Intellectual Property Rights, Multinational Firms and Technology Transfers*

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Abstract

Intellectual Property Rights (IPR) protect firms from imitation and are considered crucial to promoting innovation and technological diffusion. This paper examines the impact of IPR on import-sourcing decisions of multinational firms. We consider a framework in which firms offshore production of an intermediate good to another country. Firms can decide either to import the intermediate good from vertically integrated producers, or from independent suppliers. In both cases, offshoring part of the production process embodies a risk of imitation. The model predicts that, under reasonable parameter restrictions, stronger IPR disproportionately encourages the imports of intermediate goods through vertical integration. Using the US Related-Party Trade database, we find empirical evidence supportive of the positive link between level of IPR and the relative share of imports from vertically integrated manufacturers.
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1 Introduction

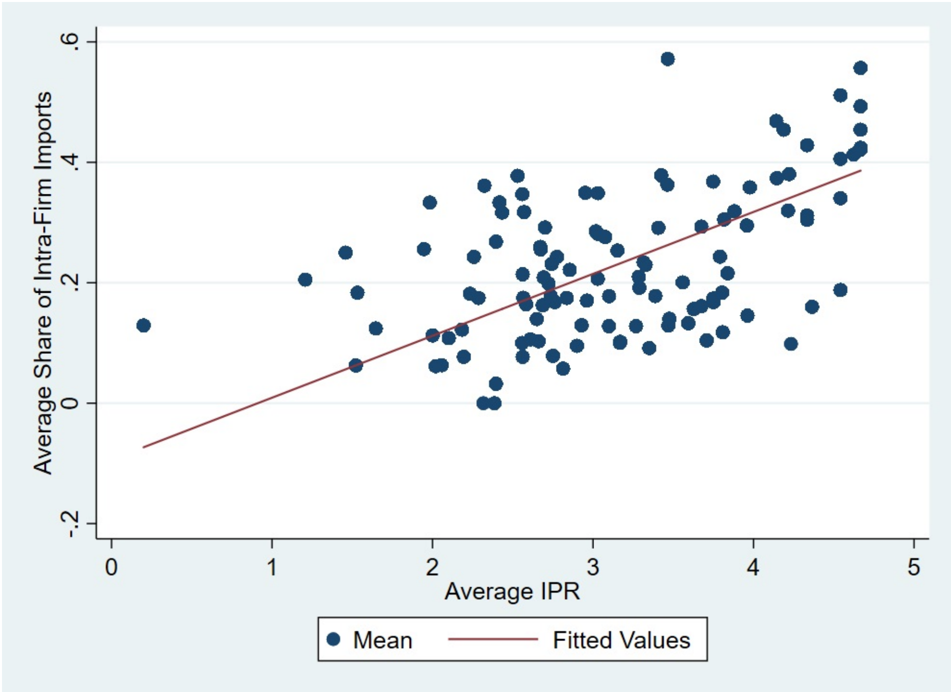
Anecdotal and empirical evidence stresses the importance of intellectual property protection and technology transfers for international trade, especially in developing countries. Where intellectual property rights (henceforth IPR) are weak, this can discourage firms from offshoring production to foreign countries. Offshoring requires the transfer of some technology abroad, and this exposes multinational firms (henceforth MNF) to the risk of imitation and technology expropriation (see Lee and Mansfield, 1996). There is a potential risk of imitation when firms use outsourcing contracts (see Yang and Maskus, 2001), as well as when technology transfers happen within the firm's boundaries, as in vertically integrated MNF. For instance, Maskus et al. (2005), analysing IPR in China, report that both former licensees (independent firms), and former employees (managers of vertically integrated firms) end up running their own factories, producing their version of the goods, and infringing the related trademarks and patents. They also write that "although FDI in subsidiaries may be designed to keep technology proprietary within the firm, such investments also train local employees and managers and transfer knowledge". Branstetter et al. (2006) point out that multinational firms investing in FDI are particularly exposed to this risk of imitation. They mention anecdotal evidence such as the case of the world's leading semiconductor manufacturer, the Taiwanese TSMC, who charged its mainland Chinese rival, SMIC, of intellectual property theft. According to public statements by TSMC representatives, SMIC hired more than one hundred TSMC employees, who brought valuable trade secrets with them.

Therefore, weak IPR in the destination country can discourage within-firm trade flows, and the associated technological transfer. Figure 1 provides an illustration of the relation between IPR and the share of overall foreign input purchases that are imported within firm boundaries in the United States. Each point represents a bilateral relation between the United States and the destination country. The vertical axis measures the average share of intra-firm imports from each destination country; the horizontal axis measures the average IPR level in each destination country.[1] The higher the level of IPR protection in the destination country, the higher the share of US intra-firm imports in total US imports.

The main contribution of this paper is to provide theoretical and empirical support to the idea that stronger IPR might encourage more strongly the propensity to engage in vertical integration as compared to outsourcing. We propose a theoretical framework based on Antràs (2003) and Antràs and Helpman (2004), embedding the property rights approach in a global value chain context. We consider multinational firms based in a developed country, the North, which offshore production of an intermediate good in another country, with a different level of IPR, the South. When the MNF engages in vertical integration, it imports the intermediate good from a foreign subsidiary; when it engages in outsourcing, it imports it from an independent contractor. Since vertical integration ensures the control of the physical capital, it shapes the contractual relationship in favor of the MNF. Departing from Antràs (2003) and Antràs and Helpman (2004), we assume that production in the South entails a risk of

[1] The level of IPR protection is measured by the Ginarte and Park (1997) index, described in Section 6.1.

Figure 1: Share of Intra-firm Imports



Source: Authors' calculation using US Input-Output tables and IPR averaged using 2000, 2005 and 2010.

imitation. More specifically, when IPR are not well protected, the Southern manufacturer can operate the technology on the side, using the technology acquired from the North. Crucially, however, the respective payoffs of the multinational firm and the imitator are affected differently depending on the chosen ownership structure. Although vertical integration guarantees control over the production facilities, the existence of an imitation risk reduces the advantage of ownership. This is in line with Blomström and Sjöholm (1999), Branstetter (2006) and Lee et al. (2016), who show that the transfer of knowledge within the boundaries of the firm is particularly important. The intuition is that knowledge transfers inside firm boundaries allows workers of the multinational firm to sell the technology or to operate it independently, thus favoring imitation.

In our model, technological transfers are larger in more productive firms, which engage in vertical integration. In this context, we show that, for both ownership modes, stronger IPR increases the profitability of the firm. This is consistent with the idea that the risk of imitation exists when dealing with an independent provider, but also with a foreign affiliate. The fact that vertical integration does not shield firms from all hold-up problems is the general message of the property right approach to incomplete contracts (see Antràs and Helpman, 2004 and Antràs, 2015), which also find empirical support (see for instance Corcos et al., 2013). Our paper extends the analysis of incomplete contracts and hold-up to account for intellectual property rights, i.e. control over intangible assets and ideas. In our framework, the existence of knowledge spillovers, makes vertical integration unable to solve the incomplete contract problem, especially when IPR protection is low.

