies for breach. See Hermalin et al. (2007) for a survey. Shavell (1980) and Edlin and Reichelstein (1996), among others, discuss the role of expectation damages for relationship-specific investment.

15 Grossman and Helpman (2002) study the vertical integration decision in general equilibrium using incomplete contracts and search frictions as transaction costs. Their focus is entirely on qualitative predictions.

16 See Lafontaine and Slade (2007) for a survey.

buy decision. Section 1.3 qualitatively assesses the model's key prediction using cross-country reduced-form regressions. Section 1.4 structurally estimates the model of section 1.2, and evaluates the productivity and welfare implications of costly contract enforcement. Section 1.5 concludes.

1.2 A MACROECONOMIC MODEL OF INPUT SOURCING

This section presents a macroeconomic model where firms face the decision between producing in-house and outsourcing. The model economy is closed. Outsourcing is subject to frictions due to the presence of contract enforcement costs. These frictions distort the relative price of outsourcing, and thus lead to over-use of in-house production. I first discuss the firm's production functions, and then turn to the modes of sourcing. I pay particular attention to the contracting game that is played in the case of outsourcing, explaining how and when enforcement costs matter, and derive an expression for the magnitude of price distortions. Finally, I put the model into general equilibrium by adding households, and derive predictions for aggregate input use.

Methodologically, the model exploits the tractability of the Eaton and Kortum (2002) approach to modeling discrete sourcing decisions, albeit for a very different purpose. I model the firm's binary decision to outsource in the same way as Eaton and Kortum model the decision which country to buy from. The contracting frictions in my model, for which I provide a microfoundation, enter the expression for intermediate input shares in the same way that iceberg trade costs enter the expression for trade shares in Eaton-Kortum. This allows me to model both frictions and input-output linkages between sectors in a tractable way, and it simplifies the structural estimation and evaluation of the welfare effects.

1.2.1 *Technology*

There are N sectors in the economy, each consisting of a mass of perfectly competitive and homogeneous firms. Sector n firms convert activities $\{(q_{ni}(j), j \in [0,1]\}_{i=1,\dots,N}$ into output y_n according to the production function[17]

$$y_n = \left(\sum_{i=1}^{N} \gamma_{ni}^{1/\rho} \left(\int_0^1 q_{ni}(j)^{(\sigma_n - 1)/\sigma_n} dj \right)^{\frac{\sigma_n}{\sigma_n - 1} \frac{\rho - 1}{\rho}} \right)^{\rho/(\rho-1)}, \quad n = 1, \dots, N. \tag{1}$$

17 This is a model where every sector buys from every other sector, but apart from parameters, they are all ex-ante identical. In a bilateral trade between two sectors, I always denote the downstream (buying) sector by n and the upstream (selling) sector by i.

The sets $\{(n, i, j), j \in [0, 1]\}_{i=1,\ldots,N}$ are the sets of inputs that sector n may source from a firm belonging to sector i, or, alternatively, produce itself using labor. The index j denotes the individual activities/-varieties within each basket. As an example, consider a car manufacturing plant. Then, $n =$ car and $i \in$ {metal, electricity, R&D, ...} are the different broad sets of activities, corresponding to the different upstream (roughly 2-digit) sectors, that need to be performed during the production process. The index j corresponds to the individual varieties of inputs (in the case of physical inputs) or tasks (in the case of intangible inputs). The firm faces the outsourcing decision for every j: a manufacturing plant may want to contract with an accounting firm to do the accounting for them, or decide to employ an accountant themselves, perhaps at a higher cost. In this case, the activity j would be 'accounting', and the upstream industry i would be the business services sector. The technological parameters γ_{ni} capture how much the broad set of inputs i are actually needed in the production process of sector n: the $\gamma_{\text{cars,steel}}$ will be high, whereas $\gamma_{\text{cars,agriculture}}$ will be low.

For each activity (n, i, j), the sector n firms have to decide whether to produce the activity themselves, or to outsource it. I model the boundaries of firms to be determined primarily by their capabilities.[18] Both the downstream firm and the potential suppliers draw an activity-specific productivity realization, which determine the cost of each option. The downstream firm decides on whether to outsource by comparing them. Outsourcing, however, is subject to contracting frictions, which increase its cost and thus lead to too much in-house production compared to a frictionless world. In order to keep the firm's decision problem tractable, I model outsourcing as buying activity (n, i, j) from a sector i firm via an intermediary. Once the decision has been taken, it is irreversible.[19] I discuss each of the two options in turn.

1.2.1.1 *In-house Production*

The sector n firm can produce activity (n, i, j) itself by employing labor. One unit of labor generates $s_{ni}(j)$ units of activity (n, i, j), thus the production function is $q_{ni}(j) = s_{ni}(j)l(n, i, j)$, where $l(n, i, j)$ is labor used and $s_{ni}(j)$ is a stochastic productivity realization that follows a Fréchet distribution,

$$P(s_{ni}(j) < z) = e^{-S_n z^{-\theta}}.$$

I assume that the $s_{ni}(j)$ are i.i.d. across i, j, and n. The parameter S_n captures the overall productivity of sector n firms: higher S_n will, on average, lead to higher realizations of the productivity parameters $s_{ni}(j)$. The parameter θ is inversely related to the variance of the distribution. The labor market is perfectly competitive. Denote the

18 This can be motivated by managers having a limited span of control (Lucas, 1978), or that there are resources that cannot be transferred across firms (Wernerfelt, 1984).

19 This eliminates competition between the potential employees and the suppliers. Bernard et al. (2003) relax this assumption to obtain variable markups.

wage by w, and the cost of one unit of activity (n, i, j) conditional on in-house production by $p^l_{ni}(j)$. Then,

$$p^l_{ni}(j) = \frac{w}{s_{ni}(j)}. \tag{2}$$

1.2.1.2 *Arm's Length Transaction*

In case of outsourcing, the sector n firms post their demand function to an intermediary. There is one intermediary per activity. In turn, the intermediary sources the goods from a sector i firm ('supplier'), who tailors the goods to the relationship. The intermediary then sells the goods on to the downstream sector firm, earning revenue $R(\cdot)$, as given by the downstream firm's demand function.

When dealing with the supplier, the intermediary chooses a contract that maximizes its profit subject to participation by a supplier firm. The supplier's outside option is zero. I will show that the chosen contract pushes the supplier down to its outside option, which means that this is also the contract that the social planner would choose if he wanted to maximize the overall surplus (conditional on the frictions). One supplier is chosen at random, and the intermediary and the supplier are locked into a bilateral relationship.

Suppliers can transform one unit of sector i output (produced using the production function (1)) into $z_{ni}(j)$ units of variety (n, i, j), thus the production function is $q_{ni}(j) = z_{ni}(j) y_i(n, i, j)$, with $y_i(n, i, j)$ being the amount of sector i goods used as inputs.[20] Again I assume that $z_{ni}(j)$ follows a Fréchet distribution,

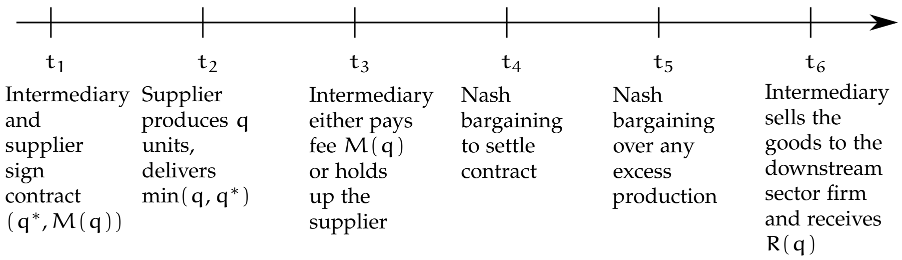
$$P(z_{ni}(j) < z) = e^{-T_i z^{-\theta}}$$

and i.i.d. across i, j, and n. The average productivity realization is increasing in the parameter T_i, which captures the upstream sector's overall capabilities (productivity, endowments, etc.). The supplier's cost of producing one unit of variety (n, i, j) is then $c_{ni}(j) = p_i / z_{ni}(j)$, where p_i is the price index of sector i's output good, (1). The production of the variety is partially reversible: by reverting, the supplier can get a fraction $\omega_{ni} \leqslant 1$ of its production cost back by selling it on the Walrasian market for the sector i good. This is meant to capture the degree of relationship-specificity of the variety: if $\omega_{ni} = 1$, the variety is not tailored to the relationship at all, whereas $\omega_{ni} = 0$ means that the good is worthless outside the relationship. All parameters, including the productivity realizations $z_{ni}(j)$, are common knowledge. I drop subscripts (n, i, j) for the remainder of the contracting game to simplify the notation.

The description of the contracting game proceeds as follows. I first describe the contracting space, and discuss the timing of events and

20 The assumption that variety (n, i, j) is produced using sector i goods in the case of outsourcing simply means that some of the supplier's production process may be outsourced as well. Ultimately, the whole production process is done using labor and a constant returns to scale production technology; the distinction between labor and intermediate inputs simply draws the firm boundaries and allows for better comparison with the data.

Figure 1: Timeline of the contracting game



the enforcement mechanism. I then solve the contracting game. Going back in time, I describe the problem of finding an optimal contract and characterize the equilibrium thereunder. I then return to the implications for input prices under arm's length transaction.

The contract The contract between intermediary and supplier is a pair $(q^*, M(\cdot))$, where $q^* \geqslant 0$ is the quantity of the good to be delivered[21], and $M : [0, q^*] \to \mathbb{R}\backslash\mathbb{R}^-$ is a nonnegative, increasing real-valued function that represents the stipulated payment to the supplier. $M(q^*)$ is the agreed fee. If $M(q) < M(q^*)$ for $q < q^*$, this represents damage payments that are agreed upon at the time of the formation of the contract, for enforcement in case of a breach of contract ("liquidated damages").[22] I will explain the exact enforcement procedure after stating the timing of events.

Timing of events

1. The intermediary and the supplier sign a contract $(M(q), q^*)$ which maximizes the intermediary's payoff, subject to the supplier's payoff being nonnegative. At this point the intermediary cannot perfectly commit to paying $M(q)$ once production has taken place, other than through the enforcement mechanism explained below.

2. The supplier produces q units. He chooses q optimally to maximize his profits. I assume that if $q < q^*$, he delivers all the produced units; if $q \geqslant q^*$, he delivers q^* and retains control of the remaining units.[23] A unit that has been delivered is under the control of the intermediary.

21 The supplier's chosen quantity q may likewise be interpreted as quality of the product, or effort. The legal literature calls this relationship-specific investment *reliance* (Hermalin et al., 2007).

22 Most jurisdictions impose strong limits on punishment under these clauses. In English law, *in terrorem* clauses in contracts are not enforced (Treitel, 1987, Chapter 20). German and French courts, following the Roman tradition of literal enforcement of *stipulationes poenae*, generally recognize penal clauses in contracts, but will, upon application, reduce the penalty to a 'reasonable' amount (BGB § 343, resp. art. 1152 & 1231, code civil, and Zimmermann, 1996, Chapter 4). Given my assumptions on the courts awarding expectation damages (see below), any restrictions on M are not going to matter.

23 A.2.1 considers an extension where the supplier decides about how much to deliver. The equilibrium production (and therefore inefficiency) under an optimal contract remains the same as in the model from the main text. See also Edlin and Reichelstein (1996).

3. The intermediary decides whether or not to hold up the supplier by refusing to pay $M(q)$.

4. If the contract has been breached (either because $q < q^*$ or because the intermediary did not pay the fee $M(q)$), either party could enforce the contract in a court. The outcome of enforcement is deterministic, and enforcement is costly. Hence, the two parties avoid this ex-post efficiency loss by settling out of court. They split the surplus using the symmetric Nash sharing rule, whereby each party receives the payoff under the outside option (i.e. the payoff under enforcement), plus half of what would have been lost to them in the case of enforcement (the enforcement costs). I explain the payoffs under enforcement below.

5. In case the supplier has retained control over some of the produced units, $q - q^*$, the two parties may bargain over them. Again I assume that they split the surplus according to the symmetric Nash sharing rule. Since there is no contract to govern the sale of these goods, the outside option is given by the supplier's option to revert the production process.

6. The intermediary sells the goods on to the downstream firm, receiving revenue $R(q)$.

Enforcement After the intermediary's decision whether or not to hold up the supplier, either party may feel that they have been harmed by the other party's actions: the supplier may have produced less than what was specified ($q < q^*$), and the intermediary may have withheld the fee $M(q)$. Either party may enforce the contract in the court. The court perfectly observes all actions by both parties, and awards *expectation damages* as a remedy. The basic principle to govern the measurement of these damages is that an injured party is entitled to be put "in as good a position as one would have been in had the contract been performed" (Farnsworth (2004), §12.8). The precise interpretation of this rule is as follows:

- If the supplier has breached the contract, $q < q^*$, he has to pay the intermediary the difference between the intermediary's payoff under fulfillment, $R(q^*) - M(q^*)$, and under breach, $R(q) - M(q)$. Hence, he has to pay

$$D(q, q^*) = R(q^*) - M(q^*) - (R(q) - M(q)) .$$

- In addition, if the intermediary has not paid the fee $M(q)$, the court orders him to do so.

It is important to stress that the resulting net transfer may go in either direction, depending on whether or not the parties are in breach, and on the relative magnitude of $M(q)$ and $D(q, q^*)$.

I assume furthermore that the plaintiff has to pay enforcement costs, which amount to a fraction δ of the value of the claim to him.

The value of the claim is the net transfer to him that would arise under enforcement.[24] These costs include court fees, fees for legal representation and expert witnesses, and the time cost. The assumption that enforcement costs are increasing in the value of the claim is in line with empirical evidence (Lee and Willging, 2010), and also strengthens the link between the model and the empirical analysis in Section 1.3: my data for enforcement costs are given as a fraction of the value of the claim.[25] In line with the situation in the United States, I assume that enforcement costs cannot be recovered in court (Farnsworth, 2004, §12.8).[26]

Solving for the equilibrium of the contracting game I solve for a subgame-perfect Nash equilibrium, which, for a given contract, consists of the supplier's production choice q_s and the intermediary's holdup decision, as a function of q. The holdup decision function gives the intermediary's optimal response to a produced quantity q, and the optimal production choice q_s is then the supplier's optimal quantity q, taking the holdup decision function as given. The full solution of the game is in A.1. Here, I discuss the intuition for the optimal responses and the payoff functions.

Case 1: Seller breaches the contract. Consider first the case where the supplier decides to breach, $q < q^*$. The intermediary refuses to pay $M(q)$, in order to shift the burden of enforcement (and thus the enforcement costs) on the supplier. Hence, in the case of enforcement, the supplier would receive a net transfer of $M(q) - D(q, q^*)$. This transfer is positive: if it was negative, the supplier's overall payoff would be negative and he would not have accepted the contract in the first place. Thus, under enforcement, the supplier would be the plaintiff and would have to pay the enforcement costs. To avoid the efficiency loss, the two parties bargain over the surplus and settle outside of court. Under the symmetric Nash sharing rule each party receives its outside option (the payoff under enforcement) plus one half of the quasi-rents (the enforcement costs). Thus, the supplier's overall payoff under breach is

$$\pi_s(q, M, q^*) = \underbrace{(1-\delta)(M(q) - D(q, q^*))}_{\text{payoff under enforcement}} + \frac{1}{2}\underbrace{\delta(M(q) - D(q, q^*))}_{\text{quasi-rents}} - \underbrace{qc_{ni}(j)}_{\text{production cost}}$$

24 If the net transfer is negative, he would not have chosen to enforce in the first place. However, the other party would then have had an incentive to enforce, and would have been the plaintiff. I show later that in equilibrium the plaintiff is always the supplier.

25 Having the cost of enforcement in proportion to the value of the claim may also be seen as a desirable, to align the incentives of the plaintiff's attorney with those of the plaintiff. Following the report on civil litigation costs in England and Wales by Lord Justice Jackson (Jackson, 2009b), the UK government passed reforms to bring costs more in line with the value of the claims.

26 Many countries have the enforcement costs paid by the losing party ('cost shifting'). See Jackson (2009a) for a comparative analysis. While cost shifting may mean that in some circumstances punishment would be possible and therefore higher quantities could be implemented, the resulting model does not allow for closed-form solutions.

(3)

if $q < q^*$. Since $D(q, q^*) = R(q^*) - M(q^*) - (R(q) - M(q))$, the above simplifies to

$$\pi_s(q, M, q^*) = \left(1 - \frac{1}{2}\delta\right)(R(q) - R(q^*) + M(q^*)) - qc_{ni}(j) \qquad \text{if } q < q^*. \tag{4}$$

Note that the intermediary's revenue function R appears in the supplier's payoff function. This is due to the courts awarding expectation damages: the fact that damage payments are assessed to compensate the intermediary for forgone revenue means that the supplier internalizes the payoff to the intermediary. The enforcement costs δ govern the supplier's outside option, and hence the settlement: higher enforcement costs means that the supplier can recover a smaller fraction of his fee net of damages; therefore, the terms of the settlement are worse for him. Note also that the contract (q^*, M) enters (4) only through q^* and $M(q^*)$, and only in an additive manner. This is because the court awards damages such that the *sum* of liquidated damages and expectation damages exactly compensates the intermediary.[27]

Case 2: Seller fulfills the contract. Consider next the case where the supplier fulfills his part of the contract, $q \geqslant q^*$. He delivers q^* units to the intermediary, and keeps the remaining units to himself. As in the case above, the intermediary refuses to pay the fee $M(q^*)$: subsequent enforcement of the contract would leave the seller with a payoff of only $(1-\delta)M(q^*)$; hence, under the settlement with the symmetric Nash solution, the intermediary only has to pay $(1 - \frac{1}{2}\delta)M(q^*)$. After the settlement of the contract, the two parties may bargain over the remaining $q - q^*$ units. The Nash sharing rule leaves the supplier with its outside option (what he would get by reversing the production process for the $q - q^*$ units) plus one half of the quasi-rents. Thus, the supplier's overall profits are

$$\pi_s(q, M, q^*) = \underbrace{\left(1 - \frac{1}{2}\delta\right)M(q^*)}_{\text{contract payoff}} + \underbrace{\omega_{ni}c_{ni}(j)(q - q^*)}_{\text{payoff under reverting}} + \tag{5}$$
$$+ \frac{1}{2}\underbrace{(R(q) - R(q^*) - \omega_{ni}c_{ni}(j)(q - q^*))}_{\text{quasi-rents}} - \underbrace{qc_{ni}(j)}_{\text{production cost}}$$

if $q \geqslant q^*$. Hence, even in the case where the supplier fulfills his part of the contract, the contract (q^*, M) only enters additively in the supplier's payoff function. The terms of the bargaining that governs the marginal return on production are now given by the degree

27 This point was first made by Shavell (1980), who argued that when courts assign expectation damages, the parties may achieve first-best even if the contractually specified payoff is not state-contingent. Similarly, I argue here that under expectation damages the state-contingent payoffs do not matter, and later show that the presence of proportional enforcement costs then leads to efficiency loss.

of relationship-specificity. A higher degree of relationship-specificity, captured by a lower ω_{ni}, worsens the supplier's outside option and hence lowers his payoff under the settlement.

Going back in time, the supplier chooses q to maximize his profits, given piecewise by (4) and (5). The supplier's profit function is continuous at q^*, and the shape of the ex-ante specified payoff schedule M does not affect π_s. This means that the intermediary is unable to punish the supplier for producing less than the stipulated quantity, and $q < q^*$ may happen in equilibrium.

Optimal Contract We now turn to the intermediary's problem of finding an optimal contract. He chooses a contract (M, q^*) that maximizes his payoff π_b subject to participation by the supplier,

$$(M, q^*) = \underset{(\hat{M},\hat{q}^*)}{\arg\max}\, \pi_b\left(q_s(\hat{M}, \hat{q}^*), \hat{M}, \hat{q}^*\right) \tag{6}$$

$$\text{s.t.}\quad \pi_s\left(q_s(\hat{M}, \hat{q}^*), \hat{M}, \hat{q}^*\right) \geqslant 0 \tag{7}$$

where $q_s(\hat{M}, \hat{q}^*)$ is the supplier's profit-maximizing quantity,

$$q_s(\hat{M}, \hat{q}^*) = \underset{q \geqslant 0}{\arg\max}\, \pi_s(q, \hat{M}, \hat{q}^*).$$

Since there is no ex-post efficiency loss, the intermediary's payoff π_b is the total surplus minus the supplier's payoff,

$$\pi_b\left(q, \hat{M}, \hat{q}^*\right) = R(q) - qc_{ni}(j) - \pi_s\left(q, \hat{M}, \hat{q}^*\right).$$

In the solution to the contracting game above, we have shown that a contract (M, q^*) enters the payoff functions in each case only in an additive manner. Therefore, by setting q^* and M, the intermediary can only influence the supplier's decision by shifting the threshold for breach q^*. In choosing an optimal contract, the intermediary thus decides whether he wants to implement the interior maximum in the case of breach by the seller (case 1), or the interior maximum in case of fulfillment by the supplier (case 2). He will choose the case that is associated with the smaller amount of distortions. The following proposition formalizes this intuition, and characterizes the equilibrium under an optimal contract. It describes (1) the produced quantity, (2) whether the equilibrium features a breach or a fulfillment by the seller, and (3) the distribution of the rents between the two parties. A.1 contains the proof.

Proposition 1 (Equilibrium under an optimal contract) *An optimal contract (M, q^*) satisfies the following properties:*

1. *The quantity implemented, $q_s(M, q^*)$, satisfies*

$$\left.\frac{dR(q)}{dq}\right|_{q=q_s(M,q^*)} = \min\left(2 - \omega_{ni}, \frac{1}{1-\frac{1}{2}\delta}\right) c \tag{8}$$

2. $q_s(M, q^*) < q^*$ *if and only if* $(1 - \frac{1}{2}\delta)^{-1} < 2 - \omega_{ni}$.

3. *The whole surplus from the relationship goes to the intermediary:*

$$\pi_s\left(q_s(M, q^*), M, q^*\right) = 0$$

To interpret this result, it is helpful to compare the equilibrium quantity $q_s(M, q^*)$ to the first-best quantity $\tilde{q}$, which is defined as the quantity that maximizes the overall surplus from the relationship,

$$\tilde{q} \equiv \arg\max_{q \geqslant 0} R(q) - qc_{ni}(j).$$

The first statement of Proposition 1 says that the equilibrium quantity produced under an optimal contract, $q_s(M, q^*)$, is lower than the first-best quantity $\tilde{q}$ (recall that R is concave, and that $2 - \omega_{ni} > 1$). The intuition for the efficiency loss depends on whether the equilibrium features a breach or a fulfillment by the supplier. If the supplier breaches by producing $q < q^*$, the presence of proportional enforcement costs mean that the supplier could only recover a smaller fraction of his fee net of damages by going to court. Under the settlement he does not get the full return on his effort, which causes him to ex-ante produce less than the efficient quantity. Note that in the absence of enforcement costs ($\delta = 0$), the supplier completely internalizes the intermediary's payoff through the expectation damages, and the resulting outcome would be first-best. Hence, the magnitude of the efficiency loss in this case depends solely on the magnitude of enforcement costs. In the case where the supplier fulfills his part of the contract, $q \geqslant q^*$, the degree of relationship-specificity governs the supplier's outside option in the bargaining, and thus the marginal return on production. A higher relationship-specificity (lower ω_{ni}) means that the supplier's outside option becomes worse, which results in a lower payoff under the settlement. The supplier anticipates the lower ex-post return on production, and produces less (Klein et al., 1979).

The second statement says that the optimal contract implements a breach by the seller if and only if the cost of enforcement is low compared to the degree of relationship-specificity. Given that it is impossible to implement the efficient quantity, the optimal contract implements the case with the lower associated distortions (hence also the minimum function in expression (8)). If the cost of enforcement is relatively low, the optimal contract implements a breach by setting a high q^*: after the hold-up, the control over the produced units is with the intermediary, and the supplier's only asset is the enforceable contract whose value depends on the (relatively low) enforcement costs. On the other hand, when the degree of relationship-specificity is low and enforcement costs are high, the optimal contract will pick a low q^* to allocate the residual rights of control over the excess production $q - q^*$ with the supplier. In that case, his ex-post return on production depends on his ability to reverse the production (i.e. the parameter ω_{ni}). Hence, the optimal contract maximizes the surplus by maximizing the producer's ex-post return on production.[28]

The third statement says that the above is implementable while still allocating the whole surplus from the relationship to the intermediary. This is not trivial, since the supplier's payoff schedule M is required to be nonnegative.

The reader may be concerned about the possibility of 'overproduction' ($q > q^*$) arising as an equilibrium outcome in the model despite there being little evidence on this actually happening in practice. The right way to interpret such an equilibrium is as an outcome to an informal contract, where the option to enforce the claim in a court is either non-existent or irrelevant. Indeed, a contract where $M = 0$ and $q^* = 0$ would be equivalent to the situation where enforceable contract are not available, as in the literature on incomplete contracts (Klein et al., 1979, and others). The only reason why the optimal contract in this case features a small but positive q^* is because this allows the intermediary to obtain the full surplus from the relationship. If I allowed for an ex-ante transfer from the supplier to the intermediary, setting q^* and M to zero would be an optimal contract in the case where the degree of relationship-specificity is relatively low compared to enforcement costs.[29]

To summarize, the main benefit of having enforceable contracts is that when the stipulated quantity q^* is sufficiently high, the degree of relationship-specificity does not matter for the resulting allocation and the ex-ante investment. The drawback is that the presence of enforcement costs distorts the supplier's decision. Hence, choosing a high q^* will only be optimal if the degree of relationship-specificity is sufficiently high, so that the efficiency loss associated with a breach is lower than the efficiency loss associated with an unenforceable contract.

The model also yields a qualitative prediction on the occurrence of breach, which I will use later to construct an empirical measure of relationship-specificity.

Corollary 1 (Relationship-specificity and breach) *Let $\delta < 1$ and the parties sign an optimal contract. Then, for sufficiently high degree of relationship-specificity (i.e. for a sufficiently low ω_{ni}) the seller breaches the contract in equilibrium.*

1.2.1.3 *Returning to the Firm's Outsourcing Decision*

How does the contracting game fit into the macromodel? The intermediary's profit-maximization problem is exactly the problem of finding an optimal contract, (6) – (7), where the revenue function $R(q)$ is

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28 This is similar to the optimal allocation of property rights (Grossman and Hart, 1986, Hart and Moore, 1990).

29 The model thus makes a case for the possible desirability of informal contracts: if the degree of relationship-specificity is low and enforcement costs are high, it is preferable to choose an informal contract rather than specifying a high q^* and have the supplier underperform due to the presence of high enforcement costs.

the product of the quantity q and the downstream sector firm's inverse demand function for activity (n, i, j). The produced quantity under the optimal contract is then given by equation (8) in Proposition 1. The quantity distortion from the contracting frictions induces a move along the downstream sector firm's demand curve, and hence increases the price to the downstream sector firm. We obtain the price of activity (n, i, j) under arm's length transaction by inserting the produced quantity into the inverse demand function:

$$p^x_{ni}(j) = \frac{\mu_n p_i d_{ni}}{z_{ni}(j)}$$

where $\mu_n = \sigma_n / (\sigma_n - 1)$ is the markup due to monopolistic competition, and

$$d_{ni} = \min\left(2 - \omega_{ni}, \frac{1}{1 - \frac{1}{2}\delta}\right) \tag{9}$$

is the resulting price distortion due to contracting frictions. The functional form of d_{ni} in terms of the parameters ω_{ni} and δ is exactly the same as the distortion in equation (8).

Going back in time, the downstream sector firms decide on whether to produce in-house or to outsource by comparing the price of the good under the two regimes, $p^l_{ni}(j)$ and $p^x_{ni}(j)$. Given the perfect substitutability between the two options, the realized price of activity (n, i, j) is

$$p_{ni}(j) = \min\left(p^l_{ni}(j), p^x_{ni}(j)\right) \tag{10}$$

1.2.2 *Households' Preferences and Endowments*

There is a representative household with Cobb-Douglas preferences over the consumption of goods from each sector,

$$U = \prod_{i=1}^{N} c_i^{\eta_i}, \tag{11}$$

with $\sum_{i=1}^{N} \eta_i = 1$. Households have a fixed labor endowment L and receive labor income wL and the profits of the intermediaries Π. Their budget constraint is $\sum_{i=1}^{N} p_i c_i \leqslant wL + \Pi$, and thus $p_i c_i = \eta_i (wL + \Pi)$.

1.2.3 *Equilibrium Prices and Allocations*

I first describe prices and input use under cost minimization, and then define an equilibrium of the macromodel and give sufficient conditions for existence and uniqueness. All proofs are in A.1.

