The Impact of Contract Enforcement Costs on Outsourcing and Aggregate Productivity

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Abstract

Contracting frictions affect the organization of firms, but how much does this matter on the aggregate level? This paper studies how costly supplier contract enforcement shapes the patterns of intermediate input use and quantifies the impact of these distortions on aggregate productivity and welfare. Using the frequency of litigation between US firms to measure the potential for hold-up problems, I find a robust relationship between countries' input-output structure and their quality of legal institutions: in countries with high enforcement costs, firms have lower expenditure shares on intermediate inputs in sector pairs where US firms litigate frequently for breach of contract. I adapt a Ricardian trade model to the study of intersectoral trade, and show that the variation in intermediate input shares that is explained by contracting frictions is large enough to generate sizeable welfare increases when enforcement institutions are improved.

Countries differ vastly in the speed and cost of formal contract enforcement: while Icelandic courts often resolve commercial disputes within a few months, cases in India that are decades old are commonplace.[1] A large and prominent literature has argued that these institutional frictions constitute transaction costs between firms, which affect their organizational choice and intermediate input sourcing decision (Williamson, 1985), and potentially even the pattern of development (North, 1990). The logic goes as follows: if enforcement of supplier contracts is costly or impossible, firms will perform a larger part of the production process in-house, instead of outsourcing it, thereby avoiding having to contract with an external supplier. Compared to a world with good enforcement, firms will have a lower expenditure on externally sourced intermediate inputs, and a higher cost of production. Higher production costs then feed into

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[1] Council of Europe (2005), Supreme Court of India (2009)

higher input prices in downstream sectors, thus amplifying the distortions on the macroeconomic scale.[2] While these Coasian transaction costs are widely acknowledged to determine firm-level outcomes such as the organization of production, we know little about whether they really matter for the aggregate economy and the level of development.

This paper studies the quantitative importance of legal institutions and imperfect contract enforcement for aggregate outcomes using recently developed tools from quantitative trade theory, together with data on contract enforcement costs and intermediate input expenditure shares across countries. I start by showing a set of correlations between industries' bilateral intermediate input expenditure shares, as observed in Input-Output tables, and the degree of contracting frictions between them— which I measure, similar to Rajan and Zingales (1998), as the product of the country's quality of contract enforcement in courts, and the industries' bilateral dependence on formal contract enforcement. To measure this dependence on formal enforcement, I construct an index of observed litigation between firms from two sectors using microdata on US case law: firms will only go to court when there is no other way to resolve hold-up problems, and this is when the quality of courts matters. The stylized fact that emerges is that in countries where the enforcement of supplier contracts in courts is more costly, intermediate input expenditure shares are lower in sector-pairs where litigation (in the US) is more prevalent: enforcement institutions affect not only the sectoral specialization of countries, but also the input mix used to produce in each of them. Since my measure of firm's dependence on enforcement is a bilateral (sector-pair-specific) measure, I can include fixed effects for upstream sectors $\times$ countries, and thereby control for a vast amount of industry characteristics that may be confounding the role of frictions in buyer-supplier relationships. This strategy allows me to separate the role of legal institutions in the enforcement of buyer-supplier contracts from its role in the provision of financing. The resulting correlations are consistent with theories where buyers of relationship-specific goods can hold up their suppliers, and where enforcement of contracts in a court is a solution to the hold-up problem as long as courts are sufficiently good.

How important is this cross-country variation in intermediate input shares that is explained by supplier contracting frictions? In order to link the differences in input shares to welfare, I construct a general-equilibrium model of domestic intersectoral trade. For each step in the production process, firms face the decision between performing it in-house using labor, which is frictionless, or outsourcing it to an external supplier, in which case they may benefit from a lower cost draw but are subject to contracting frictions that distort the cost of sourcing. These frictions are transaction costs in the spirit of Coase and Williamson. Hence, intermediate input shares are determined by the relative productivity under in-house production and under outsourcing, and by bilateral contracting frictions. This relationship resembles a gravity equation in international trade: contracting frictions reduce intermediate input shares in a similar way

[2] Nunn (2007) and Levchenko (2007) show that institutional quality affects comparative advantage of a country through this channel; see also the handbook chapter by Nunn and Trefler (2014). The idea of a 'multiplier effect' of intermediate input linkages goes back to Hirschman (1958), with more recent applications to development patterns by Ciccone (2002), and Jones (2011*a*,*b*).

to how iceberg trade costs reduce international trade shares. When frictions are large, firms perform a larger range of tasks in-house, resulting in lower expenditure shares on externally sourced intermediate inputs. Using results from theories of hold-up in bilateral buyer-supplier relationships, I identify the role of contract enforcement costs in shaping contracting frictions, and estimate the parameters of the gravity equation for intersectoral trade. I then study the importance of contract enforcement institutions for aggregate welfare by simulating the model under counterfactually low enforcement costs.

The exercise reveals that supplier contracting frictions distort intermediate input use to an extent that makes them relevant on the macroeconomic scale: even under the most conservative specifications, many countries would see their output grow by between two and ten percent if they had access to the enforcement institutions of the United States. The sectors that would benefit the most are those where intangible inputs and relationship-specific components are an important part of the production process: improvements in contracting institutions would allow firms to outsource these tasks and components to specialized suppliers. These improvements, however, need to be large enough to push firms to adopt formal contracting relationships: as long as firms prefer informal "gentlemen's agreements" over formally enforceable contracts, a marginal improvement in court quality will have no effect. The effects that I estimate are due to the improved contracting between buyers and sellers alone; they are not due to better access to financing or due to other benefits from improved legal institutions.

This paper is related to several different literatures. The first is the literature on legal institutions and trade, and includes, among others, contributions by Nunn (2007), Levchenko (2007), and Costinot (2009), who show that legal institutions determine countries' industry mix and comparative advantage. In contrast, I provide direct evidence that each industry's mix of *inputs* is distorted by poor enforcement; these distortions then increase the cost of production. The distinction is not only of interest by itself, but also yields a powerful new way to identify and quanitfy the role of enforcement institutions in shaping development. In its quantitative focus, the paper is perhaps most similar to Chor (2010), who evaluates how much legal institutions and other factors affect trade flows. In comparison, this paper studies the impact of legal institutions on domestic intersectoral trade flows. This has the advantage that the jurisdiction that governs contracts is known (international trade contracts are often written to be enforced in a third-party country); it also means that I can cover services trade, which not only accounts for a large fraction of economic activity, but is also particularly prone to hold-ups due to services being intangible by nature. This aspect also distinguishes the magnitude of results in this paper from those in the literature on quantitative trade models with multinational production[3]. Like this literature, I model firm boundaries as determined by transaction costs à la Coase and Williamson; I emphasize, however, that these transaction costs arise from contracting frictions, as in the property rights approach to international firm boundaries (see Antràs (2015) for a survey).

[3]See recent contributions by, among others, Garetto (2013), Tintelnot (2016), Irarrazabal et al. (2013), Fally and Hillberry (2015), and Ramondo and Rodriguez-Clare (2013).

The paper is also related to the burgeoning literature on the importance of intermediate inputs and linkages for productivity and, more generally, the level of development[4]. This literature typically takes the structure of intersectoral linkages as exogenous, or even uses the US input-output table to describe the industry structure in other countries. In contrast, I show that input-output tables differ substantially and systematically across countries and exploit this variation in the empirical analysis. In the model I endogenize the sectoral composition of the firm's input baskets.[5]

Finally, the paper is related to the literature on legal institutions and their macroeconomic effects. This literature typically uses reduced-form regressions to evaluate the overall importance of institutions for growth and development.[6] In contrast, this paper uses a structural approach to identify the effects of legal institutions through one particular channel — the enforcement of supplier contracts. This channel is independent of other functions of legal institutions, such as the protection of financial investors[7], the enforcement of employment contracts[8], or the provision of incentives to invest in better technology[9].

The paper proceeds as follows. Section 1 introduces the data and studies the relationship between intermediate input use and contracting frictions using linear regressions. These correlations motivate a model where contracting frictions reduce intermediate input use. I describe this model in Section 2. The model yields structural equations that are the nonlinear equivalent to the reduced-form regressions of Section 1. Section 3 discusses identification and estimation of the parameters, and conducts exercises to evaluate the importance of court quality for the contracting environment and for aggregate outcomes. Section 4 concludes.

1 Reduced-form Empirical Evidence

1.1 Empirical Strategy

My approach to identifying the importance of legal institutions relies on the differences in the degree to which buyers and sellers require formal enforcement of contracts. Some transactions will be unaffected by the quality of legal institutions, such as when the presence of spot markets

[4]See, among others, Hirschman (1958), Rodriguez-Clare (1996), Ciccone (2002), Jones (2011*a*,*b*), Caliendo and Parro (2015), Oberfield (2013), and Bosker and Westbrock (2016). Bartelme and Gorodnichenko (2014) document the cross-country dispersion in intermediate input shares and link it to the patterns of development. Similarly to this paper, Caliendo et al. (2017) argue that distortions to intermediate input use are important; however, they refrain from attaching any particular interpretation to the distortions.

[5]There is ample evidence that access to suppliers and inputs is important for firm's performance; see empirical work by Johnson et al. (2002), Goldberg et al. (2010), Halpern et al. (2015), and Bernard et al. (2015).

[6]See Rajan and Zingales (1998), La Porta et al. (1997), Djankov et al. (2003), Acemoglu and Johnson (2005), Acemoglu et al. (2009), and many others.

[7]See Ponticelli and Alencar (2016) on the quantitative effects of bankruptcy reform in Brazil, and Laeven and Woodruff (2007) and Chemin (2012) on judicial efficiency and firm size and productivity in Mexico and, respectively, India.

[8]See recent work by Grobovsek (2014).

[9]In related theoretical work, Acemoglu et al. (2007) show that supplier contracting frictions in the sourcing of intermediate inputs may lead firms to adopt inferior technologies.

or relational contracts guarantee the efficient outcome. The literature on incomplete contracts, following Klein et al. (1978), has given various justifications for contracts being incomplete: either the terms of the contract are not describable (in which case the incompleteness stems from the nature of the good or service being transacted), or judges do not understand them, or the costs of enforcement are prohibitively high. In the latter two cases the incompleteness originates from the quality of the judicial or legal institutions. In the former case, however, the quality of institutions will not matter for performance in the bilateral buyer-seller relationship.

I study the correlation between the input-output structure of an economy, which captures the inter-sectoral flows of goods and services, and the quality of its legal institutions. More specifically, I estimate the following reduced-form regression:

$$\frac{X_{ni}^c}{X_n^c} = \beta\delta^c \times z_{ni} + \alpha_{ni} + \alpha_i^c + \alpha_n^c + \varepsilon_{ni}^c \tag{1}$$

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 the cost of enforcing contracts (and hence inversely related to the quality of legal institutions); z_{ni} is a bilateral measure of how much sectors n and i depend on formal enforcement of contracts; 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. The intermediate input expenditure shares on the left-hand side of equation (1) are directly observed in input-output tables. In the field of input-output analysis they are called the "empirical technical input coefficients" (see, for example, Miller and Blair, 2009), and are typically seen as exogenous parameters that describe the technical requirements of the production process.

In equation (1), country- and sector-pair-specific expenditure shares are explained by an interaction of a country characteristic (the quality of legal institutions) with a sector-pair characteristic (the dependence on formal enforcement) and sector-pair fixed effects. Hence, the coefficient β captures the correlation of interaction term and left-hand side within sector pairs and across countries. If β is negative, countries that have worse legal institutions have lower intermediate input shares in sector-pairs that rely heavily on formal enforcement. Additional fixed effects, along the upstream sector $\times$ country and downstream sector $\times$ country dimensions, further conditionalize this correlation on attributes that vary along these dimensions.

Equation (1) is similar to the functional form used by Rajan and Zingales (1998) and many subsequent papers, who explain country-sector-level variables using an interaction of a country-specific variable (often institutions or, as in the original paper, access to financial markets) with a sector-specific variable, while controlling for country- and sector-attributes using fixed effects. In order to interpret a significant coefficient on the interaction term as a causal effect, this literature typically goes to great lengths to try to control for the plethora of confounding factors that co-vary with the interaction term. Equation (1) improves on this by exploiting variation across three different dimensions (country, upstream, and downstream sector). Hence, I can include fixed effects at the sector $\times$ country level, thereby controlling for unobserved heterogeneity in the upstream and downstream sectors.

Equation (1) also decomposes the variation of intermediate input shares into variation along different dimensions. In order to find any significant conditional correlation β, there must be cross-country variation in the left-hand side, and hence in input-output tables in general. If input-output tables are either the same across countries, or if the differences are very small (as a large number of papers tacitly assumes), then the sector-pair fixed effect should explain most of the variation in the left-hand side. The conditional correlation with the interaction term will likewise be zero if the variation in input-output tables is pure noise. We will see that neither of that is the case.

The regression equation is also similar to the ones proposed by Nunn (2007) and Levchenko (2007), who show that in countries with bad institutions, sectors that rely heavily on legal institutions trade relatively less with foreign countries. International trade contracts, however, may in principle be governed by the law of any trading partner, or even a third-party country. The advantage of using input-output relationships to study the importance of institutions is that one can be almost certain that the vast majority of transactions are governed by the local law and institutions. In addition, there is an additional dimension of variation in the data, which will help to distinguish contracting frictions from productivity differences across countries and sectors.

1.2 Data

Intermediate Input Expenditure Shares My data on intermediate input expenditure shares comes from the GTAP 8 database, (Narayanan et al., 2012), the largest available cross-sectional collection of input-output tables. GTAP contains tables from 109 countries, from varying years ranging from the 1990's to mid-2000 (see Appendix A), but all based on the 1993 System of National Accounts. These tables typically originate from national statistical sources and have been harmonized by GTAP to make them internationally comparable. A notable feature 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. My main variable of interest is X_{ni}/X_n — the share of expenditure of sector n on intermediate inputs from sector i, in gross output of sector n. Whenever not mentioned explicitly, these intermediate input purchases include imported inputs. All results are robust to excluding imported intermediate inputs (see Appendix D).

Quality of legal institutions / enforcement costs My measure of institutional quality δ^c is the "cost of contract enforcement" from the World Bank Doing Business survey. This variable measures the monetary cost necessary to enforce a standardized fictional supplier contract in a court, and is collected through surveys of local law firms. 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 cost of enforcement from Doing Business has been widely used to proxy for the quality of contract enforcement (e.g. Acemoglu et al., 2009, Nunn, 2007). While no measure of institutional quality is without drawbacks, there are two reasons why this particular measure lends itself well to my purposes: first, it is not based on observed litigation, and hence does not suffer from a potential bias due to firms switching to informal contracts when enforcement costs are too high. Second, unlike indices that aggregate over different dimensions of institutional quality, it has a direct quantitative interpretation. This will be useful when studying the quantitative importance of enforcement institutions in Section 3.

Dependence on Enforcement I construct a novel measure of dependence on formal enforcement from data on observed litigation between firms. My measure is the frequency with which firms from a particular sector-pair resolve conflicts in court, or more specifically, the number of court cases between two sectors over a fixed period of time, per buyer-seller relationship. I collect this data for one particular country where legal institutions are good (the United States), so that institutional quality itself is not censoring the prevalence of litigation in an asymmetric way across sectors.

My data come from the LexisLibrary database provided by LexisNexis, which covers 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 by Bureau Van Dijk. Orbis contains the 4-digit SIC industry classification of firms; I thus know in which sectors the plaintiffs and defendants are active in. I count the cases by (unordered) pair of sectors, and assign the plaintiffs and defendants to the two sectors in proportion to the expenditure flows in the US input-output table.[10] 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 between firms from each pair of sectors. My first proxy for this variable is the geometric mean of the number of firms in each sector, which reflects that the number of trading relationships will generally be increasing in the number of firms in each sector. This yields a measure $z_{ni}^{(1)}$.[11] As an alternative, I use data from Japan, where the number of buyer-seller relationships by sector-pair can be constructed from microdata, to fit a linear model describing the number of relationships with the number of firms in each sector and the input-output expenditure shares, and then use the

[10] If sales from the petroleum to the chemicals industry account for 80% of the total sales between petroleum and chemicals, then I assume that 80% of the cases between petroleum and chemicals are related to sales of petroleum to chemicals. Appendix D shows results using a measure where the plaintiff is the seller, which is by far the most common case. All results also hold using these measures.