Our model shows that, under reasonable parameter restrictions, higher IPR protection has a stronger effect on vertical integration. This happens because an increase in IPR restores the advantages of vertical integration in the bargaining problem, reinforcing the MNF's control over both physical capital and intangible assets. This implies that strengthening IPR in the South increases the relative share of intra-firm imports, and decreases the share of imports from independent suppliers. Since in our model vertical integration induces larger knowledge spillovers, the Southern manufacturer can imitate the technology more easily under vertical integration than under outsourcing.

To empirically examine the role of IPR in affecting the global sourcing decisions of firms, we combine the index of patent protection in Park (2008) with data on US intra-firm trade taken from the US Census Bureau's Related Party Trade Database.[2] Our baseline empirical specification considers the impact of an increase in IPR protection on the share of related party intermediate imports, controlling for industry and country characteristics. We find a positive and statistically significant impact of IPR, which supports the theoretical finding that an increase in IPR protection is more valuable for vertically integrated firms. To correct for the potential endogeneity of IPR protection, we use a two-stage instrumental variable approach. As a first instrument, we use difference in countries' legal origins: the underlying idea is that legal origin is an important determinant of national institutions. This strategy is similar to Hu and Png (2013) and Nunn (2007). Naturally, using legal origins makes it impossible to exploit the panel dimension of the data, because this variable does not change with time. We thus propose an additional time varying instrument: outward migrations of students. Migrating student, through different links with the home countries, can also influence the attitude toward institutions, as well as have an impact on technological diffusion. To reduce endogeneity concerns, the instrument takes the average number of migrating students of neighboring countries, excluding the country of interest, and it is lagged five and then fifteen years. The estimated effect of IPR on intra-firm import shares continues to be significant. Then we assess the sensitivity and robustness of our results. Firstly, to establish whether the impact of IPR enforcement is enhanced in patent-sensitive industries, we explore the role of differences in industry-level sensitivity to IPR. Then, we show that our results are confirmed using an alternative measure of IPR. All specifications confirm the main finding, that an increase in IPR protection increases the relative share of intra-firm imports.

The paper is structured as follows. Section 2 describes the contributions of this paper with respect to the existing literature. Section 3 presents the theoretical framework. Section 4 characterizes the different organizational forms. Section 5 describes the industry's equilibrium and derives the prediction to be tested. Section 6 describes the empirical strategy. The estimation results, identification strategy and robustness checks are discussed in Sections 7. Section 8 concludes.

[2]The US dataset is made available by Pol Antràs: http://scholar.harvard.edu/antras/books.

2 Related Literature

Our work is related to different strands of the literature. Firstly, it relates to theoretical and empirical studies on vertical integration and outsourcing, which build on Antràs (2003) and Antràs and Helpman (2004). In this literature, vertical integration is a response to contract incompleteness: vertical integration is here associated with ownership, which defines control rights on the physical capital of the firm, thus reducing opportunistic behavior and hold-up problems. We take a different approach, and introduce a specific role for intellectual property as distinguished from property comprising physical assets. Thus, in our model we address the importance of property rights on intangibles and the role of knowledge-spillovers in shaping global sourcing decisions. This generates a separate channel through which IPR affect the internalization decisions of multinational firms.

Secondly, our work relates to the literature that studies the impact of IPR on trade flows, licensing and FDI. Maskus and Penubarti (1995), Smith (1999), Ivus (2010) study the link between IPR and trade, finding that an increase in IPR protection positively affects bilateral trade flows. Ivus (2015) also finds that the strengthening of IPR expands the export variety of US multinationals. Lin and Lincoln (2017) and De Rassenfosse et al. (2019), using matched firm-level data sets of exports and patents, confirm the finding that patenting firms expand exports in those countries which ensure relatively stronger patent protection. Considering the impact of IPR on licensing activity, Yang and Maskus (2001) and Park and Lippoldt (2005) provide evidence of a positive effect. Javorcik (2004a), using a firm-level data set from Eastern Europe and the former Soviet Union, finds that weak IPR deter foreign investment in high-technology sectors where intellectual property rights play an important role. Similarly, Branstetter et al. (2011) find that, following IPR reforms, MNFs expand the scale of their activities, in particular those that make extensive use of intellectual property. Unlike Javorcik (2004a) and Branstetter et al. (2011), we provide a theoretical and empirical analysis of the effects of IPR on both FDI and outsourcing decisions. Adding to these findings, we show that the effect of IPR differs depending on the patent-sensitivity of the industry. None of these studies explicitly considers the relationship between IPR and global sourcing decisions.

More recently, Naghavi et al. (2015) have analyzed the impact of IPR on the outsourcing share of French multinational firms, finding that IPR protection does not affect the average outsourcing share, but it does affect the complexity of the outsourced input. In their theoretical framework, only outsourcing generates a risk of imitation, but this risk is mitigated for more complex tasks, because they are technically difficult to imitate. This implies that the share of outsourcing of complex inputs tends to be smaller in countries with stronger IPR.[3] Unlike them, we develop a model in which hold-up and imitation problems can also occur under vertical integration, and not exclusively in the case of outsourcing. We illustrate this point

[3] Ivus et al. (2016, 2017), concentrating on the technology licensing decisions of multinationals, identify a similar role of product complexity for US multinationals. In addition, Bolatto et al. (2017) show that the impact of IPR can differ at different stages of production (downstreamness) and may depend on the strategic complementarity of inputs in a sequential production chain à la Antràs and Chor (2013). Finally, Kukharskyy (2020) finds that high knowledge intensity induces MNF to increase the ownership-share in their affiliates, but that this effect is mitigated when IPR protection increases.

by adopting a theoretical framework based on the property rights approach to contract incompleteness. We consider the possibility that imitation-risk alters the bargaining games between the headquarters and the manufacturer. The manufacturer, enjoying knowledge spillovers, increases its disagreement payoff, since it is able to become an imitator or to sell the technology. Our set-up allows us to identify and then test empirically a different channel through which IPR can impact the value-chain structure. Since in our model the imitation threat differs between the two ownership structures, we find that IPR have a stronger impact on vertical integration than on outsourcing. Coherently with our model, Branstetter et al. (2006) find that strengthening patent regimes increases the value of technology transfers for multinational firms, encouraging them to increase expenditure and production in the reforming countries. Similarly, Ivus et al. (2017) show that stronger IPR disproportionately increase affiliated licensing, as measured by the value of fees and royalties from affiliated firms, as compared to non-affiliate licensing. In their framework, the result is related to the fact that vertically integrated firms, outsourcing less-complex technologies that are easy to imitate, particularly benefit from an increase in IPR. We illustrate another possible channel from which IPR can favor vertical integration. As we show, in the presence of intra-group technology spillovers, an increase in IPR can increase the benefits of vertical integration, extending control on immaterial assets, and thus increase the share of intermediate imports from related parties when MNF offshore the production of intermediate goods.