To describe sectoral price levels and expenditure shares, some definitions are helpful. Let $X_{ni} \equiv \int_0^1 p_{ni}(j) q_{ni}(j) \mathbf{1}_{\{j: p^x_{ni}(j) < p^l_{ni}(j)\}} dj$ be the expenditure of sector n firms on activities that are sourced from sector i, and $X_n = \int_0^1 p_{ni}(j)q_{ni}(j)dj$ the total expenditure (and gross output) of sector n. We then have

Proposition 2 (Sectoral price levels and expenditure shares) *Under cost minimization by the downstream sector firms, the following statements hold:*

1. *The cost of producing one unit of raw output y_n in sector n is*

$$p_n \equiv \left(\sum_{i=1}^{N} \gamma_{ni} \left(\alpha_n \left(S_n w^{-\theta} + T_i \left(p_i \mu_n d_{ni} \right)^{-\theta} \right)^{-\frac{1}{\theta}} \right)^{1-\rho} \right)^{1/(1-\rho)} \tag{12}$$

where w is the wage, and $\alpha_n \equiv \left(\Gamma \left(\frac{1-\sigma_n}{\theta} + 1 \right) \right)^{\frac{1}{1-\sigma_n}}$, with $\Gamma(\cdot)$ being the gamma function.

2. *The input expenditure shares X_{ni}/X_n satisfy*

$$\frac{X_{ni}}{X_n} = \gamma_{ni} \alpha_n^{1-\rho} p_n^{\rho-1} \frac{T_i \left(\mu_n p_i d_{ni} \right)^{-\theta}}{\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni} \right)^{-\theta} \right)^{1+(1-\rho)/\theta}}. \tag{13}$$

Furthermore, X_{ni}/X_n is decreasing in d_{ni}.

Proposition 2 gives expressions for the sectoral price levels and intermediate input expenditure shares. The sectoral price levels solve the system of equations (12), and depend on the cost of production under outsourcing and in-house production, and therefore on the productivity parameters T_i and S_n, as well as contracting frictions d_{ni}. The fact that suppliers may themselves outsource part of their production process gives rise to input-output linkages between sectors; the sectoral price levels are thus a weighted harmonic mean of the price levels of the other sectors. This amplifies the price distortions: an increase in the price of coal increases the prices of steel and machines, which in turn increases the cost of producing steel due to the steel industry's reliance on heavy machinery.

The expenditure shares on intermediate inputs, equation (13), are then determined by the relative effective cost of outsourcing versus in-house production. Higher effective cost of outsourcing will lead downstream firms to produce more activities in-house instead of outsourcing them. Thus, the expenditure share of sector n on inputs from sector i is increasing in sector i's productivity, T_i, and the importance of sector i products for sector n, γ_{ni}, and decreasing in sector i's input cost p_i and contracting frictions d_{ni}.

Proposition 2 yields the key qualitative prediction of the model, namely that contracting frictions, captured by $d_{ni} > 1$, negatively affect the downstream sector's fraction of expenditure on intermediate inputs from the upstream sector i. The elasticity θ determines the magnitude of this effect. The downstream firm may substitute away from input bundles that have become more costly due to the contracting frictions, as governed by the elasticity of substitution between input baskets ρ.

On an algebraic level, equation (13) closely resembles a structural gravity equation in international trade, with intermediate input expenditure shares replacing trade shares, and contracting frictions d_{ni} replacing trade barriers. This is the result of modeling the outsourcing decision in a similar way to Eaton and Kortum's way of modeling the international sourcing decision, and simplifies the quantitative evaluation of the model. In section 1.4 I use equation (13) to estimate the key parameters, including θ and ρ, and use these estimates to study the importance of costly contract enforcement for aggregate productivity and welfare.

I now proceed to closing the model. Intermediaries make profits due to monopolistic competition

$$\Pi = \sum_n \sum_i \Pi_{ni} = \sum_n \sum_i \left(1 - \frac{\sigma_n - 1}{\sigma_n} \frac{1}{d_{ni}}\right) X_{ni} \tag{14}$$

and the markets for sectoral output clear

$$p_i c_i + \sum_n (X_{ni} - \Pi_{ni}) = X_i, \qquad i = 1, \dots, N \tag{15}$$

An equilibrium is then a vector of sectoral price functions $(p_n(w))_{n=1,\dots,N}$ that satisfies (12). Given the sectoral prices, all other prices and quantities can be directly calculated: input shares $(X_{ni}/X_n)_{n,i}$ from (13), and profits Π and gross output levels $(X_n)_{n=1,\dots,N}$ from the linear system (14) and (15), where consumption levels are $c_i = \eta_i (wL + \Pi)/p_i$. The following proposition gives a set of sufficient conditions for existence and uniqueness of an equilibrium:

Proposition 3 (Sufficient conditions for equilibrium existence and uniqueness) *Let Ξ be the matrix with elements $\Xi_{ni} = (\alpha_n \mu_n)^{-\theta} \gamma_{ni}^{\theta/(\rho-1)} T_i$ for all $n, i = 1, \dots, N$. Assume that*

1. *the spectral radius of Ξ is strictly less than one, and*
2. $0 < \theta/(\rho - 1) < 1$.

Then, for all $(d_{ni})_{n,i}$ with $d_{ni} \geqslant 1$ for all n, i, an equilibrium price vector $(p_n(w))_{n=1,\dots,N}$ exists and is unique. Furthermore, $p_n(w)$ is homogenous of degree one in w.

The condition that the spectral radius of Ξ is less than one rules out 'infinite loops' in the production process, i.e. that one basket of sectoral output goods can be used as inputs to produce more than one basket of the same goods.

1.3 REDUCED-FORM EMPIRICAL EVIDENCE

In this section I present qualitative evidence that is consistent with my model's predictions. To do that, I exploit cross-country variation in intermediate input expenditure shares, enforcement costs, and variation across sector-pairs in the degree to which they rely on formal enforcement. The statements I make here are entirely of a qualitative nature. Later, I will turn to the quantitative importance of contracting frictions for outsourcing and welfare by structurally estimating the model from Section 1.2.

To empirically operationalize the model, I here state a corollary to Proposition 2.

Corollary 2 *For sufficiently high relationship-specificity $1 - \omega_{ni}$, sector n's expenditure share on intermediary inputs from sector i is strictly decreasing in the enforcement costs δ.*

The corollary directly follows from the fact that the expenditure share X_{ni}/X_n is strictly decreasing in d_{ni} (Proposition 2), and that d_{ni} is strictly increasing in δ for sufficiently low ω_{ni} (equation (9)). As explained in Section 1.2, when there is high relationship-specificity, the supplier and intermediary write contracts such that the supplier's outside option in ex-post bargaining is based on a threat to go to court, rather than a threat to revert production and sell it elsewhere. In these cases, the better the courts work the smaller the inefficiency and the larger the quantity supplied. This results in firms being more willing to outsource their production, and hence a higher intermediate input expenditure share.

In this section I bring Corollary 2 to the data by estimating the following reduced-form regression:

$$\frac{X_{ni}^c}{X_n^c} = \alpha_{ni} + \alpha_i^c + \alpha_n^c + \beta\delta^c(1 - \omega_{ni}) + \varepsilon_{ni}^c \tag{16}$$

where X_{ni}^c is the total expenditure of sector n in country c on intermediate inputs from sector i, both domestically and internationally sourced; X_n^c is the gross output of industry n in country c; δ^c is a country-level measure of enforcement cost; $1 - \omega_{ni}$ is relationship-specificity; α_{ni} are sector-pair fixed effects; α_i^c are upstream sector times country fixed effects, and α_n^c are downstream sector times country fixed effects. In this equation, the expenditure share on intermediate inputs is a function of an interaction of a sector-pair characteristic (relationship-specificity) with a country characteristic (enforcement costs), as well as characteristics of the upstream and downstream sectors in the country, and sector-pair characteristics that are invariant across countries. A negative value for β implies that a worsening of formal contract enforcement has particularly adverse effects on outsourcing in sector pairs characterized by high relationship-specificity, as predicted by Corollary 2. Equation (16) exploits variation in bilateral expenditure shares across countries, controlling for factors that affect the expenditure shares on the upstream side (such as sectoral productivity levels, skill and capital endowments, land and natural resources, but also institutional and policy factors such as subsidies, access to external financing, and import tariffs) and downstream side (firm scale, taxes).

Equation (16) is similar to the functional form used by Rajan and Zingales (1998) and subsequent papers, who explain country-sector-level variables using an interaction of a country-specific variable with a sector-specific variable. This literature typically goes to great lengths to try to control for the plethora of confounding factors that co-vary with the interaction term. Still, some of these factors may be left unaccounted, or badly proxied, for. My specification improves on this by exploiting variation across countries and bilateral sector *pairs*. This allows me to include upstream sector-country level fixed effects, thereby controlling for unobserved heterogeneity in the upstream sectors.

1.3.1 *Data*

Input expenditure shares I use cross-country data on input expenditure from the Global Trade Analysis Project (GTAP) database, version 8 (Narayanan et al., 2012).[30] It contains input-output tables on 109 countries, from varying years ranging from the beginning of the 1990's to mid-2000 and typically originating from national statistical sources. See 24 in A.3 for detailed information on data availability and the primary source of each country's input-output table. A notable quality of this dataset is that it includes many developing countries, for which industry-level data is typically scarce. The tables cover domestic and import expenditure for 56 sectors, which I aggregate up to 35 sectors that roughly correspond to two-digit sectors in ISIC Revision 3. To have a more direct link to my model's predictions, I use input expenditure shares rather than expenditure levels.[31] Table 1 contains summary statistics on expenditure shares at the country level.

Table 1: Summary statistics for country-wide input shares

Variable	Mean	Std. Dev.	Min	Max	N
Intermediate Input Share	0.53	0.08	0.25	0.69	109
Domestic Intermediate Input Share	0.37	0.08	0.12	0.58	109

Note: 'Intermediate input share' refers to the sum of all intermediate inputs (materials) in gross output. The domestic intermediate input share is defined analogously, but only includes domestically sourced intermediate inputs.

Enforcement cost The World Bank Doing Business project provides country-level information on the monetary cost and time necessary to

30 Recent papers outside the literature on CGE models that have used the GTAP input-output tables are Johnson and Noguera (2011) and Shapiro (2013).

31 There is a large related literature in industrial organization that measures the degree of vertical integration as the fraction of value added in gross output (see Adleman, 1955, Levy, 1985, Holmes, 1999, and also Macchiavello, 2009). My measure is similar, but distinguishes between intermediate inputs from different sectors. Furthermore, my data for intermediate input shares directly map into the theoretical counterpart in the model. I discuss concerns regarding the observability of firm boundaries in section 1.3.3.

enforce a fictional supplier contract in a local civil court. The contract is assumed to govern the sale of goods between a buyer and a seller in the country's largest business city. The value of the sale is 200% of the country's income per capita. The monetary cost is the total cost that the plaintiff (who is assumed to be the seller) must advance to enforce the contract in a court, and is measured as a fraction of the value of the claim. It includes court fees, fees for expert witnesses, attorney fees, and any costs that the seller must advance to enforce the judgment though a sale of the buyer's assets. The time until enforcement is measured from the point where the seller decides to initiate litigation, to the point where the judgment is enforced, i.e. the payments are received. I construct a total cost measure – again, as a fraction of the value of the claim – by adding the interest foregone during the proceedings, assuming a three percent interest rate:[32]

$$\delta^c = (\text{monetary cost, in pct})_c + 0.03\,(\text{time until enforcement, years})_c \,.$$

I use the cost measures for the year 2005, or, depending on availability, the closest available year to 2005.

Relationship-specificity Recall that in the model, the more relationship-specific is the good exchanged between the sectors, the more the parties rely on formal contract enforcement to minimize distortions. Hence, for my empirical implementation, I proxy relationship-specificity by "enforcement-intensity," i.e. the frequency with which firms from a particular sector-pair resolve conflicts in court. In particular, using data for the United States, for each pair of sectors I observe the number of court cases over a fixed period of time. Sector pairs with relatively more cases are considered to have higher relationship-specificity.[33]

My data come from the LexisLibrary database provided by LexisNexis. It contains cases from US federal and state courts. I take all cases between January 1990 and December 2012 that are related to contract law, ignoring appeal and higher courts, and match the plaintiff and defendant's names to the Orbis database of firms, provided

32 The expression is the proportional cost associated with a linear approximation of $v(1-\text{monetary cost, pct})/(1+\text{discount rate})^{(\text{time, yrs})}$, where v is a future payment. I obtain very similar results when using an eight percent interest rate instead of three percent.

33 Note that in my model the two parties do not actually go to court, but settle in order to avoid the enforcement costs. This is a result of my contracting game being entirely deterministic: if the outcome of the enforcement is known in advance, there is no point in actually going to court. It would be straightforward to extend the game to a setting where, in some cases, the parties do actually end up in court; however, the resulting friction would then be stochastic and it would be impossible to integrate the contracting into the general-equilibrium macromodel. One simple way to get the prediction of more litigation for higher degree of relationship-specificity would be to change the model by assuming that (1) parties cannot settle outside of court with an exogenous probability, and (2) the possibility of an ex-ante transfer from the supplier to the intermediary, so that an informal contract ($q^* = 0$ and $M = 0$) is optimal in the case when relationship-specificity is low. Then, the threat of litigation only occurs in the case of seller breach, and higher relationship-specificity is associated with a higher prevalence of litigation.

by Bureau Van Dijk.[34] Orbis contains the 4-digit SIC industry classification of firms; I thus know in which sectors the plaintiffs and defendants are active in. The Bureau of Justice Statistics (1996) documents that in cases related to the sale of goods or provision of services between two businesses, the seller is more than seven times more likely to be the plaintiff. I thus assign the plaintiff to the upstream industry. To obtain the likelihood of litigation between the two sectors, I divide the observed number of cases by a proxy for the number of buyer-seller relationships. If each downstream sector firm has exactly one supplier in each upstream sector, the correct way to normalize is to use the number of firms in the downstream sector. This yields a measure $z_{ni}^{(1)}$. Since the presence of more firms in the upstream sector may mean that there are more buyer-seller relationships, I construct an alternative measure where I divide the number of cases by the geometric mean of the number of firms active in the upstream and downstream industries, yielding a measure $z_{ni}^{(2)}$.[35,36] I interpret these two measures as related to the likelihood of litigation, and hence enforcement-intensity, for each pair of sectors. Table 2 shows summary statistics for $z_{ni}^{(1)}$ and $z_{ni}^{(2)}$.

$$z_{ni}^{(1)} = \frac{(\text{\# cases between sectors } i \text{ and } n)}{(\text{\# firms in sector } n)}, \tag{17}$$

$$z_{ni}^{(2)} = \frac{(\text{\# cases between sectors } i \text{ and } n)}{\sqrt{(\text{\# firms in sector } i)\,(\text{\# firms in sector } n)}} \tag{18}$$

My measure is conceptually different from existing measures of relationship-specificity/contract-intensity along three key dimensions.[37] First, the existing measures are only available for physical goods, whereas my measures cover services sectors as well. Second, the existing measures depend on input share data or assume that input shares are constant across countries. In section 1.3.2 I document that input shares vary sharply across countries, which renders the existing measures inapplicable to the study of cross-country input use patterns. Third, and most relevant to my identification strategy, my measure varies across bilateral sector-pairs, instead of being associated with the upstream sector. Given that the sectors in my dataset are fairly broad, it is likely that the products being sold to one sector are quite different to the ones sold to other sectors. The fact that my measure is sector-pair-specific is key to my identification strategy, as it allows me to include upstream sector-country fixed effects to control for unobserved sector characteristics like productivity.

34 See A.3 for details on the construction of matches and matching statistics.

35 I use the number of firms in Orbis. The results are extremely similar when using the number of firms from the Census Bureau's Statistics on U.S. Businesses instead.

36 Results are robust to dividing the cases by the number of upstream sector firms as well.

37 There are three existing measures of contract-intensity (sometimes directly interpreted as relationship-specificity). Nunn (2007) uses the fraction of a sector's inputs that are traded on an organized exchange, Levchenko (2007) uses the Herfindahl index of input shares, and Bernard et al. (2010) measure contractability as the weighted share of wholesalers in overall importers.

Table 2: SUMMARY STATISTICS FOR ENFORCEMENT-INTENSITY MEASURES

Variable	Mean	Std. Dev	Min	Max	N	Correlation with X_{ni}/X_n
$z_{ni}^{(1)}$	$5.34 \cdot 10^{-5}$	$1.778 \cdot 10^{-4}$	0	.00303	1225	0.17
$z_{ni}^{(2)}$	$2.22 \cdot 10^{-5}$	$0.586 \cdot 10^{-4}$	0	.00122	1225	0.29

Note: The table shows summary statistics for the relationship-specificity measures $z_{ni}^{(1)}$ and $z_{ni}^{(2)}$, as defined by equation (18). The correlation between the two variables is 0.48.

Table 3: AVERAGE ENFORCEMENT-INTENSITY OF UPSTREAM SECTORS, $z_{ni}^{(2)}$ MEASURE

Upstream sector	$\overline{z_{ni}^{(2)}} * 10^4$	Upstream sector	$\overline{z_{ni}^{(2)}} * 10^4$
Insurance	1.099	Transport nec	0.163
Business services nec	0.785	Gas manufacture, distribution	0.118
Financial services nec	0.548	Transport equipment nec	0.116
Electricity	0.443	Food products and beverages	0.114
Trade	0.388	Recreation and other services	0.112
Chemical,rubber,plastic prods	0.357	Mineral products nec	0.109
Paper products, publishing	0.354	Electronic equipment	0.108
PubAdmin/Defence/Health/Educat	0.351	Oil and Gas	0.104
Agriculture, Forestry, Fishing	0.286	Wearing apparel	0.072
Metal products	0.233	Motor vehicles and parts	0.069
Communication	0.221	Water	0.044
Ferrous metals	0.22	Minerals nec	0.040
Metals nec	0.211	Petroleum, coal products	0.036
Machinery and equipment nec	0.199	Coal	0.035
Construction	0.198	Textiles	0.032
Air transport	0.194	Wood products	0.028
Manufactures nec	0.194	Leather products	0.019
Sea transport	0.176		

Note: The table shows the enforcement-intensity $z_{ni}^{(2)}$ of an upstream sector i, averaged across downstream sectors. $z_{ni}^{(2)}$ is defined as the number of court cases where a sector i firm sues a sector n firm, divided by the geometric mean of the number of firms in sectors n and i.

Table 3 shows the ranking of upstream sectors by the average degree of enforcement-intensity, as measured by $z_{ni}^{(2)}$ (the ranking for $z_{ni}^{(1)}$ is very similar). Services sectors are on average more contract-intensive than manufacturing sectors, which are in turn more contract-intensive than raw materials-producing sectors. This is broadly in line with the interpretation of enforcement-intensity as the degree of relationship-specificity (Monteverde and Teece, 1982, Masten 1984, Nunn, 2007). Once a service has been performed, it cannot be sold to a third party, thus the scope for hold-up should be high. On the other end of the spectrum, raw materials have low depreciability and may be readily obtained through organized markets, thus there is relatively little scope for hold-up.

1.3.2 *Cross-country Dispersion in Input-Output Tables*

Table 4: CROSS-COUNTRY DISPERSION IN TWO-DIGIT INTERMEDIATE INPUT SHARES

I. Average standard deviations of intermediate input expenditure shares

	$\overline{\sigma}$
All sector pairs	.023
Goods-producing upstream sectors only	.020
Services-producing upstream sectors only	.028

II. Frequency distribution of standard deviations of input expenditure shares, σ_{ni}

Category	# sector pairs	% of total
All	1225	100
$\sigma_{ni} < .02$	838	68.4
$.02 < \sigma_{ni} < .04$	194	15.8
$.04 < \sigma_{ni} < .06$	68	5.6
$.06 < \sigma_{ni} < .08$	46	3.8
$.08 < \sigma_{ni} < .1$	18	1.5
$.1 < \sigma_{ni} < .15$	34	2.8
$\sigma_{ni} > .15$	27	2.2

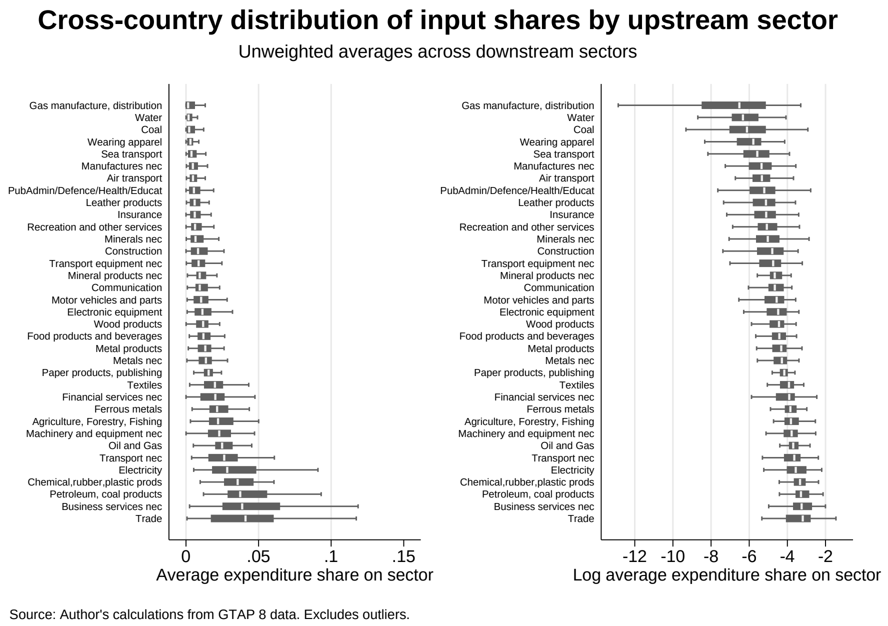
Note: The table presents statistics regarding the cross-country dispersion of intermediate input expenditure shares, at the two-digit sector-pair level. Part I shows means of the standard deviations, Part II shows the frequency distribution of standard deviations. All intermediate input shares cover both domestically and internationally sourced inputs.

Table 4 shows the dispersion of intermediate input shares at the two-digit level from their respective means.[38] To obtain the numbers in the first part of the table, I first calculated the standard deviation of the intermediate input shares for each sector-pair, and then took averages of these standard deviations. The average dispersion of expenditure shares across all sector-pairs is 2.3 percentage points. For services-producing upstream sectors, the dispersion is significantly higher (at the 1% level) than for sectors that produce physical goods. Most striking, however, is the fact that here is a sizeable number of sector-pairs for which the cross-country dispersion in input expenditure shares is high. The second part of Table 4 shows that for roughly 5 percent of sector pairs, the standard deviation is greater than 10 percentage points.

For which inputs is the cross-country dispersion in expenditure shares particularly large? Figure 2 shows for every upstream sector the expenditure share on this sector, averaged across downstream sectors. I use unweighted averages, to make sure the cross-country variation in the resulting input shares is not due to a different sectoral composition. The left panel shows that the dispersion is higher for inputs with higher average expenditure shares. Still, even in log-deviations there is considerable heterogeneity across inputs. Among the inputs

38 See Jones (2011b) for a comparison of input-output tables among OECD economies.

Figure 2: Cross-country distribution of input shares by upstream sector



with high average expenditure shares, the (wholesale and retail) trade, business services, electricity, transport, and financial services sectors show particularly high dispersion across countries. Note that these sectors are also particularly contract-intensive, as shown by Table 3, whereas the percentage-wise cross-country dispersion in input shares on the (not very contract-intensive) oil and gas and petroleum and coal products sectors is relatively low. This suggests that contracting frictions may play a role for external input use. In the following regressions I will try to rule out (or at least control for) alternative explanations.

1.3.3 *Results*

Table 5 presents the results of estimating equation (16) using ordinary least squares (standard errors clustered at the country level in parentheses). The first two columns include only sector-pair fixed effects, and do not correct for sectoral productivity differences across countries. Nevertheless, the estimates of the interaction term's coefficient, β, are negative. Columns (3) and (4) correct for the presence of unobserved heterogeneity in the upstream sectors by including fixed effect for each upstream sector-country pair. The estimates of the coefficient increase in magnitude, suggesting that the specifications that exclude upstream sector-level characteristics suffer from omitted variable bias. Both estimates are now significant at the .1% level. In columns (5) and (6) I also include downstream sector-country fixed effects to control for differences in the size of the downstream sectors across countries. The interaction coefficients increase slightly as a result, and remain statistically significant. I interpret the results from

Table 5: THE DETERMINANTS OF EXPENDITURE SHARES ON INTERMEDIATES: BENCHMARK RESULTS

Dependent variable: Expenditure share of sector n on intermediate inputs from sector i, X^c_{ni}/X^c_n						
	(1)	(2)	(3)	(4)	(5)	(6)
Contract enforcement interaction : $\delta^c(\#\text{Cases}_{ni}/\sqrt{\#\text{Firms}_n \#\text{Firms}_i})$	-71.78***		-101.0***		-120.3***	
	(15.39)		(24.07)		(28.53)	
Contract enforcement interaction : $\delta^c(\#\text{Cases}_{ni}/\#\text{Firms}_n)$		-9.246		-14.42***		-15.35***
		(4.829)		(3.987)		(4.176)
Upstream × Downstream fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Upstream × Country fixed effects			Yes	Yes	Yes	Yes
Downstream × Country fixed effects					Yes	Yes
N	133525	133525	133525	133525	133525	133525
R^2	0.447	0.447	0.531	0.531	0.537	0.537

Standard errors in parentheses, clustered at the country level

Note: Dependent variable is the expenditure of sector n in country c on domestically and internationally sourced intermediate inputs from sector i, divided by the total gross output of sector n in country c.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 as supporting my model's prediction that in countries with high enforcement costs, sectors are using less inputs that rely heavily on contract enforcement. The estimates in columns (5) and (6), my preferred specifications, imply that a one-standard deviation change in each of the interacted variables decreases the input share by .13 and .05 percentage points, respectively. I will discuss the quantitative effects of enforcement costs in more detail in section 1.4, using my structural estimates.

One potential concern is that my dependent variable, the expenditure share on intermediate inputs, does not correctly measure outsourcing. Indeed, the unit of observation that underlies the construction of an input-output table is the plant, meaning that intra-firm transactions between plants belonging to different sectors also show up in the expenditure on intermediate inputs.[39] In order to resolve this concern, I repeat the above regressions using only sector-pairs where the upstream sector is a services sector. Since services that are performed within the firm boundaries are typically not priced and are thus not included in the firm-level questionnaires that underlie the construction of input-output tables, the likelihood of the observed transactions being within the firm boundaries is much lower. The first two columns in Table 6 show that the resulting point estimates are smaller in magnitude, but still statistically significant at the 5 percent level.

There is an extensive and growing literature that documents that social capital, particularly trust, may help in overcoming frictions.[40] Bloom et al. (2012) document that interpersonal trust affects the internal organization of firms through decentralization. Thus, there is the possibility that trust also affects the make-or-buy decision, which could mean that enforcement costs do not accurately capture the magnitude of frictions between firms and potentially lead to biased estimates. To address this concern, I include an interaction of a country-level trust measure with enforcement-intensity. I follow the consensus in the literature by measuring trust as the fraction of people that respond to the question "Generally speaking, would you say that most people can be trusted, or that you can't be too careful when dealing with others?" with "Most people can be trusted" as opposed to "Need to be very careful". I use the numbers reported by Algan and Cahuc (2013) in their Figure 1, which in turn are based on data from the World Values Survey, European Values Survey, and Afrobarometer.

39 That said, Atalay et al. (2003) document that shipments of physical goods between vertically integrated plants in the U.S. are surprisingly low – less than .1 percent of overall value for the median plant.

40 See Algan and Cahuc (2013) for a survey of the relationship between trust and growth.

Table 6: THE DETERMINANTS OF EXPENDITURE SHARES ON INTERMEDIATES: ROBUSTNESS

Dependent variable: Expenditure share of sector n on intermediate inputs from sector i, $X^c_{ni,dom}/X^c_n$	(1)	(2)	(3)	(4)	(5)	(6)
Contract enforcement interaction : $\delta^c(\#Cases_{ni}/\sqrt{\#Firms_n \#Firms_i})$	-90.24***		-72.24**		-123.6***	
	(25.01)		(23.29)		(30.24)	
Contract enforcement interaction : $\delta^c(\#Cases_{ni}/\#Firms_n)$		-7.871*		-12.65**		-15.71***
		(3.796)		(3.191)		(4.635)
Trust interaction : $trust^c(\#Cases_{ni}/\sqrt{\#Firms_n \#Firms_i})$			29.99		4.808	
			(43.62)		(54.78)	
Trust interaction : $trust^c(\#Cases_{ni}/\#Firms_n)$				0.692		-7.113
				(5.996)		(8.099)
High US expenditure share × enforcement cost: $I^{US}_{ni}\delta^c$					-0.0082	-0.011*
					(0.004)	(0.0048)
High US expenditure share × trust: $I^{US}_{ni}trust^c$					-0.0007	-0.0006
					(0.005)	(0.005)
Upstream × Downstream fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Upstream × Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Downstream × Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Up services	Up services	Full	Full	Full	Full
N	53410	53410	106575	106575	106575	106575
R^2	0.459	0.459	0.482	0.481	0.566	0.566

Standard errors in parentheses, clustered at the country level

Note: Dependent variable is the fraction of expenditure of sector n on intermediate inputs from sector i in country c in total gross output of sector n in country c. Specifications (1) and (2) uses the subsample where the upstream sector is a services sector (defined as anything except agriculture, mining, and manufacturing). Specifications (3) to (6) use the subsample of countries where the trust measure is available (i.e. all countries except Bahrain, Bolivia, Cambodia, Cameroon, Sri Lanka, Costa Rica, Ecuador, Honduras, Cote d'Ivoire, Kazakhstan, Kuwait, Laos, Mauritius, Mongolia, Oman, Nepal, Nicaragua, Panama, Paraguay, Tunisia, Qatar, and the UAE).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The estimates of the trust interaction's coefficient come out as insignificant at the 5-percent level, as reported in specifications (3) and (4) of Table 6. The coefficient on the enforcement cost interaction remains negative and statistically significant. This suggests that while trust may be a way to alleviate frictions in informal interpersonal relationships, they may not be a substitute for enforcement of formal contracts between businesses in a court.