[11] Results are robust to (1) using the number of cases divided by the number of upstream sector firms (or downstream sector firms) as a measure of enforcement-intensity; (2) using the number of firms from the Census Bureau's Statistics on U.S. Businesses instead of the number of firms in Orbis.

predicted value for the US to normalize the number of cases, yielding a measure $z_{ni}^{(2)}$.[12] These two measures are capturing to the likelihood of litigation, and hence enforcement-intensity, in each pair of sectors. Appendix A provides detailed information on the construction procedure of numerator and denominator in both measures, discusses the content of cases for particular sector pairs, and compares the measures to existing measures of dependence on institutions.

$$z_{ni}^{(1)} = \frac{(\#\text{ cases between sectors } i \text{ and } n)}{\sqrt{(\#\text{ firms in sector } i)\,(\#\text{ firms in sector } n)}} \tag{2}$$

$$z_{ni}^{(2)} = \frac{(\#\text{ cases between sectors } i \text{ and } n)}{(\#\text{ buyer-seller } \widehat{\text{relationships}} \text{ between } i \text{ and } n)} \tag{3}$$

Table 1 shows the ranking of upstream sectors by the average degree of enforcement-intensity, as measured by $z_{ni}^{(1)}$ (the ranking for $z_{ni}^{(2)}$ is similar). Services sectors are on average more enforcement-intensive than manufacturing sectors, which are in turn more enforcement-intensive than raw materials-producing sectors. 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. A similar ranking is usually regarded to apply to the degree of relationship-specificity of inputs (Monteverde and Teece, 1982, Masten, 1984, Nunn, 2007). Hence, my measure is consistent with the view that relationship-specific investment leads to an increased dependence on formal enforcement.

Figure 1 shows the within-sector variation in $z^{(1)}$ in more detail. There is much litigation between firms belonging to the same sector, as the diagonal in the matrix demonstrates. Many of these disputes arise in the licensing of intellectual property, which, due to its intangible nature, relies heavily on enforcement by courts. But even apart from the diagonal, the firms' propensity to litigate seems to vary considerably across different buyer sectors: transport equipment sales, for example, are more likely to be associated with litigation when the buyer is from the ocean shipping industry, than when she belongs to the land transport industry ("transport n.e.c."). Sometimes, as in this case, the different litigation rates arise because goods and services supplied to different sectors have different characteristics, which then lead to different likelihoods of disputes; in other cases it is due to particular market structures or regulation. Appendix A.3.3 documents some of these differences based on the case descriptions in LexisLibrary.

The above measures are related to existing measures of dependence on legal institutions[13], but differ in three important ways. First, the existing measures are only available for physical

[12]The exact procedure, as well as results on the goodness of fit, are in Appendix A.3.2. I am grateful to Andreas Moxnes for sharing the statistics on the number of Japanese buyer-seller pairs. See Bernard et al. (2015) for more detailed information on the data source.

[13]Nunn (2007) uses the fraction of a sector's inputs that are traded on an organized exchange to describe relationship-specificity, arguing that legal institutions will matter only when relationship-specific investment lead to hold-ups. Levchenko (2007) uses the Herfindahl index of input shares to measure product complexity, with more complex products relying more heavily on institutions. Bernard et al. (2010) measure contractability as the weighted share of wholesalers in overall importers.

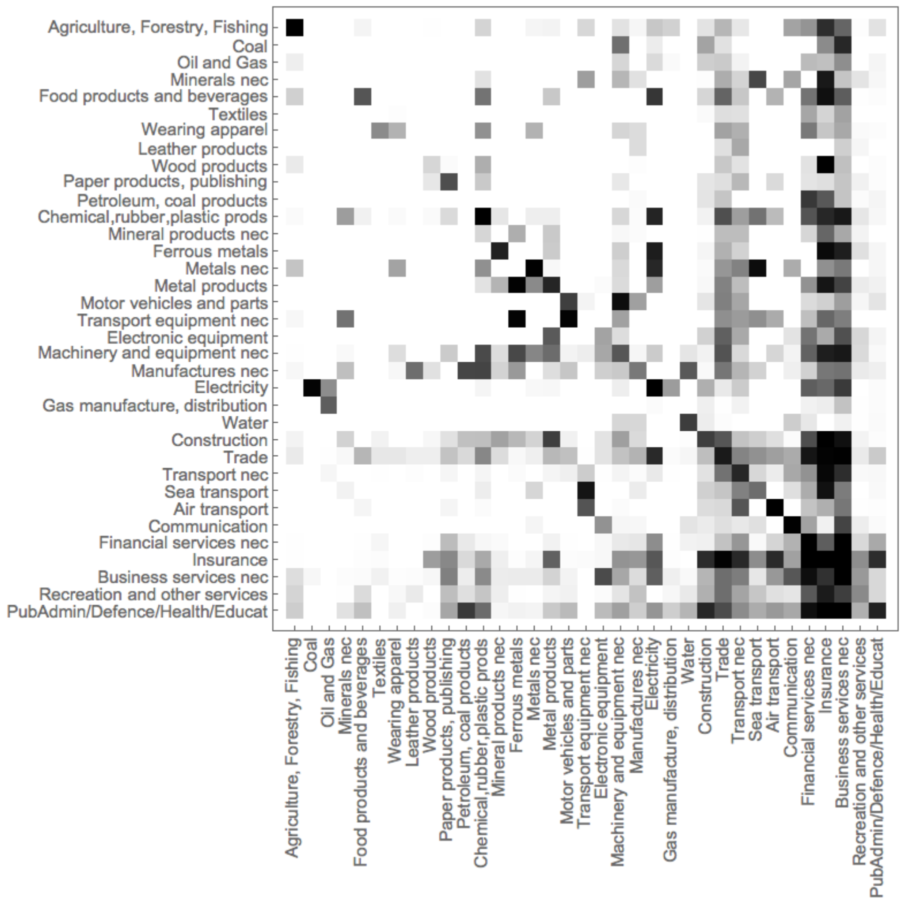

Figure 1: Enforcement-intensity $z^{(1)}$

Note: Figure shows the enforcement-intensity measure $z^{(1)}$ by sector pair. Selling sector is on the x-axis, buying sector on the y-axis. Darker shades indicate higher values. Values have been monotonically transformed to improve readability.

goods, whereas my measures cover services sectors as well. This extension is important because services contracts seem to rely heavily on formal enforcement — at least in the United States — and they account for a large share of intermediate inputs and of overall economic activity. Second, the existing measures rely heavily on each sector's intermediate input mix, which, as I will show further below, varies sharply across countries and is likely to depend on the country's quality of institutions. Third, my measure varies across bilateral sector-pairs, instead of being associated with the upstream sector. Given that the sectors in the input-output table 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, and that the form of interaction varies with the trading partner.

Using observed litigation to measure the dependence on formal enforcement has advantages and drawbacks. One advantage is that it allows me to ignore the many different possible solutions to the hold-up problem that the microeconomic literature has pointed out: if we observe firms going to court, it must mean that the other solutions are not applicable or have failed. The main disadvantage of using observed litigation is that firms may rely on it even if we do not observe it: if payoffs under enforcement are deterministic and common knowledge and enforcement is costly, then parties will settle in advance. Here lies the main difference between observed

Table 1—: Average enforcement-intensity of upstream sectors, $z_{ni}^{(1)}$ measure.

Upstream sector	$\overline{z_{ni}^{(1)}} \cdot 10^4$	Upstream sector	$\overline{z_{ni}^{(1)}} \cdot 10^4$
Insurance	1.515	Paper products, publishing	0.103
Business services nec	1.307	Manufactures nec	0.097
Financial services nec	0.863	Transport equipment nec	0.095
Trade	0.483	Recreation and other services	0.090
Electricity	0.399	Mineral products nec	0.082
Chemical,rubber,plastic prods	0.371	Electronic equipment	0.082
Transport nec	0.337	Petroleum, coal products	0.080
Machinery and equipment nec	0.225	Water	0.072
Air transport	0.211	Coal	0.069
Communication	0.205	Minerals nec	0.049
Ferrous metals	0.205	Food products and beverages	0.048
Construction	0.199	Oil and Gas	0.036
Sea transport	0.194	Wearing apparel	0.031
Metal products	0.176	Wood products	0.028
Metals nec	0.147	Gas manufacture, distribution	0.027
Agriculture, Forestry, Fishing	0.130	Leather products	0.023
Motor vehicles and parts	0.130	Textiles	0.021
PubAdmin/Defence/Health/Educat	0.121		

Note: The table shows the enforcement-intensity $z_{ni}^{(1)}$ of an upstream sector i, averaged across downstream sectors.

litigation and relationship-specificity: only when the investment is relationship-specific, legal institutions may matter; the reverse is not necessarily true. Hence, relationship-specificity is necessary for institutions to matter in the contracting, whereas observing litigation is sufficient. I will return to these considerations when interpreting the correlations.

1.3 Cross-country Dispersion in Input-Output Tables

Before turning to the regression results, I show some moments of the intermediate input shares to dispel the myth that input-output tables are the same across countries. Table 2 shows the dispersion of intermediate input shares at the two-digit level from their respective cross-country means. 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. For the average sector pair, the cross-country dispersion in materials shares equals 2.3 times the mean. Most striking, however, is that there is a sizeable number of sector-pairs for which the cross-country dispersion in input expenditure shares is high: for five percent of sector pairs, the standard deviation is greater than 10 percentage points, and for ten percent of sector pairs, the standard deviation is more than four times as high as the mean. Hence, input-output tables are not the same across countries.

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 that 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 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 enforcement-intensive (Table 1 above), whereas the percentage-wise cross-country dispersion in input shares on the (not very enforcement-intensive) oil and gas and petroleum and coal products sectors is relatively low. This suggests that contracting frictions may play a role for external intermediate input use. In the remainder of this section I will try to rule out alternative explanations.

1.4 Results

Table 3 presents the results of estimating equation (1) using ordinary least squares (coefficient estimates are standardized betas). 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. In columns (5) and (6) the regression also includes 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. Overall, Table 3 shows that in countries where enforcement costs are high, firms use less intermediate inputs in sector-pairs where litigation is more prevalent in the United States. The estimates in columns (5) and (6), my preferred specifications, imply that a one-standard deviation increase in each of the interacted variables is associated with a decrease in the input share by 0.3 and 0.2 percentage points, respectively.

Table 4 shows results when controlling for additional variables. As a large literature points out, contracting institutions are correlated with financial development. In order to make sure that the observed correlation is indeed coming from contracting institutions, and not from financial development, columns (1) and (2) control for interactions of financial development (as measured by the ratio of private debt to GDP) with enforcement-intensity. The coefficient of interest remains negative and significant, suggesting that prior specifications were not confounding the two. Interestingly, countries that are financially well-developed do seem to use more intermediate inputs in sector pairs where litigation is frequent. There are many possible explanations for this: credit market imperfections may lead to production being concentrated among larger firms, which may find it easier to produce inputs that are tailored to their production process. Alternatively, better access to financing may build trust between firms, and

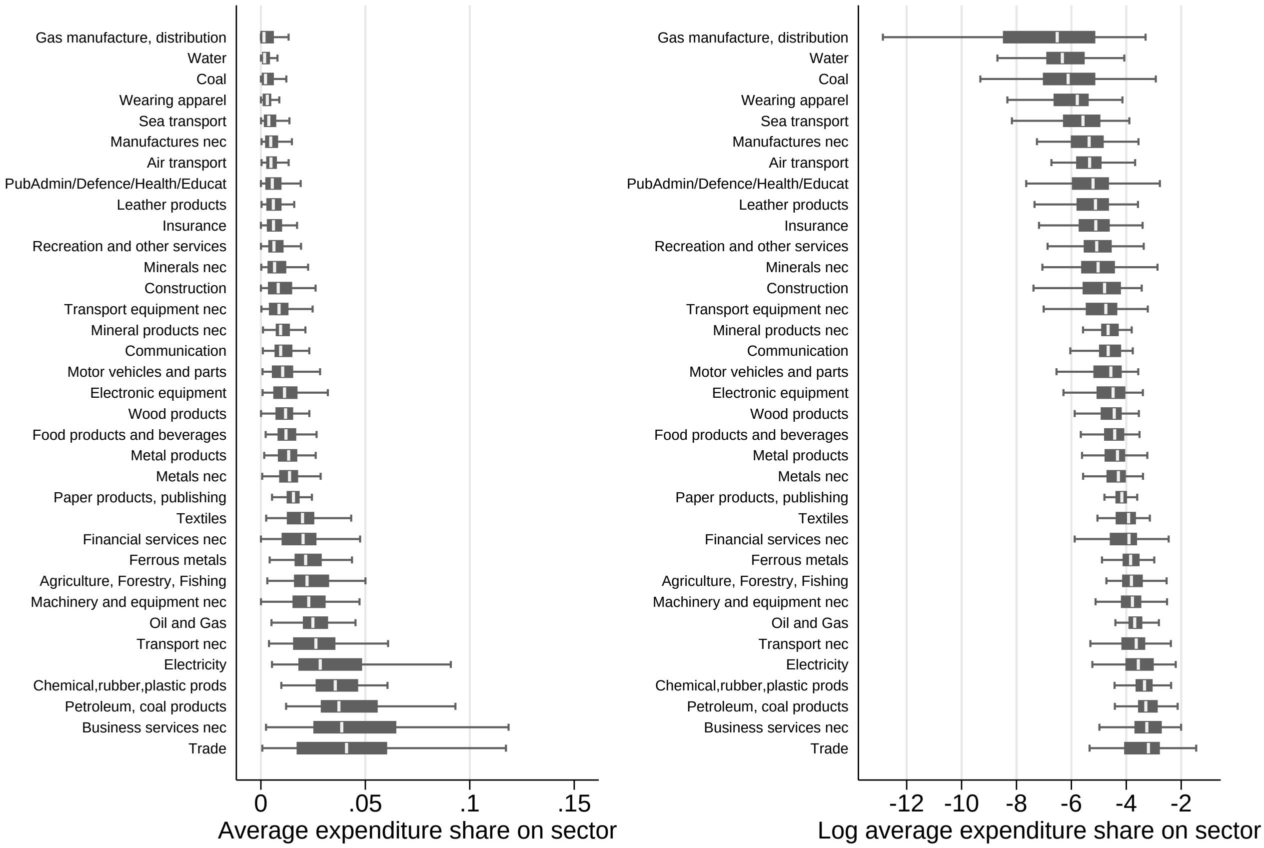

Figure 2: Cross-country distribution of input shares by upstream sector

Note: Figure shows the cross-country distribution of average intermediate input expenditure shares, by upstream sector. Averages are unweighted, and are taken within each country across downstream sectors.

Table 2—: Cross-country dispersion in two-digit intermediate input shares

I. Average standard deviations and coefficient of variation of intermediate input shares

	$\overline{\sigma}$	$\overline{\sigma/\mu}$
All sector pairs	.023	2.3
Goods-producing upstream sectors only	.020	3.5
Services-producing upstream sectors only	.028	1.9

II. Frequency distribution of standard deviations and coefficient of variation

Standard deviation			Coefficient of variation		
Category	# sector pairs	% of total	Category	# sector pairs	% of total
All	1225	100			
$\sigma_{ni} < .02$	838	68.4	$\sigma/\mu < 1$	119	9.7
$.02 < \sigma_{ni} < .04$	194	15.8	$1 < \sigma/\mu < 2$	536	43.6
$.04 < \sigma_{ni} < .06$	68	5.6	$2 < \sigma/\mu < 3$	309	25.2
$.06 < \sigma_{ni} < .08$	46	3.8	$3 < \sigma/\mu < 4$	135	11.0
$.08 < \sigma_{ni} < .1$	18	1.5	$4 < \sigma/\mu < 6$	93	7.6
$.1 < \sigma_{ni} < .15$	34	2.8	$6 < \sigma/\mu < 8$	22	1.8
$\sigma_{ni} > .15$	27	2.2	$\sigma/\mu > 8$	11	0.9

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 and coefficients of variation. All intermediate input shares cover both domestically and internationally sourced inputs.

Table 3—: The Correlation of Intermediate Input Shares and Contracting frictions

	Dependent variable: X_{ni}/X_n					
	(1)	(2)	(3)	(4)	(5)	(6)
$\delta^c \times z_{ni}^{(1)}$	-0.035***		-0.040***		-0.043***	
	(0.0069)		(0.0091)		(0.0095)	
$\delta^c \times z_{ni}^{(2)}$		-0.028***		-0.034***		-0.037***
		(0.0046)		(0.0071)		(0.0074)
Country FE	Yes	Yes				
Upstream × Downstream FEs	Yes	Yes	Yes	Yes	Yes	Yes
Upstream × Country FEs			Yes	Yes	Yes	Yes
Downstream × Country FEs					Yes	Yes
R^2	0.449	0.449	0.531	0.531	0.537	0.537
Observations	133525	133525	133525	133525	133525	133525

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. Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

may allow them to overcome hold-up problems through relational contracts. Without firm-level data these explanations are hard to distinguish. Columns (3) to (6) of Table 4 also control for interactions of enforcement-intensity with per-capita income. Again the coefficient of interest remains negative and significant.

Table 5 turns to regressions on subsamples. Columns (1) and (2) include only pairs of sectors that produce physical goods (i.e. agriculture, mining, and manufacturing; the top left square of the input-output table), and columns (3) and (4) include only pairs of services sectors (the bottom right square). Notice two things: firstly, the coefficients are larger than in the benchmark. Perhaps firms are more willing to produce an input in-house if they are in a related business. Secondly, the coefficient in the services-only subsample is substantially larger than in manufacturing. A plausible explanation would be that firms face more discretion over their choice of services tasks in the production process. Managers in developing countries may not see accounting or R&D as vital to their production, and neglect those activities when expecting difficulties in sourcing them.