Finally, our paper relates to the literature on knowledge transfers and spillovers across global value chains. Javorcik (2004b) uses firm-level data from Lithuania to study vertical spillovers. She finds positive productivity spillovers from FDI taking place through the relationship between foreign affiliates and their local suppliers in upstream sectors. Javorcik and Spatareanu (2009) study how firms become supplier of MNF, and how this interaction enhances supplier performance. To capture the relationships between suppliers and MNF, they use Czech Republic data and find that independent suppliers tend to learn from MNF and be more productive than non-suppliers. Borrowing from these empirical findings, we build a model where independent manufacturers can learn the technology, and possibly become an imitator. Crucially, in our model transfers of knowledge also occur under vertical integration; these transfers are larger in more productive firms, which engage in vertical integration.

The idea that foreign direct investment facilitates knowledge diffusion is supported in the theoretical and empirical literature. In Glass and Saggi (1998) and Lin and Saggi (1999), for instance, FDI has the effect both of transferring technology to the South and of creating knowledge spillovers favoring imitation. These effects are confirmed by the empirical literature. Blomström and Sjöholm (1999), studying Indonesian manufacturing, show that ownership matters when considering the knowledge revealed by multinational firms. Branstetter (2006) shows that Japanese FDI into the United States is a channel of knowledge transfers both from and to investing firms, because they create spillovers at the firm level. More recently, Lee et al. (2016) use Korean data to compare the knowledge spillovers arising from networks of related firms with the ones arising from arm's length relationships. They conclude that knowledge is better transferred within business groups. Görg and Strobl (2005) highlight worker mobility as a channel through which knowledge transfer may occur: workers can join or open up a domestic firm, taking with them the knowledge of the multinational. Although the threat of imitation is likely to affect both vertical integration and outsourcing, the findings in Lee et al. (2016) and Görg and Strobl (2005) seem to support the intuition that this threat is particularly important under vertical integration.

3 The Model

We adopt a monopolistic competition framework in line with Antràs and Helpman (2004). The world consists of two countries, North and South, and one factor of production, labor. Consumers have identical Dixit-Stiglitz preferences represented by:

$$U = x_0 + \frac{1}{\mu}\sum_{j=1}^{J} X_j^{\mu}, \qquad 0 < \mu < 1,$$

where x_0 is a homogeneous good, X_j is aggregate consumption in sector j, and μ is a parameter. World aggregate consumption in sector j of different varieties $x_j(i)$ is given by:

$$X_j = \left[\int x_j(i)^{\alpha}\mathrm{d}i\right]^{\frac{1}{\alpha}}, \qquad 0 < \alpha < 1$$

where i is the endogenous range of varieties in sector j, and $1/(1-\alpha)$ is the elasticity of substitution between two varieties. As a consequence, the inverse demand for each variety writes:

$$p_j = A_j x_j(i)^{\alpha-1}, \qquad 0 < \alpha < 1, \tag{1}$$

where $A_j = X_j^{\mu-\alpha}$. We set $\alpha > \mu$ so that varieties within a sector are more substitutable for each other than they are for varieties from a different sector. Parameters μ and α are the same in every industry. Each variety is produced by a monopolistically-competitive firm under increasing returns to scale.

Producers in the differentiated sector face a perfectly elastic labor supply in each country. Wage rates are considered fixed, with the wage rate in the North, w_N, larger than wage rate in the South, w_S. New varieties can only be invented in the North. To start producing a new variety, the Northern multinational firm has to bear a fixed cost f_E paid in units of Northern labor. After paying this fixed cost, a firm-specific productivity parameter θ is drawn from a known distribution $G(\theta)$. Production of the final-good variety requires the combination of two factors, $z_j(i)$ and $m_j(i)$, which represent headquarters services and manufacturing inputs respectively. The production of the final-good variety combines two intermediate inputs into a Cobb-Douglas function:

$$x_j = \theta\left[\frac{z_j(i)}{\eta_j}\right]^{\eta_j}\left[\frac{m_j(i)}{1-\eta_j}\right]^{1-\eta_j}, \quad 0 < \eta_j < 1, \tag{2}$$

where θ is the firm-specific productivity parameter, and η_j is sector specific and indicates sector intensity in headquarters services. Both intermediates $z_j(i)$ and $m_j(i)$ are produced using one unit of labor. The headquarters services, $z_j(i)$, can only be produced in the North, whereas the manufacturing input, $m_j(i)$, is produced only in the South.[4] There are two types of agents involved in production: final good producers, who also supply the headquarters services, and producers of the manufacturing inputs. The final good producer needs to stipulate a contract with a Southern manufacturing input supplier.[5] The fragmentation of the production process can take two forms: vertical integration or outsourcing. When the final good producer imports the intermediate $m_j(i)$ from a foreign affiliate, it engages in vertical integration. By contrast, when the imports come from an independent manufacturer, it engages in outsourcing. In both cases the intermediate goods are shipped back to the North where final assembling takes place. Intermediate production in the South requires the transfer of technological knowledge from the Northern MNF. This transfer differs depending on the ownership structure.

Following Antràs and Helpman (2004), we argue that managerial overload is more important than managerial economies of scope. This allows us to adopt a particular ranking for the fixed cost. Specifically, we assume that the fixed organizational costs are higher under vertical integration than under outsourcing:

$$f_V > f_O. \tag{3}$$

where the subscripts V and O indicate vertical integration and outsourcing respectively. The final good producer chooses ex-ante the ownership structure. In the case of outsourcing, the final good producer offers a contract to the manufacturer in exchange for an upfront fixed fee.

Focusing on one industry, we can drop the subscript j. Replacing (1) and (2) into the revenue expression yields:

$$R = Ax(i)^{\alpha} = A\theta^{\alpha}\left[\frac{z(i)}{\eta}\right]^{\alpha\eta}\left[\frac{m(i)}{\alpha(1-\eta)}\right]^{\alpha(1-\eta)}, \tag{4}$$

Equation (4) represents the final good producer's revenue in the absence of contractual breach. The next section describes the incomplete contracts problem, allowing for ex-post bargaining and for the possibility that the Southern manufacturer decides to breach the contract, imitate the technology, and compete against the final good producer.

4 The Incomplete Contracts Problem

Under both vertical integration and outsourcing, contracts are totally incomplete. This implies that parties cannot commit ex-ante to a certain distribution of the surplus. The assumption

[4] Alternatively, we could allow for $m_j(i)$ to be produced either in the North or in the South, with production in the North entailing a higher fixed cost. This would not alter our main results, which concentrate on the relative profitability of vertical integration and outsourcing in the South.

[5] Since the final good producer is an MNF, in the paper we use final-good producer and MNF interchangeably.

of incomplete contracts follows the property rights approach, which introduces the hold up problem for vertically integrated structures (Grossman and Hart, 1986). We denote β and $1-\beta$, with $\beta \in [0,1]$, the bargaining weights of the final good producer and the Southern manufacturer respectively. Both vertical integration and outsourcing feature an ex-ante contracting stage t_0, an investment stage t_1, and an ex-post bargaining stage t_2. At t_2, the outside options available to the final good producer and the manufacturer are a function of the ownership decision at t_0.