There is a concern that my measure of enforcement-intensity is capturing to some extent the magnitude of intersectoral expenditure flows in the United States, perhaps because of the lack of data for the number of buyer-seller relationships to normalize the number of court cases (and the possibility that the proxies in (18) are unsatisfactory). I construct a dummy I_{ni}^{US} that takes the value 1 if the intermediate input expenditure share in the US is above the median US expenditure share, and 0 otherwise. In specifications (5) and (6) of Table 6, I include an interaction of I_{ni} with enforcement costs, and with trust. The key explanatory variable, the interaction of enforcement cost with enforcement-intensity, remains statistically significant.[41]

Given that my dependent variable in the above regressions is the expenditure share on both imported and domestically sourced intermediate inputs, it is natural to ask whether the lack of distinction between the two modes of sourcing matters. Table 7 shows the results from estimating equation 16 with the expenditure share of domestically sourced inputs in gross output as the dependent variable. The point estimates of the interaction term's coefficient are slightly smaller than before. One is led to speculate that in domestic transactions, alternative ways to resolve hold-ups may be more relevant than in international transactions.

1.4 STRUCTURAL ESTIMATION, AND QUANTITATIVE RESULTS

In this section I return to my model from Section 1.2 and structurally estimate the key parameters using the dataset from the previous section. I then perform a set of counterfactuals to evaluate the importance of enforcement costs for aggregate welfare.

1.4.1 *Identifiability and Estimation Strategy*

To guide the estimation strategy, it is helpful to first establish which parameters we need to identify. I am ultimately interested in aggregate welfare, which I measure as real income per capita. Since the wage is the numeraire, we have that

$$\frac{Y^c}{P^c L^c} = \frac{1 + \Pi^c / L^c}{P^c}$$

where P is the consumer's price index in country c. Thus, changes in income per capita come about from changes in the consumer's price

41 Results are very similar when including the US input-output expenditure shares interacted with enforcement costs, instead of $I_{ni}\delta^c$.

Table 7: The Determinants of Expenditure Shares on Intermediates: Domestic Inputs Only

Dependent variable: Expenditure share of sector n on domestic intermediate inputs from sector i, $X^c_{ni,dom}/X^c_n$						
	(1)	(2)	(3)	(4)	(5)	(6)
Contract enforcement interaction : $\delta^c(\#Cases_{ni}/\sqrt{\#Firms_n \#Firms_i})$	-45.14**		-63.46***		-72.11***	
	(13.37)		(17.58)		(21.68)	
Contract enforcement interaction : $\delta^c(\#Cases_{ni}/\#Firms_n)$		-7.713		-10.75***		-10.80***
		(4.531)		(2.882)		(2.971)
Upstream × Downstream fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Upstream × Country fixed effects			Yes	Yes	Yes	Yes
Downstream × Country fixed effects					Yes	Yes
N	133525	133525	133525	133525	133525	133525
R^2	0.315	0.315	0.453	0.453	0.465	0.464

Standard errors in parentheses, clustered at the country level

Note: Dependent variable is the fraction of expenditure of sector n on domestic inputs from sector i in country c in total gross output of sector n in country c. The results are robust towards inclusion of trust and I^{US}_n interactions as used in Table 6.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

level and changes in profits per capita. The consumer price index is $P^c = \prod_i p_i^{\eta_i}$. Profits can be calculated from intermediate input expenditure levels $X_{ni}^c = \left(X_{ni}^c / X_n^c\right) X_n^c$, which in turn can be calculated from the market clearing conditions

$$\eta_i \left(L^c + \Pi^c\right) + \sum_n \left(X_{ni}^c - \Pi_{ni}^c\right) = X_i^c$$

for every $i = 1, \ldots, N$. Thus, aggregate welfare can be calculated by knowing only the parameters vectors $\eta = (\eta_i)_{i=1,\ldots,N}$ and $\sigma = (\sigma_n)_{n=1,\ldots,N}$ in addition to the equilibrium sectoral price levels p_i and the input-output expenditure shares X_{ni}^c / X_n^c. These are given by the equations (12) and (13), which are equivalent to

$$p_n^{1-\rho} = \sum_{i=1}^{N} \left(\left[\gamma_{ni}^{\theta/(\rho-1)} \alpha_n^{-\theta} S_n \right] + \left[\gamma_{ni}^{\theta/(\rho-1)} \alpha_n^{-\theta} T_i \mu_n^{-\theta} \right] (p_i d_{ni})^{-\theta} \right)^{(\rho-1)/\theta} \quad (19)$$

$$\frac{X_{ni}}{X_n} = p_n^{1-\rho} \frac{\left[\gamma_{ni}^{\frac{\theta}{\rho-1}} \alpha_n^{-\theta} T_i \mu_n^{-\theta} \right] (p_i d_{ni})^{-\theta}}{\left(\left[\gamma_{ni}^{\frac{\theta}{\rho-1}} \alpha_n^{-\theta} S_n \right] + \left[\gamma_{ni}^{\frac{\theta}{\rho-1}} \alpha_n^{-\theta} T_i \mu_n^{-\theta} \right] (p_i d_{ni})^{-\theta} \right)^{1+(1-\rho)/\theta}} \quad (20)$$

Thus, it is possible to calculate the equilibrium prices and quantities by knowing only the elasticities ρ and θ, the frictions d_{ni}^c, and the technology/productivity terms that are captured by the square brackets. In other words, it is not necessary to identify the country-specific productivity levels in order to perform the welfare counterfactuals. This attractive feature of the model vastly simplifies the welfare analysis. I thus proceed in two steps:

1. Estimate the elasticities ρ and θ and the technology/productivity terms from data on input shares X_{ni}^c / X_n^c and contracting frictions d_{ni}^c, using equations (19) and (20). I construct the contracting frictions d_{ni}^c from enforcement costs δ^c and a structural measure of relationship-specificity ω_{ni}, using the expression from my model, $d_{ni}^c = \min\left(1/(1 - \frac{1}{2}\delta^c), 2 - \omega_{ni}\right)$. I assume that relationship-specificity ω_{ni} is given by

   $$\omega_{ni}^{(i)} = 1 - m \cdot z_{ni}^{(i)}.$$

   Thus, the relative degrees of relationship-specificity are given by the measure of enforcement-intensity coming from the court data, $z_{ni}^{(i)}$. The parameter m, which I jointly estimate with the other parameters, governs the magnitude of relationship-specificity and therefore the importance of enforcement costs in shaping contracting frictions d_{ni}.

2. I set the consumer's Cobb-Douglas utility function parameters η_i to equal the corresponding (country-specific) household expenditure shares in the GTAP dataset. The last remaining parameters to determine are the σ_n, which are not identifiable through equation (20), and enter the welfare calculations through the

profit share. I set them equal to the values reported by Broda and Weinstein (2006); for services sectors I use the average of Broda and Weinstein's values, which is 3.94. Since these elasticities are fairly low and will imply higher profit shares than what we observe in the data, I also pursue an alternative strategy where I set the profit shares directly to the value observed in the United States. More on this in Section 1.4.3 below.

I then calculate the changes in real income per capita when the enforcement costs are set to US levels, using the estimated elasticities ρ and θ, the magnitude parameter m, the calibrated η_i and σ_n, and holding the estimated technology/productivity terms constant.[42]

1.4.2 *Estimation*

I use the same dataset as in the reduced-form regressions of Section 1.3. My estimating equations are the model's expressions for sectoral price levels, equation (19), and intermediate input expenditure shares, equation (20). Given the high dimsionality of the estimand (T_i^c and S_n^c are each 3815 parameters, γ_{ni} are an additional 1225), I use a simple nonlinear least squares criterion:

$$\left(\hat{m}, \hat{\theta}, \hat{\rho}, \hat{\sigma}, \hat{\gamma}, \hat{\mathbf{T}}, \hat{\mathbf{S}}\right) = \arg \min_{m,\theta,\rho,\sigma,\gamma,\mathbf{T},\mathbf{S}} \left\| \frac{X_{ni}^c}{X_n^c} - g\left(m, \theta, \rho, \sigma, \gamma, \mathbf{T}, \mathbf{S}\right) \right\|^2 \tag{21}$$

where

$$g\left(m, \theta, \rho, \sigma, \gamma, \mathbf{T}, \mathbf{S}\right) = \gamma_{ni} \alpha_n^{1-\rho} \left(p_n^c\right)^{\rho-1} \frac{T_i^c \left(\mu_n p_i^c d_{ni}^c\right)^{-\theta}}{\left(S_n^c + T_i^c \left(\mu_n p_i^c d_{ni}^c\right)^{-\theta}\right)^{1+(1-\rho)/\theta}} \tag{22}$$

and the sectoral price levels are given by (19). I also impose the conditions for existence and uniqueness of an equilibrium, Proposition 3. For every set of parameters I solve for the model's equilibrium price vector p and calculate the expenditure shares. For searching over the parameter space I use a stochastic Simulated Annealing algorithm (Kirkpatrick et al., 1983), which is designed to find global minima. Simulated Annealing is not particularly good for pinning down the exact minimum in a trough, thus I occasionally perform a Newton-type search to get to the bottom of a valley. Even though it is impossible to write g as a function of the parameters directly, the gradient admits a closed-form expression, which makes this procedure computationally feasible.

42 A series of recent papers, starting with Arkolakis et al. (2012), use a sufficient statistic approach to study the welfare impact of trade barriers. Even though my setup is structurally very similar to theirs, I cannot follow a sufficient statistic approach because I would need to have data on each country's input-output structure under the counterfactual, i.e. under the enforcement costs of the US.

Table 8: NLS ESTIMATES OF θ AND ρ

	$d_{ni}^{(1)}$	$d_{ni}^{(2)}$
θ	1.76	1.652
	(0.757)	(0.505)
$\log\rho$	1.305	1.130
	(0.267)	(0.297)
N	133525	133525
Pseudo-R^2	0.706	0.709

Note: The table shows partial results from the NLS regression (21) and (22), using $z_{ni}^{(1)}$ and $z_{ni}^{(2)}$, respectively, to construct $\omega_{ni}^{(1)}$ and $\omega_{ni}^{(2)}$. Robust standard errors are in parentheses. The Pseudo-R^2 is defined as $1 - RSS/TSS$.

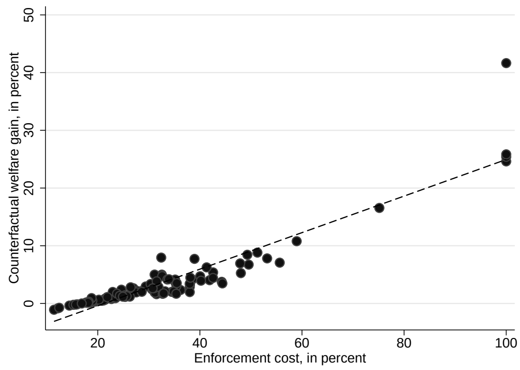
Table 8 shows the estimation results, once using the preferred $d_{ni}^{(1)}$ measure of contracting frictions, and once with the alternative measure $d_{ni}^{(2)}$. The structural estimates of the elasticity of the input share, θ, are 1.76 and 1.65, respectively, which is well below the trade elasticities typically estimated using structural gravity equations (Head and Mayer, 2013). The point estimates for the elasticity of substitution between broad input baskets ρ are 3.7 and 3.1. Lower values for ρ would mean that the impact of contracting frictions on prices would be larger, since firms are less able to substitute other input baskets when frictions are large. I will regard the first specification, which uses $d_{ni}^{(1)}$, as the benchmark, and will limit my discussion mostly to the the results coming from these estimates. The other specification generally yields larger welfare implications.

1.4.3 *Welfare Analysis*

Table 9 shows the increase in real income and decrease in the consumer's price index that would arise if each country's enforcement costs were set to US levels (17%). The first column lists the level of enforcement costs before the change. The second and third column show the percentage change in real output per capita y and the consumer price level P^c as the enforcement costs are reduced. The magnitudes are sizable, ranging up to a 41.6% increase in real income (23.5% drop in consumer prices) for the case of Indonesia. The mean changes are a 3.6% increase in real income, and a 4.1% drop in consumer prices. In Table 10, I show the average welfare changes for different groups of countries. Enforcement costs are particularly damaging in Africa and South-Eastern Asia. Figure 3 visualizes the welfare gains. A reduction in enforcement costs by one percentage point leads roughly to a 0.32% increase in real income.

According to equation (**??**), the change in real income can be decomposed into two factors: (i) a drop in the consumer's price index

Figure 3: WELFARE GAINS FROM SETTING ENFORCEMENT COSTS TO US LEVELS



Note: Welfare gains are calculated using the benchmark specification, column (1) in Table 8.

P^c due to the decrease in the firm's cost of intermediate inputs, (ii) a change in profits. The latter may be either positive or negative: on the one hand, a decrease in the d^c_{ni} increases outsourcing, which increases the amount of profits made; on the other hand, the profit share decreases as the amount of underproduction declines. Table 9 shows that the latter effect dominates for most countries.

How important are frictions in sourcing services inputs relative to physical inputs? Column 4 of Table 9 shows the fraction of the welfare gain that is explained by a reduction in frictions associated with physical inputs (agriculture, mining, manufacturing), assuming that the sourcing of services inputs is not subject to frictions. By considering contracting frictions for physical inputs only, one would miss roughly half of the welfare loss. In developing countries, the frictions on physical inputs are more important, mainly because physical goods are a larger part of the household's consumption basket. In OECD economies, they account for less than 38 percent of the welfare gains (see Table 10).

Since the Broda-Weinstein elasticities imply very high profit shares (around 20-30%), I also show the welfare results when the profit shares Π_{ni}/X_{ni} are set to 5%, which roughly corresponds to the fraction of pre-tax corporate profits in US gross output.[43] Columns four and five of Table 9 show the results. The welfare gains from a reduction in enforcement costs are higher than before, since holding the profit shares constant eliminates the profits-reducing effect from a reduction in enforcement costs. Profits now unambiguously increase as firms outsource more.

The last two columns of Table 9 show the counterfactual welfare gains using the estimates resulting from my alternative measure of

43 Data from the NIPA, Bureau of Economic Analysis, for the years 1998 to 2009. Note that this is not a direct calibration of the infrasectoral elasticities of substitution σ_n, but rather a calibration of Π_{ni}/X_{ni} which, according to the model, depends on the σ_n. This is also why the consumer price level changes in Table 9 are the same in the variable and fixed profit share columns: the σ_n enter the price level calculation only through the terms in the square brackets in equation (19), which are directly estimated from the data.

relationship-specificity, $\omega_{ni}^{(2)}$. The estimated elasticity of substitution between input baskets, ρ, is lower, thus firms are less able to substitute away when contracting frictions are large for one particular input. The resulting counterfactual welfare gains are therefore larger than in the baseline estimates.

To understand how much inter-firm transaction costs in the form of contracting frictions matter for the aggregate economy, I perform a second counterfactual, where I set the enforcement costs to zero and thereby eliminate contracting frictions altogether. The results are in Table 11. The average increase in real income is around 7 percent across all countries and 13.3 percent across low-income countries. Hence, the aggregate effects of distortions to the firm boundaries that originate from transaction costs are sizable, confirming North's (1990) hypothesis.

1.5 CONCLUSION

This paper has studied the importance of contracting frictions for the firm's outsourcing decision, and estimated the associated loss in aggregate productivity. The existing literature typically models contracting frictions through incomplete contracts. However, there is little evidence that judicial systems across countries differ in the degree of contractual incompleteness. In this paper I have thus considered a dimension along which we *know* that countries differ – the cost of contract enforcement. I have developed a rich yet tractable model to explain how costly contract enforcement increases the effective cost of intermediate inputs, and how this leads to too much in-house production. Using a novel measure of relationship-specificity constructed from microdata on US case law, I have shown that in countries where enforcement costs are high, firms tend to produce inputs that are very relationship-specific within the firm boundaries. I have then estimated my model parameters and quantified the welfare loss from costly enforcement.

What have we learned? First, contracting frictions distort the prices of externally sourced inputs, particularly those that are relationship-specific, leading to a reduction in the amount of outsourcing. The welfare effects are large. Thus, I have shown that transaction costs and the boundaries of the firm matter on a macroeconomic scale. The welfare effects exceed the gains from trade for many countries. While the literature on contracting frictions in international trade has shed much light on the role of contracting frictions in shaping input use, it is bound to miss the bulk of the distortions for two reasons. First, any barriers to international trade (such as contracting frictions) can only have welfare effects up to the gains of moving from autarky to free trade. Therefore, the welfare effects of international contracting frictions must be second-order. Second, contracting frictions are particularly important for relationship-specific goods, in particular services. These are mostly traded within the economy boundaries.

A second lesson is that economists should take care when interpreting input-output tables. Rather than being merely matrices of 'technological coefficients', they contain information on the firm's sourcing decisions and thus reflect the country's institutions and endowments. My paper also shows the shortcoming of using the United States' input-output table as a proxy for sectoral linkages in other countries, since input-output tables vary significantly and systematically across countries.

The third lesson is one for policy. My paper highlights the importance of judicial reform: the welfare costs from costly contract enforcement are substantial, and must not be ignored. A good rule of thumb to assess the magnitude of the welfare loss due to costly contract enforcement is that every percentage point in the cost of enforcement decreases welfare by 0.32 percent. Judicial reforms must weigh the benefits against the costs. They may be targeted to reduce the costs of legal representation, such as in the case of the United Kingdom (Jackson, 2009b), or attempt to clear the backlog of cases and speed up the litigation and enforcement process.

Table 9: Welfare gains from setting supplier contracting frictions to US levels

		Using relationship-specificity $\omega_{ni}^{(1)}$					Using $\omega_{ni}^{(2)}$	
		Variable Profit Shares			Fixed Profit Shares		Variable Profit Shares	
	δ	Δy, in %	ΔP, in %	% due to phys. inputs†	Δy, in %	ΔP, in %	Δy, in %	ΔP, in %
Albania	0.42	4.04	-8.79	43.6	9.87	-8.79	5.17	-9.74
Argentina	0.21	0.74	-0.95	37.6	1.03	-0.95	0.99	-1.22
Armenia	0.21	0.83	-1.18	67.9	1.27	-1.18	1.22	-1.56
Australia	0.24	1.46	-1.98	32.4	2.15	-1.98	2.02	-2.53
Austria	0.16	-0.15	0.22	29.6	-0.23	0.22	-0.26	0.30
Azerbaijan	0.21	0.47	-0.58	66.6	0.63	-0.58	0.62	-0.77
Bahrain	0.20	0.38	-0.34	35.2	0.38	-0.34	0.63	-0.53
Bangladesh	0.75	16.55	-18.14	82.7	23.10	-18.14	15.49	-16.96
Belarus	0.19	0.32	-0.46	84.2	0.49	-0.46	0.43	-0.57
Belgium	0.22	1.10	-1.60	35.5	1.73	-1.60	1.81	-2.09
Bolivia	0.38	3.28	-5.55	55.5	6.10	-5.55	4.08	-6.59
Botswana	0.36	2.34	-3.64	44.7	3.94	-3.64	3.01	-4.34
Brasil	0.23	0.77	-1.07	45.6	1.14	-1.07	1.03	-1.40
Bulgaria	0.28	2.11	-2.92	46.4	3.18	-2.92	2.96	-3.70
Cambodia	1.00	24.61	-20.94	76.6	28.11	-20.94	70.22	-35.84
Cameroon	0.53	7.81	-13.03	60.5	15.47	-13.03	11.37	-15.77
Canada	0.27	2.64	-3.30	33.8	3.66	-3.30	3.83	-4.32
Chile	0.33	5.00	-5.45	24.7	6.31	-5.45	10.87	-8.25
China PR	0.14	-0.37	0.53	72.1	-0.56	0.53	-0.52	0.67
Colombia	0.59	10.79	-11.75	40.3	14.14	-11.75	13.36	-14.03
Costa Rica	0.32	1.62	-2.37	57.0	2.54	-2.37	2.02	-2.79
Cote dIvoire	0.48	5.26	-9.19	88.4	10.35	-9.19	6.15	-10.11
Croatia	0.18	0.34	-0.38	62.9	0.42	-0.38	0.48	-0.52
Cyprus	0.22	0.89	-1.12	48.6	1.21	-1.12	1.12	-1.32
Czech Republic	0.39	7.73	-7.81	53.6	9.22	-7.81	13.90	-11.21
Denmark	0.28	2.16	-3.17	34.0	3.45	-3.17	3.18	-3.93
Ecuador	0.32	2.45	-3.17	62.8	3.46	-3.17	3.24	-4.03
Egypt	0.35	2.01	-2.53	75.3	2.75	-2.53	2.55	-3.28
El Salvador	0.26	1.27	-1.83	66.9	1.96	-1.83	1.57	-2.19
Estonia	0.18	0.28	-0.45	45.9	0.47	-0.45	0.44	-0.57
Ethiopia	0.21	0.48	-1.08	87.7	1.12	-1.08	0.61	-1.27
Finland	0.15	-0.23	0.46	44.1	-0.47	0.46	-0.33	0.55
France	0.20	0.55	-0.87	35.1	0.93	-0.87	0.84	-1.10
Georgia	0.44	3.75	-7.38	74.3	8.12	-7.38	4.15	-7.82
Germany	0.18	0.15	-0.24	32.6	0.25	-0.24	0.22	-0.30
Ghana	0.28	1.92	-3.54	68.1	3.81	-3.54	2.61	-3.89
Greece	0.21	0.52	-0.67	44.8	0.72	-0.67	0.69	-0.87
Guatemala	0.38	4.14	-6.36	62.5	7.08	-6.36	5.46	-7.67
Honduras	0.43	5.38	-6.13	54.2	6.98	-6.13	7.11	-7.33
Hong Kong	0.23	2.00	-2.87	48.5	3.13	-2.87	3.78	-3.92
mean	0.33	3.58	-4.12	53.2	4.92	-4.12	5.44	-5.18

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Table 9: WELFARE GAINS FROM SETTING SUPPLIER CONTRACTING FRICTIONS TO US LEVELS *(ctd.)*

		Using relationship-specificity $\omega_{ni}^{(1)}$					Using $\omega_{ni}^{(2)}$	
		Variable Profit Shares			Fixed Profit Shares		Variable Profit Shares	
	δ	Δy, in %	ΔP, in %	% due to phys. inputs†	Δy, in %	ΔP, in %	Δy, in %	ΔP, in %
Hungary	0.18	0.16	-0.22	47.3	0.23	-0.22	0.24	-0.28
India	0.51	8.82	-11.14	62.2	13.11	-11.14	11.12	-12.49
Indonesia	1.00	41.64	-23.51	58.5	34.21	-23.51	76.09	-34.74
Iran	0.21	0.61	-0.85	56.5	0.91	-0.85	0.76	-1.04
Ireland	0.31	5.01	-5.74	36.8	6.60	-5.74	8.13	-7.40
Israel	0.33	4.74	-3.57	39.5	4.24	-3.57	10.86	-6.54
Italy	0.41	6.26	-7.23	39.0	8.33	-7.23	9.62	-9.40
Japan	0.35	4.14	-4.87	39.5	5.48	-4.87	5.66	-6.29
Kazakhstan	0.25	1.14	-1.09	63.9	1.21	-1.09	1.95	-1.64
Kenya	0.38	2.86	-2.48	83.6	2.80	-2.48	3.73	-3.74
Kuwait	0.23	0.92	-0.98	27.9	1.07	-0.98	1.44	-1.41
Kyrgyzstan	0.31	1.92	-3.66	60.9	3.90	-3.66	2.48	-4.16
Laos	0.35	1.76	-3.91	83.6	4.12	-3.91	2.00	-4.14
Latvia	0.19	0.32	-0.41	61.1	0.44	-0.41	0.48	-0.55
Lithuania	0.25	1.42	-2.11	41.9	2.28	-2.11	1.90	-2.64
Luxembourg	0.11	-1.09	1.71	27.3	-1.78	1.71	-1.68	2.26
Madagascar	0.50	6.73	-7.27	93.4	8.28	-7.27	6.63	-7.53
Malawi	1.00	25.84	-24.54	66.3	34.05	-24.54	30.36	-26.68
Malaysia	0.32	7.95	-6.66	41.5	8.07	-6.66	20.17	-12.01
Malta	0.40	4.71	-4.72	66.4	5.37	-4.72	6.42	-5.86
Mauritius	0.24	1.01	-1.32	55.9	1.42	-1.32	1.29	-1.55
Mexico	0.35	3.02	-5.71	37.8	6.26	-5.71	4.53	-7.30
Mongolia	0.33	2.10	-3.00	30.5	3.24	-3.00	3.00	-3.74
Morocco	0.29	2.94	-3.68	58.0	4.08	-3.68	4.10	-4.65
Mozambique	1.00	25.41	-28.67	54.0	41.47	-28.67	27.88	-29.96
Namibia	0.38	1.97	-2.49	56.2	2.70	-2.49	2.92	-3.37
Nepal	0.35	3.62	-3.88	77.9	4.31	-3.88	4.68	-6.46
Netherlands	0.29	2.03	-3.06	28.2	3.33	-3.06	2.93	-3.79
New Zealand	0.24	1.70	-2.19	35.0	2.40	-2.19	2.69	-3.00
Nicaragua	0.31	1.87	-3.46	58.0	3.70	-3.46	2.23	-4.04
Nigeria	0.38	3.41	-5.98	73.9	6.53	-5.98	3.37	-6.30
Norway	0.12	-0.74	1.60	36.2	-1.63	1.60	-1.08	1.89
Oman	0.18	0.15	-0.15	43.9	0.17	-0.15	0.24	-0.24
Pakistan	0.31	2.66	-4.15	70.7	4.50	-4.15	3.33	-4.79
Panama	0.56	7.07	-8.79	39.2	10.14	-8.79	9.00	-10.56
Paraguay	0.35	2.07	-3.61	79.7	3.86	-3.61	2.56	-4.45
Peru	0.40	3.95	-4.07	69.1	4.55	-4.07	5.20	-5.31
Philippines	0.32	2.88	-3.89	68.2	4.27	-3.89	4.23	-4.96
Poland	0.20	0.65	-0.98	46.2	1.05	-0.98	0.93	-1.23
Portugal	0.19	0.46	-0.54	49.5	0.59	-0.54	0.79	-0.77
Qatar	0.26	1.19	-1.09	39.0	1.22	-1.09	1.97	-1.73
mean	0.33	3.58	-4.12	53.2	4.92	-4.12	5.44	-5.18

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Table 9: WELFARE GAINS FROM SETTING SUPPLIER CONTRACTING FRICTIONS TO US LEVELS *(ctd.)*

		Using relationship-specificity $\omega_{ni}^{(1)}$					Using $\omega_{ni}^{(2)}$	
		Variable Profit Shares			Fixed Profit Shares		Variable Profit Shares	
	δ	Δy, in %	ΔP, in %	% due to phys. inputs†	Δy, in %	ΔP, in %	Δy, in %	ΔP, in %
Romania	0.24	1.33	-2.60	67.8	2.76	-2.60	1.77	-3.05
Russia	0.16	-0.20	0.28	48.7	-0.30	0.28	-0.25	0.35
Saudi Arabia	0.33	1.67	-1.55	36.9	1.74	-1.55	2.55	-2.30
Senegal	0.33	1.76	-3.11	61.0	3.30	-3.11	2.11	-3.53
Singapore	0.19	0.93	-0.89	45.3	1.00	-0.89	2.06	-1.54
Slovakia	0.30	3.37	-4.04	48.9	4.52	-4.04	5.53	-5.48
Slovenia	0.32	3.84	-5.97	42.4	6.68	-5.97	5.77	-7.27
South Africa	0.38	4.47	-5.49	38.1	6.18	-5.49	6.79	-7.24
South Korea	0.12	-0.84	0.94	44.7	-1.02	0.94	-1.31	1.35
Spain	0.21	0.65	-0.90	36.6	0.97	-0.90	0.94	-1.15
Sri Lanka	0.34	4.15	-4.01	60.9	4.54	-4.01	5.04	-5.00
Sweden	0.35	3.52	-5.59	43.6	6.17	-5.59	5.01	-6.68
Switzerland	0.25	2.39	-2.27	25.2	2.58	-2.27	4.08	-3.43
Taiwan	0.22	1.08	-1.28	49.2	1.40	-1.28	1.66	-1.76
Tanzania	0.18	0.13	-0.33	70.8	0.34	-0.33	0.18	-0.39
Thailand	0.18	0.31	-0.46	65.7	0.48	-0.46	0.47	-0.58
Tunisia	0.26	2.80	-3.42	72.2	3.76	-3.42	4.49	-4.51
Turkey	0.31	2.62	-2.90	53.4	3.21	-2.90	3.33	-3.72
Uganda	0.49	8.44	-8.76	61.0	10.30	-8.76	12.63	-11.74
Ukraine	0.44	3.48	-3.47	45.9	3.86	-3.47	5.01	-4.83
United Arab Emirates	0.31	2.45	-2.02	42.5	2.31	-2.02	4.16	-3.20
United Kingdom	0.25	1.25	-1.73	28.1	1.87	-1.73	1.86	-2.22
United States	0.17	0.00	0.00	–	0.00	0.00	0.00	0.00
Uruguay	0.25	1.18	-1.90	33.4	2.03	-1.90	1.76	-2.38
Venezuela	0.48	6.94	-8.15	52.8	9.42	-8.15	10.01	-10.83
Vietnam	0.34	4.21	-5.53	76.7	6.18	-5.53	6.20	-7.05
Zambia	0.43	4.42	-7.66	64.0	8.54	-7.66	5.80	-8.63
Zimbabwe	0.35	1.69	-2.36	61.1	2.52	-2.36	2.16	-2.88
mean	0.33	3.58	-4.12	53.2	4.92	-4.12	5.44	-5.18

†'Percentage due to physical inputs' is the fraction of the change in real income (column 2) that is explained through frictions associated with physical inputs, i.e. agricultural, mining, and manufacturing products.