Let's take a closer look at how δ^c and z_{ni} interact. Table 6 shows the results of a regression of intermediate input shares on interactions of the enforcement-intensity measures with dummies for whether enforcement costs are in each of the five quintiles of the cross-country distribution of enforcement costs (the first quintile being the base category):

$$\frac{X_{ni}^c}{X_n^c} = \sum_{j=2}^{5} \beta_j \mathbf{1}\left(\delta^c \in \text{Quintile } j\right) \times z_{ni} + \alpha_{ni} + \alpha_i^c + \alpha_n^c + \varepsilon_{ni}^c$$

and likewise with interactions of quintile dummies for enforcement-intensity z with δ. We see that the correlation with the interaction term is only significant when enforcement costs (respectively, z) are in the highest quintile. This is in line with the view that when enforcement

Table 4—: Contracing Institutions vs. Financial Development vs. Overall Development

	Dependent variable: X_{ni}/X_n					
	(1)	(2)	(3)	(4)	(5)	(6)
$\delta^c \times z_{ni}^{(1)}$	-0.029**		-0.019*		-0.021*	
	(0.0099)		(0.0094)		(0.011)	
$\delta^c \times z_{ni}^{(2)}$		-0.026**		-0.018*		-0.020*
		(0.0078)		(0.0077)		(0.0084)
$FINDEV^c \times z_{ni}^{(1)}$	0.050***				0.041***	
	(0.010)				(0.012)	
$FINDEV^c \times z_{ni}^{(2)}$		0.040***				0.032***
		(0.0082)				(0.0094)
$\log GDPC^c \times z_{ni}^{(1)}$			0.22**		0.093	
			(0.068)		(0.076)	
$\log GDPC^c \times z_{ni}^{(2)}$				0.18***		0.074
				(0.049)		(0.054)
Upstream × Downstream FEs	Yes	Yes	Yes	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.54	0.54	0.54	0.54	0.54	0.54
Observations	132300	132300	133525	133525	132300	132300

Note: Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

costs are sufficiently low, parties use formal contracts that are enforceable in courts. In such cases, product-specific attributes that determine the scope for hold-ups do not affect performance in the bilateral relationship: once you can cheaply enforce your contract in the court, how relationship-specific your good is does not matter anymore. When you get held up, you either threaten to enforce the contract, or to sell the goods to a third party — but not both. I will return to these considerations when writing the model in Sections 2 and 3.

1.5 Discussion

It is important to stress that the significant coefficient of the interaction term cannot be interpreted as evidence for a "causal effect". Naturally, the quality of legal institutions is going to determine to some extent whether firms litigate; hence, even if we had data on litigation in every country, it would not make sense to use it in place of z_{ni}. In other words, the true model for X_{ni}/X_n will not be a linear one with δ^c times a frequency of litigation on the right hand side. Instead, the tables above show statistically significant correlations, from which we can draw some conclusions, and which will guide the model. But it does not make sense to speak of "endogeneity" in this context: the estimated coefficient does not have an interpretation as a parameter of an economic model. In Sections 2 and 3 I will, however, construct such a model where input-output relationships and litigation are jointly determined by productivity parame-

Table 5—: Within Manufacturing & Within Services

	Dependent variable: X_{ni}/X_n			
	(1)	(2)	(3)	(4)
$\delta^c \times z_{ni}^{(1)}$	-0.047**		-0.11***	
	(0.015)		(0.023)	
$\delta^c \times z_{ni}^{(2)}$		-0.040***		-0.10***
		(0.010)		(0.020)
Upstream × Downstream FEs	Yes	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes	Yes
Sample	M only	M only	S only	S only
R^2	0.64	0.64	0.47	0.47
Observations	48069	48069	21364	21364

Note: Table shows standardized betas, with standard errors clustered at the country level. For columns (1) and (2), the sample consists of all sector pairs where both sectors are producing physical goods (agriculture, mining, and manufacturing); for columns (3) and (4) the sample consists of all sector pairs where both sectors are services sectors.

ters, institutions, and product-specific attributes. This model will yield an estimating equation where a corresponding parameter estimate can be interpreted as capturing the magnitude of a causal effect.

So what do these correlations tell us? First of all, they are consistent with the view that good formal enforcement helps with overcoming holdup problems when sourcing intermediate inputs, in line with the empirical results of Nunn (2007) and Levchenko (2007) at the industry level, and the results of Johnson et al. (2002) at the firm level. Secondly, while there may be alternative ways to get around holdup problems (relational contracts, hostages, option contracts — ways that do not depend on the characteristics of the product being traded), these do not seem to be a perfect substitute for formal enforcement in courts: if they were, the correlation would disappear. Thirdly, for some sector-pairs formal and informal enforcement are indeed substitutes: when a product is not relationship-specific, firms will use informal contracts and never litigate; for these sector-pairs the quality of legal institutions is not correlated with intermediate input use. Likewise, when formal enforcement costs are low, the degree of relationship-specificity does not matter (Table 6).

Stronger contracting frictions are associated with lower intermediate input use. But is that because the firm vertically integrates, or because it decides to use a production technology that omits certain inputs? Both interpretations are consistent with the above results. Input-Output tables are typically constructed at the plant level, and are therefore not fully conclusive about the extent of vertical integration.[14] That said, there are several arguments that suggest that a lot of the variation in intermediate input use is coming from different degrees of vertical

[14]There is, however, a large related literature in industrial organization that measures the degree of vertical integration as the fraction of value added in gross output (see Adelman, 1955, Levy, 1985, Holmes, 1999, and also Macchiavello, 2012).

Table 6—: Conditional correlations for different degrees of enforcement costs

	Dependent variable: X_{ni}/X_n			
	Using $z_{ni}^{(1)}$	Using $z_{ni}^{(2)}$	Using $z_{ni}^{(1)}$	Using $z_{ni}^{(2)}$
	(1)	(2)	(3)	(4)
$\mathbf{1}\,(\delta^c \in$ 2nd Quintile $) \times z_{ni}$	0.0076	0.0017		
	(0.010)	(0.0081)		
$\mathbf{1}\,(\delta^c \in$ 3rd Quintile $) \times z_{ni}$	-0.0070	-0.010		
	(0.0087)	(0.0071)		
$\mathbf{1}\,(\delta^c \in$ 4th Quintile $) \times z_{ni}$	-0.0074	-0.011		
	(0.011)	(0.0083)		
$\mathbf{1}\,(\delta^c \in$ 5th Quintile $) \times z_{ni}$	-0.024*	-0.024**		
	(0.010)	(0.0082)		
$\mathbf{1}\,(z_{ni} \in$ 3rd Quintile $) \times \delta^c$			-0.0042	-0.0018
			(0.0032)	(0.0037)
$\mathbf{1}\,(z_{ni} \in$ 4th Quintile $) \times \delta^c$			-0.0058	-0.0033
			(0.0061)	(0.0059)
$\mathbf{1}\,(z_{ni} \in$ 5th Quintile $) \times \delta^c$			-0.029**	-0.028**
			(0.011)	(0.0096)
Upstream × Downstream FEs	Yes	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes	Yes
R^2	0.537	0.537	0.537	0.537
Observations	133525	133525	133525	133525

Note: Table shows standardized betas, with standard errors clustered at the country level. In columns (3) and (4), the base category for the interactions are the observations where z is zero, which account for the first two quintiles of the z distribution. * $p < 0.05$, ** $p < 0.01$.

integration. Firstly, Atalay et al. (2014) and Ramondo et al. (2016) show that shipments of physical goods between vertically integrated plants are very low; in the case of the former paper, less than 0.1 percent of overall sales for the median plant. Hence, most of the intermediate input use that one observes in Input-Output tables are going to be transactions across firm boundaries. Secondly, even though the SNA 1993, which underlies the construction of the Input-Output tables, mandates the recording of all types of intermediate inputs that come from outside the unit of observation (the plant), it is a fact of the data collection process that services inputs that come from within the firm are typically not priced, and therefore have no expenditure associated with it. Hence, services inputs would typically only show up in input-output tables if they are coming from outside the firm. Variation in the services input shares will therefore be variation in the use of services sourced from other firms (cf. columns (3) and (4) of Table 5). Thirdly, Ferguson and Formai (2013) extend the work of Nunn (2007) to show that contracting institutions shape comparative advantage less for industries that have the ability to vertically integrate, suggesting that integration alleviates (at least to some extent) the hold-up problem. Similar evidence is also found on the microeconomic level: Boehm and Oberfield (2017) study detailed microdata on outputs and inputs of Indian manufacturing plants and argue that plants perform a larger range of production steps within the plant when judicial institutions are poor.

Finally, I mention some additional results and robustness checks. The correlations between contracting frictions and the intermediate input shares are certainly not smaller (if anything, it it larger) for homogeneous-good-producing sectors, suggesting that firms producing lower quality products when contracting frictions are large is not the main driver of the correlation reported above. Furthermore, the negative correlation remains statistically significant (a) when having the input-output share with domestically source intermediate inputs only on the left hand side; (b) when excluding the top three most litigous sectors — insurance, business services, and financial services; (c) when controlling for interactions of δ^c with the US input-output shares; (d) when replacing z_{ni} by a measure of relationship-specificity using Rauch's classification of goods, in the spirit of Nunn (2007). Furthermore, they are not driven by problems in the measurement of intermediate inputs in developing countries. The interested reader can find all this in Appendix D.

2 A Quantitative Model of Input Sourcing

This section presents a simple macroeconomic model where firms face the decision between producing in-house and outsourcing. The purpose of the model is twofold: to explain how differences in input-output shares emerge from differences in productivity patterns and from frictions, and to present a framework for empirical work, in which productivity differences and contracting frictions can be identified and their importance for aggregate outcomes evaluated. The model explains the correlations from the preceding section, and allows me to link them to welfare. It also tackles the issue that litigation is an outcome of institutional quality itself.

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 the modes of sourcing. I then 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. Intersectoral intermediate input flows hence follow a "gravity" equation. Contracting frictions enter the expression for intermediate input shares in the same way that iceberg trade costs enter the expression for trade shares in Ricardian trade models.

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 inputs $\{(q_{ni}(j), j \in [0,1]\}_{i=1,\ldots,N}$ into output y_n

according to the production function[15]

$$(4) \qquad y_n = \prod_{i=1}^{N} \left(\int_0^1 q_{ni}(j)^{(\sigma_n - 1)/\sigma_n} dj \right)^{\frac{\sigma_n}{\sigma_n - 1}\gamma_{ni}}, \quad n = 1, \dots, N.$$

where $\sum_i \gamma_{ni} = 1$ for all $n = 1, \dots, N$. The sets $\{(n, i, j), j \in [0, 1]\}_{i=1,\dots,N}$ 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 $i \in \{\text{metal, electricity, R\&D}, \dots\}$ 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) in each basket (n, i). The firm faces the outsourcing decision for every (n, i, 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} captures the weight of the broad set of inputs i in the production process of sector n: $\gamma_{cars,steel}$ will be high, whereas $\gamma_{cars,agriculture}$ 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 by the existence of inter-firm transaction costs, as in the transaction-cost economics literature on the vertical integration problem (see Williamson, 1985) and by the existence of firm-specific capabilities, as emphasized by Wernerfelt (1984). 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. Once the decision of whether to outsource has been taken, it is irreversible. I discuss each of the two options in turn.

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,

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

[15] 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 productivity draws $s_{ni}(j)$ are independent across i, j, and n. The parameter S_n captures the overall productivity of in-house production by 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 wage by w, and the cost of one unit of activity (n, i, j) under on in-house production by $p^l_{ni}(j)$. Then,

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

Outsourcing. Alternatively to in-house production, sector n firms can outsource production of activity (n, i, j) to the the upstream sector i. For each activity (n, i, j), there is one sector i firm that can produce it, and firms are monopolistically competitive in the market for activities. Each sector i firms can transform one unit of sector i output (produced using the production function (4)) into $t_{ni}(j)$ units of its activity (n, i, j), thus the production function is $q_{ni}(j) = t_{ni}(j)y_i(n, i, j)$, with $y_i(n, i, j)$ being the amount of sector i goods used as inputs.[16] Again I assume that the $t_{ni}(j)$ follow a Fréchet distribution,

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

and that they are independent 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 $c_{ni}(j) = p_i/t_{ni}(j)$, where p_i is the price index of sector i's output good, (4).

Institutions. Assume further that outsourcing is subject to contracting frictions that take the form of a multiplicative wedge $d_{ni} \geq 1$ on the cost of the activity (but that it is not a resource cost). One should think of d_{ni} as being determined by the efficiency loss associated with a hold-up problem: when the traded good is relationship-specific, the buyer has an incentive to hold up the seller by withholding payment. The degree of relationship-specificity and the quality of enforcement institutions then determine the seller's payoff. This ex-post payoff affects the supplier's ex-ante incentives to perform, and therefore the surplus from the relationship. Hence, d_{ni} is shaped both by institutions and by product-specific attributes: when enforcement of the contract ensures that the supplier receives her full return on the investment, the equilibrium is efficient and $d_{ni} = 1$. When institutions are such that enforcement is not possible, the outcome will be below the first-best, with the degree of efficiency loss (and d_{ni}) being determined by the scrap value of the produced goods, and hence the degree of relationship-specificity. Appendix B formalizes this intuition and provides a microfoundation for d_{ni}. For the purpose of explaining

[16] The assumption that variety (n, i, j) is produced using sector i goods in the case of outsourcing means that the model exhibits input-output linkages across sectors. 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 sector boundaries and allows for better comparison with the data.

the macro-structure of the model, it is sufficient to treat it as a black box. In Section 3 I will place a structure consistent with the microfoundation on d_{ni}, and use it to evaluate the role of institutions in shaping frictions and aggregate outcomes.

Taking the contracting friction into account, the overall cost of sourcing one unit of activity (n, i, j) is

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

where $\mu_n = \sigma_n / (\sigma_n - 1)$ is the markup due to monopolistic competition. Going back in time, the downstream sector firms decide on whether to produce in-house or to outsource by comparing the cost of the activity under the two regimes, $p^l_{ni}(j)$ and $p^x_{ni}(j)$. Given the perfect substitutability between the two options, the realized cost of activity (n, i, j) is

$$p_{ni}(j) = \min\left(p^l_{ni}(j), p^x_{ni}(j)\right). \tag{5}$$

2.2 Households' Preferences and Endowments

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

$$U = \prod_{i=1}^{N} c_i^{\eta_i}, \tag{6}$$

with $\sum_{i=1}^{N} \eta_i = 1$. The output of each sector, y_i, is hence being used both for final consumption by households, and as intermediate input in the production of outsourced activities. Households have a fixed labor endowment L and receive labor income wL and the profits of the monopolistically competitive suppliers, Π. Their budget constraint is $\sum_{i=1}^{N} p_i c_i \leq wL + \Pi$, and thus $p_i c_i = \eta_i (wL + \Pi)$.

2.3 Equilibrium Prices and Allocations

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 $X_n = \sum_i \int_0^1 p_{ni}(j) q_{ni}(j) dj$ the total expenditure (and gross output) of sector n. We then have

Proposition 1 (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 output y_n in sector n satisfies*

$$p_n = \prod_{i=1}^{N} \left(\frac{\alpha_n}{\gamma_{ni}} \left(S_n w^{-\theta} + T_i (\mu_n p_i d_{ni})^{-\theta} \right)^{-\frac{1}{\theta}} \right)^{\gamma_{ni}} \tag{7}$$

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*

$$\frac{X_{ni}}{X_n} = \gamma_{ni} \frac{T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}}{S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}} \tag{8}$$

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

Proposition 1 gives expressions for the sectoral price levels and intermediate input expenditure shares. The sectoral price levels solve the system of equations (7), and depend on the cost of production under outsourcing and under in-house production, and therefore on the productivity parameters T_i and S_n, as well as on the contracting frictions d_{ni}. Suppliers may themselves outsource part of their production process, which 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 mechanism strengthens the impact of the price distortions: an increase in the price of coal increases the prices of steel and, through steel, machines, which in turn increases the cost of producing steel further due to the steel industry's dependence on machines.

The expenditure shares on intermediate inputs, equation (8), 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 1 yields the key qualitative prediction of the model, namely that contracting frictions, captured by $d_{ni} \geq 1$, 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.