Departing from the existing literature, we allow for a degree of uncertainty in the protection of IPR in the South. Specifically, λ represents the strength of this protection, with $\lambda \in (0,1)$. The higher the value of λ, the higher is the probability that MNF are protected from imitation when offshoring production in the South. In fact, in our model, the Southern manufacturer can learn the technology developed by the Northern MNF. Thus, in case of contractual breach, the Southern manufacturer can free-ride on the Northern technology, and possibly replicate the good by infringing the MNF's property rights. If the level of IPR protection is sufficiently high, this should prevent the manufacturer from selling the imitated good, protecting the intellectual property held by the headquarters. Therefore, an increase in λ increases the outside option of the headquarters and decreases that of the manufacturer. Notice that in our setup, the strength of IPR protection in the South, λ, matters both under outsourcing and vertical integration. Under both offshoring modes, the Southern manufacturer can free-ride on the final good producer's technology and become an imitator. Since λ characterizes the institutional IPR environment of the country, it is independent from the offshoring mode.[6]

We now describe what happens after a contractual breach. In this case, the role of λ is crucial. In our framework, a contractual breach implies a loss in efficiency under both ownership structures. Similarly to Antràs and Helpman (2004), the MNF is able to assemble only a share $\delta^H \in (0,1)$ of the output x_i. In addition, we introduce the assumption that with probability $1-\lambda$, IPR are not protected. In this case the Southern manufacturer can exploit the learned technology and produce a copy of the good produced by the multinational. In this case, the manufacturer is able to produce a share $\varphi_k^M \in (0,1)$ of the potential output, where $k \in \{V, O\}$.[7] This share depends on the manufacturer's ability to imitate the foreign technology: if under vertical integration technological spillovers are higher, then this share will be higher, i.e. $\varphi_V^M > \varphi_O^M$. The impact of imitation on MNF's profits differs across offshoring modes, and it depends on both λ and φ_k^M. In the following sections, we characterize profits and outside options under integration and under outsourcing respectively.

[6] For simplicity, we do not consider the risk of technological expropriation coming from imitators external to the relationship between the final good producer and the manufacturer. This choice should not alter our results. In fact, by reducing the size of the demand for the differentiated good produced by the MNF, the existence of external imitators would have a scale effect without qualitatively altering our results.

[7] Notice that the subscript H denotes the final good supplier, and the subscript M denotes the manufacturer.

4.1 Vertical Integration

When the organizational form is vertical integration, the MNF has the ability to fire the manufacturer (i.e. the manager of the affiliate) if it refuses to agree on a transfer price, and instead find an alternative way to assemble the final good. This happens because the MNF holds property rights over the inputs. In our framework, the fraction of the total revenue that the MNF is able to realize depends crucially on the enforcement of intellectual property rights. If IPR are enforced, which occurs with probability λ, firing the manufacturer only results in a loss of a fraction of the final-good production. This happen because the MNF cannot use the intermediate inputs as effectively as under cooperation. In this scenario, the MNF's revenue equals $A{\delta^H}^\alpha x_i^\alpha = \delta R$, with ${\delta^H}^\alpha \equiv \delta < 1$. Otherwise, if IPR are not enforced, which occurs with probability $1-\lambda$, the MNF can still assemble a quantity $\delta^H x_i$, but now may face competition from the manufacturer, who can independently start to sell the quantity $\varphi_V^M x_i$. The size of φ_V^M depends on the efficiency of imitation, which is related to the capacity to learn and reproduce the technology (*i.e.* on technological spillovers). In this case, the total quantity sold in the market is $(\delta^H + \varphi_V^M)x_i$, and the revenue of the final good supplier falls to $A(\delta^H + \varphi_V^M)^{(\alpha-1)}{\delta^H}^\alpha x_i^\alpha = \delta_I R$, where $(\delta^H + \varphi_V^M)^{(\alpha-1)}{\delta^H}^\alpha \equiv \delta_I$, with the subscript $_I$ indicating imitation. Therefore, with probability $1-\lambda$, the MNF's revenue drops to $\delta_I R$, with $\delta_I < \delta$, because of the competition effect generated by the Southern manufacturer. Similarly, the revenue for the manufacturer is $A(\delta^H + \varphi_V^M)^{(\alpha-1)}{\varphi_V^M}^\alpha x_i^\alpha = \phi_V R$, where ϕ_V is the manufacturer's outside option under integration.

To summarize, in case of contractual breach, the expected revenue of the MNF is $\lambda\delta R + (1-\lambda)\delta_I R$. Therefore, the MNF's share of the total revenue R is written as:

$$\beta(1 - \lambda\delta - (1-\lambda)(\delta_I + \phi_V)) + \lambda\delta + (1-\lambda)\delta_I \equiv \beta_V[\lambda], \tag{5}$$

while manufacturer's share of the revenue is written as:

$$(1-\beta)(1 - \lambda\delta - (1-\lambda)(\delta_I + \phi_V)) + (1-\lambda)\phi_V \equiv 1 - \beta_V[\lambda]. \tag{6}$$

Notice that when $\lambda \to 1$ our model corresponds to Antràs and Helpman (2004), which represents our benchmark case with perfect IPR enforcement. When λ decreases, control on the physical assets is not enough to ensure a high revenue, and this shrinks the outside option of the headquarters. This captures the idea that property rights on intangibles are crucial to determine the relative advantages of integration. Using (5) and (6), the operating profits of the MNF can be written as:

$$\Pi_V^H = \beta_V[\lambda]R - zw_N \tag{7}$$

where β_V is the MNF's share of the revenue, and w_N represents the wage rate in the North. Similarly, the operating profit of the integrated manufacturer can be written as:

$$\Pi_V^M = (1 - \beta_V[\lambda])R - mw_s \tag{8}$$

4.2 Outsourcing

We can now describe the incomplete contract problem in case of outsourcing. In the absence of an agreement at $t = 2$, the final good supplier is left with a zero payoff. This comes from the fact that the headquarters, based in the developed country, cannot quickly find an alternative supplier for the provision of the intermediate manufactured input. This lower disagreement payoff captures the idea that under outsourcing the headquarter is less able to control the operations of the manufacturer than in the case of vertical integration. Similar to the case of integration, the manufacturer can exploit the foreign technology only if intellectual property rights are not protected. In this case, the manufacturer can decide to free-ride on the technology and operate the technology on the side, to realize a positive revenue. Therefore, with probability $1 - \lambda$, the Southern independent manufacturer imitates the variety, and realizes a share of the potential revenue equal to $A{\varphi_O^M}^\alpha x_i^\alpha R = \phi_O R$, where $\phi_O R$ is its outside option under outsourcing.

Therefore, the MNF's share of revenue under outsourcing is as follows,

$$\beta(1 - (1 - \lambda)\phi_O) \equiv \beta_O[\lambda]. \tag{9}$$

Similarly, manufacturer's share of the revenue is written as:

$$(1 - \beta)(1 - (1 - \lambda)\phi_O) + (1 - \lambda)\phi_O \equiv 1 - \beta_O[\lambda]. \tag{10}$$

Again, when $\lambda \to 1$ the model converges to the benchmark case in Antràs and Helpman (2004), where contractual breach under outsourcing leaves both parties with zero outside option. Differing from this, in our set-up, when property rights are not perfectly enforced, the independent manufacturer can realize a positive outside option by operating the technology on the side. Therefore, his outside option decreases with λ.