Table 10: WELFARE GAINS FROM SETTING CONTRACTING FRICTIONS TO US LEVELS: AVERAGES

		Using relationship-specificity $\omega_{ni}^{(1)}$					Using $\omega_{ni}^{(2)}$	
		Variable Profit Shares			Fixed Profit Shares		Variable Profit Shares	
	δ	Δy, in %	ΔP, in %	% due to phys. inputs†	Δy, in %	ΔP, in %	Δy, in %	ΔP, in %
High income: OECD	0.24	1.95	-2.31	37.7	2.62	-2.31	3.26	-3.12
High income: non-OECD	0.24	1.21	-1.34	45.7	1.49	-1.34	1.90	-1.85
Upper middle income	0.31	2.72	-3.44	54.5	3.89	-3.44	4.05	-4.42
Lower middle income	0.39	4.95	-5.87	65.0	6.88	-5.87	7.30	-7.18
Low income	0.54	9.86	-10.18	73.0	13.36	-10.18	14.75	-12.30
Africa	0.42	5.41	-6.69	66.4	8.27	-6.69	6.70	-7.68
Northern Africa	0.30	2.58	-3.21	68.5	3.53	-3.21	3.71	-4.15
Eastern Africa	0.48	7.70	-8.45	69.8	11.08	-8.45	9.13	-9.44
Middle Africa	0.53	7.81	-13.03	60.5	15.47	-13.03	11.37	-15.77
Western Africa	0.37	3.09	-5.46	72.8	6.00	-5.46	3.56	-5.96
Southern Africa	0.37	2.92	-3.87	46.3	4.28	-3.87	4.24	-4.98
Americas	0.35	3.38	-4.40	50.6	4.97	-4.40	4.68	-5.51
Northern America	0.22	1.32	-1.65	33.8	1.83	-1.65	1.92	-2.16
Central America	0.37	3.48	-4.95	53.7	5.52	-4.95	4.56	-5.98
South America	0.35	3.72	-4.57	50.1	5.21	-4.57	5.31	-5.85
Asia	0.33	4.47	-4.30	56.2	5.27	-4.30	7.97	-5.83
Western Asia	0.27	1.67	-1.90	48.0	2.13	-1.90	2.69	-2.60
Central Asia	0.28	1.53	-2.37	62.4	2.55	-2.37	2.21	-2.90
Eastern Asia	0.23	1.35	-1.76	47.4	1.94	-1.76	2.05	-2.28
South-Eastern Asia	0.46	10.54	-8.22	64.5	10.81	-8.22	22.68	-12.61
Southern Asia	0.41	6.07	-7.03	68.5	8.41	-7.03	6.74	-7.79
Europe	0.25	1.75	-2.26	44.2	2.54	-2.26	2.66	-2.89
Northern Europe	0.23	1.44	-1.91	41.3	2.13	-1.91	2.18	-2.40
Western Europe	0.20	0.71	-0.87	30.5	0.97	-0.87	1.13	-1.16
Eastern Europe	0.27	2.11	-2.47	54.3	2.78	-2.47	3.39	-3.33
Southern Europe	0.29	2.60	-3.65	48.1	4.12	-3.65	3.73	-4.45
Oceania	0.24	1.58	-2.08	33.7	2.27	-2.08	2.35	-2.76

Note: Table shows the average counterfactual welfare changes when enforcement costs are set to US levels (17%). Income groups are from the July 2013 World Bank income classifications; Regions are defined according to the UN geographical classification.

Table 11: WELFARE GAINS FROM ELIMINATING SUPPLIER CONTRACTING FRICTIONS: AVERAGES

		Using relationship-specificity $\omega_{ni}^{(1)}$					Using $\omega_{ni}^{(2)}$	
		Variable Profit Shares			Fixed Profit Shares		Variable Profit Shares	
	δ	Δy, in %	ΔP, in %	% due to phys. inputs†	Δy, in %	ΔP, in %	Δy, in %	ΔP, in %
All Countries	0.33	7.03	-8.51	53.14	10.46	-8.51	11.35	-10.77
High income: OECD	0.24	5.86	-7.26	38.0	8.60	-7.26	10.07	-9.64
High income: non-OECD	0.24	4.60	-5.20	46.0	6.07	-5.20	7.78	-7.18
Upper middle income	0.31	5.89	-7.56	55.0	8.96	-7.56	9.45	-9.66
Lower middle income	0.39	8.15	-10.28	64.5	12.62	-10.28	12.23	-12.36
Low income	0.54	13.37	-14.41	72.6	19.73	-14.41	21.58	-17.47
Africa	0.42	8.34	-10.90	66.1	13.90	-10.90	10.72	-12.61
Northern Africa	0.30	6.31	-7.79	68.5	9.10	-7.79	9.37	-9.93
Eastern Africa	0.48	10.79	-12.56	69.4	17.01	-12.56	13.18	-14.16
Middle Africa	0.53	11.06	-18.63	58.8	23.75	-18.63	16.68	-22.53
Western Africa	0.37	5.33	-9.95	72.0	11.50	-9.95	6.31	-10.89
Southern Africa	0.37	5.29	-7.15	46.9	8.26	-7.15	7.75	-9.09
Americas	0.35	6.38	-8.59	50.0	10.16	-8.59	9.27	-10.72
Northern America	0.22	5.07	-6.58	36.6	7.65	-6.58	7.57	-8.53
Central America	0.37	6.08	-8.99	53.1	10.52	-8.99	8.08	-10.79
South America	0.35	6.86	-8.72	50.5	10.42	-8.72	10.45	-11.12
Asia	0.33	8.49	-8.57	56.2	10.87	-8.57	16.30	-11.64
Western Asia	0.27	4.42	-4.99	48.2	5.81	-4.99	7.49	-6.86
Central Asia	0.28	3.79	-5.74	62.4	6.48	-5.74	5.77	-7.07
Eastern Asia	0.23	4.93	-6.37	47.5	7.42	-6.37	7.95	-8.33
South-Eastern Asia	0.46	17.53	-14.11	64.2	19.48	-14.11	42.33	-21.40
Southern Asia	0.41	9.69	-11.49	68.5	14.41	-11.49	11.07	-13.00
Europe	0.25	5.18	-6.96	44.7	8.15	-6.96	8.03	-8.82
Northern Europe	0.23	4.74	-6.77	41.8	7.87	-6.77	7.27	-8.40
Western Europe	0.20	4.24	-5.70	30.8	6.54	-5.70	6.87	-7.52
Eastern Europe	0.26	5.58	-7.05	54.8	8.30	-7.05	8.87	-9.11
Southern Europe	0.29	6.07	-8.17	48.7	9.72	-8.17	8.97	-10.08
Oceania	0.24	5.42	-7.25	34.2	8.40	-7.25	8.23	-9.40

Note: Table shows the average counterfactual welfare changes when enforcement costs (and hence contracting frictions) are eliminated altogether. Income groups are from the July 2013 World Bank income classifications; Regions are defined according to the UN geographical classification.

2

IS RED TAPE A RED HERRING? STARTUP COSTS AND MISALLOCATION ACROSS COUNTRIES

2.1 INTRODUCTION

The presence of bureaucratic barriers to starting businesses is often considered to be one of the main culprits of underdevelopment in poor countries, and has hence featured prominently on the development policy agenda. However, showing a causal link between entry barriers and development is far from easy due to the presence of confounding factors, the difficulty of measurement, and the possibility of reverse causality.

The present paper investigates the quantitative importance of several different channels through which bureaucratic startup costs may affect aggregate outcomes. We study a dynamic model of occupational choice, intergenerational inheritance of wealth and managerial talent, and decreasing returns to scale at the level of the production unit. Agents live for one period and are heterogeneous in wealth and managerial talent. At the beginning of each period, they face a decision about whether to become an entrepreneur, in which case they receive the profits from running a firm, or to work on the labor market, thus earning a wage. Entrepreneurs borrow to cover a fixed bureaucratic startup cost and factor payments, but the option to default and limits to asset recovery mean that they face an endogenous borrowing constraint. Hence, their return from operating a firm depends not only on their managerial talent, but also on their ability to scale up production. On the aggregate scale, outcomes are the result of three forces: (i) the allocation of capital among existing firms, (ii) the selection of agents of different managerial talent into entrepreneurship, and (iii) the distortion of the average scale of production from the optimal level in the presence of decreasing returns to scale.

To understand the quantitative importance of these mechanisms, we calibrate the model economy to match several key moments of the US data, and set the institutional parameters to values observed in the World Bank's Doing Business survey of business regulations across countries. We show that the net effect of abolishing bureaucratic startup costs is small; it would only increase income per capita on average by 1% across the countries in our sample, and at most by 6%. On the other hand, the importance of access to external financing seems to be much higher; countries that move from no external financing to unconstrained access to capital would experience an increase in income per capita of more than 35% – this also being the corresponding counterfactual for some of the countries in our sample.

Our result that bureaucratic startup costs have a small net effect comes from the fact that their effects go in opposite directions, and hence partially offset each other. Higher startup costs increase the entry cutoff for managerial talent and wealth. Since the correlation of wealth and talent increases for higher levels of wealth and talent, selection becomes better. On the other hand, higher startup costs decrease the mass of firms, thus the average scale of production is too high, and output per capita decreases. The latter effect is slightly stronger than the former, hence the negative net effect on welfare. The bureaucratic startup costs also interact with the financial frictions by changing the allocation of capital to firms, though the magnitude of this effect is rather small.

2.1.1 *Related Literature*

There is an extensive literature on the effects of startup costs and financial frictions on misallocation and aggregate productivity.[1] Moscoso Boedo and Mukoyama (2012) and Barseghyan and DiCecio (2011) study the effects of bureaucratic startup costs on Total Factor Productivity (TFP) using a dynamic model. Startup costs result in lower TFP due to the Hopenhayn-Melitz selection mechanism: lower sunk costs lead to a larger mass of entrants, thus higher labor demand, higher wage, and hence a higher productivity cutoff with more firms exiting (stronger selection). Their mechanism requires that agents have no knowledge of their entrepreneurial ability when they face the entry decision. Given our emphasis on generational talent shocks, this is unlikely to be of relevance in our situation. If and entrepreneur enters, tries out for one or two years, and subsequently decides to exit and work, we would count him as a worker in the first place. Given that young firms tend to be small and account for only a small fraction of output, the mistake that we making by taking these firms not into account is small.

Startup costs may affect misallocation through competition and changes in markups. However, Peters (2013) finds that the static effects on misallocation are fairly small (decreases TFP by roughly 1%). We thus abstract from the effects of market structure on misallocation in this paper.

Our work is also strongly related to a large literature that studies the effect of financial frictions on aggregate outcomes (among others, Amaral and Quintin, 2010, Jeong and Townsend, 2007, Buera and Shin, 2013, Caselli and Gennaioli, 2013, Midrigan and Xu, 2014). Perhaps the most closely related paper is Buera et al. (2011), who emphasize the complementarity between fixed costs and financial frictions for selection into entrepreneurship and TFP loss. However, their fixed costs are largely production infrastructure, and not institutional features, and may therefore vary not much across countries. Our bureaucratic startup costs are magnitudes smaller, hence our finding of their limited quantiative importance.

1 See Hopenhayn (2014) for a survey.

2.2 MODEL

2.2.1 *Preferences and Endowments*

We study a model of occupational choice in the spirit of Lucas (1978), with intergenerational transmission of managerial talent and dynastic misallocation as in Caselli and Gennaioli (2013). The economy is populated by a unit continuum of individuals, who each live for one period and each have exactly one child. They choose consumption c_{it} and bequests b_{it} to maximize utility over consumption and the child's future income y_{it+1},

$$\max_{c_{it}, b_{it}} \log c_{it} + \beta \log y_{it+1}(b_{it})$$

subject to a budget constraint

$$c_{it} + b_{it} \leqslant y_{it}.$$

and the constraint that bequests have to be nonnegative, $b_{it} \geqslant 0$. Agents are endowed with one unit of time, which they can either spend by inelastically supplying it on the labor market, or by operating a firm, which we explain below.

Agents vary in their entrepreneurial talent θ_{it}. We assume that θ_{it} follows a random growth process,

$$\theta_{it+1} = q\gamma_{it+1}\theta_{it} + 1 \tag{23}$$

where $q < 1$ and the growth rate γ_{it+1} follows a lognormal distribution and is i.i.d. across individuals i and time t.

$$\log \gamma_{it+1} \sim N\left(0, \sigma^2\right), \quad \sigma > 0.$$

Equation (23) captures the idea that managerial talent may be positively correlated across generations. The parameter q governs the persistence of talent, wheas σ affects the variance of talent shocks. Our choice of the talent process is guided by the asymptotic properties of the talent distribution. Appendix B shows that the tail of the steady state distribution of talent θ follows a power law.[2] Gabaix and Landier (2008) argue that a distribution of managerial talent that has approximately power law tails is necessary to explain the distribution of CEO compensation and firm size in the US.[3] We assume that the parent spends enough time with the child to know its entrepreneurial talent θ_{it+1}.

2 The result that the stationary distribution associated with equation (23) is asymptotically Pareto in the tail does not rest on the distributional assumptions regarding γ_{it+1}. Indeed, this is true for much more general processes. See Gabaix (2009) for a discussion, and Kesten (1973) for proofs.

3 Buera et al. (2011) and Hsieh et al. (2013) obtain power law tails for the talent distribution by making the assumption that the cross-section of talent at any point in time follows a Pareto distribution. Our modeling strategy of using random growth processes has the advantage that it replicates the concavity of the empirical establishment size distribution; see Section 2.3.1.

2.2.2 *Technology and Financial Frictions*

At the beginning of each period, each individual decides whether to become a manager/entrepreneur[4] or a worker. If they decide to become a manager, they have to obtain a license to operate a firm. They can pay κ in administrative fees to create a new license, or buy one from an existing owner at price p, both in units of the output good.[5] The parameter κ are the administrative costs faced by the entrant, and is hence one of our key parameters of institutional quality in this paper.

Once the entrepreneurs have acquired a license, they face a fixed cost of f units of the output good, and subsequently produce using a technology that is Cobb-Douglas in capital and labor. The managerial talent of the entrepreneur, θ_{it}, determines firm-level TFP.

$$Y_{it}(\theta_{it}) = \theta_{it}\left(K_i^{\alpha}L_i^{1-\alpha}\right)^{\rho}. \tag{24}$$

Following Lucas (1978), we assume $\rho < 1$, thus the production technology exhibits decreasing returns to scale. Capital fully depreciates after production takes place. Output, the consumption good, is perfectly storable and transformable into capital. We take the output good as the numeraire. With probability δ a license/firm is destroyed at the end of the period. If the license is not destroyed, it is bequeathed to the son.[6] To keep the household's problem a deterministic one, we assume that the realization of the firm destruction shock is known at the time the decision is made.

We model financial frictions as limits to the enforcement of lending contracts. The entrepreneurs may borrow and lend capital at a fixed interest factor $R > 1$. After production takes place and wages are paid, but before agents consume, the entrepreneurs may default on their loans. If that happens, the lenders can seize a fraction ϕ of the entrepreneur's assets. The debtor keeps the remaining share $1 - \phi$. The possibility of default means that lenders limit the amount they are willing to lend. This gives rise to a borrowing constraint that depends on the net worth of the entrepreneur.

Entrepreneurs receive the revenue from production net of factor payments, hence their income is

$$y_{it}^{\text{entrepreneur}} \equiv Y_{it}(\theta_{it}) - wL_{it} - R\left(K_{it} - (b_{it-1} - \min\{p, \kappa\} - f)\right).$$

The non-default constraint ensures that the debt does not exceed the amount that lenders could recover:

$$R\left(K - (b_{it} - \min(\kappa, p) - f)\right) \leqslant \phi\left(Y_{it}(\theta_{it}) - wL_{it}\right) \tag{25}$$

4 We will use these two terms interchangeably. See Caselli and Gennaioli (2012) for a discussion of delegated control in this setting.

5 The third way to obtain a license would be to inherit it. However, given that the market for licenses is frictionless, we do not distinguish between inheriting a license and inheriting p.

6 For the sake of brevity we include the value of a licence p in the bequest b_{it} whenever the son inherits the licence.

Alternatively, agents may become workers instead of entrepreneurs, in which case they supply their unit labor endowment on the Walrasian labor market and receive a wage w. Naturally, if a son inherits a licence but decides to become a worker, he sells the licence. A worker's total income consists of labor and capital income, the latter being the gross return from lending their bequest (including the revenue from selling the licence, if applicable) on the capital markets,

$$y_{it}^{\text{worker}}(\theta_{it}) = w_t + Rb_{it-1}.$$

2.2.3 *Equilibrium*

We focus on steady state equilibria, where individuals choose consumption, bequests, and occupation to maximize utility; firms choose capital and labor to maximize profits; the goods market, labor market, and the market for licences clear; the aggregate variables are constant, and the wealth and ownership distributions are time-invariant.

2.2.3.1 *The Firm's Decision*

Entrepreneurs maximize revenue minus factor payments. The labor market is frictionless, thus the wage is equal to the marginal product of labor. Hence, labor demand is

$$L_i^d = \left(\frac{\rho\,(1-\alpha)\,\theta_i}{w}\right)^{\frac{1}{1-\rho(1-\alpha)}} K_i^{\frac{\alpha\rho}{1-\rho(1-\alpha)}}. \tag{26}$$

We can then rewrite the entrepreneur's profit as

$$y_{it}^{\text{entrepreneur}} = \pi(\theta_{it})K_i^{\frac{\alpha\rho}{1-\rho(1-\alpha)}} - R\,(K_{it} - (b_{it-1} - \min\{p,\kappa\} - f)) \tag{27}$$

where $\pi(\theta_{it}) \equiv (1-\rho\,(1-\alpha))\,\theta_{it}^{\frac{1}{1-\rho(1-\alpha)}}\,(w/\rho\,(1-\alpha))^{\frac{\rho(1-\alpha)}{\rho(1-\alpha)-1}}$. The first term in (27) is revenue minus labor cost, which is concave due to the presence of decreasing returns to scale. The entrepreneur chooses capital K_{it} optimally to maximize (27) subject to the borrowing constraint (25). Given the decreasing returns to scale, it may be the case that the optimal capital stock lies in the interior of the feasible set; hence, the borrowing constraint may not be binding.

2.2.3.2 *The Household's Decision, and the Market for Licences*

Since the agent's occupation enters in his utility function only through his income y_{it}, we can split his utility maximization problem into two stages: (i) maximize income y_{it} over the occupation, (ii) maximize utility over consumption and bequest, taking the occupation as given. The latter is the usual consumption-saving decision, and does not require discussion. In the first stage, the agent will choose entrepreneurship if and only if $y_{it}^{\text{entrepreneur}} \geqslant y_{it}^{\text{worker}}$, or

$$\pi(\theta_{it})K_i^{\frac{\alpha\rho}{1-\rho(1-\alpha)}} - R\,(K_{it} + \min\{p,\kappa\} + f) \geqslant w. \tag{28}$$

The presence of the cost of acquiring a licence distorts the entry decision both directly in (28), and indirectly through the amount of capital that entrepreneurs can raise. Hence, it affects aggregate outcomes through distorting the selection of agents into entrepreneurship, and, to a much lesser extent, through the misallocation of capital.

Will the entrepreneur buy an existing license at cost p or pay κ to create a new one? In steady state the market price p for a licence has to equal the cost of setting up a new licence κ: if $p < \kappa$, agents would only buy existing licences when setting up new firms, and given that licences get destroyed at rate δ, it would mean that the number of licences would not be constant. Conversely, if $p > \kappa$, demand for existing licenses would be zero. Since there are always some licence owners who want to sell their licence for any $p > 0$, markets would not clear. Hence $p = \kappa$ and in steady-state the entrepreneurs are indifferent between creating a new licence and purchasing an existing one. The mass of newly created ones will equal the mass of firms that are destroyed by the δ-shock in every period.

2.2.3.3 *Extensive and intensive-margin distortions*

How would the social planner's solution in this economy look like? Firstly, he would allocate capital among entrepreneurs as to equalize their marginal product of capital. Secondly, he would want to select the agents with the highest talent to become entrepreneurs. In an economy with constant returns to scale, he would pick only the best agent to operate one big firm. However, since our economy features decreasing returns to scale at the firm level, he would prefer to pick a positive mass of firms to operate, in order to decrease the average scale of operations. It it thus reasonable to define and separate three different margins of adjustment, all of which shape the performance of this economy at the aggregate level: first, the mass of firms that are operating, and hence the average scale of operating establishments, second, the selection of agents into entrepreneurship, and third, the allocation of capital among operating establishments.

The equilibrium is distorted by the presence of the two frictions. Firstly, the possibility of default means that lenders will not lend more than a certain amount. Thus, entrepreneurs with low levels of net worth are constrained in the amount of capital that they can borrow. Hence, the marginal product of capital is not equalized, and there is misallocation of capital among the operating firms. There is, however, also an effect on selection: agents with low net worth are not going to enter. This lowers the mass of firms and increases the average scale of production, which in turn leads to lower output per capita. The presence of bureaucratic startup costs distorts mostly the ownership decision, and hence the affects output per capita to a large extent through the selection and scale channels. It is with respect to these three channels that we evaluate the quantitative impact of the two frictions in Section 2.3.

2.2.3.4 *Two measures of aggregate productivity*

Before proceeding to the quantitative exercise, we define some measures of aggregate productivity. In an economy that features decreasing returns to scale on the firm level, it is not immediately clear which measure of aggregate total factor productivity to use. We derive two different measures: one which we believe to be close to what empirical researchers would use in a development accounting exercise, and a second, which resembles more closely a weighted mean of firm-level productivities.

Suppose agents had perfect access to credit markets, $\phi = 1$, then the firm's optimal choice of capital would equalize the maginal product of capital with the interest factor R. This implies, together with the firm's first-order condition for labor, that

$$Y = \int Y_i \, di = \left(\frac{1}{L} \int \theta_i^{\frac{1}{1-\rho}} \, di \right)^{1-\rho} K^{\alpha\rho} L^{1-\alpha\rho} \tag{29}$$

where $K \equiv \int K_i \, di$ and $L \equiv \int L_i \, di$ denote the aggregates of the factors. Hence, one can define

$$\mathrm{TFP}_E \equiv \frac{Y}{K^{\alpha\rho} L^{1-\alpha\rho}} \tag{30}$$

which corresponds to the definition of TFP in the most common form of the development accounting exercise, where the exponent of the capital stock is set to the capital share of production, and the exponent of the labor share to one minus the capital share (Caselli, 2005).

Alternatively, one can write equation (29) as

$$Y = \left(\frac{1}{M} \int \theta_i^{\frac{1}{1-\rho}} \, di \right)^{1-\rho} M^{1-\rho} K^{\alpha\rho} L^{\rho(1-\alpha)} \tag{31}$$

where M denotes the measure of operating firms. The term

$$\mathrm{TFP}_M \equiv \frac{Y}{M^{1-\rho} K^{\alpha\rho} L^{\rho(1-\alpha)}}$$

hence corresponds to a weighted mean of the operating firms' productivity levels, and is as such a reasonable measure of aggregate productivity. Compared to the definition of TFP in (30), it corrects for the efficiency gains that arise from operating the plants at a lower scale when more firms are present. While equations (29) and (31) only hold in a perfect-credit world, we use them to motivate the factor shares in the definitions of TFP_E and TFP_M.

2.3 QUANTITATIVE ANALYSIS

In this section, we use our model's predictions to investigate the quantitative importance of barries to entry and financial market imperfections, which correspond to the parameters κ and ϕ respectively, for aggregate productivity. We do this by calibrating our model of financial frictions and entry barriers to match moments from the US data. We then study how misallocation changes when we set our two key institutional parameters, the debt recovery parameter ϕ and entry costs κ, to values that we observe in countries across the world. In performing this exercise, we are holding the distribution of entrepreneurial talent constant.

2.3.1 *Calibration*

We calibrate our model to match firm size and intergenerational statistics from the United States. In total, we need to calibrate ten parameters: two talent parameters, q, σ, three technological parameters, α, ρ, and f, two institutional parameters, ϕ and κ, the relative weight on the child's income in the utility function, β, the interest rate R, and the firm destruction probability δ. We interpret one period in our model as a span of 20 years.

For the institutional parameters ϕ and κ, we use data from the World Bank's Doing Business survey. The dataset contains a variable that captures the percentage that creditors can retrieve from debtors through reorganization, liquidation, or debt enforcement proceedings in a standardised insolvency case (the 'recovery rate'); hence, it directly maps into the parameter ϕ in our model. The survey is designed to make the results internationally comparable and the terms of the insolvency case are the same across countries. The measure takes into account the costs of insolvency proceedings and the possibility that business operations may be continued through debt restructuring.

We use the "cost of starting a new business" variable from the same dataset to calibrate the cost of acquiring a new license κ in our model. These costs are the official fees of setting up a limited liability company, or its equivalent, and include fees for legal and professional services that are required by law. Again the costs refer to a benchmark case, and, in the baseline specification, exclude the paid-in minimum capital required by law. No bribes or side payments are recorded. The survey states the startup cost as a fraction of the country's income per capita. Hence, we set the entry cost κ such that the model generates a κ/Y that is equal to what we observe in the dataset. For both the recovery rate and the startup cost we use the time-averages by country over the years 2009 to 2012, as this is where we have the largest sample of countries. Table 26 shows summary statistics and correlations with income per capita for both institutional measures.

We calibrate the remaining parameters to jointly match statistics on firm size and dynamics and intergenerational income dynamics in the United States. We assume an annual interest rate of four percent, hence $R = 1.04^{20} \approx 2.19$. For the exit probability δ, we note that the annual exit rates for establishments are roughly ten percent (Business Dynamics Statistics, 2012), which means that the probability of

Table 12: SUMMARY STATISTICS FOR INSTITUTIONAL PARAMETERS

					Quantiles		
Variable	Mean	Std. Dev.	Min	Max	10%	50%	90%
Access to capital ϕ	0.33	0.24	0.00	0.93	0.02	0.30	0.73
Bureaucratic startup costs κ/Y	0.02	0.04	0.00	0.38	0.00	0.01	0.06

Source: Author's calculations from World Bank Doing Business (2013)

surviving for 20 years is roughly $(1 - 10/100)^\wedge 20 \approx 12,1\%$. Hence, $\delta = 0.88$. The large firms in the economy, i.e. the right tail of the firm size distribution, is key for overall labor demand and therefore the wage. We thus calibrate our model economy to match the US employment share of the largest ten percent of establishments (69%, from the US Small Business Administration). To get the intertemporal correlation of talent right, we match the elasticity of a child's lifetime income with respect to the parents income of 0.3, as reported by Charles and Hurst (2003). We calibrate β, the weight of the child's income in the parent's utility function, to match the fraction of bequests in total lifetime wealth (0.34, from Gale and Scholz, 1994)[7]. We set α so as to match the capital-output ratio (0.109 using data from Caselli, 2005), ρ as to match the earnings share of the top 5 percent of earners (Buera et al., 2011), and fixed costs f as to match the fraction of entrepreneurs as implied by the mean firm size (19.93, from the US Census Bureau's Statistics of US Businesses). Table 13 summarizes parameters and targets.[8]

Table 13: CALIBRATION TARGETS

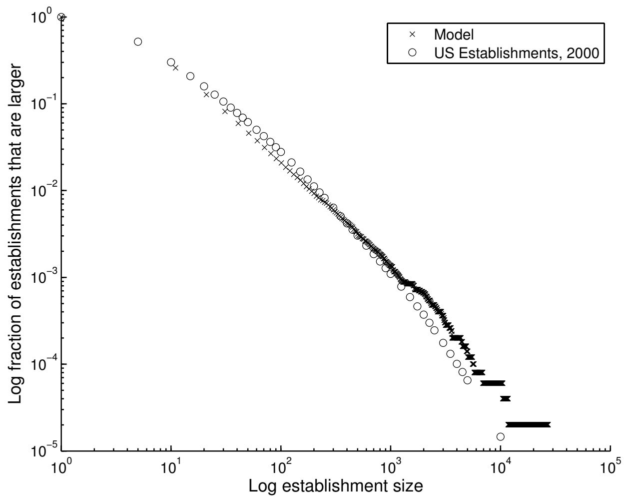
Target Moments	Source	US Data	Model	Parameter
Capital-output ratio	Caselli (2005)	0.11	0.11	$\alpha = 0.325$
Bequests in lifetime wealth	Gale and Scholz (1994)	0.34	0.34	$\beta = 0.66$
Fraction of entrepreneurs	US SUSB (2007)	0.05	0.05	$f = 0.2$
Top 10-percentile employment share	US SBA (2007)	0.69	0.65	$\sigma = 0.69$
Top 5-percent earnings share	Buera et al. (2011)	0.30	0.33	$\rho = 0.735$
Elasticity of child income	Charles and Hurst (2003)	0.30	0.31	$q = 0.334$

Figure 4 shows the simulated size distribution of establishments for the US case ($\kappa/Y = 7 \times 10^{-4}, \phi = 0.791$), together with percentiles from the US data. For each establishment size, we compute the fraction of establishments of greater or equal size. In the resulting plot with log scales, a straight line would indicate a Pareto distribution of establishment sizes. The fact that the establishment size distribution features a slight concavity means that there are slightly fewer small and large establishments than what would be indicated by a Pareto

7 $(63.19 + 105.00 + 35.29) \cdot 20/11976 = 0.3398$.