Firms make profits in inter-sectoral relationships due to them having monopoly power for their variety. Aggregate profits are $\Pi = \sum_{n,i} \Pi_{ni} = \sum_{n,i} 1/(\sigma-1) X_{ni}$ and the markets for sectoral output clear:

$$p_i c_i + \sum_n \left(X_{ni} - \Pi_{ni}\right) = X_i, \qquad i = 1, \ldots, N. \tag{9}$$

An equilibrium is a vector of sectoral price functions $(p_n(w))_{n=1,\ldots,N}$ that satisfies (7). Given sectoral prices, all other endogenous variables can be directly calculated from the preceding equations. We obtain:

Proposition 2 *Under constant returns to scale, $\sum_i \gamma_{ni} = 1$ for all n, an equilibrium exists and is unique.*

The proof is straightforward: since $\partial \log p_n / \partial \log p_i = X_{ni}/X_n$, and $\exists\, \overline{x} < 1$ such that $\sum_i X_{ni}/X_n < \overline{x}$ for all n, the function defined by the right-hand side of (7) is a contraction mapping and has a unique fixed point.

2.4 The welfare gains from eliminating enforcement frictions

Let's now take a closer look at the welfare gains from reducing enforcement frictions. My measure of welfare is real income per capita. Since households receive both labor income and the profits of intermediaries, and the wage is the numeraire, welfare is

$$\frac{Y}{PL} = \frac{1 + \Pi/L}{P}. \tag{10}$$

Welfare gains therefore arise from a decrease in consumer prices P, and from an increase in profits per capita Π/L, as more tasks become outsourced. Taking the total differential of the sectoral price levels p_n in equation (7), and holding constant the T and S parameters, we obtain

$$d \log p_n = \sum_i \frac{X_{ni}}{X_n} \left(d \log p_i + d \log d_{ni} \right). \tag{11}$$

Enforcement costs affect the sector's price index both directly through the multiplicative distortion d_{ni}, and indirectly through the price level of its upstream sectors. The strength of the input-output linkages is given by the expenditure shares X_{ni}/X_n. Write (11) in matrix notation,

$$d \log p = (I - \Xi)^{-1} \operatorname{diag}\left(\Xi \left(d \log d_{ni} \right)'_{n,i} \right) \tag{12}$$

where $\Xi = (X_{ni}/X_n)_{n,i}$ denotes the matrix of expenditure shares. We see that the impact of distortions on sectoral price levels is determined by the Leontief inverse $(I - \Xi)^{-1}$, as in standard sectoral models with input-output linkages. What is new, however, is that the expenditure shares, and hence the Leontief inverse, are endogenously determined by the cost of in-house production versus outsourcing. Hence, equations (11) and (12) are only first-order approximations which hold exactly only for small changes in $\log d_{ni}$. Note, in particular, that the first-order effects do not depend on the elasticity θ; it matters only for the change in the multiplier (i.e. the second-order effects).

3 Evaluating the Importance of Enforcement Costs

If, as shown in Section 1, some of the variation in Input-Output tables is explained by contracting frictions, then how much do these distortions matter for welfare? In this section, I apply the model to address this question. The strategy is to identify and estimate the parameters in the gravity-like expression for the input-output share, equation (8).

I start by taking the closed-economy model to a cross-country setting. Assume each country is described by the closed-economy model of Section 2, with country-specific cost parameter vectors T and S. The γ_{ni} capture the country-invariant technical aspects of the production process. Furthermore, the demand elasticities σ and the trade elasticity θ are assumed to be constant across countries. Denoting country-specific parameters by a superscript c, the expression for the input-output shares becomes

$$\frac{X^c_{ni}}{X^c_n} = \gamma_{ni} \frac{T^c_i \left(\mu_n p^c_i d^c_{ni}\right)^{-\theta}}{S^c_n + T^c_i \left(\mu_n p^c_i d^c_{ni}\right)^{-\theta}}.$$

3.1 Putting Structure on the Contracting Frictions

In the setup of the model in Section 2, contracting frictions are described by a multiplicative wedge d^c_{ni} on the cost of sourcing. Guided by the extensive literature on the hold-up problem and by the empirical findings in Section 1, I will now put enough structure on this wedge to be able to identify and quantitatively evaluate the importance of formal enforcement institutions. Readers who are interested in a more explicit microfoundation for these ad-hoc assumptions are referred to Appendix B, which describes a bilateral contracting game that yields a special case of the expressions below.

The literature on the hold-up problem, following Klein et al. (1978), emphasizes efficiency losses in buyer-seller relationships when assets are specific to the relationship. In empirical applications, the degree of specificity is typically seen as a characteristic of the product or the market (Nunn, 2007, Levchenko, 2007). Denote by d^I the distortion under an *informal contract*, i.e. the efficiency loss in a situation where enforcement of a contract in a court was not possible at all. If parties always have access to such a contracting environment (e.g. through the use of a "gentlemen's agreement"), then the availability of formal enforcement can only act to reduce the overall amount of efficiency loss:

$$d^c_{ni} = \min\left((d^F)^c_{ni}, (d^I)^c_{ni}\right)$$

where $(d^F)^c_{ni}$ denotes the efficiency loss in a "formal" contracting environment, where parties have access to formal legal recourse. Assume now that the distortion in a formal contracting environment depends on the quality of the legal institutions, and that the distortions under an informal contract only depend on product-specific attributes such as the degree of relationship-specificity of the produced goods,

$$(d^F)^c_{ni} = d^F(\delta^c), \qquad (d^I)^c_{ni} = (d^I)_{ni}$$

then the expression above becomes

$$d^c_{ni} = \min\left(d^F(\delta^c), d^I_{ni}\right). \tag{13}$$

Equation (13) captures the intuition that whenever the formal legal institutions are good enough to make them preferable over an informal contract, then agents will write a contract in such a way that in a hold-up situation, the outside option is to enforce the contract in a court. In such a case, the equilibrium performance of agents will depend on the quality of the legal system, including the cost of enforcement, and the degree of relationship-specificity of assets will not matter. If, however, formal enforcement is expensive, unpredictable, or generally unavailable, or if asset specificity is sufficiently low (more precisely, whenever $d^F > d^I$), then agents will use an informal arrangement for exchange, and then—on the margin—the quality of formal enforcement institutions will not matter. The equilibrium performance, and hence the wedge, will then depend entirely on the degree of relationship-specificity of the produced goods.

From the above considerations, it should be clear that litigation will only be observed when parties use a formal contract, i.e. when $d^F < d^I$. Hence, for a given country c, the prevalence of litigation tells us something about how likely it is that the distortions from informal arrangements exceed the distortions from formal contracts: sector-pairs with frequent litigation will on average have high d^I_{ni}; the scope for hold-up is high. Hence, one can write

$$d^I_{ni} = d^I(z_{ni})$$

where z_{ni} is the empirical prevalence of litigation between firms from sectors n and i in one country, as captured by the measure of dependence on enforcement in Section 1, and d^I is an increasing function. To be conservative, I assume $d^I(0) = 1$, which means that enforcement frictions are not present when we do not observe litigation. Violations of this assumption (for example when in a particular sector pair, firms benefit from the possibility of going to court, but would always settle outside of court) would mean that the importance of institutions would be larger than what I estimate them to be. Finally, I normalize $d^F(0) = 1$ (if enforcement is completely costless, there is no distortion either).[17]

The above functional form, equation (13), is consistent with the correlations in Section 1: Table 6 showed that litigiosity z_{ni} is only correlated with intermediate input shares for the countries where enforcement costs are sufficiently high, supporting the view that the overall distortion is a minimum of the distortion under formal contracting (which is a increasing in the country-wide enforcement costs) and the distortion under informal contracting (which is decreasing in the degree of litigation in each pair of sectors).

[17]This assumption may seem counterfactual: even when enforcement is costless, limits to e.g. verifiability may mean that contracting frictions are present. It does not, however, impose a strong loss of generality on the estimation: in the estimation approach below where d^F is estimated nonparametrically (the "first strategy"), the estimated function values for the countries with the best courts (around $\delta^c = 10\%$) would capture the distortion in these countries. Mathematically, the d^F curve is restricted to go through the point $(0, 1)$, but only the function values for $\delta^c \in [0.1; \infty)$ matter for the estimation and welfare counterfactual.

3.2 Identification and Estimation

My estimating equation is the model's expression for intermediate input expenditure shares, with an additive error term with zero conditional mean,

$$\frac{X^c_{ni}}{X^c_n} = \gamma_{ni} \frac{T^c_i \left(\mu_n p^c_i d^c_{ni}\right)^{-\theta}}{S^c_n + T^c_i \left(\mu_n p^c_i d^c_{ni}\right)^{-\theta}} + \varepsilon^c_{ni} \tag{14}$$

where the parameter restrictions for constant returns to scale, $\sum_i \gamma_{ni} = 1$ for all n, are imposed. One can re-write this equation in the form

$$\frac{X^c_{ni}}{X^c_n} = \gamma_{ni} \frac{1}{1 + \exp(\alpha^c_n - \alpha^c_i + \theta \log d^c_{ni})} + \varepsilon^c_{ni} \tag{15}$$

where, in a slight abuse of notation, $\alpha^c_n = \log(S^c_n / \mu_n^{-\theta})$ and $\alpha^c_i = \log\left(T^c_i (p^c_i)^{-\theta}\right)$. Since markups μ_n are not identified separately, I calibrate $\sigma_n = \sigma = 3.5$, which implies markups of 40 percent. This renders the above mapping invertible; the T^c_i and S^c_n parameters are therefore exactly identified.

To identify contracting frictions, I follow two different strategies. In the first, I follow the motivation from above and set

$$d^c_{ni} = \min\left(d^F(\delta^c), d^I(z_{ni})\right) \tag{16}$$

and estimate d^I and d^F semiparametrically as quadratic polynomials with intercept equal to one. Since the curvature of these polynomials is hard to distringuish from θ, I calibrate θ directly by setting it to the consensus estimate for the trade elasticity, $\theta = 4$ (see Head and Mayer, 2013, Simonovska and Waugh, 2014): like the trade elasticity in models that follow Eaton and Kortum (2002), such as Caliendo and Parro (2015), the elasticity θ emerges from the tail parameter of the Fréchet productivity draw distributions.

In the second strategy I set d^c_{ni} equal to the distortion as it would arise when microfounding it using the contracting game of Appendix B,

$$d^c_{ni} = \min\left(\frac{1}{1 - \frac{1}{2}\delta^c}, d^I(z_{ni})\right),$$

and again estimate d^I as a quadratic polynomial. This approach makes use of the fact that my measure for institutional quality (the cost of enforcement, as a fraction of the value of the claim) has a direct quantitative interpretation as a model parameter. If plaintiffs are not compensated for costs incurred during enforcement (such as, for instance, in the United States), suppliers may underperform because they know that they will be held up and that subsequent enforcement is costly, with the cost being increasing in their performance level. The parameter $\frac{1}{2}$ is the assumed bargaining power of the supplier in the out-of-court settlement. This choice of parameters implies, for example, that the distortion under formal contracting is 3.7 times higher in India, a country with notoriously slow and ineffective courts, than in the United States. In the countries with the best courts ($\delta^c \approx 0.1$), the assumption implies that frictions are bounded above by around 5%. This second approach places stronger assumptions on the distortion under formal contracting, but allows me to estimate the elasticity θ myself. As we will see, both approaches lead to similar results.

Compare the nonlinear estimating equation (15) to the linear expressions in the regressions in Section 1, equation (1). In both expressions the input-output share is a function of enforcement costs. Here, however, the sector $\times$ country fixed effects have a structural interpretation as parameters governing the cost of sourcing or producing inputs. The multiplicative interaction of δ and z has been replaced by the minimum: when enforcement costs are prohibitively high, firms use arrangements that do not rely on the quality of courts — and then, on the margin, enforcement costs do not matter. Finally, the elasticity θ governs how strongly frictions decrease intermediate input shares. In contrast to the coefficient on the interaction term in the linear regressions, which described the strength of a conditional correlation, θ governs the magnitude of a causal effect.

Let's turn to the estimation. The problem of choosing a suitable estimator for the parameters in equation (15) shares many similarities with the choice of an estimator for gravity equations in international trade (see Head and Mayer, 2013, for a summary). The nonlinear least squares estimator would place much weight on large observations and suffers from numerical problems due to nonconvexities. These difficulties would be resolved when estimating the equation in logs. However, a NLS estimator on the log of (15) would place much weight on the many intermediate input share observations that are close to zero in levels, and deeply negative in the log. Instead, I use a Poisson pseudo-maximum likelihood (PPML) estimator, which emerges as a compromise between placing weight on large and small observations, while still being numerically feasible. The PPML has been widely used to estimate gravity-type equations since being recommended by Santos Silva and Tenreyro (2006). Mathematically, the estimator is defined as

$$\hat{\beta} = \arg\max_{\beta} \sum_{n,i,c} \left(\frac{X_{ni}^c}{X_n^c} \log g\left(\beta\right) - g\left(\beta\right) \right) \tag{17}$$

where β is the vector of estimands, $g\left(\beta\right) = \gamma_{ni}/(1+\exp(\alpha_n^c - \alpha_i^c + \theta \log d_{ni}^c))$, and the maximization is subject to the constraints $\sum_i \gamma_{ni} = 1$ for every $n = 1, \ldots, N$. The PPML is consistent if the conditional mean of the intermediate input shares is as described by the model equation. Numerically, the estimator turns out to be friendly for the above functional form: for given country- and sector-invariant parameters, the maximization converges to a unique solution, hence it is easy to find a global maximum by searching over the space of the country- and sector-invariant parameters.

Table 7 shows the results from estimating the model under the two approaches. The R^2 (defined as the square of the correlation coefficient between observed and fitted intermediate input shares) is around 0.65, substantially larger than in the linear regressions of Section 1,

Table 7—: Structural estimation results

	Calibrated θ, Estimated d^F		Estimated θ, Calibrated d^F	
	(1)	(2)	(3)	(4)
θ	4	4	4.31	4.77
			(0.07)	(0.01)
z measure used	$z^{(1)}$	$z^{(2)}$	$z^{(1)}$	$z^{(2)}$
Pseudo-loglikelihood	-8550.91	-8551.35	-8553.52	-8549.03
Pseudo-R^2	0.65	0.65	0.64	0.65

Note: Table shows calibrated (columns (1) and (2)) and estimated (columns (3) and (4)) values for θ, and statistics on the model fit. The pseudo-R^2 is defined as the squared correlation coefficient between fitted input-output shares and the data.

where it is around 0.54. In the strategy where θ is estimated, the estimates are 4.31 and 4.77 when using $z^{(1)}$ and $z^{(2)}$, close to the calibrated value in the other approach, and close to structural estimates of the trade elasticity (perhaps unsurprisingly, since θ refers both here and in Eaton and Kortum (2002) to the Fréchet tail index of the productivity draw distribution).

3.3 Welfare Analysis

With the model estimated, I am now able to evaluate the importance of enforcement frictions. I take the estimated values for the model parameters and simulate welfare (real per-capita income).[18] Subsequently, I set each country's enforcement costs to the level of the United States (14%), a level that is low in international comparison but still possible to achieve for most countries through judicial reform, and see how much welfare changes.

Figure 3 visualizes the results of these exercises in a scatter plot.[19] Each dot corresponds to a country; the location on the x-axis is the contract enforcement cost prior to the change, δ^c; the location on the y-axis is the counterfactual increase in real per-capita income Y/P, in percent. The main message of the figure is that in all specifications, the effects of reducing enforcement costs to US levels can be large, ranging up to ten percentage points of real income for some countries. But even under the most conservative specifications, shown in the bottom-right panel, half of all countries would experience an increase of more than three percent, and a third would experience an increase of more than 4.5 percent in real income. Hence, the welfare loss from poor enforcement institutions is relevant on the macroeconomic scale.

Figure 3 also shows the concave relationship between enforcement costs and the gains from reducing them. When enforcement costs are high (such as for the four countries where they exceed 100 percent), firms use informal contracts, and then a marginal change in enforcement costs would not matter. Only when they are sufficiently low and firms use formal contracting

[18] In order to evaluate welfare, I need to calibrate the households' consumption shares η_i^c. I set them to the values reported in GTAP.

[19] Appendix D shows the results separately for each country, and performs a robustness check where broad input baskets are more substitutable than implied by the Cobb-Douglas production function.