The operating profit of the MNF under outsourcing writes:

$$\Pi_O^H = \beta_O[\lambda]R - zw_N. \tag{11}$$

Similarly, the operating profit of the independent manufacturer writes:

$$\Pi_O^M = (1 - \beta_O[\lambda])R - mw_s. \tag{12}$$

Following the literature, we assume that $\beta_V[\lambda] > \beta_O[\lambda]$. This captures the idea that the MNF is able to achieve a higher share of the surplus under vertical integration than under outsourcing.

5 Equilibrium

Under vertical integration, the final good producer and the manufacturer maximise (7) and (8) respectively, while under outsourcing they maximise (11) and (12). From the first-order conditions of these programs and using (4) we can write the total operating profits as:

$$\pi_k = A^{1/(1-\alpha)}\theta^{\alpha/(1-\alpha)}\Psi_k(\beta_k[\lambda]) - w^N f_k, \qquad k = \{V, O\}, \tag{13}$$

where

$$\Psi_k(\beta_k[\lambda]) = \frac{1-\alpha\left(\beta_k[\lambda]\eta + (1-\beta_k[\lambda])(1-\eta)\right)}{((1/\alpha)(w_n/\beta_k[\lambda])^{\eta}(w_s/(1-\beta_k[\lambda]))^{1-\eta})^{\alpha/(1-\alpha)}}, \qquad k = \{V, O\}. \tag{14}$$

It is important to note that $\Psi_k(\beta_k[\lambda])$ is not necessarily increasing in λ. When λ increases, the share of revenue retained by the final good producer, $\beta_k[\lambda]$, increases. However, due to incomplete contracts, this does not necessary increase profits. In fact, an increase in the share of the MNF's revenues augments total profits only when the headquarters intensity, η, is sufficiently large. Conversely, for low levels of η, higher operating profits are associated with low revenue shares retained by the MNF. This results from standard hold-up theory: efficient allocation of property rights requires that ownership is allocated to the party that contributes more to the value of the relationship.

Since the fixed cost from vertical integration is higher than that under outsourcing, $f_V > f_O$, and vertical integration is associated with a higher share of revenues retained by the MNF, $\beta_V[\lambda] > \beta_O[\lambda]$, then vertical integration can only arise when η is high. Therefore, an improvement in IPR protection, λ, increases the difference in profitability between vertical integration and outsourcing if and only if:

$$\partial\beta_V[\lambda]/\partial\lambda > \partial\beta_O[\lambda]/\partial\lambda. \tag{15}$$

Under vertical integration the MNF has property rights over production facilities. This reinforces its ability to respond to contractual breaches and allows it to reap a higher part of the surplus. Nonetheless, this ability shrinks if intellectual property rights are not well protected. In this case, even if the MNF controls the production facilities, it still faces competition from the independent manufacturer in case of contractual breach. This explains the importance of λ. Increasing the protection of IPR, λ, generates a contraction in the manufacturer's outside option under both ownership structures. This reduction is related to the manufacturer's ability to imitate the foreign technology, φ_k^M. If this ability is higher under vertical integration than under outsourcing, then higher IPR protection increases by a larger extent the share of surplus of vertically integrated MNF.

We now consider firm heterogeneity. We suppose that the productivity parameter θ is randomly drawn at the ex-ante stage t_O. The ranking chosen for fixed organizational costs, $f_V > f_O$, implies that less efficient firms choose outsourcing and more efficient firms select vertical integration. The critical threshold above which firms outsource is given by the following zero profit condition:

$$\pi^O = A^{\frac{1}{1-\alpha}}\theta^{\frac{\alpha}{1-\alpha}}\Psi_O(\beta_O[\lambda]) - f_O w_n \geq 0. \tag{16}$$

Using equation (16), we can then derive the minimum cutoff productivity for outsourcing to a Southern independent manufacturer, which is:

$$\theta^O[\lambda] = A^{-\frac{1}{\alpha}} \left(\frac{f_O w_n}{\Psi_O(\beta_O[\lambda])} \right)^{\frac{1-\alpha}{\alpha}}. \tag{17}$$

Therefore, firms outsource in the South if their productivity level is higher than the threshold $\theta_O[\lambda]$.

The vertical integration cutoff is obtained by setting the operating profits from vertical integration as equal to those from outsourcing. In particular, the MNF chooses to be vertically integrated if and only if this strategy generates at least the same profits as the outsourcing strategy, namely, if $\pi^V - \pi^O \geq f_V - f_O$:

$$\pi^V - \pi^O = (A^{\frac{1}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \Psi_V(\beta_V[\lambda]) - f_V w_n) - (A^{\frac{1}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \Psi_O(\beta_O[\lambda]) - f_O w_n) > 0. \tag{18}$$

Therefore, vertical integration is preferred to outsourcing for those firms which have productivity at least equal to $\theta_V[\lambda]$:

$$\theta^V[\lambda] = A^{-\frac{1}{\alpha}} \left(\frac{(f_V - f_O) w_n}{(\Psi_V(\beta_V[\lambda]) - \Psi_O(\beta_O[\lambda]))} \right)^{\frac{1-\alpha}{\alpha}}. \tag{19}$$

In our framework, an increase in λ moves both productivity thresholds, (17) and (19), to the left. Less efficient firms begin to outsource, while the more efficient ones choose vertical integration.

To compute the share of manufacturing inputs transacted within multinational firm boundaries, we assume foreign inputs are priced such that these input expenditures constitute the same multiple of operating profits under all organizational forms. Integrating over firm types and taking the ratio, gives the share of imports transacted within firm boundaries, $\sigma_V[\lambda]$, which is:

$$\sigma_V[\lambda] = \frac{\int_{\theta^V}^{\infty} A^{\frac{1}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \Psi_V(\beta_V[\lambda]) \, dG(\theta)}{\int_{\theta_O}^{\theta^V} A^{\frac{1}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \Psi_O(\beta_O[\lambda]) dG(\theta) + \int_{\theta^V}^{\infty} A^{\frac{1}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \Psi_V(\beta_V[\lambda]) \, dG(\theta)}. \tag{20}$$

Assuming that θ follows a Pareto distribution with parameter $\kappa > 1/(1-\alpha) - 1$, and using thresholds (17) and (19) we obtain:

$$\sigma_V[\lambda] = \frac{\frac{\Psi_V(\beta_V[\lambda])}{\Psi_O(\beta_O[\lambda])}}{\left[\left(\frac{\theta_V[\lambda]}{\theta_O[\lambda]} \right)^{\kappa - (\frac{1}{1-\alpha} - 1)} - 1 \right] + \frac{\Psi_V(\beta_V[\lambda])}{\Psi_O(\beta_O[\lambda])}}, \tag{21}$$

where:

$$\frac{\theta_V[\lambda]}{\theta_O[\lambda]} = \left[\frac{f_O}{f_V - f_O} \left(\frac{\Psi_V(\beta_V[\lambda])}{\Psi_O(\beta_O[\lambda])} - 1 \right) \right]^{-\frac{\alpha}{1-\alpha}}. \tag{22}$$

Therefore, the relative share of intra-firm imports in equation (21) is increasing in the ratio $\Psi_V(\beta_V[\lambda])/\Psi_O(\beta_O[\lambda])$. This ratio is a complex function of λ. Nevertheless, we can establish that when ϕ_O/ϕ_V is sufficiently small, then an increase in IPR protection, λ, will increase the share of intra-firm trade.