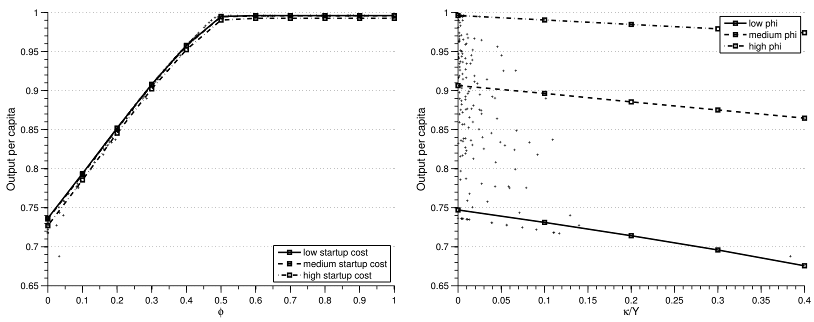
8 Capital-output share: $(k/y)/20 = 0.109$ using data from Caselli (2005). Bequests in lifetime wealth: from Gale and Scholz (1994), $(63.19 + 105.00 + 35.29) \cdot 20/11976 = 0.3398$. Fraction of entrepreneurs implied by average firm size of 19.93 (SUSB 2007). Elasticity of child income is the coefficient in a regression of log labor income of the child's family on log labor income of the parents, as reported by Charles and Hurst (2003), Table 3.

Figure 4: Size distribution: Model vs Data



Note: Comparison of percentiles of the simulated establishment size distribution with percentiles from the US establishment size distribution in 2000. US establishment size data from Rossi-Hansberg and Wright (2007).

Figure 5: The Impact of Financial Frictions and Startup Costs on Income/Capita



Note: Simulated output per capita, relative to the undistorted economy benchmark, as a function of the recovery rate ϕ (left pane) and startup costs κ/Y (right panel). Solid (dashed, dash-dotted) line denotes startup costs κ/Y (left panel) or financial frictions ϕ (right panel) at the 10th (50th, 90th) percentile.

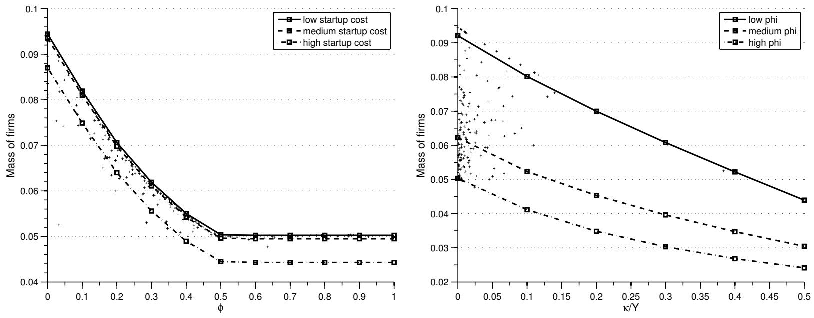
distribution. The model matches the observed US establishment size distribution well, and even manages to replicate the observed concavity in the data.[9]

2.3.2 *The Impact of Startup Costs and Financial Frictions*

We now turn to the quantitative evaluation of financial frictions and startup costs, as described by the parameters ϕ and κ/Y, respectively. We vary ϕ and κ/Y to span the full range of values observed in the cross-country data, and simulate the key variables of interest in the steady-state.

9 Rossi-Hansberg and Wright (2007) explain the concavity using a theory of industry-specific human capital. In our model, the concavity arises directly from the agent's talent distribution.

Figure 6: Mass of operating firms as a function of ϕ and κ/Y

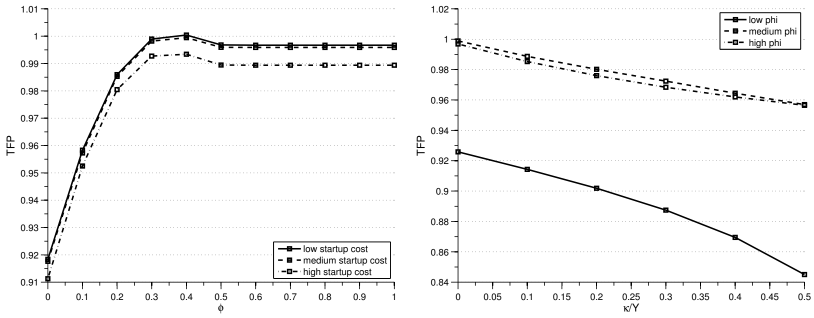


Note: Mass of operating firms, as a function of the recovery rate ϕ (left pane) and startup costs κ/Y (right panel). Solid (dashed, dash-dotted) line denotes startup costs κ/Y (left panel) or financial frictions ϕ (right panel) at the 10th (50th, 90th) percentile.

The left panel of Figure 5 shows output per capita for the simulated economies, relative to a frictionless benchmark ($\phi = 1, \kappa = 0$), as a function of credit market access ϕ. The three lines refer to startup costs being set at the 10th (solid line), 50th (dashed line), and 90th percentile (dash-dotted line). Moving from a perfect-credit world to a world with no access to external financing decreases output per capita by more than a quarter. The kink in the curve at around ϕ equal to one half arises due of the presence of decreasing returns to scale in production: for high values of ϕ, the firms are able to operate their firms at the efficient scale, and the borrowing constraint becomes non-binding. The lines referring to the three different levels of startup costs almost overlap, showing that startup costs have a very minor impact on welfare in this economy. This can be seen more clearly in the right panel of Figure 5, which plots output per capita as a function of the bureaucratic startup costs. Here, the solid, dashed, and dash-dotted line correspond to output per capita when capital market access ϕ is set to the 10th, 50th, and 90th percentile. The slopes of the three curves are only slightly negatively sloped, indicating that startup costs distort the economy only in a very minor way. Note that the slopes become steeper as financial frictions increase: startup costs have more bite when access to credit is limited, since entrepreneurs may need to borrow in order to finance the startup costs. The dots in Figure 5 (and all subsequent figures) refer to the countries in our sample.

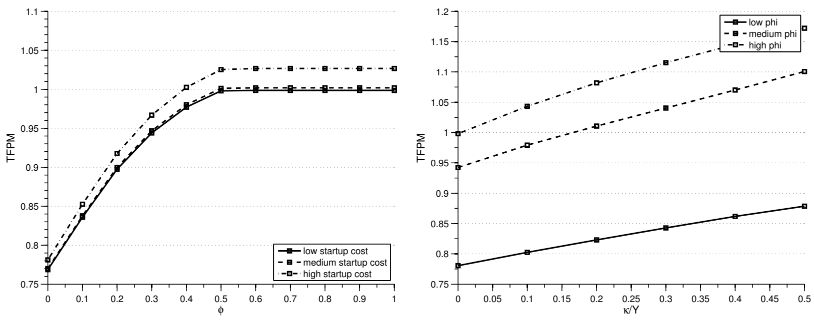
Before turning to productivity, it is instructive to look at how the frictions shape the mass of operating firms in the economy, and hence the average firm size. Figure 6 shows the mass of firms as functions of ϕ and κ/Y. Better access to credit increases the average firm size: firms are able to scale up, which increases labor demand and raises the wage. This, in turn, increases the talent cutoff for becoming an entrepreneur. Higher startup costs increase selection and the average firm size, with the effect being stronger for a higher degree of financial frictions. On a quantitative dimension, the cross-country variation in ϕ explains roughly half of difference in average firm size across countries (Poschke, 2014).

Figure 7: TFP_E AS A FUNCTION OF ϕ AND κ/Y



Note: Aggregate productivity as measured by TFP_E, as a function of the recovery rate ϕ (left pane) and startup costs κ/Y (right panel). Solid (dashed, dash-dotted) line denotes startup costs κ/Y (left panel) or financial frictions ϕ (right panel) at the 10th (50th, 90th) percentile.

Figure 8: TFP_M AS A FUNCTION OF ϕ AND κ/Y



Note: Aggregate productivity as measured by TFP_M, as a function of the recovery rate ϕ (left pane) and startup costs κ/Y (right panel). Solid (dashed, dash-dotted) line denotes startup costs κ/Y (left panel) or financial frictions ϕ (right panel) at the 10th (50th, 90th) percentile.

Figures 7 and 8 show the two measures of aggregate productivity as a function of ϕ and κ/Y. Better access to credit unambiguously increases TFP_M through the extensive-margin reallocation of firms to the most productive agents, and intensive-margin reallocation of capital to equalize the marginal product of capital. As described above, this also decreases the mass of firms that are operating in the economy; hence, firms are operating on a larger scale. Given the presence of decreasing returns in the production technology, aggregate productivity as measured by TFP_E is nonmonotonous in ϕ; only when one corrects for the mass of firms (and hence the scale of production) it becomes unambiguously increasing. These counteracting forces are even clearer for the effects of startup costs, which operate mostly on the extensive margin: as startup costs increase, the talent cutoffs shift to the right, and fewer firms operate in the economy (Figure 6). The operating firms are more productive, hence TFP_M increases (Figure 8), but the average scale of operations increase, which decreases aggregate productivity as measured by TFP_E. The net effect on the wage and output per capita is negative (Figure 5).

Finally, we calculate the predicted changes in the aggregate variables when bureaucratic startup costs are abolished ($\kappa = 0$). Table 14 summarizes the results.

Table 14: WELFARE GAINS FROM ELIMINATING BUREAUCRATIC STARTUP COSTS: AVERAGES

	ϕ	κ/Y, in %	ΔY, in %	ΔTFP_E, in %	ΔTFP_M, in %
All countries	33.2	2.1	1.05	0.75	-0.08
High income: OECD	66.0	0.3	0.64	0.48	0.52
High income: non-OECD	42.4	0.6	0.75	0.56	0.45
Low income	15.4	6.6	2.04	1.37	-1.35
Lower middle income	21.3	2.3	1.02	0.76	-0.20
Upper middle income	31.2	1.1	0.82	0.59	0.23
Africa	19.7	4.9	1.63	1.13	-0.90
Northern Africa	36.0	0.8	0.72	0.54	0.26
Eastern Africa	16.1	4.0	1.50	1.05	-0.57
Middle Africa	7.0	9.8	3.07	1.97	-1.96
Western Africa	18.4	5.6	1.55	1.10	-1.35
Southern Africa	41.6	0.9	0.66	0.51	0.23
Americas	32.8	1.8	0.94	0.69	-0.03
Northern America	84.5	0.0	0.63	0.45	0.63
Central America	37.3	2.1	0.83	0.67	-0.27
Caribbean	28.2	1.7	1.03	0.74	0.12
South America	25.8	1.9	0.96	0.69	-0.11
Asia	34.0	1.1	0.84	0.61	0.24
Western Asia	32.0	1.3	0.86	0.63	0.18
Central Asia	28.5	0.6	0.73	0.53	0.36
Eastern Asia	65.5	0.3	0.65	0.48	0.49
South-Eastern Asia	27.0	1.3	0.96	0.70	0.23
Southern Asia	27.3	1.2	0.83	0.61	0.16
Europe	50.9	0.3	0.65	0.48	0.50
Northern Europe	71.7	0.1	0.62	0.45	0.61
Western Europe	61.5	0.2	0.65	0.48	0.56
Eastern Europe	33.2	0.3	0.63	0.46	0.48
Southern Europe	42.2	0.6	0.69	0.54	0.40
Oceania	30.6	1.5	0.96	0.69	0.10
Australia and New Zealand	78.8	0.0	0.62	0.45	0.63
Melanesia	27.5	1.9	0.87	0.66	-0.20
Micronesia	15.0	2.4	1.29	0.90	0.01
Polynesia	20.0	0.7	0.80	0.55	0.34

Note: Table shows the average percentage change in income per capita, TFP_E, and TFP_M (Columns 3, 4, and 5, respectively) when bureaucratic startup costs are lowered from the value in Column 2 to zero, holding access to capital ϕ (Column 1) constant. Income groups are from the July 2013 World Bank income classifications; Regions are defined according to the UN geographical classification.

3 INPUT CAPABILITIES AND THE DIRECTION OF PRODUCT CHANGE: EVIDENCE FROM INDIA

3.1 INTRODUCTION

Multiproduct firms dominate production and export activity, and their continual product turnover contributes substantially to aggregate output growth. In the United States, multiproduct firms account for over 90 per cent of manufacturing output and multiproduct exporters account for over 95 per cent of exports. About 89 per cent of multiproduct firms vary their product mix within five years and these changes in the product mix make up a third of the increase in US manufacturing output (see Bernard et al., 2007, 2010).

Adding or dropping a product is an important event for firms. For US firms, product churning affected over a third of the firm's products and output, on average. A growing literature shows firms continually adapt their product mix to focus on their core competencies (Bernard et al. 2005, 2011; Eckel and Neary 2010; Mayer et al. 2014; Iacovone and Javorcik 2010). Over time, firms tend to move towards a few successful products, and focusing on these selected products enables them to respond to changes in their economic environment. While the literature explains the importance of core competencies, it does not address the sources of firms' core competencies. Understanding the sources of core competencies requires an examination of product characteristics that determine which products firms add and drop. This paper focuses on the role of input-output linkages in firms' decisions to add and drop products.

A multiproduct firm can internalize the supply linkages across its products. This implies firms would choose to focus on products that have supply linkages to existing products. We examine the extent to which supply linkages determine the products which are added and dropped by firms. We address this for manufacturing establishments in India. During the 2000s, manufacturing value added in India was on the rise and product turnover contributed 28 per cent to net sales growth. Indian firms actively changed their product mix, and we use detailed survey data on the input and product mix of firms to study the role of input linkages in product turnover. We find that input linkages are an important determinant of the product mix of firms. Controlling for firm-time, product-time and firm-product fixed effects, shocks to a firm's input mix make the firm more likely to move into products that require a similar mix of inputs. Quantitatively, a one standard deviation rise in the correlation between a firm's input mix and the product's input mix is associated with a 0.02 percentage point rise in the probability of not dropping the product.

Our findings echo the results from previous work which suggests that firms tend to add products that have supply linkages to their core products. Studies in the business literature document firms are more likely to add products that use similar technologies to the firm's main product, measured by the extent of commonality in patents used across industries. Scherer (1982) estimated technology flows between industries from data on the proportion of patents filed in the origin industry that were used in the destination industry and data on interindustry economic transfers drawn from the input-output tables. Using this measure of technological relatedness, Robins and Wiersema (1995) show firm performance is positively related to technological relatedness, controlling for industry and firm characteristics in a cross-section of 120 publicly listed US firms. Regressing the relatedness measure on industry-level import penetration, Bowen and Wiersema (2005) find a positive correlation between technological relatedness of a firm's products and import penetration in the core product, after controlling for industry and firm characteristics of publicly-listed US firms from 1985 to 1994.

Focusing on input relatedness, Fan and Lang (2000) construct measures for vertical relatedness and complementarity across industries using the input output tables for US firms. Vertical relatedness refers to the dollar amount of input transfer between industries and complementarity is captured by the degree of overlap in the industries' input and output markets. They find that the vertical relatedness and complementarity of US firms' products increased between 1979 to 1997, but relatedness and complementarity were not always positively related to the valuation of firms.[1] Liu (2010) embeds the relatedness measures to determine the heterogeneous impact of import competition on various products within a multiproduct firm. For publicly-listed US firms, import competition leads multiproduct firms to drop peripheral products to refocus on core production. The weaker the linkages that a peripheral product shares with the core (as measured by the extent of joint sales, joint procurement, joint production, and joint sectorship), the more likely it is for the peripheral product to be dropped in response to import competition after controlling for industry and firm characteristics. Using a special survey of 108 leading European manufacturers, Rondi and Vannoni (2005) find European firms expanded their output of core industries after integration of the European Union. Highly diversified firms were more likely to focus on products that shared intermediate input and markets with their core products.

We contribute to this literature in two ways. First, controlling for a full set of firm-time and product-time fixed effects, we show the positive relationship between a firm's supply relatedness and product additions is driven by firm's ability to internalize supply linkages across products. Second, we provide the first systematic study of supply linkages within multiproduct firms in the context of a developing

1 Using plant-level observations from the Longitudinal Research Database, Schoar (2002) finds firms diversifying into more 2-digit SIC industries experience a net reduction in productivity.

country. This is important because supply-side bottlenecks are particularly acute in developing countries (The World Bank, 2013), and we provide estimates for the extent to which multiproduct firms are able to overcome these bottlenecks by internalizing supply linkages.In related work, Aw and Lee (2009) focus on four industries within the Taiwanese electronics sector for which they have detailed data on firm sales by products and on firm inputs. They estimate the firm's cost function to arrive at the incremental marginal cost of the core product when the firm adds a new product. This provides a cost-based measure of supply linkages across products made by the firm, and they find that firms move towards specializing in core products in the nineties. After controlling for plant characteristics, multiproduct plants tend to drop products that have higher measures of dissimilarity index from their core products. While Aw and Lee focus on one sector, we study supply linkages for all manufacturing industries. This enables us to show that supply linkages are important across a whole host of manufacturing products. Studying the period just after the liberalization of 1991, Goldberg et al. (2009) find that Indian firms in the nineties engaged in very little product dropping, relative to their US counterparts. They suggest that this might be due to remnants of the licensing regime that make it difficult to drop unprofitable products or due to the rapid growth in the post-reform era. We find instead that Indian firms in the 2000s dropped products at rates similar to those for US firms. Firms concentrated on on their core products during the period and product churning was driven by supply linkages across products. We therefore capture the process of product turnover in firms that operated in an environment that moved from severe constraints on product rationalization to a more dynamic economy.

3.2 PRODUCT TURNOVER AMONG INDIAN MANUFACTURING FIRMS

3.2.1 *Data*

We use annual data on manufacturing firms from the Indian Annual Survey of Industry (ASI), which is conducted by the Indian Ministry of Statistics and Programme Implementation, and is the Indian government's main source of industrial statistics on the formal manufacturing sector. The ASI consists of two parts: a census of all manufacturing plants that are larger than 100 employees, and a random sample of one fifth of all plants that employ between 20 and 100 workers.[2] The ASI's sampling methodology and product classifications have changed several times over the course of its history. In order to ensure consistency, we focus on the timeframe of the fiscal years (May to April) 2001/02 to 2007/08.

2 While the ASI is meant to sample at the plant level, firms can (and typically will) use the same survey form for several of their plants. Hence, we generally interpret the observations to be at the firm level.

The unique aspect of the ASI is that it contains detailed information on both intermediate inputs and outputs at the plant level, which allows us to link the firm's input characteristics to their product mix decisions. This, in particular, distinguishes the ASI from two other datasets that have been used to study product turnover: the US Census Bureau's Longitudinal Business Database, used by Bernard et al. (2010) (henceforth Bernard, Redding, and Schott (2010) (BRS)), and the Prowess database, published by the Centre for Monitoring the Indian Economy and used by Goldberg et al. (2009) (henceforth Goldberg, Khandelwal, Pavcnik, and Topalova (2009) (GKPT)) to document product turnover among Indian manufacturing firms. Compared to the ASI, the Prowess database contains only information on listed firms.

3.2.2 *Definition of Products*

At their finest levels, BRS have 1,440 5-digit SIC products for US firms under 455 4-digit SIC industries. GKPT have 1,886 "products" under 108 4-digit NIC industries in 22 2-digit NIC sectors. Compared to them, we have 5,204 products in 5-digit ASIC industries and 1,108 products in 4-digit ASIC which should be comparable with the finest levels in BRS and GKPT. These products are in 262 3-digit ASIC industries and 64 2-digit ASIC sectors, as shown in Table 15. We also show results for nine broad sectors (1-digit ASIC).

Table 15: PRODUCT DEFINITIONS

	BRS	GKPT	ASI
Products	1,440	1,886	5,204 5-digit/1,108 4-digit
Industries	455	108	262
Sectors	20	22	64 2-digit/9 1-digit
Classification	5/4 digit SIC	CMIE/4 digit NIC	5/4/3/2/1 digit ASIC

3.2.3 *Multi-Product and Multi-Industry Firms in the Aggregate Economy*

We define a multi-product firm as a plant-year observation where the plant produces two or more 4-digit (alternatively, 5-digit) products. Table 16 shows the prevalence of multi-product and multi-industry firms in the sample. Multi-product firms account for 41% (39% if products are defined on the four-digit level) of observations. The number is similar in BRS and GKPT's datasets (39% and 47%, respectively). As is well known, multi-product firms tend to be larger: they account of 71% of sales. Multi-sector firms account for 19% (two-digit) and 8% (one-digit) of the observations in the sample, but 49% (32% respectively) of sales. In GKPT's sample, 24% of firms are multi-sector firms; their share in total sales is 54%.[3]

3 Table 25 in Appendix C compares sales shares in our sample and GKPT's.

Table 16: Frequency and Sales Shares of Single- and Multi-product Firms

# of Products/Industries	5-digit			4-digit			3-digit			2-digit			1-digit		
	Firm-Year Obs	Percent of firms	Percent of Sales	Firm-Year Obs	Percent of firms	Percent of Sales	Firm-Year Obs	Percent of firms	Percent of Sales	Firm-Year Obs	Percent of firms	Percent of Sales	Firm-Year Obs	Percent of firms	Percent of Sales
1	152,946	58.6	28.7	159,873	61.2	30.4	176,882	67.8	37.8	212,420	81.4	50.7	239,970	91.9	68.3
2	53,859	20.6	20.4	56,503	21.6	21.5	54,777	21.0	24.1	36,568	14.0	28.4	19,219	7.4	27.3
3	26,864	10.3	12.4	24,460	9.4	14.4	19,430	7.4	13.3	8,608	3.3	12.2	1,683	0.6	4.1
4	14,477	5.5	8.6	11,413	4.4	9.7	5,869	2.2	8.0	2,523	1.0	5.0	168	0.1	0.3
5	6,183	2.4	7.4	4,585	1.8	5.7	2,415	0.9	5.3	717	0.3	2.0	15	0.0	0.0
6	3,028	1.2	3.7	2,134	0.8	4.3	1,030	0.4	5.8	180	0.1	1.6	2	0.0	0.0
7	1,678	0.6	3.7	1,085	0.4	5.6	441	0.2	2.2	34	0.0	0.0			
8	1,050	0.4	3.3	599	0.2	3.6	139	0.1	1.1	5	0.0	0.0			
9	641	0.2	4.9	299	0.1	2.0	51	0.0	0.6	2	0.0	0.0			
10+	331	0.1	7.1	106	0.0	2.7	23	0.0	1.8						

Source: Author's calculations from ASI data.

3.2.4 *Core competencies*

Table 17 shows the sales distribution of products within firms. The fact that the firms generate a large proportion of its sales revenue from its primary products suggests that firms have 'core competencies'. The concentration of sales is similar to the findings of GKPT (Table 2), so we are confident that the data on reported products is consistent with the CMIE data.

Table 17: Sales Shares by Product Rank

4-digit products											2-digit sectors									
rank	1	2	3	4	5	6	7	8	9	10	rank	1	2	3	4	5	6	7	8	9
1	100	87	78	72	62	57	54	51	46	44	1	100	86	75	68	63	59	52	56	53
2		13	17	18	21	22	22	20	20	20	2		14	19	21	21	21	21	17	21
3			5	7	10	11	11	12	12	11	3			5	8	10	10	12	12	11
4				2	5	6	64	7	8	8	4				3	5	5	7	7	9
5					2	3	4	5	5	6	5					2	3	4	5	3
6						1	2	3	4	4	6						1	2	2	1
7							1	2	3	3	7							1	1	1
8								1	2	2	8								0	1
9									1	1	9									0
10									0	1										

Note: Number in the table is the average sales share of the firm's n-th most important product/sector, ranked by sales. Columns indicate the firm's number of products/sectors, rows indicate the rank of the product/sector.

3.2.5 *Product Turnover*

We now turn to documenting product and industry turnover among the ASI firms. Table 18 shows the fraction of firms that change their product/industry scope over a one-year, three-year, and five-year horizon. Given the nature of the ASI sampling methodology, our panel is not balanced; an n-year horizon hence consists of all observation pairs that are n years apart from each other. The product scope changes are forward-looking: a plant that produces one product in year t and the same product together with a new one in year $t+1$ would be counted as an 'add only' for a single-product firm at the one-year horizon.

Table 18: Product Turnover

		Percentage of Firms												Sales-Weighted Percentage of Firms											
		1-year horizon				3-year horizon				5-year horizon				1-year horizon				3-year horizon				5-year horizon			
		no activity	add only	drop only	add and drop	no activity	add only	drop only	add and drop	no activity	add only	drop only	add and drop	no activity	add only	drop only	add and drop	no activity	add only	drop only	add and drop	no activity	add only	drop only	add and drop
1-digit	single	93	4		3	92	5		4	91	5		4	93	6		1	92	7		1	91	7		1
	multi	51	4	38	7	40	4	48	8	34	3	53	9	59	5	25	11	58	5	30	7	56	4	36	4
	all	89	4	4	4	86	4	5	4	85	5	6	5	81	5	9	5	80	6	10	3	80	6	12	2
2-digit	single	84	7		10	81	8		11	79	9		12	89	7		4	89	7		4	89	7		4
	multi	41	7	31	21	30	7	38	24	26	7	42	25	41	9	27	23	35	10	34	22	35	6	40	19
	all	74	7	7	12	69	8	9	14	66	9	11	15	64	8	14	14	61	8	18	13	62	6	20	12
3-digit	single	75	8		17	70	11		19	68	12		20	86	7		7	85	8		7	84	8		8
	multi	36	8	24	33	26	8	29	36	22	8	31	39	29	10	25	37	23	14	26	38	22	9	34	36
	all	62	8	8	22	54	10	11	25	51	10	12	27	48	9	16	27	44	12	17	27	43	9	22	26
4-digit	single	63	7		30	56	10		35	52	11		37	80	5		15	79	6		15	77	7		16
	multi	26	6	16	51	18	7	20	56	15	6	21	58	23	6	17	54	16	11	17	56	15	6	20	59
	all	47	7	7	39	39	8	9	44	35	9	10	47	39	5	12	44	33	10	12	45	32	6	15	47
GKPT	single	94	6		0	87	13		1	80	19		1	93	7		0	84	16		0	76	24		0
	multi	86	9	5	1	73	17	7	2	63	26	8	3	81	14	4	1	65	25	3	7	53	29	3	15
	all	90	7	2	0	80	15	3	1	72	22	4	2	83	13	3	1	69	23	2	6	57	28	2	12

Note: Number in the table is the (sales-weighted) percentage of firm-year observations that fall in the respective category. Product additions and drops are defined forward-looking, i.e. if a firm has one product in year 2001, and sells the same product plus an additional one in year 2002, this would count as one observation in the "add only" category in 2001 (also, it would count as a single-product firm). Hence, by definition, single-product firms cannot only drop a product. Rows “GKPT” are reproduced from Table 4 in Goldberg et al. (2009).

The main fact that emerges is that product turnover in the ASI data is substantially higher than in GKPT or BRS. Even looking at the highly aggregate 2-digit ASIC category (which has 64 product categories), we find that 26% of all firms make some change in their product range. GKPT find instead that only 10% of firms engage in product range changes where the product is the finest level of aggregation which has 1,500 product categories. For multi-product firms, this difference is even wider: 59% in the ASI data compared with 14% in GKPT. These differences are also present for both the subset of sample firms of the ASI and the subset of census ASI firms.