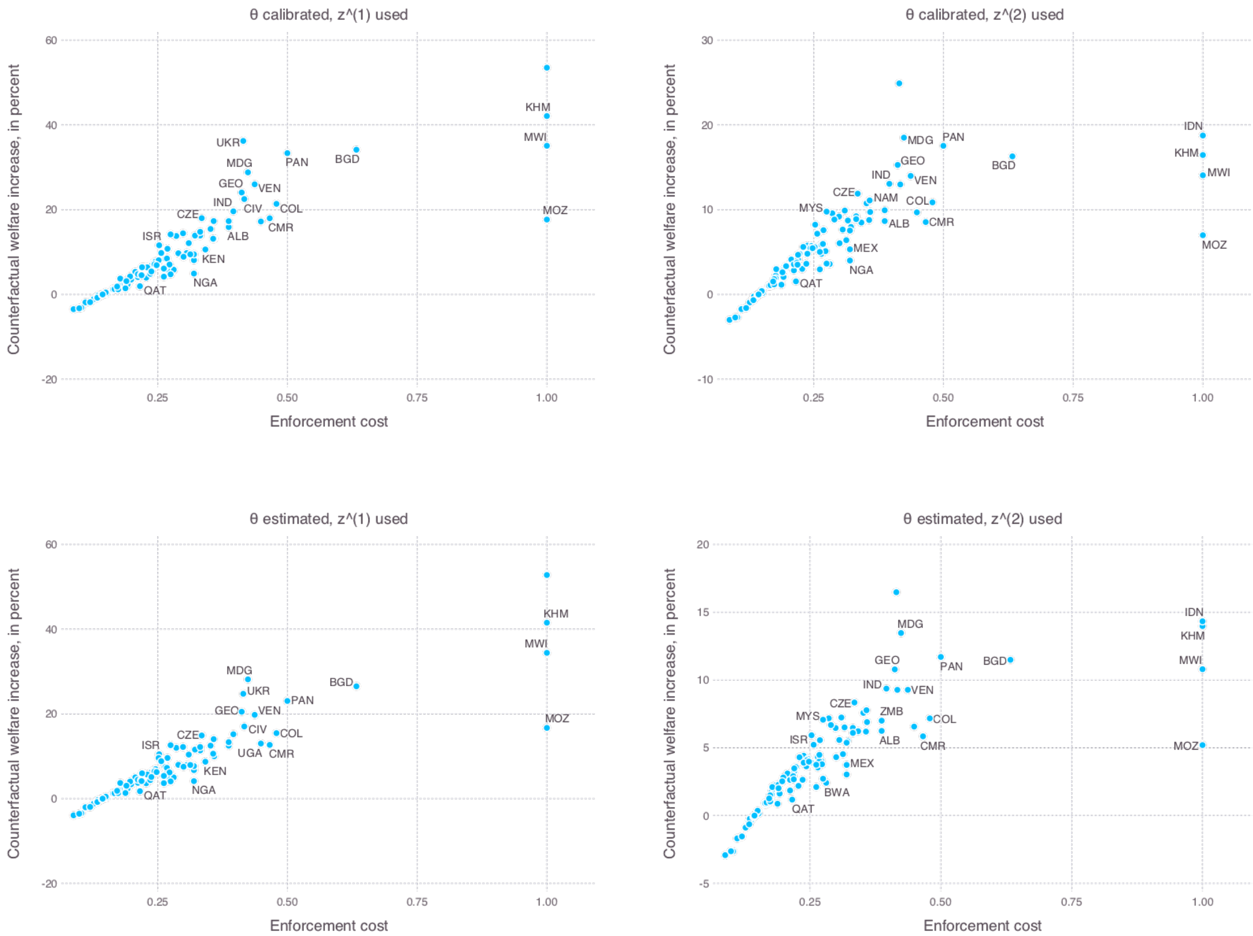

Figure 3: Counterfactual welfare gains from setting enforcement costs to US levels

Note: Enforcement costs are top-coded at one to help exposition.

relationships, a reduction in enforcement costs will start having an effect on performance in bilateral relationships.

To understand the sources of the welfare gains above, it is helpful to draw parallels to the literature on the gains from international trade. Like in Arkolakis et al. (2012), changes in real income are a function of changes in trade shares (here, intermediate input shares) and the elasticity θ.[20] For a given variation of intermediate input shares that is explained by contracting frictions, a lower θ would imply that the underlying price distortions are larger, and lead to larger gains from eliminating frictions. If in-house production was also associated with contracting frictions $\tilde{d}$, such as in Property Rights Theories of the firm, the regression would only identify the net of the two frictions, $d/\tilde{d}$. A given variation in input-output shares will then lead to larger estimated frictions $d, \tilde{d}$, and to larger welfare counterfactuals; likewise if the productivity parameters T or S were decreasing in enforcement costs. Hence, the counterfactual welfare gains reported above are only a lower bound for the true welfare gains from improving the institutions that govern the enforcement of supplier contracts.

3.4 Discussion

What do these results tell us about the importance of legal institutions? Note that in the model, legal institutions affect economic outcomes only through one particular mechanism, namely the enforcement of supplier contracts. As such, the above welfare estimates do not include other channels of how legal institutions may matter, such as in the protection of investors: Ponticelli and Alencar (2016) find that a one-standard deviation improvement in the quality of Brazilian district courts is associated with firms having 0.5% higher investment over assets and 2.3% higher output; this is on the same order of magnitude as the results above. Furthermore, the results above should not be read as saying that the quality of legal institutions matters more than other types of institutions. In a highly influential paper, Acemoglu and Johnson (2005) argue that contracting institutions matter less for development than property rights institutions because agents can substitute for the former using informal arrangements. This paper takes this substitutability seriously, and while settling the question of which aspects of institutions are more important is outside of its scope, the role of legal institutions in the enforcement of supplier contracts and in shaping development turns out to be significant.

As we have seen, the benefits of improving legal institutions can be large — but do they outweigh the costs? The literature on the determinants of court performance generally finds no correlation between spending on the judiciary and the efficiency of courts (Buscaglia and Dakolias, 1999, Cross and Donelson, 2010, Palumbo et al., 2013), and suggests that incentivizing judges and improving case management are more important. But even if the amount of spending mattered, it is unlikely that the cost of court reform would outweigh the benefits, since the counterfactual welfare gains are an order of magnitude larger than countries' total spending

[20] The "sufficient statistic" approach cannot be used here because the expenditure on in-house production is not observed separately for each triple (n, i, c)— only as value added for each sector-country pair.

on the judiciary: the US spends around 0.38 percent of GDP on the judiciary; European countries on average 0.19 percent. India, a country whose judiciary and industry structure are symptomatic of the problems discussed here[21], spends 0.12 percent of GDP on the judiciary — but would grow by at least 5%, and possibly much more, if it had US enforcement institutions.[22] In light of these numbers, it would be hard to deny the need for judicial reform in India.

4 Conclusion

This paper studies the importance of contracting frictions for the firm's sourcing of intermediate inputs. In countries where the cost of enforcing supplier contracts is high, firms use less externally sourced intermediate inputs in sector pairs where US firms litigate a lot for breach of contract. The amount of litigation correlates with measures of relationship-specificity of the intermediate inputs. Hence, this fact is consistent with the view that when legal institutions are good, firms manage to overcome hold-up problems caused by asset specificity through the possibility of enforcing formal supplier contracts. The paper quantifies the importance of courts by estimating the how much of the distortions in intermediate input use are explained by contracting frictions. If all countries had access to US courts, per-capita income would rise by more than three percent for half of all countries, and by more than 4.5 percent for a third of all countries. These results confirm North's points about transaction costs shaping macroeconomic development through the organization of production.

Another lesson is that economists should take great care when using input-output tables. Input-output tables differ *systematically* and *significantly* across countries. They differ systematically across countries in the sense that they are correlated with institutions and patterns of dependence on formal enforcement, and significantly, because the fraction of the variation that is explained by these frictions suggest that the welfare gains from removing them are large. Hence, intermediate input expenditure shares are not mere 'technical coefficients', but are instead the endogenous outcome of firm's sourcing decisions. In particular, economists should be cautious of using the United States' input-output table to describe input use patterns in other countries.

The last lesson is one for policy. The paper's findings highlight the importance of judicial reform: the welfare costs from costly contract enforcement are substantial, and must not be ignored. In countries with poor courts, improvements in court quality must be sufficiently large to induce firms to adopt formal contracting practices. Judicial reforms must weigh the benefits against the costs. They may be targeted to reduce the costs of legal representation, such as in

[21] India is host to several strongly vertically integrated conglomerates, like Tata and Reliance, and also to some of the world's most congested courts: Narasappa and Vidyasagar (2016) report that 82% of all High Court cases are between 10 and 15 years old. See Khanna and Palepu (2000) on integration and performance among Indian firms, and Ahsan (2013) on judicial quality and intermediate input use in India.

[22] Data on Indian expenditure on the judiciary from India's Department of Justice (2015) and the Government of India (2015) for the fiscal year 2014/15, on US expenditures from the Bureau of Justice Statistics (2014) for the year 2010. European data is from Palumbo et al. (2013) and refer to the year 2010.

the case of the United Kingdom (Jackson, 2009), or attempt to clear the backlog of cases and speed up the litigation and enforcement process.

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A Data Description (Print Appendix)

A.1 Input-Output data

A.1.1 Definition and Sources

My input-output tables are from GTAP, Version 8. GTAP harmonizes the tables from different sources and years; Table 8 shows which tables are from which year. I aggregate sectors in such a way that they correspond to ISIC two-digit sectors (all agricultural goods into one sector, all food products into one sector, and oil and gas into the same sector). The shares X_{ni}/X_n are the "Value of Firms' purchases of i, by sector n, in region c at Agents' prices", divided by the sector's "Value of Firms' Output at Agents' prices". The former is the sum of "Value of Firms' Domestic Purchases at Agents' prices" and "Value of Firms' Imports at Agents' prices". Both values (and hence the shares) originate from the contributed IO table and are harmonized across countries; the import data is also cross-checked for consistency with Comtrade (see Chapter 7 of the GTAP Documentation).

Table 8—: Source years for the GTAP 8 Input-Output tables

Year	Countries
1988	Hong Kong
1991	Zimbabwe
1992	Tanzania
1994	Bangladesh, Botswana, Malawi, Paraguay
1995	Croatia, Mozambique, Tunisia, Zambia
1996	New Zealand, Panama, Senegal, Singapore
1997	Mauritius, Uruguay, Venezuela
1998	Cote D'Ivoire, Turkey
1999	Madagascar, Nigeria, Taiwan
2000	Albania, Argentina, Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, El Salvador, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Nicaragua, Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sri Lanka, Sweden, United Kingdom
2001	Azerbaijan, Georgia, Guatemala, Iran, Kenya
2002	Armenia, Costa Rica, Ethiopia, Laos, Pakistan, Uganda, USA
2003	Cambodia, Cameroon, Canada, Chile, Colombia, Egypt, India, Kyrgyzstan, Mexico, Russia, South Korea
2004	Belarus, Bolivia, Ecuador, Honduras, Indonesia, Israel, Kazakhstan, Morocco, Namibia, Peru, Ukraine
2005	Australia, Bahrain, Brazil, Ghana, Kuwait, Malaysia, Mongolia, Oman, Qatar, Saudi Arabia, South Africa, Thailand, United Arab Emirates, Vietnam
2007	China, Nepal, Norway
2008	Switzerland

Note: Source: GTAP 8.

A.1.2 Comparing domestic input shares and total input shares

Broadly speaking, the expenditure shares on domestically sourced intermediate inputs only (henceforth denoted $X_n i^{\mathrm{dom}}/X_n$) are similar to the shares that include both imported and domestically sourced intermediates: the unconditional correlation across all country and sector-pair observation is 0.83. The sectors for which total and domestic input shares differ most asymmetrically across countries (as measured by the average standard deviation of log-differences of domestic and total input shares, see Table 9) are those whose production depends to a large extent on natural resouces: oil and gas, coal, petroleum and coal products, and gas manufacture and distribution. For these inputs, whether they are sourced domestically or imported depends mostly on the country's endowment in the respective natural resource. Note that the most litigation-intensive inputs (Insurance, Business services, and Financial services) do *not* differ a lot across countries in their import intensity.

Table 9—: Cross-country Dispersion in Differences between Domestic and Total Input Shares

Sector	Dispersion	Sector	Dispersion
Oil and Gas	3.86	Chemical,rubber,plastic prods	1.07
Coal	2.68	Manufactures nec	1.06
Petroleum, coal products	2.15	Metal products	0.99
Gas manufacture, distribution	1.66	Wood products	0.97
Motor vehicles and parts	1.61	Sea transport	0.94
PubAdmin/Defence/Health/Educat	1.60	Insurance	0.93
Ferrous metals	1.50	Air transport	0.74
Minerals nec	1.49	Food products and beverages	0.73
Electronic equipment	1.48	Construction	0.68
Transport equipment nec	1.47	Business services nec	0.68
Machinery and equipment nec	1.43	Paper products, publishing	0.61
Metals nec	1.36	Trade	0.45
Mineral products nec	1.26	Financial services nec	0.45
Leather products	1.23	Communication	0.41
Recreation and other services	1.22	Transport nec	0.24
Agriculture, Forestry, Fishing	1.22	Electricity	0.19
Wearing apparel	1.13	Water	0.16
Textiles	1.09		

Note: *Dispersion* is the average standard deviation of within-sector-pair log difference of total and domestic input expenditure shares: $\frac{1}{N}\sum_{n=1}^{N}\frac{1}{|C|-1}\sum_{c\in C}\left(\log\left(\frac{X^c_{ni}}{X^c_n}/\frac{X^{dom,c}_{ni}}{X^c_n}\right)-\overline{\log\left(\frac{X^c_{ni}}{X^c_n}/\frac{X^{dom,c}_{ni}}{X^c_n}\right)}\right)^2$.

A.1.3 Similarity of Input-Output tables across countries

Figure 4 shows the distribution of pairwise correlations of input shares X^c_{ni}/X^c_n. The mean correlation is .48. Input-output tables are much more similar in OECD countries (light grey bars); there, the mean correlation is .70.

A.2 Enforcement Cost

The enforcement cost δ^c is the "Cost (% of claim)" from the World Bank's Doing Business Survey, as reported on their website in December 2011. For each country, I use the value for 2005, or, if missing, for the year closest to 2005. Table 18 in Appendix D shows the values for each country.

A.3 Enforcement-Intensity

A.3.1 Construction of the number of court cases by pair of sectors

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 the core terms

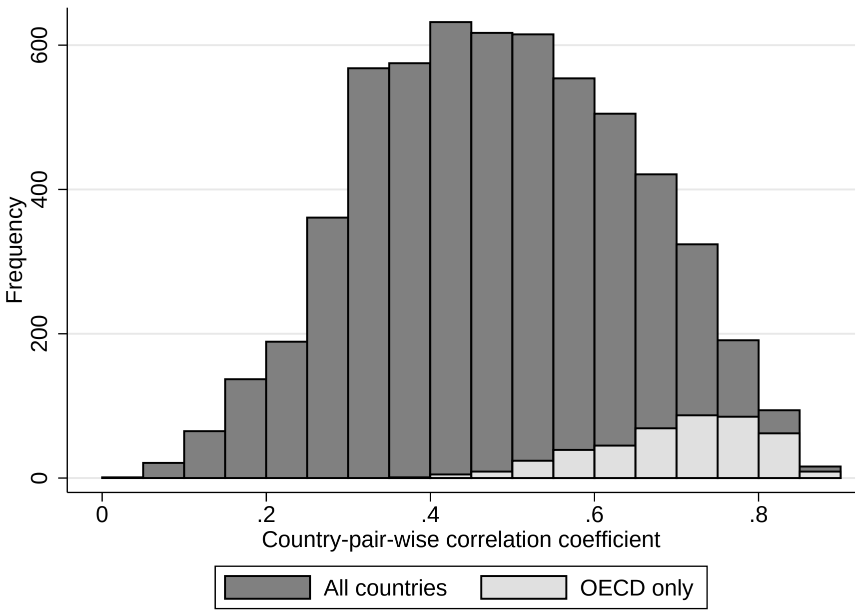


Figure 4: Pairwise correlation of IO-table expenditure shares

in the court opinion document.[23] 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 23,261 cases that span 34,219 plaintiffs and 50,599 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.[24] 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[25], 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 10 summarizes the results of the matching process. I manage to associate 50.5 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 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

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

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

[25] See https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp

covers (among other things) a sample of 6,802 contract cases in state courts.[26] 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, this comparison supports the view that I am able to match most of the relevant parties.