Proposition 1 *Suppose that the intensity in headquarters services, η, is sufficiently large, so that the function $\Psi_k(\beta_k[\lambda])$ is increasing in $\beta_k[\lambda]$. Then, the ratio $\Psi_V(\beta_V[\lambda])/\Psi_O(\beta_O[\lambda])$ is increasing in λ if and only if ϕ_O/ϕ_V is sufficiently small.*

Proof: Using standard derivation rules and developing computations, we have that $\partial(\Psi_V(\beta_V[\lambda])/\Psi_O(\beta_O[\lambda]))/\partial\lambda > 0$ if and only if:

$$\frac{\frac{\partial\Psi_V(\beta_V[\lambda])}{\partial\beta_V[\lambda]}}{\frac{\partial\Psi_O(\beta_O[\lambda])}{\partial\beta_O[\lambda]}}\frac{\Psi_O(\beta_O[\lambda])}{\Psi_V(\beta_V[\lambda])} > \frac{\phi_O}{\phi_V + \frac{\beta}{1-\beta}(\delta-\delta_I)}. \tag{23}$$

Let us start by studying the following term:

$$\frac{\frac{\partial\Psi_k(\beta_k[\lambda])}{\partial\beta_k[\lambda]}}{\Psi_k(\beta_k[\lambda])} = \frac{(1-\alpha)\eta + \alpha\eta^2 + \beta_k[\lambda]^2(2\eta-1) + 2\eta\beta_k[\lambda](1-(1-\eta))}{(1-\beta_k[\lambda])(1-\alpha)\beta_k[\lambda](1-\alpha(1-\eta)+\alpha\beta_k[\lambda](2\eta-1))},\quad k\in\{V,O\}, \tag{24}$$

which is a decreasing function of $\beta_k[\lambda]$. Using this fact, and remembering that $\beta_V[\lambda] > \beta_O[\lambda]$, and that $\frac{\partial\Psi_k(\beta_k[\lambda])}{\partial\beta_k[\lambda]} > 0$, we can conclude that the left hand side of equation (23) is strictly positive, and smaller than one. Since the left hand side is strictly positive and the right hand side is increasing in the ratio ϕ_O/ϕ_V, then a sufficient condition for the inequality in (23) to hold is that ϕ_O/ϕ_V is sufficiently small. Q.E.D.

A sufficient condition for (23) to be satisfied is that ϕ_O/ϕ_V is smaller than one, which means that a vertically integrated manufacturer is relatively more able to replicate the variety produced by the final good producer. To ensure that equation (23) is satisfied for all $\phi_O < \phi_V$, we use the following parameter values: $\beta = 1/2$, $\eta = 2/3$, $\alpha = 4/5$, $\lambda = 2/3$, $\phi = 0.2$, and $\delta = 0.4$. Few comments about the choice of the parameter values. $\beta = 1/2$ corresponds to the standard assumption of symmetric Nash bargaining in the incomplete contract problem. In line with the literature, we choose $\alpha = 4/5$, which translates into a relatively high elasticity of substitution, equal to $1/(1-\alpha) = 5$ (see Imbs and Mejean, 2017 and Broda and Weinstein, 2006 among others). The value of $\eta = 4/5$ is chosen to be sufficiently large to give a high weight to headquarter services (including intangibles and knowledge). This condition ensures that profits are increasing in β_k and that vertical integration can arise in equilibrium (see Antràs and Helpman (2004)). Similarly, the values of δ and ϕ (with $\delta > \phi$, following the model) are chosen to make the incomplete contract problem interesting. This implies that the profits of the headquarter under both vertical integration and outsourcing always increase when its bargaining power increases. Finally, the value for λ implies that, in case of contractual breach, the headquarter has a 2/3 probability of obtaining IPR protection. This value of λ imposes stringent condition: in fact lower values of λ relax the condition in (23).[8] When

[8] Elmer and Lewis (2010) show that in developed countries the probability that the plaintiff wins an IPR trial is usually around one half in the best case scenario. Despite this finding cannot be directly translated into our λ, it can be used to support our choice for having a relatively high value of λ.

slightly changing the parameter values, we find qualitatively similar results.

The result in Proposition 1 states that an increase in IPR protection increases the relative profitability of vertical integration whenever the outside option of the manufacturer under outsourcing, ϕ_O, is sufficiently smaller than its outside option under integration, ϕ_V. Indeed, the term ϕ_k, with $k = \{V, O\}$, captures the manufacturer's ability to free-ride on the technology invented by the Northern multinational in case of contractual breach. Therefore, two scenarios are possible. If vertical integration allows the manufacturer to grab a sufficiently higher level of knowledge through technological spillover, then an increase in IPR enforcement is more valuable for vertical integrated firms. On the other hand, if technology spillovers are higher under outsourcing, then the opposite result holds. Both results are theoretically possible. However, in line with the empirical evidence discussed in Section 1 and with our model, knowledge spillovers can be larger under vertical integration. In our model, transfers of the intermediate input z to the Southern manufacturer are larger in more productive firms. Since in equilibrium more productive firms choose vertical integration, technology transfers will be larger in these types of firms.

6 Empirical Evidence

The goal of this section is to quantify empirically the role of IPR in affecting the global sourcing decisions of firms. Since our model describes firm organizational decisions, firm-level data would seem more appropriate. One possibility would be to use the French firm-level data that provides information on the global sourcing practice of firms, called *EIIG* (Echanges Internationaux Intra-Groupe). However these data have several limitations. Firstly, *EIIG* is a survey available only for 1999, and so it lacks the time dimension which is crucial to evaluating the effect of IPR. Secondly, *EIIG* covers only French firms that traded more than 1 million euros in 1999, which are owned by manufacturing groups that control at least fifty percent of the equity capital of an affiliate based outside France. This, in turn, raises concerns about sample selection biases. Our approach will thus exploit industry-level variations, taking advantage of the US Related-Party Trade database made available by Pol Antràs.[9] The dataset provides information on goods transactions across borders within and outside of firm boundaries over the period 2000–2010. This database defines a related party as a foreign counterpart in which the US importer has at least 6% equity. This is lower than the conventional 10% threshold used by the International Monetary Fund (IMF) to identify FDI. However, Nunn and Trefler (2008) provide suggestive evidence that related party trade is generally associated with one of the entities having a controlling stake in the other entity. In the following sections we present the description of the data, our empirical strategy, and a discussion of the results.