Compared to GKPT, we also find substantially higher dropping of products. In our sample, 7 percent of all firms drop products (4-digit) without adding new ones in the same year. The figure is higher over a three-year horizon (9%) and five-year horizon (10%). In GKPT's sample, only 2% of firms drop products without adding new ones (3% and 5% over a three-year and five-year horizon). This suggests that product rationalization is indeed prevalent among Indian manufacturing firms. But is it important? The right panel of Table 18 weighs the fractions of product-changing firms by their sales revenue. Twelve percent of sales revenue gets dropped at an annual frequency without being replaced by a new product in the same period (in GKPT's sample, the corresponding fraction is three percent). Hence, product rationalization is not only prevalent, but also quantitatively important.

The fact that many firms seem to be replacing existing products by new ones raises concerns about the quality of the reported product codes. If plant managers are inconsistent over time in their reporting of product codes, the true fraction of firms that is either adding or dropping products would be higher than the observed fraction of firms. Hence, our estimates of the prevalence of product additions or droppings are lower bounds for the true number. Note also that misreporting of product codes is likely to be washed out as we aggregate products to three-digit industries and one- or two-digit sectors.

Perhaps the most striking difference between our results and GKPT's is the prevalence of product droppings by multi-product firms. In Table 19 we decompose product scope changes by studying the transition matrix of the number of products. Element (n, k) is the number (top panel) or percentage (lower panel) of firm-year observation with n products that have k products the next time we observe them. The matrix in the top panel looks fairly symmetric, suggesting that there is no salient trend in the average number of products in our sample. Since the distribution is skewed towards firms with fewer products, the transition probabilities are higher for a reduction in the number of products, which also explains the high probability of product droppings among multi-product firms in Table 18.

Table 19: TRANSITION MATRIX FOR THE NUMBER OF PRODUCTS

A. Number of Observations

# products, current period	# products, next time we observe the firm: 1	2	3	4	5	6	7	8	9	10	11+
1	76023	7817	1688	528	209	92	35	18	8	3	0
2	7810	19402	3766	897	260	78	31	10	5	2	1
3	1767	3597	6790	1720	451	133	51	17	12	3	1
4	597	865	1762	2890	697	206	63	26	8	5	0
5	257	244	441	696	917	334	114	51	13	8	0
6	107	77	142	224	312	338	142	55	21	4	1
7	46	43	49	75	107	143	162	83	27	6	4
8	41	16	19	22	38	62	91	99	40	7	1
9	13	3	6	8	14	26	33	44	53	13	3
10	2	1	2	8	3	4	7	8	11	8	2
11+	0	0	0	1	0	2	4	0	1	1	8

B. Transition Probabilities

# products, current period	# products, next time we observe the firm: 1	2	3	4	5	6	7	8	9	10	11+
1	88	9	2	1	0	0	0	0	0	0	0
2	24	60	12	3	1	0	0	0	0	0	0
3	12	25	47	12	3	1	0	0	0	0	0
4	8	12	25	41	10	3	1	0	0	0	0
5	8	8	14	23	30	11	4	2	0	0	0
6	8	5	10	16	22	24	10	4	1	0	0
7	6	6	7	10	14	19	22	11	4	1	1
8	9	4	4	5	9	14	21	23	9	2	0
9	6	1	3	4	6	12	15	20	25	6	1
10	4	2	4	14	5	7	13	14	20	14	4
11+	0	0	0	6	0	12	24	0	6	6	47

Note: Products are defined at the four-digit level.

3.2.6 *Sales Concentration and Product Turnover*

We now turn to investigating the relationship between the diversification of a firm across product lines and product turnover. We use the specification

$$CHANGE_{jt} = \beta CONC_{jt} + \delta NUMPROD_{jt} + \gamma CTRL_{jt} + \alpha_j + \alpha_t + \varepsilon_{jt} \quad (32)$$

The dependent variable $CHANGE_{jt} \in \{ADD_{jt}, DROP_{jt}\}$ is a dummy variable that is one if firm j either adds or drops a four-digit product between year t and $t+1$. $CONC_{jt}$ is a Herfindahl-Hirschman concentration index of sales among the firm's products,

$$CONC_{jt} = \sum_{i \in I_{jt}} s_{jit}^2$$

where s_{jit} is firm j's share of sales coming from product i and I_{jt} is the set of its products. An index of close to one would mean that almost all the sales revenue is coming from a single product; if the revenue coming from the different products is equal, the index takes its minimum of $1/\#I_{jt}$. $NUMPROD_{jt}$ is a vector of dummies for the number of products. $CTRL_{jt}$ is a vector of firm-year specific controls, such as size and age, and α_j and α_t are firm and year fixed effects.

By using the specification of equation (32), we are studying the correlation between product turnover and sales concentration, conditional on firm characteristics. While it is true that firms with fewer products will typically have higher concentration of sales as measured by the Herfindahl, we are explicitly taking out any effect of the number of products on turnover by including a set of dummies for the number of products. Hence, the coefficient β in equation (32) is the conditional correlation of concentration and product turnover both within the firm (over time) and within a group of firms that have the same number of products. In order to avoid spurious results due to potential misclassification of products, we only consider product additions and droppings where the rest of the products range remains unchanged ('add only' and 'drop only' in Table 18).

Table 20 shows the results from estimating equation (32) using ordinary least squares. With a product drop dummy as a dependent variable, the coefficient of the sales concentration index is positive and statistically significant: a higher concentration of sales is positively correlated with the firm dropping a product. Quantitatively, a one standard deviation increase is associated with a 1.9-3.5% increase in the probability of the firm dropping one or more products. Similarly, with a product addition dummy as the dependent variable (columns 5 and 6 of Table 20), the coefficient of the sales concentration index is negative and significant. Hence, firms that see an increase in their sales concentration index are more likely to drop, and less likely to add a product.

Table 20: CONCENTRATION AND PRODUCT TURNOVER

	Dependent variable: Product drop dummy				Product add dummy	
	(1)	(2)	(3)	(4)	(5)	(6)
$CONC_{jt}$	0.101***	0.114***	0.166***	0.182***	-0.127***	-0.114***
	(0.00825)	(0.0128)	(0.0190)	(0.0323)	(0.0163)	(0.0221)
firm age	-0.00182**	-0.00438*				
	(0.000689)	(0.00173)				
log firm size	-0.00588***	-0.0141***	-0.0105**	-0.0223*	0.00353	0.0133
	(0.000739)	(0.00178)	(0.00380)	(0.0102)	(0.00326)	(0.00694)
# products dummies	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Firm FE			yes	yes	yes	yes
Sample	full	multi-product	full	multi-product	full	multi-product
N	66822	28283	66822	28283	66822	28283
R-sq	0.131	0.012	0.664	0.661	0.560	0.515

*p < 0.05, **p < 0.01 Note: Dependent variable is a dummy that is one if the firm adds a product without dropping one (columns 1-4), or a dummy that is one if the firm drops a product without adding one (columns 5 and 6). $CONC_{jt}$ is a Herfindahl index of the firm's sales shares. Standard errors (in parentheses) are clustered at the firm level.

3.3 THE DIRECTION OF PRODUCT CHANGE

What determines which products firms add? In this section, we document a robust relationship between a firm's intermediate input mix and the direction of product switching. Firms tend to add (and are less likely to drop) products that require a mix of inputs that is similar to the firm's existing basket of intermediate inputs. Hence, firms have 'input capabilities' that they use to position themselves strategically in the product spectrum.

We study the direction of product change using the following regression specification:

$$\begin{aligned} AddProd_{jt}^k = \beta s_{jt}^k + \gamma Upstream_{jt}^k + Downstream_{jt}^k + \\ + \lambda SameSector_{jt}^k + \alpha_{jt} + \alpha_t^k + \alpha_j^k + \varepsilon_{jt}^k \end{aligned} \quad (33)$$

The variable $AddProd_{jt}^k$ is a dummy variable that is one if firm j adds at least one four-digit product of the two-digit sector k during the time between years t and t + 1; s_{jt}^k is a measure of similarity of firm j's basket of intermediate inputs and sector k's intermediate input requirements. The variables $Upstream_{jt}^k$ and $Downstream_{jt}^k$ are measures of vertical linkages between sector k and the sectors where firm j is active in. $SameSector_{jt}^k$ is a dummy variable that takes a value of one if firm j is already producing sector k products at time t.

We include a number of fixed effects to control for unobserved heterogeneity. α_{jt} is a firm-year fixed effect, and takes out any factors that may influence the firm's decision to change the product scope at all; α_t^k is a sector-year fixed effect that controls for aggregate sector k supply and demand shocks, and α_j^k is a firm-sector fixed effect that controls for time-invariant firm-sector-specific capabilities.

Equation (33) explains product additions through the similarity between the firm's current basket of intermediate inputs and the sector in which the firm may add a product, controlling for vertical linkages between that sector and the firm's current product mix. The presence of firm-year fixed effects means that the variation we exploit is within firm-year observations (across targeted sectors), with α_t^k eliminating the effect of sector-wide demand and supply shocks. When including the α_j^k fixed effect in the regression, we identify the relationship from time variation in the dependent and independent variable: does a change in the composition of the input basket make it more likely that the firm moves into segments of the product space that require a similar mix of inputs?

3.3.1 *A Measure of Input Similarity*

Our measure of input similarity is a normalized inner product (or correlation coefficient) between the firm's intermediate input expenditure shares and the sector's aggregate intermediate input shares, which are typically observed in Input-Output tables. The fact that our dataset contains detailed information on intermediate inputs allows us to calculate these aggregate intermediate input shares ourselves. More precisely, we define the input similarity of firm j with sector k as

$$s_{jt}^k = \frac{\sum_{n=1}^N \theta_{jt}^n \theta_k^n}{\sqrt{\left(\sum_{n=1}^N \left(\theta_{jt}^n\right)^2\right)\left(\sum_{n=1}^N \left(\theta_k^n\right)^2\right)}}$$

where θ_{jt}^n is firm j's share of spending on intermediate inputs coming from sector n, and θ_k^n is the aggregate share of spending on intermediate inputs from sector n of plants that derive the largest fraction of their revenue from a product belonging to sector k (henceforth called 'sector k plants'). It is easy to show that s_{jt}^k is bounded below by zero and above by one, takes a value of zero if and only if firm j and sector k have no two-digit inputs in common, and takes a value of one if and only if the input expenditure shares of firm j and sector k are the same.

3.3.2 *Vertical Linkages*

We consider two sectors to be strongly vertically linked if the expenditure share in the input-output table is high. Hence, we define $Upstream_{jt}^k$ as the expenditure share of firm j's two-digit sector on intermediate inputs from sector k, and $Downstream_{jt}^k$ as the expenditure share of sector k on inputs from firm j's two-digit sector. In case firm j's products span more than one two-digit sector, we take the maximum of each of the sectors' input expenditure shares. We calculate the two measures ourselves from the microdata on intermediate inputs; in doing so, we aggregate across years and do not distinguish between imports and domestically sourced intermediate inputs.

3.3.3 *Results*

Table 22 shows the result of estimating equation (33) using ordinary least squares, with standard errors clustered at the firm level in columns 5 and 6. To avoid misclassification of products to induce spurious product additions and hence measurement error in the dependent variable, we only consider product additions that occur without the firm dropping a product in the same year. Hence, our estimate should be regarded as a lower bound for the importance of the firm's input basket in shaping the direction of product change.

The estimate of the input similarity index in Table 22 is negative and significant at the 1% level throughout all specifications, which leads us to conclude that the firm's current basket of intermediate inputs is a causal factor in driving the direction of product additions, with firms preferring to add products in sectors that share common intermediate inputs with the firm's existing activities.

The coefficient on the $SameSector^{l}_{jt}$ is positive and statistically significant in columns 1 to 5, suggesting that firms are more likely to add products in sectors in which they are already active. However, once one controls for time-invariant capabilities of firms by including firm-sector fixed effects, the coefficient switches sign and becomes significantly negative: once the firm has moved into a new two-digit sector (and hence the dummy changes from zero to one), the firm is less likely to add new products in that sector.

Firms are also more likely to add new products in sectors that are vertically linked to the firm's product portfolio: the coefficients of both $Upstream^{k}_{jt}$ and $Downstream^{k}_{jt}$ in columns 1 to 5 of Table 22 are positive; the former being much larger than the latter. When conditioning on time-invariant characteristics at the firm-sector level (column 6), the coefficient becomes negative, suggesting that firms tend to avoid adding products in sectors that are vertically linked to the ones that they have moved into.

3.3.4 *Product Droppings*

Do input capabilities also manifest themselves in product droppings? To study this question, we estimate the following regression equation:

$$\text{DropProd}^{k}_{jt} = \beta s^{k}_{jt} + \lambda \text{SameSector}^{k}_{jt} + \alpha_{jt} + \alpha^{k}_{t} + \alpha^{k}_{j} + \varepsilon^{k}_{jt} \quad (34)$$

The variables and fixed effects are defined analogously to equation (33). Since product droppings are only possible in sectors where the firm is producing at least one product, we control for a dummy that is one if firm j is producing a product in sector k at time t. The resulting estimates are hence numerically equivalent to estimating equation (34) only on the subset of sectors where the firm is producing at least one product, without the same Sector dummy.

Table 21 shows results from estimating equation (34) using ordinary least squares. Again we only consider product droppings that

Table 21: Input capabilities: Product Droppings

Dependent variable: Product drop dummy	(1)	(2)	(3)
Similarity Index s_{jt}^{k}	-0.001***	-0.001***	-0.001**
	(0.00003)	(0.0001)	(0.0004)
Same Sector dummy	0.022***	0.022***	0.042***
	(0.00004)	(0.0003)	(0.001)
Firm-year FE α_{jt}	yes	yes	yes
Sector-year FE α_{kt}^{t}	no	yes	yes
Firm-sector FE α_{kj}	no	no	yes
Clustering	no	firm	firm
N	18,563,460	18,563,460	18,563,460
R^2	0.042	0.043	0.243

*$p < 0.05$, **$p < 0.01$

Table 22: Input capabilities: Product Additions

	Dependent variable: Product addition dummy					
	(1)	(2)	(3)	(4)	(5)	(6)
Similarity Index s_{jt}^{k}	0.0057779**	0.0061662**	0.0017977**	0.0020104**	0.0020104**	0.0013595**
	(.0000246)	(.0000253)	(.0000346)	(.0000358)	(.0001067)	(.0003947)
Same Sector dummy			0.0063971**	0.0063555**	0.0063555**	-0.0161054**
			(.0000539)	(.0000545)	(.000228)	(.0008082)
Downstream proximity			0.0004985**	0.0003605**	0.0003605	-0.0085875**
			(.0000848)	(.0000866)	(.0002468)	(.0008181)
Upstream proximity			0.0110931**	0.0106407**	0.0106407**	-0.0086534**
			(.0000889)	(.000095)	(.0003395)	(.0017088)
Firm-year FE α_{jt}	no	yes	yes	yes	yes	yes
Sector-year FE α_{kt}	no	no	no	yes	yes	yes
Firm-sector FE α_{kj}	no	no	no	no	no	yes
Clustering	no	no	no	no	firm	firm
N	18,563,460	18,563,460	18,254,069	18,254,069	18,254,069	18,254,069
R^2	0.003	0.0247	0.031	0.0316	0.0316	0.2334

*$p < 0.05$, **$p < 0.01$

occur without a product addition by the same firm in the same year. The coefficient of the similarity index is negative and statistically significant, suggesting that firms tend to avoid dropping products that require an input mix that is closer to what the firm is using.

3.4 CONCLUSION

The firm's product scope and turnover is a popular subject for study among the literature in economics and business, yet there is little concrete evidence of the determinants of the direction of product turnover. This paper has established that input competencies are one important factor in this decision: firms tend to add products that share similar input characteristics with the firm's existing products.

More generally, our paper has investigated product turnover in a large developing country. While previous work has suggested that product droppings in India have been lower because of its history of licensing constraints, we instead find product churning rates that are comparable to the United States.

Part II

APPENDIX

A

APPENDIX TO CHAPTER 1

A.1 PROOFS

A.1.1 *Proof of Proposition 1*

For the sake of ease of exposition, I will refer to the supplier as the 'seller', and the intermediary as the 'buyer'. A contract is a pair $(q^*, M(q))$ where $q^* \geqslant 0$ and $M : [0, q^*] \to R \backslash R^-$ is a nonnegative increasing function. I call a contract C *feasible* if there is a quantity $q \geqslant 0$ such that the ex-ante profit from the relationship to the seller if he produces q, $\pi_s(C, q)$, is nonnegative. Feasible contracts will be accepted by a potential supplier. Moreover, I call a quantity $\hat{q} \geqslant 0$ *implementable* if there is a feasible contract C such that the seller decides to produce $\hat{q}$ once he has accepted the contract (i.e. $\hat{q} = \arg\max_q \pi_s(C, q)$). Finally, a feasible contract C is *optimal* if the payoff to the buyer under the seller's optimal production choice is maximal in the class of feasible contracts (i.e. $\hat{C}$ is optimal if $\hat{C} = \arg\max_{C,\ C \text{ feasible}} \pi_b(C, \arg\max_q \pi_s(C, q))$).

Suppose the buyer and seller have signed a feasible contract C. Our first step is to find the payoff functions for the buyer and seller, π_b and π_s. Let q be the produced quantity. Distinguish two cases:

1. The seller decides to breach the contract by producing less than the stipulated quantity: $q < q^*$. The buyer will then hold up the seller by refusing to pay $M(q)$. I will show later that this is indeed optimal. If one of the two parties decides to go to court, the court would (i) order the buyer to pay the agreed fee $M(q)$ to the seller, (ii) order the seller to pay damages to compensate the buyer for the loss that has arisen due to breach. Under fulfillment of the contract, the buyer should receive the proceeds from selling q^* to the downstream firm, $R(q^*)$, minus the fee paid to the seller, $M(q^*)$. Thus, the amount of damages are

$$D(q, q^*) \equiv R(q^*) - M(q^*) - (R(q) - M(q)). \tag{35}$$

The plaintiff also has to pay enforcement costs. In order to determine who the plaintiff would be, we need to distinguish between two subcases.

   a) $M(q) - D(q, q^*) > 0$. In this case the fee that the seller would receive exceed the damages that he would have to pay, thus the seller would have an incentive to go to court. If he did that, he would receive the above amount minus enforcement costs, which amount to a fraction δ of the value of the claim. Thus, under enforcement, the supplier would get

$$(1-\delta)\left(M(q)-D(q,q^{*})\right), \tag{36}$$

whereas the intermediary would get the revenue from selling to the downstream firm, net of fees $M(q)$ and plus damage payments

$$R(q)+D(q,q^{*})-M(q). \tag{37}$$

From the definition of the damages (35) it is easy to see that the latter equals $R(q^{*})-M(q^{*})$. Since enforcement entails a social loss of $\delta\left(M(q)-D(q,q^{*})\right)$, the buyer and seller will bargain over the surplus and settle out of court. (36) and (37) are the seller's and buyer's outside options in the Nash bargaining. The symmetric solution in the bargaining leaves each party with its outside option and one-half of the quasi-rents (surplus minus the sum of outside options). Thus, the total payoffs under breach are, respectively

$$\begin{aligned} \pi_s(q) &= \left(1-\frac{1}{2}\delta\right)\left(M(q)-D(q,q^{*})\right)-cq \qquad \text{if } q<q^{*} \\ \pi_b(q) &= R(q)-\left(1-\frac{1}{2}\delta\right)\left(M(q)-D(q,q^{*})\right) \qquad \text{if } q<q^{*} \end{aligned} \tag{38}$$

Comparing π_b here with the payoff in case the buyer did not hold up the seller, $R(q)-M(q)$, shows that it is preferable for the buyer to hold up. Note that since the buyer already has control over the produced goods, the seller cannot revert the production process.

b) $M(q)-D(q,q^{*})<0$. In this case, the damages paid to the buyer exceed the fee that he would have to pay to the seller. The buyer thus has an incentive to enforce the contract in a court, and would have to pay the enforcement costs. Thus, under enforcement, the seller's payoff is

$$M(q)-D(q,q^{*})$$

and the buyer's payoff is

$$R(q)+D(q,q^{*})-M(q)-\delta\left(D(q,q^{*})-M(q)\right).$$

The two parties settle outside of court using the symmetric Nash sharing rule; each receives its outside option (i.e. payoff under enforcement) plus one half of the quasi-rents (enforcement costs). Thus, the seller's ex-ante payoff is

$$\begin{aligned} \pi_s(q) &= M(q)-D(q,q^{*})+\frac{1}{2}\delta\left(D(q,q^{*})-M(q)\right)-cq \\ &= \left(1-\frac{1}{2}\delta\right)\left(M(q)-D(q,q^{*})\right)-cq<0 \end{aligned}$$

Since the ex-ante payoff of the seller is negative and we are only considering feasible contracts (i.e. the seller's payoff function is nonnegative for some q), this case will never be chosen by the seller.

2. Fulfillment of the contract, $q \geqslant q^*$. The supplier delivers q^* units and holds back the rest. The intermediary holds up the supplier by refusing to pay $M(q^*)$ (again, comparing this to the non-hold-up payoff shows that this is optimal). If the supplier goes to court to claim his payment, he would receive $M(q^*)$ minus the enforcement costs $\delta M(q^*)$. The court awards no damages, since there has not been any *loss in value*.[1] Since going to court entails a welfare loss, the parties are going to settle outside of court using the symmetric Nash sharing rule. Under the settlement the supplier receives $M(q^*) - \delta M(q^*) + \frac{1}{2}\delta M(q^*) = \left(1 - \frac{1}{2}\delta\right) M(q^*)$, and the buyer receives $R(q^*) - M(q^*) + \frac{1}{2}\delta M(q^*)$. Once this is done, there may be excess production $q - q^*$ left, which is still more valuable to the buyer than to the seller. Again, the two parties bargain over the surplus from these goods, which is the additional revenue from selling the excess production to the downstream firm, $R(q) - R(q^*)$. Since there is no contract governing the sale of these goods, the seller is left with the option to revert the production process if the bargaining breaks down, in which case he gets $\omega c(q - q^*)$ (whereas the buyer gets nothing[2]). The quasi-rents are the difference between the surplus and the sum of the outside options, $R(q) - R(q^*) - \omega c(q - q^*)$. Under the Nash sharing rule, the supplier receives in addition to his payoff from the settlement of the contract dispute

$$\omega c(q - q^*) + \frac{1}{2}\left(R(q) - R(q^*) - \omega c(q - q^*)\right) = \frac{1}{2}\left(R(q) - R(q^*) + \omega c(q - q^*)\right)$$

which means that his overall ex-ante payoff is

$$\pi_s(q) = \left(1 - \frac{1}{2}\delta\right) M(q^*) + \frac{1}{2}\left(R(q) - R(q^*) + \omega c(q - q^*)\right) - cq \quad \text{if } q \geqslant q^* \tag{39}$$

and the intermediary receives in the second settlement

$$\frac{1}{2}\left(R(q) - R(q^*) - \omega c(q - q^*)\right)$$

which means his total ex-ante payoff is

$$\pi_b(q) = R(q^*) - \left(1 - \frac{1}{2}\delta\right) M(q^*) + \frac{1}{2}\left(R(q) - R(q^*) - \omega c(q - q^*)\right) \quad \text{if } q \geqslant q^*.$$

1 Cf. Farnsworth (2004), §12.10 in US law.

2 These payoffs are in addition to the payoffs from the first bargaining ($R(q^*) - \frac{1}{2}\delta M(q^*)$ and $(1 - \frac{1}{2}\delta)M(q^*)$ for the intermediary and supplier, respectively).

We have now characterized the payoff functions for seller and buyer, for a given contract. Going back in time, the supplier chooses q optimally to maximize his ex-ante payoff π_s. Let's first establish the fact that the supplier's payoff function is continuous at q^*, which means that it is impossible to punish him for breaching the contract.

Lemma 1 *Let $(q^*, M(q))$ be a feasible contract. The supplier's payoff function π_s is continuous at q^*.*

Proof 1 *The left-limit of π_s at q^* only exists if $q^* > 0$, in which case it is*

$$\lim_{q \nearrow q^*} \pi_s(q) = \left(1 - \frac{1}{2}\delta\right) M(q^*) - cq^*$$

and the right-limit of $\pi_s(q)$ at q^* is

$$\lim_{q \searrow q^*} \pi_s(q) = \left(1 - \frac{1}{2}\delta\right) M(q^*) - cq^*$$

which is the same as the left-limit, thus π_s is continuous at q^*.

Let's now look at the set of implementable quantities. The seller's payoff maximization problem is

$$\max_q \pi_s(q) = \max\left(\max_{q, q<q^*} \pi_s(q), \max_{q, q\geqslant q^*} \pi_s(q)\right). \tag{40}$$

Denote the interior maxima of (38) and (39) by q_δ and q_ω respectively. They satisfy the first-order conditions

$$\begin{aligned} R'(q_\delta) &= \frac{1}{1-\frac{1}{2}\delta}c \\ R'(q_\omega) &= (2-\omega_i)\,c. \end{aligned}$$

From (40) and the fact that both expressions $\pi_s(q)$ for $q < q^*$ and $q \geqslant q^*$ have unique maxima at q_δ and q_ω respectively, it is clear that the $\arg\max_q \pi_s(q)$ can only be either q_δ, q_ω, or q^*. Because of the continuity of π_s, q^* can only be implementable if either $q^* \leqslant q_\delta$ or $q^* \leqslant q_\omega$.[3] Also, note that both q_δ and q_ω do not depend on the contract $(q^*, M(q^*))$ – though whether they will be chosen by the supplier depends of course on the contract.

We now turn to the optimal contracting problem. In a world where the Coase Theorem holds, the buyer would implement the efficient quantity $\tilde{q} = \arg\max_q R(q) - cq$ and appropriate all the rents from the relationship. In the world of my model, since the implementable quantities are all less or equal[4] $\tilde{q}$, a contract that implements the largest implementable quantity (either q_δ or q_ω) and leaves the full surplus from the relationship with the buyer will be an optimal contract. In the following I will construct such a contract. Distinguish two cases:

3 Suppose $q^* > q_\delta$ and $q^* > q_\omega$. Because of continuity of π_s and the fact that R is concave, either $\pi_s(q_\delta) > \pi_s(q^*)$ or $\pi_s(q_\omega) > \pi_s(q^*)$, thus q^* is not implementable.

4 Equal if and only if either $\omega = 1$ or $\delta = 0$.

1. Case 1, $2 - \omega_i \geqslant 1/(1-\frac{1}{2}\delta)$, or, equivalently, $q_\omega \leqslant q_\delta$. In this case, choosing q^* to be greater than q_δ and setting

$$M(q) = M(q^*) = \frac{1}{1-\frac{1}{2}\delta} c q_\delta + R(q^*) - R(q_\delta)$$

will implement q_δ. The seller's payoff under $q = q_\delta$ is then zero, and the buyer receives $R(q_\delta) - c q_\delta$.

2. Case 2, $2 - \omega_i < 1/(1-\frac{1}{2}\delta)$, or, equivalently, $q_\omega > q_\delta$. The buyer wants to implement q_ω. Set $M(q^*) = 0$ and q^* such that

$$R(q_\omega) - (2-\omega_i)\, q_\omega c = R(q^*) + \omega_i q^* c. \tag{41}$$

Such a q^* exists because the RHS of this equation is zero for $q^* = 0$ and goes to infinity for $q^* \to \infty$, and is continuous in q^*, and the LHS is positive. Furthermore, it satisfies $q^* < q_\omega$. Distinguish two subcases.

a) $q^* \geqslant q_\delta$. Then the greatest profit that could be obtained by breaking the contract is

$$\begin{aligned} &\left(1-\frac{1}{2}\delta\right)(R(q_\delta) + M(q^*) - R(q^*)) - c q_\delta \\ = &\left(1-\frac{1}{2}\delta\right)(R(q_\delta) - R(q^*)) - c q_\delta < 0 \end{aligned}$$

thus $q = q_\omega$ is incentive-compatible.

b) $q^* < q_\delta$. Since $\pi_s(q)$ is increasing for all $q < q^*$, an upper bound for the profits that could be obtained by breaking the contract is

$$\left(1-\frac{1}{2}\delta\right)(R(q^*) + M(q^*) - R(q^*)) - c q^* = -c q^* < 0$$

thus $q = q_\omega$ is incentive-compatible.

Thus, setting $M(q^*) = 0$ and q^* as in (41) implements q_ω with $\pi_s(q_\omega) = 0$.