Table 10—: 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	1609	4.7	1551	3.1	3160	3.7
	above threshold	12778	37.2	25838	49.2	37779	44.3
	based on trade name	808	2.3	1325	2.6	2133	2.5
Total matches:		15195	44.2	27877	54.9	43072	50.5
Civil Justice Survey:	non-individuals						53.9
	businesses						49.6

A.3.2 Construction of the proxy for US buyer-seller relationships from Japanese data

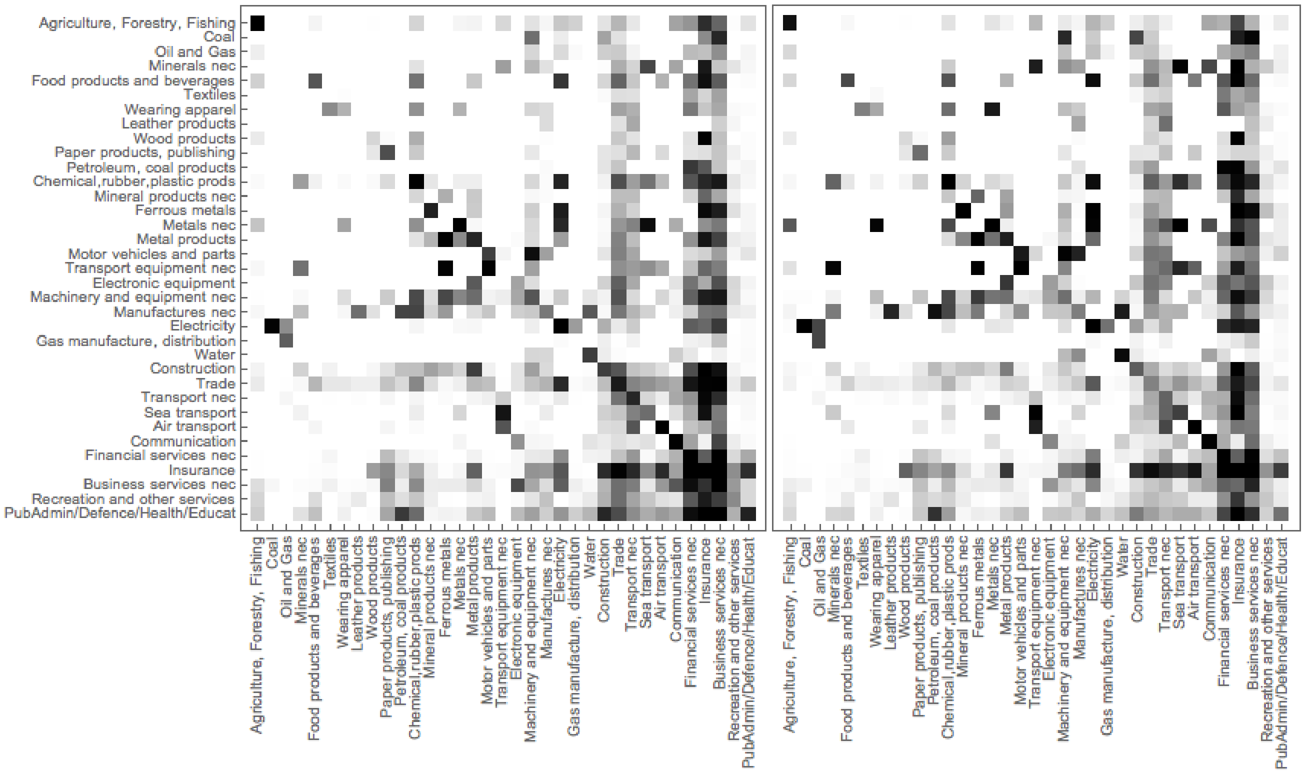
I construct a proxy for the number of buyer-seller relationships by sector pair in the United States using data on Japanese buyer-supplier linkages from Tokyo Shoko Research (TSR). The TSR data covers more than 950,000 firms from all sectors of the economy, which is close to the population of Japanese firms with more than four employees (see Bernard et al., 2015, for a more detailed description). Its underlying industry classification is based on JSIC, which I map to the GTAP sectors using a JSIC–NACE concordance provided by Eurostat. I then project the number of buyer-supplier relationships by pair of GTAP sectors on the number of firms in upstream and downstream sectors (from the 2004 Establishment and Enterprise Census of the Japanese Statistics Bureau, again concorded from JSIC) and the IO table expenditure shares (from GTAP):

$$\log(\#\text{links})^{JPN}_{ni} = \underset{(0.29)}{-4.15} + \underset{(0.02)}{0.70} \log(\#\text{firms})^{JPN}_{n} + \underset{(0.02)}{0.57} \log(\#\text{firms})^{JPN}_{i} + \underset{(0.01)}{0.13} \log\left(\frac{X_{ni}}{X_n}\right)^{JPN} + \hat{\varepsilon}_{ni}$$

The R^2 in this regression is 0.69. I then use this linear model together with data on the number of US enterprises by sector (from the US Census Bureau, mapped to GTAP using the NAICS–ISIC concordance) to construct an estimate of the number of buyer-supplier linkages in the US:

$$\log\left(\widehat{\#\text{links}}\right)^{US}_{ni} \equiv -4.15 + 0.70 \log(\#\text{firms})^{US}_{n} + 0.57 \log(\#\text{firms})^{US}_{i} + 0.13 \log\left(\frac{X_{ni}}{X_n}\right)^{US}$$

[26] See US Department of Justice (1996) for a description. In calculating the figures in Table 10 I exclude cases that pertain to mortgage foreclosure, rental agreements, fraud, and employment.



(a) $z^{(1)}$ (b) $z^{(2)}$

Figure 5: Enforcement-intensity $z^{(1)}$ and $z^{(2)}$

Note: Figure shows the enforcement-intensity measures $z^{(1)}$ and $z^{(2)}$ by sector pair. Selling sector is on the x-axis, buying sector on the y-axis. Darker shades indicate higher values. Values have been monotonically transformed to improve readability.

The alternative enforcement-intensity measure is then

$$z_{ni}^{(2)} = (\#\text{ cases between sectors } i \text{ and } n) \Big/ \left(\widehat{\#\text{links}}\right)_{ni}^{US}.$$

A.3.3 The resulting enforcement-intensity measures $z_{ni}^{(1)}$ and $z_{ni}^{(2)}$

The resulting measures $z^{(1)}$ and $z^{(2)}$ are very similar, with a correlation of 0.85. Most of the variation is driven by characteristics of the selling sector: 18.5% of the overall variation in $z_{ni}^{(1)}$ is explained by upstream sector dummies (18.7% for $z_{ni}^{(2)}$), and only 8.4% (6.8%) by downstream sector dummies.

Figure 5 shows the values of $z^{(1)}$ by sector pair, with higher values marked in a darker shade of grey. Observe that the measures vary considerably across buying sectors within selling sectors: columns are not uniformly of the same shade. Reading through Lexis' case summaries yields a sense for why the litigiosity measures look the way they do.

The first observation is that contracts with firms from the same sector are, on average, more litigious than with other buyers (i.e. the diagonal is darker in Figure 5a). This is not only because there are disproportionally many vertical relationships within the same sector (a fact known from input output tables themselves), but particularly because many of the within-sector disputes arise from horizontal licensing of patents, trademarks, and intellectual property more generally (examples are, among many others, *Verson Corp. vs. Verson International PLC et al., 93 C 2996 (N.D. Ill. 1993)*, *Zaro Licensing Inc. et al. vs. Cinmar Inc. et al., 779 F. Supp. 276 (N.D. NY 1991)*), sometimes in conjunction with antitrust considerations (e.g. *Advanced Micro Devices, Inc. vs. Intel Corp., C 91 20541 JW (N.D. Cal. 1991)*). Such agreements are at the heart of firms' organizational and technological choices. The Economist (2017)[27] documents a prominent example: the invention of small-scale steel mills and their subsequent licensing and adoption by other steel producers. Collard-Wexler and De Loecker (2015) study the associated productivity gains and organizational changes. From an economic point of view, many (though not all) licensing contracts are highly prone to hold-ups: once technological knowledge has been shared, it cannot be withdrawn, and may enable the licensee to build new technologies on top of the licensed ones; similarly, a licensor cannot physically prevent a licensee from using a copyrighted trademark. In such situations the availability of formal legal recourse is often indespensable to the establishment of market transactions.

The second observation is that services sectors, in particular Insurance, Business Services, and Finance, are more litigious than the other sectors. Insurance contracts, by nature, are subject to the problem of default on the side of insurer, and if the insurance contract cannot be enforced, it is worthless. Similarly to licensing agreements, business services and financial services are prone to hold-ups due to the intangibility of the product. While the enforcement-intensity of insurance contracts do not vary as much across downstream sectors as other sectors, it is apparent that litigation is more frequent with heavy industry sectors (ferrous metals, machinery, chemicals, minerals), construction, transportation, and public services (chiefly, healthcare). Reading the case narratives, one gets the impression that litigation is particularly prevalent whenever the insurance claims are large. In such cases, the insurer has a stronger incentive to ex-post renege on the contract.

Figure 5 also shows that litigation is surprisingly high for particular off-diagonal sector pairs. These pairs are not alike, and there are often particular circumstances associated with trade between certain sectors that give rise to litigation. In the following discussion I attempt, based on my reading of the case backgrounds in each industry's cases in LexisLibrary, an interpretation why in some sector pairs litigation is particularly prevalent.

In cases between coal suppliers to electricity producers, disputes arise mostly because these markets use formal contracts that tie trading partners together for a long time, under very specific (and often strongly regulated) conditions. In *Teco Coal Corp. et al. vs. Orlando Utilities Commission (6:07-CV-444-KKC, E.D. Kent. 2008)* the supplier finds these terms to make its business commercially unviable. In *Central Lousiana Electric Co. et al. vs. Dolet Hills Mining Venture (116 F. Supp. 2d 710 (W.D. Louis. 1999))*, parties are in disagreement on whether the specific clauses of their long-term contract have been satisfied. In each case, the existence of long-term contracts that strongly ties buyers and suppliers together destroys

[27] "New technologies could slash the cost of steel production", The Economist, 9 March 2017.

the generic nature of a good that might otherwise be traded on a spot market (coal/lignite) with little litigation arising.

Cases between manufacturers of ferrous metals and metal products, machinery, and transport equipment arise mainly due to disputes about the quality and specifications of the specific metals. A typical case is *Alloys International vs. Aeronca (1:10-cv-293 S.D. Ohio 2012)*, in which the plaintiff, a manufacturer of specialized metals, seeks damages for the sunk production cost of custom-made metal coils after the defendant cancels the order and refuses payment. A similar debt recovery case is *Eliott Brothers Steel Co. vs. Michigan Metals et al. (07-15520, E.D. Mich. 2008).* These cases are close to the stylized hold-up problem in Klein et al. (1978).

Cases between manufacturers of transport equipment and transportation companies often revolve around claims related to construction, maintenance and repair of maritime vessels (the latter typically taking place in the shipyards where the ships were built). Examples are *United Rentals North America vs. Maritrend Inc. et al. (OO-3600 T 4, E.D. Louis. 2002)* and *Susquehanna Santee Boatworks vs. River Street Ferry (01-4229, E.D. Penn. 2005).* Note that cases related to maritime vessels are more frequent than cases related to aircraft; this is in line with aircraft being more homogeneous and standardized than ships (see Benmelech and Bergman's papers on aircraft as collateral).

Cases where the seller belongs to the machinery and equipment industry are relatively most frequent in transactions with motor vehicles industry. These contracts typically involve relationship-specific investments on the side of the supplier, and sometimes also on the side of the buyer — indeed, they were Monteverde and Teece's (1982) classic example of relationship-specific investment. Examples include *Techsys Chassis Inc. vs. Sullair Corp. (4:08-cv-203, E.D. Tex. 20XX)*, where plaintiff and defendent worked together on a new chassis for one of defendant's products, under the agreement that plaintiff would be the exclusive supplier for these components. This agreement was alleged to have been violated. In *Arens Controls Co. vs. Enova Systems Inc. (08 CV 6994, N.D. Ill. 2012)*, the plaintiff designed and produced custom-made power inverters for the defendant; the defendant was alleged to have reneged on the purchase of some of the power inverters. Similar situations are found in disputes with firms from the coal, mining, and construction industries.

Cases between electricity companies and heavy industry often revolve around the installation of electricity-related equipment (transformers, compensators). An example is *Structural Metals vs. S&C Electric Company (SA-09-CV-984-XR, W.D. Tex. 2012).* As the power infrastructure of these factories is typically custom-made and site-specific, hold-ups may arise.

Cases where the supplier is providing an ocean shipping service seem to be more prevalent when the transported good is a basic raw material (e.g. iron ore) than when it's a finished good (toys from China). Cases related to the former often feature problems during the delivery (contamination of chemicals in *Sterling Chemicals Inc. et al. vs. Stolt-Nielsen Inc et al. (97 Civ. 8018, S.D. NY 2004)*, disappearance of the cargo in *Luvata Buffalo Inc. et al. vs. Mol Mitsui Lines et al. (08-CV-0701(A)(M), W.D. NY 2010).* A plausible explanation would be that in such cases the recipient's revenue elasticity of the shipped products is higher, therefore the value of the claim is higher, which is more likely to lead to litigation. In other words, when Walmart does not receives a shipment of toys from China it is harmed less than when a steel company cannot produce because it did not receive its shipment of iron ore. (Normally these shipments are insured, and often the insurer is an interested party in the case.)

Finally, cases between firms in the PubAdmin/Defence/Health/Education sector and Insurance companies are varied. In some cases they are about regulation of insurers, in others about contracts between health providers and insurers, as in *Shady Grove Orthopedic Assoc. et al. vs. Allstate Insurance Co. (466 F. Supp. 2d 467, E.D. NY 2006).*

A.3.4 Comparing my enforcement-intensity measures to existing measures

I construct measures of dependence on enforcement institutions analogously to Levchenko (2007), and, similar to Nunn (2007), using the Rauch classification of goods. The measure similar to Levchenko's is the Herfindahl index of US intermediate input expenditures, which I construct from GTAP data:

$$l_i = \sum_{n=1}^{N} \left(\frac{X_{ni}^{US}}{\sum_{n'=1}^{N} X_{n'i}^{US}} \right)^2$$

I also construct, for each of my sectors, the fraction of its output in the US that is neither traded on an organized exchange, nor for which there exists a reference price in a trade publication, according to Rauch's (1999) classification for SITC products. This yields measures r_i^{con} and r_i^{lib}, using Rauch's conservative and liberal classification, respectively. Rauch's classifications are only available for physical goods, so I set r equal to one for services industries.

The resulting measures are positively correlated with the averages of $z^{(1)}$ and $z^{(2)}$ by selling industry. Table 11 shows the Spearman rank correlation coefficients.

Table 11—: Spearman rank correlations between institutional dependency measures

	$z^{(1)}$	$z^{(2)}$	r^{con}	r^{lib}	l
$z^{(1)}$	1.00				
$z^{(2)}$	0.92	1.00			
r^{con}	0.18	0.15	1.00		
r^{lib}	0.16	0.16	0.95	1.00	
l	0.58	0.44	0.15	0.15	1.00

A.4 Other data

Data for the number of firms by US sector come from Census Bureau Statistics on US Businesses (for the year 2000; concorded using the official NAICS-SIC concordance and the SIC-GTAP concordance). Financial development, $FINDEV^c$, is the amount of domestic credit to private sector as fraction of GDP, in the year 2000, from the World Bank's World Development Indicators. Data for $GDPC^c$ (GDP per capita, PPP adjusted, in constant USD, for the year 2000) are also from the World Bank's World Development Indicators. Finally, Rauch's classification of goods was downloaded from James Rauch's website and concorded to GTAP sectors via Feenstra's SITC-HS concordance and the HS-GTAP concordance.

Table 12—: Summary statistics

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
Enforcement Costs δ	0.29	0.22	.088	1.425	109
Enforcement-Intensity $z_{ni}^{(1)}$	$2.36 \cdot 10^{-5}$	$7.73 \cdot 10^{-5}$	0	.0015	1225
Enforcement-Intensity $z_{ni}^{(2)}$	$1.13 \cdot 10^{-4}$	$4.11 \cdot 10^{-4}$	0	.0041	1225

Note: 'Intermediate input share' refers to the sum of all intermediate inputs (materials) divided by gross output. The correlation between $z_{ni}^{(1)}$ and $z_{ni}^{(2)}$ is 0.85.

B A microfoundation for the contracting frictions (Print or Online Appendix)

This section presents a contracting game between a buyer and supplier, where relationship-specific investment leads to hold-up. Contracts are enforceable, but enforcement is costly: the plaintiff has to pay a fraction δ of the value of the claim to the court. Courts award expectation damages, i.e. they order damage payments to compensate the innocent party for any loss that has arisen due to the breach. As in Shavell (1980), this limits the contracting space. In the presence of $\delta > 0$, the optimal contract does not achieve the first-best. When enforcement costs are sufficiently low, the outcome improves on the incomplete contract outcome; if they are higher, parties will prefer the incomplete contract outcome, in which case the distortion depends only on the degree of relationship-specificity of the produced goods. The resulting distortion is a special case of the assumed functional form for d_{ni} in the main text.

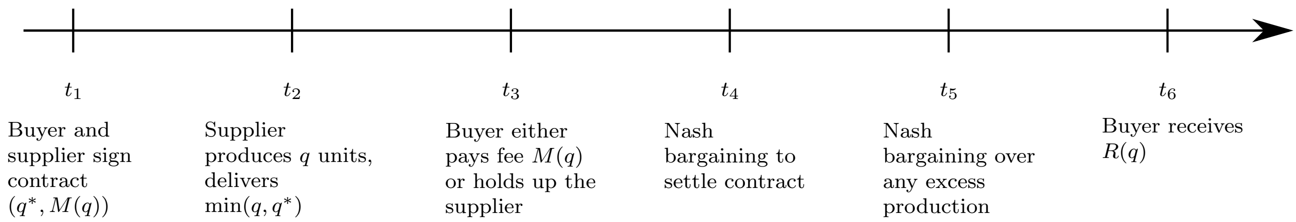
The description of the contracting game proceeds as follows. I first describe the contracting space, and discuss the timing of events and the enforcement mechanism. I then solve the contracting game. Going back in time, I describe the problem of finding an optimal contract and characterize the equilibrium thereunder.