[9] These data are available for 193 countries and 253 manufacturing industries. Chapters 5 and 8 in Antràs (2015), and Antràs' web page http://scholar.harvard.edu/antras/books, provide additional information about the data.

6.1 Data Description

To capture US firms' decisions to integrate foreign suppliers, we follow the recent literature in using the share of related party imports in total US imports, i.e. (Related Trade)/(Related Trade + Non-Related Trade). This is known in the literature as the *share* of intra-firm imports, and varies at the exporting country-industry-year level over the period 2000–2010. In line with our theoretical set-up, we follow Antràs and Chor (2013) who mapped NAICS industry codes to six-digit IO2002 industries using a correspondence from the Bureau of Economic Analysis (BEA). This mapping has the advantage of constructing measures of headquarters intensity for the US industry *buying* those inputs. This is different from using the raw data in NAICS codes, which instead give information on the industry of the product being imported. Additionally, using the Wright (2014) methodology, the IO2002 classification can isolate the intermediate input component of import flows.[10] This cleaning should eliminate possible confounding effects for the role of IPR due to the fact that original US product-level data combine intermediate input as well as finished goods imports. One shortcoming of using US manufacturing data is related to the fact that, in recent years, different multinationals have concentrated on pre-production activities such as design and engineering. The presence of "factoryless goods producers", as referred to in Bernard and Fort (2015), introduces errors since the IO tables are not able to capture outsourcing by wholesalers.[11] Nonetheless, this dataset remains one of the most reliable sources of information concerning global value chains.

To better capture the type of global sourcing in our model, it is important to distinguish between trade within US multinationals and trade within foreign multinationals operating in the United States. Therefore we follow Antràs (2015) and apply the Nunn and Trefler (2013) correction. This implies dropping from the initial set of countries those for which shipments from foreign headquarters to their US affiliates are likely to be predominant, relative to shipments to US parents from their foreign affiliates in those countries. Specifically, this consists in keeping those countries for which the share of US headquarters is above 50 percent.[12] However, this sample restriction has almost no impact on our estimates.

To measure IPR protection we use Park (2008), who updates the index of patent protection published in Ginarte and Park (1997). The new IPR index, always calculated in periods of 5 years, includes more years, and it is extended to 122 countries. This index ranges between 0 and 5, with 5 being the highest level of IPR protection. It is computed as an unweighted sum of five separate scores associated with patent protection: coverage, duration of protection, enforcement mechanisms, membership in international treaties, and restrictions that limit the control over an invention by a patent holder. After merging the IPR index with data on shares of intra-firm imports we are left with 115 countries and three years 2000, 2005 and 2010.

The Ginarte and Park index has a long history of being used as a measure of IPR protection. In fact, there is no obvious alternative index that allows to compare the strength of the

[10] For more details on the Wright (2014) methodology, see appendix B.3 in Antràs (2015).

[11] For instance, starting from 2004, Apple has become a wholesale firm, while its production process has been carried out by other firms, such as Foxconn in China.

[12] The dropped destination countries are Iceland, Italy, Finland, Liechtenstein, and Switzerland.

patent system for a large panel of countries and years. Of course, the index also has some limitations. For instance, it captures only *de jure* enforcement, measuring to which extent the legal system provides for preliminary injunctions, pleadings of contributory infringement, and reversal of the burden of proof. Therefore, the IPR measure proposed by Ginarte and Park (1997) might not completely capture the *de facto* state of patent rights. To partly overcome these problems, we also replicate our results using alternative measure of IPR. Specifically, following Hu and Png (2013), we interact the Ginarte and Park index with the Fraser Institute's index of legal systems and property rights.

To control for headquarters intensity of an industry, we follow the bulk of the literature and proxy for it with measures of physical capital, skill and R&D intensities of US manufacturing firms (see Nunn and Trefler (2013) and Antràs and Chor (2013) among others). Capital intensity is separated into expenditures on capital equipment (computers and data processing), and on capital structure (automobile and trucks). Skill intensity is the ratio of the number of non-production workers divided by total employment. R&D intensity is computed as R&D expenditures divided by sales. The underlying data from NBER-CES and Orbis are available on a yearly basis, but others, like specificity and contractability, are not.[13] Therefore, to capture the *average* buyer in an industry, Antràs and Chor (2013) and Antràs (2015) use weighted average measures of headquarters intensity. Therefore, in our estimations, we also rely on those averaged industry measures.

To control for country-level characteristics we use different measures. From the World Development Indicators (World Bank), we use a time-varying governance indicator that captures perceptions of the extent to which agents have confidence in and abide by the rules of society (rule of law). We also add a dummy variable that equals one when the importing country is a WTO member. Finally, since our theoretical framework is characterized by incomplete contracts, we include a contractibility measure at the IO2002 industrial level. This variable, borrowed from Antràs and Chor (2013) who build on the methodology of Nunn (2007), measures the importance of relationship-specific investments across industries. It is normalized so that higher levels imply lower dependence on formal contract enforcement, and averaged over time.

6.2 Empirical Specification

In this section we describe our empirical specification for disentangling the effect of IPR on the propensity of transacting a particular input within firm boundaries. We use the US data on intra-firm imports to test part of the prediction implied by Proposition 1, namely, that intra-firm share is increasing in the level of IPR.

Following our model, and to address possible biases coming from the endogenous location decisions of firms regarding stages of production, we exploit the country-industry variation in

[13] For additional information on the different database used, see Appendices in Antràs and Chor (2013) and in Antràs (2015).

our intra-firm shares. Our baseline regression is then:

$$S_{ict} = \beta_1 + \beta_2 IPR_{ct} + \beta_3 c_i + \bar{\boldsymbol{X}}_{\boldsymbol{i}}\boldsymbol{\theta} + \boldsymbol{Z}_{\boldsymbol{ct}}\boldsymbol{\delta} + \mu_c + \gamma_t + \epsilon_{ict}, \tag{25}$$

where S_{ict} is intra-firm import shares in industry i, importing from country c, in a given year t. IPR_{ct} is the IPR index at the country-year level. c_i is the average buyer contractibility measure from Nunn (2007). The vector $\bar{\boldsymbol{X}}_{\boldsymbol{i}}$ comprises a set of US industry controls for headquarters intensity averaged over time. The vector $\boldsymbol{Z}_{\boldsymbol{ct}}$ are destination country controls like rule of law and WTO membership. We also control for destination country unobservable characteristics and for any trend using country and year fixed effects, μ_c and γ_t respectively. Finally, we cluster the standard errors by country and time, since our key explanatory variable, related to the level of IPR protection in a country, varies by country and time.

Our theory predicts that if vertical integration allows the obtaining of a sufficiently high level of knowledge through technological spillover, then an increase in IPR protection is more valuable for vertically integrated firms. Thus, IPR should encourage relatively more intra-firm imports, and we expect our coefficient of interest, β_2, to be positive. The average buyer contractibility, β_3, is expected to be negative, indicating that industries with a lower dependence on formal contract enforcement should be less inclined to import the input within firm boundaries. The industry-level controls in the vector $\bar{\boldsymbol{X}}_{\boldsymbol{i}}$ identify the *average* characteristics of the buying US industry. Rule of law and the WTO dummy capture time-varying destination country characteristics.