A.1.2 *Proof of Proposition 2*

1. We have

$$p_{ni}(j) = \min\left(p^l_{ni}(j), p^x_{ni}(j)\right)$$

and

$$\begin{aligned} p^l_{ni}(j) &= \frac{w}{s_{ni}(j)} \\ p^x_{ni}(j) &= \frac{\sigma_n}{\sigma_n - 1} \frac{p_i d_{ni}}{z_{ni}(j)}. \end{aligned}$$

From the fact that $z_{ni}(j)$ follows a Frechet distribution,

$$P(z_{ni}(j) < z) = e^{-T_i z^{-\theta}}$$

we have that

$$P(p^l_{ni}(j) > c) = \exp\left(-S_n\left(\frac{w}{c}\right)^{-\theta}\right)$$

and analogous for $s_{ni}(j)$,

$$P(p^x_{ni}(j) > c) = \exp\left(-T_i\left(\frac{\sigma_n}{\sigma_n - 1}\frac{p_i d_{ni}}{c}\right)^{-\theta}\right)$$

$$\begin{aligned} P(p_{ni}(j) &< c) = 1 - P(p_{ni}(j) > c) = 1 - \exp\left(-S_n\left(\frac{w}{c}\right)^{-\theta} - T_i\left(\frac{\sigma_n}{\sigma_n - 1}\frac{p_i d_{ni}}{c}\right)^{-\theta}\right) \\ &= 1 - \exp\left(-\left(S_n w^{-\theta} + T_i\left(\frac{\sigma_n}{\sigma_n - 1}p_i d_{ni}\right)^{-\theta}\right)c^{\theta}\right) \\ &= 1 - e^{-\Phi_{ni}c^{\theta}} \end{aligned}$$

where

$$\Phi_{ni} = \left(S_n w^{-\theta} + T_i\left(\mu_n p_i d_{ni}\right)^{-\theta}\right). \tag{42}$$

and $\mu_n = \sigma_n/(\sigma_n - 1)$. Denote

$$Q_{ni} = \left(\int_0^1 q_{ni}(j)^{(\sigma_n-1)/\sigma_n} dj\right)^{\frac{\sigma_n}{\sigma_n-1}}$$

then

$$y_n = \left(\sum_{i=1}^{N} \gamma_{ni}^{1/\rho} Q_{ni}^{\frac{\rho-1}{\rho}}\right)^{\rho/(\rho-1)}$$

Derive the demand function for sector n firms,

$$\min_{Q_{ni}} \sum_i P_{ni} Q_{ni} \quad \text{s.t. } y_n = 1$$

thus

$$\begin{aligned} P_{ni} &= \lambda\left(\sum_{i=1}^{N} \gamma_{ni}^{1/\rho} Q_{ni}^{\frac{\rho-1}{\rho}}\right)^{1/(\rho-1)} \gamma_{ni}^{1/\rho} Q_{ni}^{-\frac{1}{\rho}} \\ P_{ni} &= \lambda y_n^{1/\rho} \gamma_{ni}^{1/\rho} Q_{ni}^{-\frac{1}{\rho}} \end{aligned}$$

$$Q_{ni} = \gamma_{ni}\left(\frac{\lambda}{P_{ni}}\right)^{\rho} y_n \tag{43}$$

From plugging this into the formula for y_n,

$$p_n \equiv \lambda = \left(\sum_{i=1}^{N} \gamma_{ni} P_{ni}^{1-\rho}\right)^{1/(1-\rho)}$$

and similarly

$$P_{ni} = \left(\int p_{ni}(j)^{1-\sigma_n}\right)^{1/(1-\sigma_n)}.$$

The latter becomes, using the distribution of $p_{ni}(j)$ above,

$$\begin{aligned}
P_{ni} &= \left(\int_0^1 p_{ni}(j)^{1-\sigma_n} dj\right)^{1/(1-\sigma_n)} \\
&= \left(\int_0^\infty \theta p_{ni}^{1-\sigma_n+\theta-1} \Phi_{ni} e^{-\Phi_{ni} c^\theta} dc\right)^{1/(1-\sigma_n)} \\
&= \left(\int_0^\infty \theta \left(\Phi_{ni} c^\theta\right)^{(\theta-\sigma_n)/\theta} \Phi_{ni}^{\sigma_n/\theta} e^{-\Phi_{ni} c^\theta} dc\right)^{1/(1-\sigma_n)} \\
&= \left(\int_0^\infty \theta t^{(\theta-\sigma_n)/\theta} \Phi_{ni}^{\sigma_n/\theta} e^{-t} \Phi_{ni}^{-1} \theta^{-1} c^{1-\theta} dt\right)^{1/(1-\sigma_n)} \\
&= \left(\Phi_{ni}^{(\sigma_n-1)/\theta} \int_0^\infty t^{\frac{1-\sigma_n}{\theta}} e^{-t} dt\right)^{1/(1-\sigma_n)} \\
&= \left(\Gamma\left(\frac{1-\sigma_n+\theta}{\theta}\right)\right)^{\frac{1}{1-\sigma_n}} \Phi_{ni}^{-\frac{1}{\theta}}
\end{aligned}$$

Thus the cost of one unit of y_n is

$$p_n \equiv \left(\sum_{i=1}^{N} \gamma_{ni} \left(\alpha_n \Phi_{ni}^{-\frac{1}{\theta}}\right)^{1-\rho}\right)^{1/(1-\rho)}$$

where

$$\alpha_n \equiv \left(\Gamma\left(\frac{1-\sigma_n+\theta}{\theta}\right)\right)^{\frac{1}{1-\sigma_n}}$$

and Φ_{ni} as defined above.

2. The probability that activity (n, i, j) is outsourced is

$$\begin{aligned}
\pi_{ni}(j) &\equiv P(p_{ni}^x(j) \leqslant p_{ni}^l(j)) = \int_0^\infty \exp\left(-S_n \left(\frac{\sigma_n}{\sigma_n-1}\frac{w}{p}\right)^{-\theta}\right) dF_{p^x}(p) \\
&= \int_0^\infty T_i \left(\frac{\sigma_n}{\sigma_n-1}\right)^{-\theta} (p_i d_{ni})^{-\theta} \theta p^{\theta-1} \exp\left(-\Phi_{ni} p^\theta\right) dp \\
&= T_i \left(\frac{\sigma_n}{\sigma_n-1}\right)^{-\theta} (p_i d_{ni})^{-\theta} \frac{1}{\Phi_{ni}} \int_0^\infty \theta p^{\theta-1} \Phi_{ni} \exp\left(-\Phi_{ni} p^\theta\right) dp \\
&= \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{\Phi_{ni}} = \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}
\end{aligned}$$

and because of a Law of Large Numbers, it is also the fraction of type-i varieties that sector n sources from sector i. The distribution of cost $p_{ni}(j)$ conditional on activity (n, i, j) being outsourced is

$$\begin{aligned}
p_{ni|x}(j) &\equiv P\left(p_{ni}(j) < p | p^x_{ni}(j) \leqslant p^l_{ni}(j)\right) \\
&= \frac{1}{\pi_{ni}(j)} \int_0^p \exp\left(-S_n \left(\frac{\sigma_n}{\sigma_n - 1}\frac{w}{z}\right)^{-\theta}\right) dF_{p^x}(z) \\
&= \frac{1}{\pi_{ni}(j)} \int_0^p T_i \left(\frac{\sigma_n}{\sigma_n - 1}\right)^{-\theta} (p_i d_{ni})^{-\theta} \theta z^{\theta-1} \exp\left(-\Phi_{ni} z^\theta\right) dz \\
&= \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{\pi_{ni}(j)} \frac{1}{\Phi_{ni}} \int_0^p \Phi_{ni} \theta z^{\theta-1} \exp\left(-\Phi_{ni} z^\theta\right) dz \\
&= 1 - e^{-\Phi_{ni} p^\theta} = P\left(p_{ni}(j) < p\right)
\end{aligned}$$

From this, it follows that the fraction of expenditure on outsourced type-i activities in total expenditure on type-i activities is also $\pi_{ni}(j)$,

$$\frac{\int_0^1 \pi_{ni}(j) p_{ni|x}(j) q_{ni}(j) dj}{\int_0^1 p_{ni}(j) q_{ni}(j)} = \pi_{ni}(j) = \pi_{ni}.$$

Let's calculate the expenditure on outsourced type-i activities in total expenditure. From (43), the expenditure share on type-i activities is

$$\frac{P_{ni} Q_{ni}}{p_n y_n} = \gamma_{ni} \left(\frac{P_{ni}}{p_n}\right)^{1-\rho}.$$

where $P_{ni} = \alpha_n \Phi_{ni}^{-\frac{1}{\theta}}$. Thus, the expenditure share on outsourced type-i activities is

$$\begin{aligned}
\frac{X_{ni}}{p_n y_n} &= \gamma_{ni} \alpha_n^{1-\rho} \left(\frac{\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}\right)^{-1/\theta}}{p_n}\right)^{1-\rho} \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}} \\
&= \gamma_{ni} \alpha_n^{1-\rho} p_n^{\rho-1} \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}\right)^{1+(1-\rho)/\theta}}.
\end{aligned}$$

I provide here a brief sketch of the proof of X_{ni}/X_n being decreasing in d_{ni}. Note that

$$\frac{X_{ni}}{X_n} = \gamma_{ni} \alpha_n^{1-\rho} \left(\frac{\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}\right)^{-1/\theta}}{p_n}\right)^{1-\rho} \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}} \tag{44}$$

We now look at the log-derivative of each of these terms and determine their sign. Since $\partial \log p_i / \partial \log d_{ni} > 0$, we have that

$$\frac{\partial \log \left(T_i \left(\mu_n p_i d_{ni} \right)^{-\theta} \right)}{\partial \log d_{ni}} < 0$$

and thus the second fraction of (44) is decreasing in d_{ni}. By the same argument, $\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni} \right)^{-\theta} \right)^{-1/\theta}$ is increasing in d_{ni}. Since p_n is a harmonic mean of the aforementioned and other expressions, p_n must rise less than $\left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni} \right)^{-\theta} \right)^{-1/\theta}$ to any change in d_{ni} (intuitively, the firms can substitute away). Thus, since $\rho > 1$, the second term in (44) is also decreasing in d_{ni}.

A.1.3 *Proof of Proposition 3*

Lemma 2 *Suppose*

$$f_n(z) = \sum_i^N \left(a_{ni} + b_{ni} z_i^\eta \right)^{\frac{1}{\eta}}$$

with $1 > \eta > 0$*, and*

$$\rho(B^{1/\eta}) < 1$$

where $B^{1/\eta} = \left(b_{ni}^{1/\eta} \right)_{n,i}$ *and* $\rho(\cdot)$ *is the spectral radius. Then* $f(z)$ *has a unique fixed point* z^**, and* $z^* = \lim_{n \to \infty} f^{(n)}(z)$.

Proof 2 *The Jacobian is*

$$\begin{aligned} \frac{\partial f_n}{\partial z_i} &= \left(a_{ni} + b_{ni} z_i^\eta \right)^{\frac{1}{\eta} - 1} b_{ni} z_i^{\eta - 1} = \frac{b_{ni}}{\left(a_{ni} + b_{ni} z_i^\eta \right)^{1 - 1/\eta} z^{1-\eta}} = \frac{b_{ni}}{\left(a_{ni} z_i^{-\eta} + b_{ni} \right)^{1 - 1/\eta}} \\ &= \left(b_{ni}^{\frac{\eta}{1-\eta}} a_{ni} z_i^{-\eta} + b_{ni}^{\frac{1}{1-\eta}} \right)^{1/\eta - 1} = \left(b_{ni}^{-1} a_{ni} z_i^{-\eta} + 1 \right)^{1/\eta - 1} b_{ni}^{\frac{1}{\eta}} \end{aligned}$$

We have that, if $\eta < 1$

$$\lim_{z_i \to 0} \frac{\partial f_n}{\partial z_i} = \infty, \qquad \lim_{z_i \to \infty} \frac{\partial f_n}{\partial z_i} = b_{ni}^{1/\eta}$$

The second derivatives are

$$\frac{\partial^2 f_n}{\partial z_i^2} = -\eta \left(1/\eta - 1 \right) \left(b_{ni}^{-1} a_{ni} z_i^{-\eta} + 1 \right)^{1/\eta - 2} b_{ni}^{-1} z_i^{-\eta - 1} a_{ni} b_{ni}^{\frac{1}{\eta}} < 0$$

and 0 *for the cross derivatives, thus* f_n *is globally concave, with the Jacobian converging monotonically to* $B^{1/\eta}$ *for* $z \to \infty$*. Since the space is finite-dimensional, this convergence is uniform.*

Since the spectral radius is a continuous mapping, we can find a $\underline{z}$ *such that* $\rho\left(\frac{Df}{Dz}(z)\right) \leqslant r < 1$ *for all* $z \geqslant \underline{z}$*. Let* $Z \equiv \{z \in R^N : z \geqslant \underline{z}\}$*. Given the concavity of* f_n*, there is a* $z^* \in Z$ *such that*

$$\left|f_n(z') - f_n(z)\right| \leqslant \sum_i \frac{\partial f_n}{\partial z_i^*} \left|z_i' - z_i\right|$$

with $\rho\,(Df/dz^*) \leqslant r$*. Thus* f *is a* Df/dz^**-contraction on* Z *and by Theorem 13.1.2 in Ortega and Rheinboldt (1970)* $\lim_{n\to\infty} f^{(n)}(z)$ *is the unique fixed point of* f.

Proposition 4 *Assume that*

$$\rho\left(\left(\alpha_n^{1-\rho}\gamma_{ni}\right)^{\frac{\theta}{\rho-1}} T_i \mu_n^{-\theta}\right) < 1.$$

and that $0 < \theta/(\rho - 1) < 1$*. Then, for all* $(d_{ni})_{n,i}$ *with* $d_{ni} \geqslant 1$ *for all* n, i*, an equilibrium price vector* p *exists and is unique.*

Proof 3 *The price vector satisfies the system of equations*

$$p_n \equiv \alpha_n \left(\sum_{i=1}^{N} \gamma_{ni} \left(\left(S_n w^{-\theta} + T_i \left(p_i \mu_n d_{ni}\right)^{-\theta}\right)^{-1/\theta}\right)^{1-\rho}\right)^{1/(1-\rho)} \tag{45}$$

which can be rewritten

$$z_n \equiv \sum_{i=1}^{N} \left(\gamma_{ni}^{\theta/(\rho-1)} \alpha_n^{-\theta} S_n w^{-\theta} + \gamma_{ni}^{\theta/(\rho-1)} \alpha_n^{-\theta} T_i \left(\mu_n d_{ni}\right)^{-\theta} z_i^{\eta}\right)^{1/\eta} \tag{46}$$

with $z_n = p_n^{1-\rho}$ *and* $\eta = \frac{\theta}{\rho-1}$*. We have that*

$$\rho\left(\left(\alpha_n^{1-\rho}\gamma_{ni}\right)^{\frac{\theta}{\rho-1}} T_i \mu_n^{-\theta} d_{ni}^{-\theta}\right) \leqslant \rho\left(\left(\alpha_n^{1-\rho}\gamma_{ni}\right)^{\frac{\theta}{\rho-1}} T_i \mu_n^{-\theta}\right) < 1$$

and $0 < \eta < 1$*, and by Lemma 2 there exists a unique* z *that satisfies (46) and thus a unique* p *that satisfies (45).*

A.2 EXTENSIONS

A.2.1 *A model with a delivery decision*

Consider a model that differs from the one in Section 1.2 in the following way. After production has taken place, the seller faces the decision of how much of the produced goods to deliver to the buyer. Denote this quantity by d. Once delivered, the goods cannot be retrieved anymore. The stipulated quantity q^* in the contract is the quantity to be delivered. Both buyer and the court have no way of verifying that any goods in excess of d have been produced. The enforcement of the contract is as described in Section 1.2. Once the parties have settled, the seller and the buyer may bargain over the surplus from the excess production, with the control over the goods being with the seller (i.e. he can partially revert the production process in case the bargaining breaks down). Again the settlement is as described in Section 1.2.

First, note that the seller will not deliver more than q^* to the buyer: the contract and the court will not reward him for producing/delivering more than q^*. Suppose now that the seller delivers $0 \leqslant d \leqslant q^*$ and holds back $x \equiv q - d \geqslant 0$. Then his payoff is

$$\left(1-\frac{1}{2}\delta\right)(R(d)-R(q^*)+M(q^*))+\frac{1}{2}(R(d+x)-R(d)+\omega c x)-c(d+x).$$

and his profit maximization problem consists of maximizing this expression subject to the constraints $d \geqslant 0$, $d \leqslant q^*$, and $x \geqslant 0$. Note that if $\delta < 1$, the first constraint is never binding, since $\lim_{d\to 0} R(d) = \infty$.

The first-order conditions for this problem are

$$\left(1-\frac{1}{2}\delta\right)R'(d)+\frac{1}{2}\left(R'(d+x)-R'(d)\right) = c \quad (47)$$

$$\frac{1}{2}\left(R'(d+x)+\omega c\right) = c \quad (48)$$

Let's discuss all cases. For q^* sufficiently high, we have that (47) holds. If

$$\frac{1}{2}\left(R'(d)+\omega c\right) > c$$

then the seller holds back some production ((48) holds), and we have

$$R'(d+x) = (2-\omega)c$$
$$R'(d) = \frac{\omega c}{1-\delta}. \quad (49)$$

$R'(d) > (2-\omega)c$ and $R'(d) = \frac{\omega c}{1-\delta}$ implies that $\frac{\omega c}{1-\delta} > (2-\omega)c$ and thus $q_\omega > q_\delta$. Thus, this case can only happen if the latter holds. On the other hand, if $\frac{1}{2}(R'(d)+\omega c) < c$, then $x = 0$ and d satisfies $(1-\frac{1}{2}\delta)R'(d) = c$ thus $d = q_\delta$.

If (47) does not hold, then $d = q^*$. As above, if $R'(d) > (2-\omega)c$ then $R'(d+x) = (2-\omega)c$, otherwise $x = 0$, and $d < q_\delta$.

To summarize, it is impossible to implement a higher quantity than $\max(q_\delta, q_\omega)$. It remains to show that there is a contract that implements $\max(q_\delta, q_\omega)$ and where the seller is pushed down to his participation constraint.

- Case 1, $2-\omega_i \geqslant 1/(1-\frac{1}{2}\delta)$, or, equivalently, $q_\omega \leqslant q_\delta$. In this case, choosing q^* to be greater than q_δ and setting

  $$M(q) = M(q^*) = \frac{1}{1-\frac{1}{2}\delta}cq_\delta + R(q^*) - R(q)$$

  will implement $d = q_\delta$, since $R'(d) = 1/(1-\frac{1}{2}\delta)$ and thus $R'(d) < 2-\omega$ means $x = 0$.

- Case 2, $2-\omega_i < 1/(1-\frac{1}{2}\delta)$, or, equivalently, $q_\omega > q_\delta$. Total payoff to seller is

$$\left(1-\frac{1}{2}\delta\right)(R(d)-R(q^*)+M(q^*))+\frac{1}{2}(R(q_\omega)-R(d)+\omega c(q_\omega-d))-cq_\omega$$

Set $M(q^*)=0$ and q^* such that

$$\left(1-\frac{1}{2}\delta\right)(R(d)-R(q^*))+\frac{1}{2}(R(q_\omega)-R(d)+\omega c(q_\omega-d)=cq_\omega$$

where d satisfies equation (49). The q^* is greater than d. Since $2-\omega_i < 1/(1-\frac{1}{2}\delta)$, we have that $R'(d) > (2-\omega)c$, thus $q > d$ and $R'(d+x) = (2-\omega)c$.

A.2.2 *How important are Input-Output Linkages?*

In order to get a sense of how much the input-output linkages between sectors contribute to the welfare gains from reducing enforcement costs, I discuss here a version of the model without linkages.

Assume that the production function in the case of outsourcing is linear in labor instead of sector i output,

$$q_{ni}(j) = z_{ni} l(n,i,j)$$

where $l(n,i,j)$ denotes labor input, and z_{ni} is the Frechet-distributed productivity realization as in section 1.2.1.2. Then, the equations for sectoral price levels and input expenditure shares, (12) and (13), become

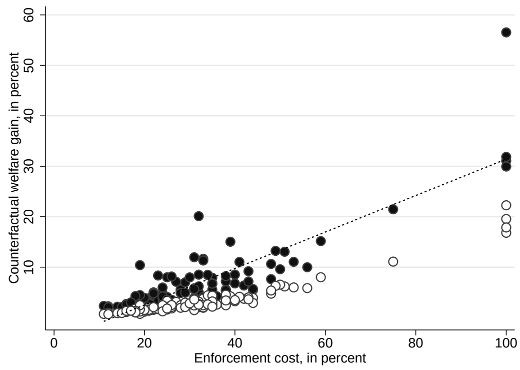
$$p_n = \left(\sum_{i=1}^{N}\gamma_{ni}\left(\alpha_n\left(S_n w^{-\theta}+T_i\left(w\mu_n d_{ni}\right)^{-\theta}\right)^{-\frac{1}{\theta}}\right)^{1-\rho}\right)^{1/(1-\rho)} \tag{50}$$

$$\frac{X_{ni}}{X_n} = \gamma_{ni}\alpha_n^{1-\rho}p_n^{\rho-1}\frac{T_i\left(\mu_n w d_{ni}\right)^{-\theta}}{\left(S_n w^{-\theta}+T_i\left(\mu_n w d_{ni}\right)^{-\theta}\right)^{1+(1-\rho)/\theta}}. \tag{51}$$

The estimation of equations (50) and (51) yields exactly the same point estimates as in the main text, since p_i and T_i only appear together in (12) and (13) and are thus not separately identified.

I then calibrate the remaining parameters and perform the welfare counterfactuals as described in Section 1.4.1, using the baseline specifications (Broda-Weinstein elasticities, $\omega_{ni}^{(1)}$). Figure 9 compares the welfare increases in the model without input-output linkages (white dots) with the baseline model (black dots), when enforcement costs are reduced to zero. The welfare gains in the model without intersectoral linkages are roughly half as big as in the baseline model, which implies that the I-O linkages magnify the macroeconomic importance of transaction costs by a factor of two.

Figure 9: WELFARE GAINS WITH AND WITHOUT I-O LINKAGES



Note: Welfare gains with I-O linkages in black, without I-O linkages in white. Both are calculated using the benchmark specification (Broda-Weinstein elasticities, $\omega_{ni}^{(1)}$).

A.3 DATA DESCRIPTION

A.3.1 *Construction of the enforcement-intensity measures*

I start off with all cases in the 'Federal and State court cases' repository from LexisLibrary that are between January 1990 and December 2012 and include 'contract' as one of their core terms.[5] I then exclude all cases that are filed in a court of appeals, or a higher court. If there have been any counterclaims, I treat them as separate cases. This leaves me with 23261 cases that span 34219 plaintiffs and 50599 defendants.

I match the plaintiffs and defendants to the universe of US firms that are contained in the Orbis database of firms, based on the name strings.[6] I use a Fellegi-Sunter matching algorithm that compares the occurence of bigrams in each possible pairing. The first four characters are weighted more heavily. If the score is above a threshold (0.92), I consider the match to be successful. I then match the SIC classifications from Orbis to GTAP sectors, using a hand-written concordance table, which is partly based on the definition of the GTAP sectors in terms of CPC or ISIC codes[7], and partly on the description of the sectors. Since I am only interested in the industry of the plaintiff and defendant firms, if both firm names in a candidate pair contain the same trade name ('bank','architects', etc.), I also regard the pair as matched even if their matching score is below the threshold.

Table 23 summarizes the results of the matching process. I manage to associate 52.2 percent of all parties to firms in Orbis. In order to see whether the fraction of matched entries is close to the number of possible matches, one needs to know the fraction of businesses (or at least non-individuals) among the plaintiffs and defendants. This

5 I thank Jinesh Patel and the legal team at LexisNexis UK for permission to automatically retrieve and process the LexisLibrary data.

6 This includes many US subsidiaries of foreign firms. The total number of US firms in my version of Orbis is 21,014,945.

7 See https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp

information is not available in LexisLibrary. However, I compare the matching rates with the fraction of business plaintiffs and defendants in an auxiliary dataset, the Civil Justice Survey of State Courts 1992, which covers (among other things) a sample of 6,802 contract cases in state courts.[8] In that dataset, 53.9 percent of all parties are non-individuals, and 49.6 percent are businesses. Even though it is likely that parties in federal courts are more likely to be businesses and organizations rather than individuals, I view this comparison as supporting the view that I am able to match most of the relevant parties.

Table 23: MATCHING PLAINTIFFS AND DEFENDANTS TO ORBIS FIRMS: STATISTICS

		Plaintiffs		Defendants		All	
		number	*in pct*	*number*	*in pct*	*number*	*in pct*
Handmatched:		169		223		392	
Population:		34388	100.0	50822	100.0	85210	100.0
Matches:	perfect matches	1649	4.8	1666	3.3	3315	3.9
	above threshold	13058	38.0	25838	50.8	38896	45.6
	based on trade name	839	2.4	1419	2.8	2258	2.6
Total matches:		15546	45.2	28923	56.9	44469	52.2
Civil Justice Survey:	non-individuals						53.9
	businesses						49.6

A.3.2 *Input-Output data*

My data on input-output tables come from Version 8 of the Global Trade Analysis Database (Narayanan et al., 2012). Table 24, which is taken from its documentation, shows which year each of the country tables correspond to, and the primary source.

Table 24: I-O TABLES IN GTAP 8: YEARS AND SOURCES

Country	Year	Source
Albania	2000	Albanian Ministry of Finance (2001), and others
Argentina	2000	National Institute of Statistics and Census, and Secretary of Agriculture, Livestock-farming, Fisheries and Food Industry
Armenia	2002	Social accounting matrix developed by Miles K. Light, Ekaterine Vashakmadze, and Artsvi Khatchatryan.
Australia	2005	MMRF database derived from ABS Input Output tables, 2005-06
Austria	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Azerbaijan	2001	Statistical Committee of Azerbaijan Republic in Statistical Yearbook of Azerbaijan 2005.
Bahrain	2005	Central Informatics Organisation, Bahrain. Detailed national accounts statistics 2006 and 2007, Central Informatics Organisation, Bahrain. Also, the Kuwait I/O table.
Bangladesh	1993-94	Bangladesh Planning Commission and Bangladesh Institute of Development Studies (1998)
Belarus	2004	Ministry of Statistics and Analysis of Belarus (2006)
Belgium	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Bolivia	2004	Industry Instituto Nacional de Estadï¿œstica
Botswana	1993-94	McDonald
Brazil	2005	Instituto Brasileiro de Geografia e Estatistica - IBGE
Bulgaria	2000	also discussions with taxation officials. Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Cambodia	2003	National Institute of Statistics (2006), National Institute of Statistics (2005), and National Bank of Cambodia (2006)

8 See US Department of Justice (1996) for a description. In calculating the figures in Table 23 I exclude cases that pertain to mortgage foreclosure, rental agreements, fraud, and employment.