B.1 Setup of the contracting game

The contract between buyer and supplier is a pair $(q^*, M(\cdot))$, where $q^* \geq 0$ is the quantity of the good to be delivered[28], and $M : [0, q^*] \to R \backslash R^-$ 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

[28]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).

Figure 6: TIMELINE OF THE CONTRACTING GAME



of the formation of the contract, for enforcement in case of a breach of contract ("liquidated damages").[29] I will explain the exact enforcement procedure after stating the timing of events.

Timing of events:

1. The buyer and the supplier sign a contract $(q^*, M(q))$ which maximizes the buyer's payoff, subject to the supplier's payoff being nonnegative. At this point the buyer 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 $q \geq q^*$, he delivers q^* and retains control of the remaining units.A unit that has been delivered is under the control of the buyer.

3. The buyer 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 buyer 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 buyer receives revenue/utility $R(q)$.

[29] 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.

Enforcement:

After the buyer'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 buyer 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 buyer the difference between the buyer'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 buyer 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.[30] 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 the main text: my data for enforcement costs are given as a fraction of the value of the claim. In line with the situation in the United States, I assume that enforcement costs cannot be recovered in court (Farnsworth, 2004, §12.8).[31]

B.2 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 buyer's holdup decision, as a function of q. The holdup decision function gives the buyer'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

[30] 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.

[31] 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.

function as given. The full solution of the game is in Appendix C. 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 buyer 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

$$\pi_s(q, M, q^*) = \underbrace{(1-\delta)\left(M(q) - D(q, q^*)\right)}_{\text{payoff under enforcement}} + \frac{1}{2}\underbrace{\delta\left(M(q) - D(q, q^*)\right)}_{\text{quasi-rents}} - \underbrace{q c_{ni}(j)}_{\text{production cost}} \tag{18}$$

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

$$\pi_s(q, M, q^*) = \left(1 - \frac{1}{2}\delta\right)\left(R(q) - R(q^*) + M(q^*)\right) - q c_{ni}(j) \qquad \text{if } q < q^*. \tag{19}$$

Note that the buyer'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 buyer for forgone revenue means that the supplier internalizes the payoff to the buyer. 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 (19) 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 buyer. If enforcement costs δ were zero, the expectations damages rule would ensure an outcome that is efficient within the bilateral relationship.[32]

Case 2: Seller fulfills the contract. Consider next the case where the supplier fulfills his part of the contract, $q \geq q^*$. He delivers q^* units to the buyer, and keeps the remaining units to himself. As in the case above, the buyer 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 buyer 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

[32] 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 that the presence of proportional enforcement costs then leads to efficiency loss.

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

$$\begin{aligned}
\pi_s\left(q, M, q^*\right) = & \underbrace{\left(1 - \frac{1}{2}\delta\right) M(q^*)}_{\text{contract payoff}} + \underbrace{\omega_{ni} c_{ni}(j)\left(q - q^*\right)}_{\text{payoff under reverting}} \\
& + \frac{1}{2} \underbrace{\left(R(q) - R(q^*) - \omega_{ni} c_{ni}(j)\left(q - q^*\right)\right)}_{\text{quasi-rents}} - \underbrace{q c_{ni}(j)}_{\text{production cost}}
\end{aligned} \tag{20}$$

if $q \geq q^*$. 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 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 (19) and (20). 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 buyer is unable to punish the supplier for producing less than the stipulated quantity, and $q < q^*$ may happen in equilibrium.

The Optimal Contract:

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

$$(q^*, M) = \arg\max_{(\hat{q^*}, \hat{M})} \pi_b\left(q_s(\hat{q^*}, \hat{M}), \hat{q^*}, \hat{M}\right) \tag{21}$$

$$\text{s.t.} \quad \pi_s\left(q_s(\hat{q^*}, \hat{M}), \hat{M}, \hat{q^*}\right) \geq 0 \tag{22}$$

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

$$q_s(\hat{q^*}, \hat{M}) = \arg\max_{q \geq 0} \pi_s(q, \hat{M}, \hat{q^*}).$$

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

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

In the solution to the contracting game above, I have shown that a contract (q^*, M) enters the payoff functions in each case only in an additive manner. Therefore, by setting q^* and M, the buyer can only influence the supplier's decision by shifting the threshold for breach q^*. In choosing an optimal contract, the buyer 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. Appendix C contains the proof.

Proposition 3 (Equilibrium under an optimal contract) *An optimal contract* (q^*, M) *satisfies the following properties:*

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

$$\left.\frac{dR(q)}{dq}\right|_{q=q_s(q^*,M)} = \min\left(2 - \omega_{ni}, \frac{1}{1-\frac{1}{2}\delta}\right) c \tag{23}$$

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

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

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

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

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

The first statement of Proposition 3 says that the equilibrium quantity produced under an optimal contract, $q_s(q^*, M)$, 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 buyer's payoff through the expectation damages, and the resulting outcome would be first-best. 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, $q \geq q^*$, 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 (23)). 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 buyer, 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.[33]

The third statement says that the above is implementable while still allocating the whole surplus from the relationship to the buyer. 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 buyer to obtain the full surplus from the relationship. If I allowed for an ex-ante transfer from the supplier to the buyer, 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.[34]

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.

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.*

If litigation can only happen in the case of breach, then this means that litigation should be

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

[34] 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.

more frequent when goods are more relationship-specific.

C Proofs (Online Appendix)

C.1 Proof of Proposition 3

A contract is a pair $(q^*, M(q))$ where $q^* \geq 0$ and $M : [0, q^*] \to R \backslash R^-$ is a nonnegative increasing function. I call a contract C *feasible* if there is a quantity $q \geq 0$ 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 $\hat{q} \geq 0$ *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. The 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

$$D(q, q^*) \equiv R(q^*) - M(q^*) - (R(q) - M(q)) . \tag{24}$$

The plaintiff also has to pay enforcement costs. In order to determine who the plaintiff would be, I 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

$$(1 - \delta) (M(q) - D(q, q^*)) , \tag{25}$$

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

$$R(q) + D(q, q^*) - M(q). \tag{26}$$

From the definition of the damages (24) 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. (25) and (26) 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

$$\begin{aligned} \pi_s(q) &= \left(1 - \frac{1}{2}\delta\right)\left(M(q) - D(q, q^*)\right) - cq \qquad \text{if } q < q^* \\ \pi_b(q) &= R(q) - \left(1 - \frac{1}{2}\delta\right)\left(M(q) - D(q, q^*)\right) \qquad \text{if } q < q^* \end{aligned} \tag{27}$$

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 I am 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, $q \geq q^*$. The supplier delivers q^* units and holds back the rest. The buyer 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*.[35] 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[36]). 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

$$\pi_s(q) = \left(1 - \frac{1}{2}\delta\right) M(q^*) + \frac{1}{2}\left(R(q) - R(q^*) + \omega c\,(q - q^*)\right) - cq \quad \text{if } q \geq q^* \tag{28}$$

and the buyer 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

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

I 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 that the supplier's payoff function is continuous at q^*, which means that it is impossible to punish him for breaching the contract.

[35] Cf. Farnsworth (2004), §12.10 in US law.

[36] 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 buyer and supplier, respectively).

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

Proof. 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

$$\max_q \pi_s(q) = \max\left(\max_{q, q<q^*} \pi_s(q), \max_{q, q \geq q^*} \pi_s(q)\right). \tag{29}$$

Denote the interior maxima of (27) and (28) 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 (29) and the fact that both expressions $\pi_s(q)$ for $q < q^*$ and $q \geq q^*$ 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 $q^* \leq q_\delta$ or $q^* \leq q_\omega$.[37] 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.

I 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[38] $\tilde{q}$, 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:

1. Case 1, $2 - \omega_i \geq 1/(1 - \frac{1}{2}\delta)$, or, equivalently, $q_\omega \leq q_\delta$. In this case, choosing q^* to be

[37] 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.

[38] Equal if and only if either $\omega = 1$ or $\delta = 0$.

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

$$R(q_\omega) - (2-\omega_i)\, q_\omega c = R(q^*) + \omega_i q^* c. \tag{30}$$

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

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

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

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

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

Thus, setting $M(q^*) = 0$ and q^* as in (30) implements q_ω with $\pi_s(q_\omega) = 0$.

C.2 Proof of Proposition 1

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 $z_{ni}(j)$ following a Fréchet 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

$$\Phi_{ni} = \left(S_n w^{-\theta} + T_i \left(\mu_n p_i d_{ni}\right)^{-\theta}\right). \tag{31}$$

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

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

then

$$y_n = \prod_i Q_{ni}^{\gamma_{ni}}$$

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

$$P_{ni} Q_{ni} = \lambda \gamma_{ni} \tag{32}$$

From plugging this into the formula for y_n,

$$p_n \equiv \lambda = \prod_{i=1}^{N} \left(\frac{P_{ni}}{\gamma_{ni}}\right)^{\gamma_{ni}}$$

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,

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

Thus the cost of one unit of y_n is

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

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

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

and because of a LLN, 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

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

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 (32), the expenditure share on type-i activities is

$$\frac{P_{ni}Q_{ni}}{p_n y_n} = \gamma_{ni}.$$

Thus, the expenditure share on outsourced type-i activities is

$$\frac{X_{ni}}{p_n y_n} = \gamma_{ni}\frac{T_i\left(\mu_n p_i d_{ni}\right)^{-\theta}}{S_n w^{-\theta} + T_i\left(\mu_n p_i d_{ni}\right)^{-\theta}} \tag{33}$$

which is decreasing in d_{ni}.

D Robustness checks and Results by country (Online Appendix)

D.1 Reduced-form regressions

Table 13 shows the results of estimating equation (1) when replacing the dependent variable by the expenditure share on domestically sourced intermediate inputs. Table 14 shows results estimating 1 but excluding the three most litigious sectors according to $z^{(1)}$, Insurance, Financial Services, and Business Services, from the sample (columns (1) and (2)); hence the results are not purely driven by those sectors. In columns (3) and (4), the regression explicitly controls for an interaction of enforcement costs with the US input-output shares, showing that the litigation ratio is not just proxying for unobserved buyer-seller relationships. In all specifications the coefficient of the interaction of enforcement costs with enforcement-intensity remains negative and statistically significant.

Table 15 further interacts $\delta^c \times z_{ni}$ with the fraction r_n of the downstream sector's products that are traded on organized exchanges or for which there is a reference price listed in a trade publication, as indicated by Rauch's (1999) classification. Products that are traded on organized exchanges are more homogeneous. If the interaction $\delta^c \times z_{ni} \times r_n$ has a negative coefficient, it would suggest that contracting frictions lead firms to change the products they produce (e.g. a car producer in India might produce low-tech cars instead of high-tech cars if contracting frictions prevent the sourcing of tailored electronics components). Table 15 suggests that this is not the case. If anything, the coefficient tends to be positive.

Table 16 shows the results from running specification (1) where the enforcement-intensity variable is replaced by a measure of relationship-specificity that is constructed from the Rauch (1999) classification of goods: r_i measures the fraction of sector i's products that are traded on an organized exchange or where reference prices are listed in trade publications. The resulting measure is hence similar to what Nunn (2007) uses to describe relationship-specificity. The point estimates of the interaction term coefficient come out as statistically significant at the 5% level when using Rauch's conservative classification, and marginally insignificant when using the the liberal classification. This may be due to the presence of unobserved heterogeneity across upstream sectors and countries, a problem that can be avoided by using the bilateral enforcement-intensity measure.

Table 17 shows results when the enforcement-intensity variables is constructed in different ways. Columns (1) and (2) refer to the z-measures when assuming that the plaintiff is the seller and the defendant is the buyer (as opposed to using the relative sales volumnes in the I-O table). Column (3) constructs a litigation ratio just by dividing the number of cases in each sector-pair by the number of buyer-seller links between the two sectors in the Japanese TSR data.

Tables 18 and 19 show the results of the welfare counterfactuals from Section 3 for each country.

Table 13—: Results with expenditure on domestically sourced intermediate inputs

	Dependent variable: X_{ni}^{dom}/X_n	
	(1)	(2)
$\delta^c \times z_{ni}^{(1)}$	-0.036***	
	(0.010)	
$\delta^c \times z_{ni}^{(2)}$		-0.026**
		(0.0084)
Upstream × Downstream FEs	Yes	Yes
Upstream × Country FEs	Yes	Yes
Downstream × Country FEs	Yes	Yes
R^2	0.465	0.465
Observations	133525	133525

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. Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.2 Robustness of the structural estimates: substitution of broad input baskets

This section shows results from the quantitative exercise when the sectoral production functions exhibit more substitutability across the broad sets of inputs than what is implied by the Cobb-Douglas functional form used in section 2. Specifically, we assume that the production function takes a CES form. Equation (4) is replaced by

Table 14—: Further Robustness

	Dependent variable: X_{ni}/X_n			
	(1)	(2)	(3)	(4)
$\delta^c \times z_{ni}^{(1)}$	-0.021***		-0.028***	
	(0.012)		(0.0075)	
$\delta^c \times z_{ni}^{(2)}$		-0.023***		-0.024***
		(0.0074)		(0.0053)
$\delta^c \times X_{ni}^{US}/X_n^{US}$			-0.041	-0.044
			(0.024)	(0.024)
Sample	Excl. I/F/B	Excl. I/F/B	Full	Full
Upstream × Downstream FEs	Yes	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes	Yes
R^2	0.541	0.541	0.538	0.538
Observations	122080	122080	133525	133525

Note: The first two columns exclude pairs where the upstream sector belongs to the three most litigious sectors (Insurance, Financial Services, and Business Services). Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

$$(34) \qquad y_n = \left(\sum_{i=1}^{N} \gamma_{ni}^{\frac{1}{\rho}} \left(\int_0^1 q_{ni}(j)^{(\sigma_n - 1)/\sigma_n} dj \right)^{\frac{\sigma_n}{\sigma_n - 1} \frac{\rho - 1}{\rho}} \right)^{\frac{\rho}{\rho - 1}}, \quad n = 1, \ldots, N.$$

where, again, $\sum_i \gamma_{ni} = 1$ for all $n = 1, \ldots, N$. The implied expression for the input-output shares are then

$$\frac{X_{ni}^c}{X_n^c} = \left(\frac{\gamma_{ni} \left(\alpha_n \left(S_n^c + T_i^c \left(\mu_n p_i^c d_{ni}^c \right)^{-\theta} \right)^{-\frac{1}{\theta}} \right)^{1-\rho}}{\sum_j \gamma_{nj} \left(\alpha_n \left(S_n^c + T_j^c \left(\mu_n p_j^c d_{nj}^c \right)^{-\theta} \right)^{-\frac{1}{\theta}} \right)^{1-\rho}} \right) \frac{T_i^c \left(\mu_n p_i^c d_{ni}^c \right)^{-\theta}}{S_n^c + T_i^c \left(\mu_n p_i^c d_{ni}^c \right)^{-\theta}}$$

The expression in the bracket corresponds to the substitution across broad input baskets; a choice of $\rho = 1$ (Cobb-Douglas) reduces the expression to the one from the main text.

Estimating the parameters using a PPML with the conditional mean of the input shares given by (34) is not straightforward; the parameters ρ and θ are quite collinear. To force the CES structure on the model, I follow Caliendo et al. (2017) and calibrate the elasticity across broad input baskets to $\rho = 4$. I also set the productivity draw dispersion to $\theta = 4$, a common parameter choice in quantitative calibrations of Eaton-Kortum-type models, and close to the estimates from the main text. The remaining parameters I estimate using the PPML.

Figure 7 shows the welfare counterfactuals under these estimates. The welfare gains from moving enforcement costs to the levels of the United States are on average slightly smaller than in the main text, but still in the range of zero to about twenty percent of GDP for

Table 15—: Homogeneous vs Non-homogeneous Downstream Sectors

	Dependent variable: X_{ni}/X_n			
	(1)	(2)	(3)	(4)
$\delta^c \times z_{ni}^{(1)}$	-0.043***		-0.076***	
	(0.0095)		(0.022)	
$\delta^c \times z_{ni}^{(2)}$		-0.037***		-0.029**
		(0.0074)		(0.0085)
$\delta^c \times z_{ni}^{(1)} \times r_n^{\text{lib}}$			0.035	
			(0.018)	
$\delta^c \times z_{ni}^{(2)} \times r_n^{\text{lib}}$				-0.011
				(0.0087)
Upstream × Downstream FEs	Yes	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes	Yes
R^2	0.537	0.537	0.537	0.537
Observations	133525	133525	133525	133525

Note: r_n^{lib} is the fraction of sector n's products that are traded on organized exchanges, or reference-priced in a trade publication, based on Rauch's liberal classification. Results are very similar when using Rauch's conservative measure. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

most countries. Overall, the distortions are sufficiently small so that the additional curvature ($\rho > 1$) in the production function does not have a strong impact on the welfare effects of reducing frictions.