Country	Year	Source
Cameroon	2003	Not specified.
Canada	2003	Statistics Canada
Chile	2003	Banco Central de Chile (2001)
China	2007	Input-Output Tables of China 2007
Colombia	2003	Colombian National Statistical Office (DANE)
Costa Rica	2002	SAM built by Sanchez (2006), based on data from Central Bank of Costa Rica
Cote d'Ivoire	1998	1998 Input-Output table for Cote d'Ivoire
Croatia	1995	Henrichsmeyer, W., J. Kï¿œckler, A. Quiring and T. Mï¿œllmann (1999)
Cyprus	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Czech Republic	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Denmark	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Ecuador	2004	Central Bank of Ecuador (2000)
Egypt	2003	National Accounts, National Planning Unit of Egypt
El Salvador	2000	Social Accounting Matrix, year 2000, from IFPRI (International Food Policy Reasearch Institute)
Estonia	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Ethiopia	2002	Social Accounting Matrix 2001/02 compiled by IDS in collaboration with EDRI
Finland	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
France	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Georgia	2001	Unofficial table provided by the Economic Policy Research Center (EPRC) in Georgia. General national accounts data for 2005.
Germany	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Ghana	2005	SAM for Ghana, published in October 2007, by Ghana Statistical Services (GSS), International Food Policy Research Institute (IFPRI) under the Ghana Strategy Support Program (GSSP)
Greece	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Guatemala	2001	Guatemalas Secretaria General de Planificacion (SEGEPLAN).
Honduras	2004	Honduras 2004 SAM
Hong Kong	1988	Tormey (1993)
Hungary	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
India	2003	Input-output transactions table, 2003-04, (Government of India, 2008)
Indonesia	2004	Biro Pusat Statistik (1999)
Iran	2001	Statistical Center of Iran
Ireland	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Israel	2004	Israeli Central Bureau of Statistics, the Central Bank of Israel, and the Israeli Tax Authority (ITA), and others.
Italy	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Japan	2000	Statistics Bureau, the Ministry of Public Management, Home Affairs, Posts and Telecommunications (2004)
Kazakhstan	2004	Abdiev (2007)
Kenya	2001	National accounts, and 1997 SAM constructed by the Kenya Institute for Public Policy Research and Analysis KIPPRA
Kuwait	2005	Kuwait Central Statistics Office, and others
Kyrgyzstan	2003	Miles Light
Laos	2002	Asian Development Bank (2005), Menon and Warr (2006), and Rao (1993)
Latvia	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Lithuania	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Luxembourg	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Madagascar	1999	INSTAT (2003), also documented in Dorosh, P., S. Haggblade, C. Lungren, T. Razafimanantena, and Z. Randriamiarana (2003)
Malawi	1994	MERRISA/Wobst
Malaysia	2005	Malaysian Input-output tables for the year 2005, Department of Statistics, 2009.
Malta	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Mauritius	1997	Supply and Use Table (SUT) 1997 compiled by the Central Statistical Office (CSO) of Mauritius and others
Mexico	2003	Mexican Instituto Nacional de Estadistica Geografia e Informatica (INEGI)
Mongolia	2005	Mongolian Inter-Sector Balance Table for 2005
Morocco	2004	Bussolo and Roland-Holst (1993)
Mozambique	1995	MERRISA/Arndt et al.
Namibia	2004	Marie-Lange, G. (2008)
Nepal	2007	Input-output technology matrix of year 2001 from the Planning Commission of Nepal, and other sources
Netherlands	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
New Zealand	1996	Statistics New Zealand (1996)
Nicaragua	2000	Central Bank of Nicaragua (2006)
Nigeria	1999	Official 1990 Input-Output Table (30 sector), and an un-official 1999 Input-Output Table (18 sector) suppliedby the UN Economic Commission for Africa (UNECA)
Norway	2007	Statistics Norway
Oman	2005	National Accounts 2005, Ministry of National Economy, Oman, and others.
Pakistan	2001/02	Labour Force Survey and Nepal Living Standard Survey by CBS Dorosh, Niazi and Nazli (2008)
Panama	1996	SAM built by Marco V. Sanchez and Rob Vos based on Supply and Use Tables "Contralorï¿œa General of Panamaï¿œ
Paraguay	1994	Central Bank of Paraguay (2006)
Peru	2004	Peruvian Ministry of Finance (2004)
Philippines	2000	Input-Output Table of the Philippines (National Statistical and Coordination board)
Poland	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Portugal	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Qatar	2005	Annual Statistical Abstract, 2007, Qatar Statistics Authority, and others
Romania	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Russia	2003	Rosstat (2008) and (2006)

Country	Year	Source
Saudi Arabia	2005	National Accounts Data 2005, Central Department of Statistics and Information, Saudi Ministry of Economy and Planning; The National Accounts Statistics 2005, also the 2005 Kuwait I/O table
Senegal	1996	1996 SAM prepared by Dr Mamadou Dansokho and Amadou Diouf in 1999 for the Senegal government.
Singapore	1996	Department of Statistics, Singapore (1995).
Slovakia	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Slovenia	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
South Africa	2005	Statistics South Africa (2006)
South Korea	2003	The Bank of Korea (2007)
Spain	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Sri Lanka	2000	Amarasinghe and Bandara (2005), and Bandara and Kelegama (2008)
Sweden	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Switzerland	2008	Swiss Input-Output Table 2008 (Swiss Federal Office of Statistics)
Taiwan	1999	Directorate-General of Budget, Accounting and Statistics (DGBAS) (2001)
Tanzania	1992	MERRISA/Wobst
Thailand	2005	Office of the National Economic and Social Development Board (NESDB)
Tunisia	1995	Institut National de la Statistique, Tunisia (1998)
Turkey	1998	was also used (e.g. refining capacity, crude oil production, etc.). State Institute of statistics (2004) National Accounts Data, 2005, UAE
Uganda	2002	Uganda SAM 2002, provided by the Uganda Bureau of Statistics (UBoS), Kampala, Uganda
Ukraine	2004	Ukrainian Input-Output table, State Statistics Committee of Ukraine
United Arab Emirates	2005	Ministry of Economy. Ten-Sector Input- Output Table for the UAE, 2003. SAM of the UAE Economy, 2006, and others
United Kingdom	2000	Mueller, M., Pï¿œrez Domï¿œnguez, I., & Gay, S. H. (2009)
Uruguay	1997	Terra, Olivieri, Tellechea and Zaclicever (2008)
USA	2002	Dixon and Rimmer (2001), Dixon, Rimmer, and Tsigas (2004), and Lawson (1997)
Venezuela	1997	Department of Macroeconomic Accounts, Central Bank of Venezuela
Viet Nam	2005	Vietnam General Statistics Office (GSO)
Zambia	1995	MERRISA/Hausner
Zimbabwe	1991	MERISSA/Thomas and Bautista

Source: Global Trade Analysis Project (Narayanan et al., 2012)

B

APPENDIX TO CHAPTER 2

Proposition 5 *Let*

$$\theta_{t+1} = q\gamma_{t+1}\theta_t + 1, \qquad t = 1, 2, \ldots \tag{52}$$

where $q < 1$ *and* γ_{t+1} *satisfies*

$$\log \gamma_{t+1} \sim N\left(0, \sigma^2\right), \quad \sigma > 0$$

and is i.i.d. across time t. *Then there exist an ergodic distribution* θ *for* $\{\theta_t\}_t$ *and* $k^+, k^- \in R$, *at least one of them positive, such that*

$$x^{\zeta}P(\theta > x) \to k^+, \; x^{\zeta}P(\theta < x) \to k^-$$

where $\zeta = -2\log q/\sigma^2$.

Proof 4 *It is straightforward to verify that*

$$E\left((q\gamma)^{\zeta}\right) = 1.$$

Hence, the conditions for applying Theorem 1 in Gabaix (2009) are fulfilled and θ *has power law tails with slope parameter* ζ.

Proposition 6 *If* $\phi = 1$, *then aggregate output* Y *satisfies*

$$Y = \left(\int \theta_i^{\frac{1}{1-\rho}} di\right)^{1-\rho} K^{\alpha\rho} L^{\rho(1-\alpha)}.$$

Proof 5 *If there are no credit frictions, demand for capital is given by the firm's first-order condition*

$$\alpha\rho\theta_i K_i^{\alpha\rho-1} L_i^{(1-\alpha)\rho} = R$$

which, together with the one for labor, implies

$$\frac{w}{R}\frac{\alpha}{1-\alpha} = \frac{K_i}{L_i} \tag{53}$$

and on the aggregate, with $K \equiv \int K_i \, di$ *and* $L \equiv \int L_i \, di$,

$$\frac{w}{R}\frac{\alpha}{1-\alpha} = \frac{K}{L}.$$

Aggregate output is then

$$Y = \int Y_i \, di = \int \frac{w}{\rho(1-\alpha)} L_i \, di = \left(\int \theta_i^{\frac{1}{1-\rho(1-\alpha)}} \left(\frac{K_i}{K}\right)^{\frac{\alpha\rho}{1-\rho(1-\alpha)}} di\right)^{1-\rho(1-\alpha)} K^{\alpha\rho} \left(L^s\right)^{\rho(1-\alpha)}. \tag{54}$$

Plugging (53) into (54) yields

$$\begin{aligned} Y &= \left(\int \theta_i^{\frac{1}{1-\rho(1-\alpha)}} (K_i)^{\frac{\alpha\rho}{1-\rho(1-\alpha)}}\, di\right)^{1-\rho(1-\alpha)} L^{\rho(1-\alpha)} \\ &= \left(\int \theta_i^{\frac{1}{1-\rho(1-\alpha)}+\frac{1}{1-\rho}\frac{\alpha\rho}{1-\rho(1-\alpha)}} \left(\frac{\alpha\rho}{R}\right)^{\frac{1}{1-\rho}\frac{\alpha\rho}{1-\rho(1-\alpha)}} \left(\frac{R}{w}\frac{1-\alpha}{\alpha}\right)^{\frac{(1-\alpha)\rho}{1-\rho}\frac{\alpha\rho}{1-\rho(1-\alpha)}} di\right)^{1-\rho(1-\alpha)} L^{\rho(1-\alpha)} \\ &= \left(\int \theta_i^{\frac{1}{1-\rho}} di\right)^{1-\rho(1-\alpha)} (\alpha\rho)^{\frac{\alpha\rho}{1-\rho}} \left(\frac{1-\alpha}{\alpha}\frac{R}{w}\right)^{\frac{(1-\alpha)\rho\alpha\rho}{1-\rho}} R^{\frac{\alpha\rho}{\rho-1}} L^{\rho(1-\alpha)} \\ &= \left(\int \theta_i^{\frac{1}{1-\rho}} di\right)^{1-\rho(1-\alpha)} (\alpha\rho)^{\frac{\alpha\rho}{1-\rho}} \left(\frac{1}{K}\right)^{\frac{(1-\alpha)\rho\alpha\rho}{1-\rho}} R^{\frac{\alpha\rho}{\rho-1}} L^{\rho(1-\alpha)\frac{1-\rho(1-\alpha)}{1-\rho}} \end{aligned}$$

and hence

$$\begin{aligned} Y &= \left(\int \theta_i^{\frac{1}{1-\rho}} di\right)^{1-\rho} K^{\alpha\rho} L^{\rho(1-\alpha)} \\ &= \left(\frac{1}{L}\int \theta_i^{\frac{1}{1-\rho}} di\right)^{1-\rho} K^{\alpha\rho} L^{1-\alpha\rho}. \end{aligned}$$

C

APPENDIX TO CHAPTER 3

Table 25: Comparison of Multi-Category Firms in GKPT and ASI

	Share of Firms		Share of Output		Mean Categories	
Type of Firm	Our Sample	GKPT	Our Sample	GKPT	Our Sample	GKPT
Single Product	0.61	0.53	0.30	0.20	1.00	1.00
Multiple Product	0.39	0.47	0.70	0.80	2.81	3.06
Multiple Industry	0.22	0.33	0.62	0.62	2.55	2.01
Multiple Sector	0.19	0.24	0.49	0.54	2.34	1.68

Note: 'Mean categories' refers to the average number of products, industries, or sectors in the respective subsample. Moreover, 'product' refers to 4-digit products, 'industry' refers to 3-digit industries, and 'sector' refers to two-digit sectors.

Table 26: Summary Statistics for the Variables in Product Turnover Regressions

Variable	Obs	Mean	Std. Dev.	Min	Max
Product addition dummy	18254069	0.00046	0.02136	0	1
Product drop dummy	18254069	0.00045	0.02122	0	1
Input Similarity Index	18254069	0.08349	0.19536	0	1
Downstream Linkages	18254069	0.03192	0.10362	0	0.97
Upstream Linkages	18254069	0.01966	0.09201	0	0.97

Note: Table refers to the joint sample (all observations that are present for all variables). Product add and drop dummies refer to additions (droppings) without simultaneous droppings (additions) by the same firm in the same year.

Table 27: Fraction of net sales growth due to within-product/industry growth

	1-digit	2-digit	3-digit	4-digit	5-digit
2003	0.93	0.89	0.91	0.81	0.78
2004	0.97	0.97	0.83	0.65	0.63
2005	1.02	0.95	0.95	0.92	0.77
2006	0.98	1.00	0.93	0.77	0.69
2007	0.88	0.81	0.74	0.58	0.56
2008	0.99	0.89	0.72	0.60	0.46
average	0.96	0.92	0.85	0.72	0.65

Notes: This table shows how much of the net sales growth is within products/industries. Some details on the construction: (1) we only look at firm-year observations in subsequent years (i.e. if there is a gap, then we don't take these observations into account. (2) we calculate the net sales growth of firms in subsequent years (3) the table then shows the net growth within x-digit products as a fraction of total net growth in (2). Hence, a fraction of 1 would mean that switching of products/industries did not contribute anything to *net* growth (but could still be large). A fraction of greater than one would mean that product switching led on average to lower sales values.

BIBLIOGRAPHY

[1] Acemoglu, Daron, Pol Antràs, and Elhanan Helpman. "Contracts and Technology Adoption." American Economic Review 97, no. 3 (2007): 916-943.

[2] Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi. "The network origins of aggregate fluctuations." Econometrica 80, no. 5 (2012): 1977-2016.

[3] Acemoglu, Daron, and Simon Johnson. "Unbundling Institutions." Journal of Political Economy 113, no. 5 (2005).

[4] Acemoglu, Daron, Simon Johnson, and Todd Mitton. "Determinants of vertical integration: financial development and contracting costs." The Journal of Finance 64, no. 3 (2009): 1251-1290.

[5] Adelman, Morris A. "Concept and statistical measurement of vertical integration." In: Business concentration and price policy, pp. 279-328. Princeton University Press, 1955.

[6] Algan, Yann, and Pierre Cahuc, "Trust and Growth." Annual Review of Economics, vol. 5 (2013)

[7] Amaral, Pedro S., and Erwan Quintin. "Limited Enforcement, Financial Intermediation, and Economic Development: A Quantitative Assessment." International Economic Review 51, no. 3 (2010): 785-811.

[8] Anand, Bharat, and Tarun Khanna. "Must Zee TV." Harvard Business School Case 700-122, June 2000. (Revised February 2003.)

[9] Antràs, Pol. "Firms, Contracts, and Trade Structure." Quarterly Journal of Economics 118, no. 4 (2003): 1375-1418.

[10] Antràs, Pol, and Elhanan Helpman. "Global Sourcing." Journal of Political Economy 112, no. 3 (2004).

[11] Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez-Clare. "New Trade Models, Same Old Gains?." American Economic Review 102, no. 1 (2012): 94-130.

[12] Atalay, Enghin, Ali Hortacsu, and Chad Syverson. "Why Do Firms Own Production Chains?." forthcoming, American Economic Review, 2013.

[13] Aw, B. Y. and Y. Lee. "Product choice and market competition: The case of multiproduct electronic plants in taiwan*," The Scandinavian Journal of Economics, 111 (2009), 711–740

[14] Barseghyan, Levon, and Riccardo DiCecio. "Entry costs, industry structure, and cross-country income and TFP differences." Journal of Economic Theory 146, no. 5 (2011): 1828-1851.

[15] Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. "Plants and Productivity in International Trade." The American Economic Review 93, no. 4 (2003): 1268-1290.

[16] Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott. "Firms in International Trade," The Journal of Economic Perspectives, 21 (2007), 105–130.

[17] Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott. "Intrafirm Trade and Product Contractibility," American Economic Review 100(2), 444-48, (2010)

[18] Bernard, A. B., S. Redding, and P. K. Schott. “Multi-Product Firms and the Dynamics of Product Mix,” Yale School of Management (2005).

[19] Bernard, A. B., S. J. Redding, and P. K. Schott. “Multiple-Product Firms and Product Switching,” The American Economic Review, 100 (2010), 70–97.

[20] Bernard, A. B., S. J. Redding, and P. K. Schott. “Multiproduct Firms and Trade Liberalization,” The Quarterly Journal of Economics, 126 (2011), 1271–1318.

[21] Besley, Timothy and Maitreesh Ghatak, "Property Rights and Economic Development." In: Dani Rodrik and Mark Rosenzweig (eds.): Handbook of Development Economics, Vol. 5, North-Holland, 2010, pp. 4525-4595

[22] Bloom, Nicholas, Benn Eifert, Aprajit Mahajan, David McKenzie, and John Roberts, "Does Management Matter? Evidence from India." The Quarterly Journal of Economics (2013)

[23] Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. "The organization of firms across countries." The Quarterly Journal of Economics (2012) 127 (4): 1663-1705

[24] Bloom, Nicholas, and John Van Reenen. "Measuring and explaining management practices across firms and countries." The Quarterly Journal of Economics 122, no. 4 (2007): 1351-1408.

[25] Bowen, H. P. and M. F. Wiersema. “Foreign-based competition and corporate diversification strategy,” Strategic Management Journal, 26 (2005), 1153–1171.

[26] Bresnahan, Timothy F., and Jonathan D. Levin. "Vertical Integration and Market Structure." in Gibbons and Roberts (eds.), Handbook of Organizational Economics, Princeton University Press (2013)

[27] Broda, Christian, and David E. Weinstein. "Globalization and the Gains from Variety." The Quarterly Journal of Economics 121, no. 2 (2006): 541-585.

[28] Buera, Francisco J., and Yongseok Shin. "Financial Frictions and the Persistence of History: A Quantitative Exploration." Journal of Political Economy 121, no. 2 (2013): 221-272.

[29] Buera, Francisco J., Joseph P. Kaboski, and Yongseok Shin. "Finance and Development: A Tale of Two Sectors." The American Economic Review 101, no. 5 (2011): 1964-2002.

[30] Caselli, Francesco. "Accounting for cross-country income differences." Handbook of economic growth (2005): 679-741.

[31] Caselli, Francesco, and Nicola Gennaioli. "Dynastic management." Economic Inquiry 51, no. 1 (2013): 971-996.

[32] Caliendo, Lorenzo, and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," NBER Working Papers 18508 (2012), National Bureau of Economic Research

[33] Carvalho, Vasco, and Xavier Gabaix. "The great diversification and its undoing" American Economic Review 103 (5), 1697-1727 (2013)

[34] Charles, Kerwin Kofi, and Erik Hurst. "The Correlation of Wealth across Generations." Journal of Political Economy 111, no. 6 (2003): 1155-1182.

[35] Chemin, Matthieu. "Does court speed shape economic activity? Evidence from a court reform in India." Journal of Law, Economics, and Organization 28, no. 3 (2012): 460-485.

[36] Chor, Davin. "Unpacking sources of comparative advantage: A quantitative approach." Journal of International Economics 82, no. 2 (2010): 152-167.

[37] Ciccone, Antonio. "Input chains and industrialization." The Review of Economic Studies 69, no. 3 (2002): 565-587.

[38] Cole, Harold L., Jeremy Greenwood and Juan M. Sanchez. "Why Doesn't Technology Flow from Rich to Poor Countries?" Working Paper 2012-040A, Federal Reserve Bank of St Louis (2012)

[39] Costinot, Arnaud, Dave Donaldson, and Ivana Komunjer. "What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas." The Review of Economic Studies 79, no. 2 (2012): 581-608.

[40] Council of Europe. "European Judicial Systems 2002." Report of the European Commission for the Efficiency of Justice (CEPEJ), 2005.

[41] Djankov, Simeon, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. "Courts." The Quarterly Journal of Economics 118, no. 2 (2003): 453-517.

[42] Dupor, Bill. "Aggregation and irrelevance in multi-sector models." Journal of Monetary Economics 43, no. 2 (1999): 391-409.

[43] Eaton, Jonathan, and Samuel Kortum. "Technology, geography, and trade." Econometrica 70, no. 5 (2002): 1741-1779.

[44] Eckel, C. and P. Neary. "Multi-product firms and flexible manufacturing in the global economy," Review of Economic Studies, 77 (2010), 188–217.

[45] Edlin, Aaron S., and Stefan J. Reichelstein. "Holdups, standard breach remedies, and optimal investment." American Economic Review 86, no. 3 (1996): 478-501.

[46] Fan, J. P. H. and L. H. P. Lang. "The measurement of relatedness: An application to corporate diversification*," The Journal of Business, 73 (2000), 629–660.

[47] Farnsworth, E. Allan. Farnsworth on Contracts, 4th Edition. Aspen Publishers, New York, 2004.

[48] Gabaix, Xavier. "Power Laws in Economics and Finance." Annual Review of Economics 1, no. 1 (2009): 255-294.

[49] Gabaix, Xavier, and Augustin Landier. "Why has CEO Pay Increased So Much?." The Quarterly Journal of Economics 123, no. 1 (2008): 49-100.

[50] Gale, William G., and John Karl Scholz. "Intergenerational transfers and the accumulation of wealth." The Journal of Economic Perspectives 8, no. 4 (1994): 145-160.

[51] Garetto, Stefania. "Input sourcing and multinational production." American Economic Journal: Macroeconomics 5, no. 2 (2013): 118-151.

[52] Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova. "Multi-product firms and product turnover in the developing world: Evidence from India," The Review of Economics and Statistics (2009).

[53] Grossman, Sanford J., and Oliver D. Hart. "The costs and benefits of ownership: A theory of vertical and lateral integration." The Journal of Political Economy (1986): 691-719.

[54] Grossman, Gene M., and Elhanan Helpman. "Integration versus outsourcing in industry equilibrium." The Quarterly Journal of Economics 117, no. 1 (2002): 85-120.

[55] Hart, Oliver, and John Moore. "Property Rights and the Nature of the Firm." Journal of Political Economy (1990): 1119-1158.

[56] Head, Keith, and Thierry Mayer, "Gravity Equations: Workhorse,Toolkit, and Cookbook", chapter to appear in the Handbook of International Economics Vol. 4, eds. Gopinath, Helpman, and Rogoff, Elsevier (2013)

[57] Hermalin, Benjamin E., Avery W. Katz, and Richard Craswell. "Contract law." in: Polinsky and Shavell (eds.), Handbook of Law and Economics (2007): 3-138.

[58] Hirschman, Albert O. The Strategy of Economic Development, Yale University Press (1958)

[59] Holmes, Thomas J. "Localization of industry and vertical disintegration." Review of Economics and Statistics 81, no. 2 (1999): 314-325.

[60] Hopenhayn, Hugo. "Firms, Misallocation, and Aggregate Productivity: A Review." Annual Review of Economics 6 (2014). 32.1-32.36

[61] Horvath, Michael. "Sectoral shocks and aggregate fluctuations." Journal of Monetary Economics 45, no. 1 (2000): 69-106.

[62] Hsieh, Chang-Tai, Erik Hurst, Charles I. Jones, and Peter J. Klenow. "The allocation of talent and us economic growth." NBER Working Paper 18693. National Bureau of Economic Research (2013).

[63] Iacovone, L. and B. S. Javorcik. "Multi-Product Exporters: Product Churning, Uncertainty and Export Discoveries," The Economic Journal, 120 (2010), 481–499.

[64] Irarrazabal, Alfonso, Andreas Moxnes, and Luca David Opromolla. "The margins of multinational production and the role of intrafirm trade." Journal of Political Economy 121, no. 1 (2013): 74-126.

[65] Jackson, Rupert LJ. "Review of Civil Litigation Costs: Preliminary Report." Office of the Judiciary of England and Wales (2009a)

[66] Jackson, Rupert LJ. "Review of Civil Litigation Costs: Final Report." Office of the Judiciary of England and Wales (2009b)

[67] Jeong, Hyeok, and Robert M. Townsend. "Sources of TFP growth: occupational choice and financial deepening." Economic Theory 32, no. 1 (2007): 179-221.

[68] Johnson, Robert C., and Guillermo Noguera. "Accounting for intermediates: Production sharing and trade in value added." Journal of International Economics 86, no. 2 (2012): 224-236.

[69] Jones, Charles I. "Intermediate goods and weak links in the theory of economic development." American Economic Journal: Macroeconomics 3, no. 2 (2011): 1-28.

[70] Jones, Charles I. "Misallocation, Economic Growth, and Input-Output Economics." NBER Working Paper Series 16742 (2011).

[71] Katz, Lawrence F., and David H. Autor. "Changes in the wage structure and earnings inequality." Handbook of labor economics 3 (1999): 1463-1555.

[72] Kesten, Harry. "Random difference equations and renewal theory for products of random matrices." Acta Mathematica 131, no. 1 (1973): 207-248.

[73] Khandelwal, Amit, and Petia Topalova. "Trade liberalization and firm productivity: The case of india." Review of Economics and Statistics 93, no. 3 (2011): 995-1009.

[74] Khanna, Tarun, and Krishna Palepu. "Is group affiliation profitable in emerging markets? An analysis of diversified Indian business groups." The Journal of Finance 55, no. 2 (2000): 867-891.

[75] Kirkpatrick, Scott, D. Gelatt Jr., and Mario P. Vecchi. "Optimization by Simmulated Annealing." Science 220, no. 4598 (1983): 671-680.

[76] Klein, Benjamin, Robert G. Crawford, and Armen A. Alchian. "Vertical integration, appropriable rents, and the competitive contracting process." Journal of Law and Economics 21, no. 2 (1978): 297-326.

[77] Laeven, Luc, and Christopher Woodruff. "The quality of the legal system, firm ownership, and firm size." The Review of Economics and Statistics 89, no. 4 (2007): 601-614.

[78] Lafontaine, Francine, and Margaret Slade. "Vertical integration and firm boundaries: the evidence." Journal of Economic Literature (2007): 629-685.

[79] La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer and Robert W. Vishny, "Legal Determinants of External Finance." The Journal of Finance, vol. 52 no. 3 (1997): 1131-50.

[80] Lee, Emery G. III, and Thomas E. Willging. "Litigation Costs in Civil Cases: Multivariate Analysis." Report to the Judicial Conference Advisory Committee on Civil Rules, Federal Judicial Center, 2010

[81] Levchenko, Andrei A. "Institutional quality and international trade." The Review of Economic Studies 74, no. 3 (2007): 791-819.

[82] Levy, David T. "The transactions cost approach to vertical integration: an empirical examination." The Review of Economics and Statistics (1985): 438-445.

[83] Liu, R. "Import competition and firm refocusing," Canadian Journal of Economics/Revue canadienne d'économique, 43 (2010), 440–466.

[84] Lucas Jr, Robert E. "On the size distribution of business firms." The Bell Journal of Economics (1978): 508-523.

[85] Macchiavello, Rocco. "Financial Development and Vertical Integration: Theory and Evidence", Working Paper, Warwick University, 2009

[86] Mayer, T., M. J. Melitz, and G. I. P. Ottaviano. "Market size, Competition, and the Product Mix of Exporters," American Economic Review, 104(2) (2014): 495-536.

[87] Midrigan, Virgiliu, and Daniel Yi Xu. "Finance and Misallocation: Evidence from Plant-Level Data." The American Economic Review 104, no. 2 (2014): 422-458.

[88] Moscoso Boedo, Hernan J., and Toshihiko Mukoyama. "Evaluating the effects of entry regulations and firing costs on international income differences." Journal of Economic Growth 17, no. 2 (2012): 143-170.

[89] Narayanan, G., Badri, Angel Aguiar and Robert McDougall, Eds. 2012. Global Trade, Assistance, and Production: The GTAP 8 Data Base, Center for Global Trade Analysis, Purdue University

[90] North, Douglass C. "Institutions, Institutional Change and Economic Performance." Cambridge University Press, 1990.

[91] Nunn, Nathan. "Relationship-specificity, incomplete contracts, and the pattern of trade." The Quarterly Journal of Economics 122, no. 2 (2007): 569-600.

[92] Nunn, Nathan, and Daniel Trefler, "Domestic Institutions as a Source of Comparative Advanage," Hanbook of International Economics, Volume 4. forthcoming.

[93] Oberfield, Ezra. "Business Networks, Production Chains, and Productivity: A Theory of Input-Output Architecture." Mimeo, Princeton University (2013)

[94] Ponticelli, Jacopo. "Court Enforcement and Firm Productivity: Evidence from a Bankruptcy Reform in Brazil." Mimeo, University of Chicago (2013)

[95] Poschke, Markus. The firm size distribution across countries and skill-biased change in entrepreneurial technology. No. 7991. IZA Discussion Paper, 2014.

[96] Rajan, Raghuram G., and Luigi Zingales. "Financial Dependence and Growth." The American Economic Review 88, no. 3 (1998): 559-586.

[97] Ramondo, Natalia, and Andres Rodriguez-Clare. "Trade, Multinational Production, and the Gains from Openness." Journal of Political Economy 121, no. 2 (2013): 273-322.

[98] Robins, J. and M. F. Wiersema. "A resource-based approach to the multibusiness firm: Empirical analysis of portfolio interrelationships and corporate financial performance," Strategic Management Journal, 16 (1995), 277–299.

[99] Romer, Paul M. "Endogenous technological change." Journal of Political Economy (1990): S71-S102.

[100] Rondi, L. and D. Vannoni. "Are EU leading firms returning to core business? Evidence on refocusing and relatedness in a period of market integration," Review of Industrial Organization, 27 (2005), 125–145.

[101] Rossi-Hansberg, Esteban, and Mark L. J. Wright. "Establishment Size Dynamics in the Aggregate Economy." American Economic Review, 97, no. 5 (2007): 1639-1666.

[102] Scherer, F. M. "Inter-industry technology flows and productivity growth," The review of economics and statistics (1982), 627–634.

[103] Schlesinger, Rudolf B., Hans W. Baade, Peter E. Herzog, and Edward M. Wise. Comparative law: cases, text, materials. Foundation Press, 2001.

[104] Schoar, A. "Effects of corporate diversification on productivity," The Journal of Finance, 57 (2002), 2379–2403.

[105] Schwartz, Alan, and Joel Watson. "The law and economics of costly contracting." Journal of Law, Economics, and Organization 20, no. 1 (2004): 2-31.

[106] Shapiro, Joseph S. "Trade, CO2, and the Environment." Mimeo, MIT (2013).

[107] Shavell, Steven. "Damage measures for breach of contract." The Bell Journal of Economics (1980): 466-490.

[108] Supreme Court of India. "Notes on Agenda Items, Chief Justices' Conference". Accessible at http://supremecourtofindia.nic.in/cjiconference/agenda2009.pdf (2009)

[109] Syverson, Chad. "What Determines Productivity?." Journal of Economic Literature 49, no. 2 (2011): 326-365.

[110] Treitel, Guenter Heinz. "Remedies for Breach of Contract" in: David and Von Mehren (eds.), International Encyclopedia of Comparative Law, Bd. VII, Tübingen 1976

[111] Treitel, Guenter Heinz. The law of contract. Stevens, 1987.

[112] US Department of Justice, Bureau of Justice Statistics, "Contract Cases in Large Counties" Accessible at http://www.bjs.gov/content/pub/pdf/ccilc.pdf (1996)

[113] Wernerfelt, Birger. "A resource-based view of the firm." Strategic management journal 5, no. 2 (1984): 171-180.

[114] Williamson, Oliver E. The economic institutions of capitalism. Simon and Schuster, 1985.

[115] World Bank. Doing Business 2013 (2013). Available from http://www.doingbusiness.org.

[116] World Bank. Global Economic Prospects, vol. 7 (2013), World Bank Publications.

[117] Zimmermann, Reinhard. The law of obligations: Roman foundations of the civilian tradition. Oxford University Press, 1996.

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