Table 16—: Results when using Rauch's classification of goods

	Dependent variable: X_{ni}/X_n	
	(1)	(2)
$\delta^c \times r_i^{\text{con}}$	-0.025*	
	(0.012)	
$\delta^c \times r_i^{\text{lib}}$		-0.020
		(0.011)
Upstream × Downstream FEs	Yes	Yes
Downstream × Country FEs	Yes	Yes
R^2	0.454	0.454
Observations	133525	133525

Note: Independent variable is an interaction of enforcement cost with the fraction of the upstream sector's goods that are traded on an organized exchange or reference-priced in trade publications (according to Rauch's (1999) liberal and conservative classifications). Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

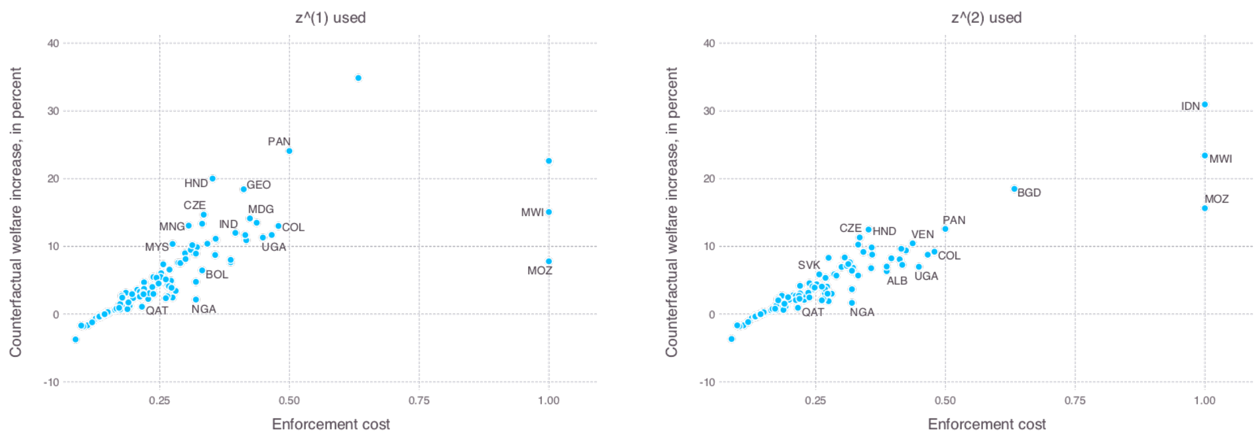


Figure 7: Counterfactual welfare gains from setting enforcement costs to US levels – CES specification
Note: Enforcement costs are top-coded at one to help exposition.

Table 17—: Alternative z-measures

	Dependent variable: X_{ni}/X_n		
	(1)	(2)	(3)
$\delta^c \times \tilde{z}^{(1)}_{ni}$	-0.043***		
	(0.010)		
$\delta^c \times \tilde{z}^{(2)}_{ni}$		-0.029**	
		(0.0096)	
$\delta^c \times (\text{Cases / Links in Japan})_{ni}$			-0.0079*
			(0.0038)
Upstream × Downstream FEs	Yes	Yes	Yes
Upstream × Country FEs	Yes	Yes	Yes
Downstream × Country FEs	Yes	Yes	Yes
R^2	0.537	0.537	0.542
Observations	133525	133525	118701

Note: $\tilde{z}^{(1)}$ and $\tilde{z}^{(2)}$ are the measures $z^{(1)}$ and $z^{(2)}$ but with plaintiffs/defendants assumed to belong to the selling/buying industry. (Cases / Links in Japan) is the number of cases by sector pair divided by the raw number of relationships between these sectors in Japan (using data from Bernard et al. (2015)). Table shows standardized betas, with standard errors clustered at the country level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 18—: Welfare counterfactuals, by country, in percent

			Calibrated θ, Estimated d^F				Estimated θ, Calibrated d^F			
			Using $z^{(1)}$		Using $z^{(2)}$		Using $z^{(1)}$		Using $z^{(2)}$	
		δ	to US	to zero	to US	to zero	to US	to zero	to US	to zero
Albania	ALB	0.39	15.9	31.0	8.7	20.9	12.5	33.5	6.2	20.1
Azerbaijan	AZE	0.18	2.6	12.3	2.4	12.8	2.7	18.5	2.3	16.9
Argentina	ARG	0.17	1.2	10.5	1.0	10.3	1.2	15.1	0.8	12.2
Australia	AUS	0.21	5.3	19.9	4.1	18.4	5.0	27.1	3.1	20.1
Austria	AUT	0.13	-1.1	8.9	-0.9	9.4	-1.2	13.9	-0.9	11.6
Bahrain	BHR	0.15	0.1	4.9	0.1	5.1	0.1	7.1	0.1	6.1
Bangladesh	BGD	0.63	34.1	50.9	16.3	29.8	26.5	48.2	11.5	26.1
Armenia	ARM	0.19	2.8	13.2	2.8	13.7	2.8	17.7	2.3	15.1
Belgium	BEL	0.18	2.7	15.8	2.2	15.3	2.7	22.8	1.8	17.2
Bolivia	BOL	0.33	13.9	30.8	9.2	24.7	11.4	35.1	6.5	24.1
Botswana	BWA	0.28	5.8	13.6	3.6	10.7	5.0	15.8	2.4	10.3
Brasil	BRA	0.17	1.1	9.7	1.0	10.1	1.1	13.8	0.8	11.8
Bulgaria	BGR	0.24	6.8	19.5	5.8	18.9	6.3	24.8	4.4	20.0
Belarus	BLR	0.17	1.2	7.9	1.3	8.7	1.2	10.7	1.2	10.0
Cambodia	KHM	1.00	42.1	67.6	16.4	32.1	41.5	80.5	14.0	34.0
Cameroon	CMR	0.47	18.0	32.5	8.5	19.6	12.7	30.3	5.8	18.1
Canada	CAN	0.22	6.4	21.0	4.8	18.8	6.0	28.2	3.6	20.4
Sri Lanka	LKA	0.23	4.0	12.7	3.0	11.8	3.6	16.3	2.2	12.6
Chile	CHL	0.29	13.8	33.2	9.6	27.8	12.0	41.1	7.2	29.1
China PR	CHN	0.11	-1.9	7.3	-1.7	7.9	-2.0	11.3	-1.7	9.9
Taiwan	TWN	0.18	2.2	13.0	1.9	13.3	2.2	18.5	1.5	15.4
Colombia	COL	0.48	21.4	38.1	10.9	23.7	15.5	37.1	7.2	21.3
Costa Rica	CRI	0.24	7.5	20.6	5.2	17.8	6.7	25.7	3.6	18.0
Croatia	HRV	0.14	-0.4	10.9	-0.3	11.1	-0.4	16.2	-0.3	13.7
Cyprus	CYP	0.16	1.2	11.0	1.0	10.9	1.2	15.9	0.9	13.0
Czech Republic	CZE	0.34	18.0	40.1	11.9	31.2	14.9	47.1	8.3	30.2
Denmark	DNK	0.25	7.7	21.4	5.7	18.8	7.0	27.4	4.2	19.5
Ecuador	ECU	0.27	6.8	16.6	5.3	14.9	6.1	20.0	4.0	15.3
El Salvador	SLV	0.19	2.4	10.7	2.1	10.7	2.4	14.8	1.6	12.1
Ethiopia	ETH	0.15	0.2	4.6	0.2	4.5	0.2	6.5	0.2	5.2
Estonia	EST	0.15	0.3	10.8	0.3	11.2	0.3	15.9	0.3	13.4
Finland	FIN	0.13	-0.6	8.3	-0.5	8.6	-0.7	12.5	-0.5	10.4
France	FRA	0.17	2.1	13.2	1.8	13.2	2.1	18.8	1.5	15.1
Georgia	GEO	0.41	24.0	44.6	15.3	32.4	20.5	51.4	10.8	29.6
Germany	DEU	0.14	0.0	9.2	0.0	9.6	0.0	13.9	0.0	11.8
Ghana	GHA	0.23	6.4	19.2	5.6	19.6	5.7	23.3	4.3	20.9
Greece	GRC	0.14	0.0	7.6	0.0	8.0	0.0	11.1	0.0	9.8
Guatemala	GTM	0.27	8.4	21.6	5.9	18.5	7.5	26.5	4.3	19.3
Honduras	HND	0.35	15.4	31.7	10.7	25.7	12.5	34.9	7.6	24.6
Hong Kong	HKG	0.21	4.1	13.4	2.8	12.1	3.7	17.4	1.9	11.7
Hungary	HUN	0.15	0.5	12.8	0.4	13.2	0.5	19.1	0.4	16.1
India	IND	0.40	19.6	37.2	13.1	28.5	15.2	39.1	9.4	26.7
Indonesia	IDN	1.00	53.5	92.7	18.8	38.3	52.8	116.6	14.3	36.5
Iran	IRN	0.17	1.2	8.8	1.1	9.0	1.2	12.2	0.9	10.7
Ireland	IRL	0.27	10.8	27.2	7.6	23.1	9.6	34.3	5.6	23.7
Israel	ISR	0.25	11.6	32.3	8.2	27.6	10.5	42.1	5.9	28.4
Italy	ITA	0.30	14.4	33.7	9.2	26.5	12.2	40.4	6.5	26.3
Cote dIvoire	CIV	0.42	22.5	40.0	13.0	27.7	17.0	40.6	9.3	25.8
Japan	JPN	0.32	13.9	30.7	8.0	22.3	11.6	36.1	5.5	21.7
Kazakhstan	KAZ	0.22	4.7	15.1	4.1	15.1	4.3	19.5	3.3	16.5
Kenya	KEN	0.34	10.6	22.2	8.5	19.8	8.7	24.8	6.2	19.3
South Korea	KOR	0.10	-3.2	8.8	-2.7	9.8	-3.5	14.4	-2.6	12.8
Kuwait	KWT	0.19	1.4	6.5	1.1	6.2	1.3	8.8	0.9	6.8
Kyrgyzstan	KGZ	0.29	9.7	21.7	8.8	21.5	8.0	24.3	6.7	21.4
Laos	LAO	0.32	9.7	19.6	8.7	18.4	8.1	21.3	6.5	17.2
Latvia	LVA	0.17	1.2	10.2	1.1	10.3	1.3	14.7	1.0	12.2
Lithuania	LTU	0.24	4.9	14.2	3.6	12.9	4.4	18.2	2.6	13.6
Luxembourg	LUX	0.09	-3.5	5.3	-3.0	6.1	-3.9	9.0	-2.9	7.8
Madagascar	MDG	0.42	28.8	50.0	18.5	36.7	28.2	65.9	13.5	33.6

Note: The table shows the the counterfactual increase in real income (in percent) when enforcement costs are set to the level of the US, or to zero.

Table 19—: Welfare counterfactuals, by country, in percent

			Calibrated θ, Estimated d^F				Estimated θ, Calibrated d^F			
			Using $z^{(1)}$		Using $z^{(2)}$		Using $z^{(1)}$		Using $z^{(2)}$	
		δ	to US	to zero	to US	to zero	to US	to zero	to US	to zero
Malawi	MWI	1.00	35.1	55.8	14.1	26.8	34.4	66.1	10.8	25.2
Malaysia	MYS	0.28	14.2	35.1	9.8	29.7	12.6	44.9	7.1	30.1
Malta	MLT	0.36	13.2	24.6	9.7	20.8	10.0	24.4	6.9	19.4
Mauritius	MUS	0.17	1.2	7.3	1.2	7.8	1.3	10.7	1.0	8.9
Mexico	MEX	0.32	8.1	16.7	5.3	13.5	6.7	19.0	3.7	13.2
Mongolia	MNG	0.31	9.7	19.7	7.7	17.5	7.9	21.4	5.6	16.6
Morocco	MAR	0.25	8.1	22.3	5.6	19.2	9.6	38.7	3.9	19.9
Mozambique	MOZ	1.00	17.7	29.4	7.0	14.6	16.7	34.0	5.2	13.7
Oman	OMN	0.14	-0.3	4.6	-0.2	4.8	-0.3	6.8	-0.2	5.8
Namibia	NAM	0.36	17.3	34.9	11.1	26.7	14.0	38.6	7.8	25.2
Nepal	NPL	0.27	6.0	13.1	5.0	12.5	5.3	15.5	4.0	12.8
Netherlands	NLD	0.24	7.1	19.5	5.4	17.6	6.4	24.9	4.1	18.3
New Zealand	NZL	0.22	6.4	21.5	4.7	18.9	6.0	28.7	3.5	20.1
Nicaragua	NIC	0.27	8.5	22.0	6.0	18.8	7.3	26.2	4.5	19.9
Nigeria	NGA	0.32	4.9	9.8	4.0	8.9	4.1	11.1	3.0	8.9
Norway	NOR	0.10	-3.3	7.4	-2.7	8.2	-3.6	12.2	-2.6	10.4
Pakistan	PAK	0.24	5.4	15.6	4.8	15.3	5.1	20.1	3.9	16.6
Panama	PAN	0.50	33.3	54.4	17.5	33.8	23.1	50.1	11.7	29.4
Paraguay	PRY	0.30	8.9	20.5	6.0	16.9	7.5	23.7	4.3	16.9
Peru	PER	0.36	13.1	27.5	8.8	21.7	10.6	30.6	6.2	20.8
Philippines	PHL	0.25	6.9	19.1	5.5	17.7	6.3	24.2	4.0	18.9
Poland	POL	0.12	-1.8	10.4	-1.6	11.1	-2.0	16.5	-1.5	14.0
Portugal	PRT	0.14	-0.1	10.7	-0.1	11.0	-0.1	16.1	-0.1	13.3
Qatar	QAT	0.22	1.9	6.4	1.5	6.0	1.8	8.2	1.2	6.5
Romania	ROU	0.20	3.5	14.6	3.4	15.2	3.4	19.8	2.8	17.4
Russia	RUS	0.13	-0.8	11.6	-0.7	12.6	-0.8	17.8	-0.6	16.0
Saudi Arabia	SAU	0.28	4.7	11.1	3.6	9.9	4.1	13.1	2.7	10.2
Senegal	SEN	0.27	6.4	15.9	4.8	14.0	5.7	19.4	3.5	14.5
Singapore	SGP	0.18	3.7	23.3	3.0	22.7	3.7	35.1	2.1	23.5
Slovakia	SVK	0.26	9.8	26.1	7.2	22.9	8.8	33.7	5.2	23.7
Vietnam	VNM	0.31	12.1	25.9	9.9	23.5	10.4	30.2	7.2	22.6
Slovenia	SVN	0.20	4.2	18.3	3.3	17.0	4.0	25.5	2.5	18.7
South Africa	ZAF	0.33	14.8	31.7	8.9	23.7	12.2	36.4	6.1	22.7
Zimbabwe	ZWE	0.32	9.4	19.8	7.5	17.5	7.7	21.5	5.4	16.4
Spain	ESP	0.17	1.9	12.8	1.5	12.4	1.9	18.3	1.3	14.3
Sweden	SWE	0.31	9.5	19.7	6.4	16.0	7.9	22.6	4.5	15.5
Switzerland	CHE	0.21	4.8	16.6	3.6	15.1	4.5	22.4	2.6	16.2
Thailand	THA	0.14	-0.1	9.9	-0.1	10.2	-0.1	14.8	-0.0	12.6
United Arab Emirates	ARE	0.26	4.2	10.5	3.0	9.1	3.7	12.8	2.1	9.3
Tunisia	TUN	0.22	4.6	15.9	3.7	14.9	4.4	21.0	2.9	16.3
Turkey	TUR	0.27	7.1	17.1	5.1	15.0	6.2	20.7	3.8	15.6
Uganda	UGA	0.45	17.2	31.8	9.7	21.1	13.0	32.2	6.6	19.3
Ukraine	UKR	0.41	36.2	78.3	24.9	59.0	24.7	75.0	16.5	54.0
Egypt	EGY	0.26	6.1	15.6	5.0	14.8	5.4	19.2	3.7	15.4
United Kingdom	GBR	0.22	4.5	14.5	3.5	13.4	4.1	19.1	2.7	14.5
Tanzania	TZA	0.14	-0.0	6.9	-0.0	7.0	-0.0	10.1	-0.0	8.3
United States	USA	0.14	0.0	9.7	0.0	10.0	0.0	14.7	0.0	12.1
Uruguay	URY	0.19	3.1	15.6	2.6	15.2	3.0	22.1	2.0	17.6
Venezuela	VEN	0.44	26.0	50.9	14.0	33.3	19.8	53.0	9.3	30.5
Zambia	ZMB	0.39	17.3	35.1	9.9	24.5	13.3	37.6	7.0	23.3

Note: The table shows the the counterfactual increase in real income (in percent) when enforcement costs are set to the level of the US, or to zero.