7 Empirical Results

7.1 Benchmark Specification

We now turn to our estimations. OLS estimates of equation (25) are reported in Table 1. In column (1) we provide estimation results for equation (25) including only the IPR variable, and controlling for country, industry and time characteristics. The estimated coefficient for IPR is positive and statistically significant, which supports the idea that an increase in IPR protection is more valuable for vertically integrated firms. This is consistent with our intuition that vertical integration allows the manufacturer to obtain sufficiently high levels of knowledge through technological spillovers. In column (2) we control for average headquarters intensity characteristics, and WTO dummy. Since average headquarters intensity characteristics have no time variation, we drop the industry fixed effects in this specification. In column (3) we add the contractibility measure of the buyer, which is negative and statistically significant, supporting the hypothesis that industries with a lower dependence on formal contract enforcement should be less inclined to import the input within firm boundaries. In column (4) we control for rule of law which measures the quality of contract enforcement at the country level. The impact of this variable is significant and negative, which is related to the fact that an increase in the quality of contract enforcement should facilitate writing contracts with independent parties, thus favoring arm's length transactions relative to intra-group imports. In the attempt to isolate the intensive margin effect, in column (5) we add the level of initial total imports (sum of related and non-related imports). In fact, if sectors structurally differ in the share of intra-firm trade, the observed changes could simply be related to the evolution of the total volume of imports. Controlling for the initial level of total imports is an attempt to isolate the effect of IPR on the intensity of vertical integration.

Finally in columns (6) and (7) we consider sub-samples of countries. More precisely, in column (6) we restrict the sample to less developed countries (i.e. less DEV), while in column (7) we only consider developed economies (i.e. DEV). The grouping of countries is based on United Nations classification and follows Park and Lippoldt (2008).[14] As shown, the results are confirmed for the less developed countries, and become not significant for the developed economies. This might be related to the fact that in the set of developed economies the IPR index has very limited variation (see also in Lin and Lincoln, 2017 and Palangkaraya et al., 2017). These results suggest that much of the action takes place in those countries which have experienced larger changes in IPR protection.

To provide a quantification for our results we could use column (1). Since in our empirical specification IPR is an index, these results suggest that a one standard deviation increase in IPR (0.77), increases by 0.018 the intra-firm import share.[15] Concretely, comparing two countries, which are one standard deviation above (like Canada, or France), and one standard deviation below (like Mauritania, or Thailand) the sample average of IPR, we would expect their share of intra-firm imports to differ by around 4 percent ($0.024 \times 2 \times 0.77$).

[14]The list of developed and less developed countries is provided in Table 9.

[15]Table 7 in Appendix provides in-sample summary statistics.

Table 1: IPR and Intermediate Intra-firm Trade Shares

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1)	(2)	(3)	(4)	(5)	(6) less DEV	(7) DEV
IPR	0.024***	0.028***	0.028***	0.027***	0.032***	0.029***	0.042
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.035)
WTO member		-0.028*	-0.028*	-0.026	-0.036**	-0.025	
		(0.017)	(0.017)	(0.017)	(0.015)	(0.017)	
log R&D/Sales		0.023***	0.021***	0.021***	0.019***	0.020***	0.022***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
log (Skill/Unskilled)		0.026***	0.020**	0.020**	0.021***	0.009	0.040***
		(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.014)
log (Capital Struct/Labor)		-0.023***	-0.021***	-0.021***	-0.041***	-0.007	-0.045***
		(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.013)
log (Capital Equip/Labor)		0.056***	0.061***	0.061***	0.073***	0.051***	0.076***
		(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.011)
Contractibility			-0.062***	-0.062***	-0.069***	-0.088***	-0.015
			(0.011)	(0.011)	(0.011)	(0.013)	(0.019)
Rule of law				-0.016	-0.005	-0.008	-0.140***
				(0.012)	(0.012)	(0.013)	(0.032)
log Imp t_0					0.023***		
					(0.001)		
Observations	30,209	30,209	30,209	30,209	27,054	19,998	10,211
R-squared	0.239	0.179	0.180	0.180	0.231	0.140	0.117
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	No	No	No	No	No	No

Notes: The regressions are OLS estimations of equation (25). The dependent variable is the US intra-firm import share of importing industry i in year t. Manufacturing sectors only. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. Heteroskedasticity-robust standard errors clustered by country-year are reported in parentheses. $***$, $**$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively.

7.2 Identification

We should be cautious in interpreting the OLS estimates, because the choice of IPR made by our destination countries could be endogenous. The main reason is that the size of FDI and outsourcing attracted by a country, could also influence the propensity to protect IPR, raising a possible reverse-causality issue. For instance, developed countries could exert pressure on countries hosting FDI to modify their institutions, causing an upward bias of OLS estimates. FDI, outsourcing and IPR could also be influenced by other omitted confounding factors, like market size and technological development, which again would bias our results. For example, countries can reduce their propensity to enforce IPR so as to exploit the benefits from imitating an MNF. This would instead cause a downwards bias in OLS estimates.[16]

To account for these problems, we estimate equation (25) using instrumental variable (IV) techniques. First, in line with Hu and Png (2013) and Nunn (2007), we use differences in countries' legal origins as instruments for IPR.[17] Different studies show that legal origin is an important determinant of national institutions (see La Porta et al., 2008 and Acemoglu and Johnson, 2005 among others). Since IPR reflect the specific level of contract enforcement between countries, we believe there is a strict connection between IPR and legal origin. Additionally, because each country's legal origin is predetermined and unaffected by trade flows in 2000, this can be used to isolate exogenous variation in IPR. The legal origins are indicator variables that equal one if country c has a legal origin that is British common law, French civil law, or German civil law. The omitted category is for Scandinavian civil law countries.

Table 2 presents the results with legal origins and cross-sectional data. More specifically, column (1) presents results on a pooled OLS regression. Column (2) presents IV results using a pooled regression and legal origins. Columns (3), (4) and (5) present cross-sectional IV results for 2000, 2005, and 2010 respectively. The first-stage estimates suggest that IPR are strongest in Scandinavian legal origin countries, followed by English legal origin countries, and French legal origin countries. These results are consistent with previous evidence of the relationship between legal origins and national institutions. In the top panel of Table 2 we report the second-stage estimates. The IV coefficient is positive and statistically significant, providing support for the importance of IPR for vertically integrated firms.

[16] Notice that rule of law could also suffer from endogeneity concerns (see Nunn (2007)). Therefore, we omit this variable from the following analysis.

[17] Data are taken from La Porta et al. (1999).

Table 2: Instrumenting IPR (Cross Section)

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1) OLS Pooled	(2) IV Pooled	(3) IV 2000	(4) IV 2005	(5) IV 2010
IPR	0.096***	0.154***	0.160***	0.130***	0.176***
	(0.013)	(0.042)	(0.033)	(0.045)	(0.054)
WTO member	0.059**	0.018	0.032	0.019	-0.014
	(0.026)	(0.051)	(0.043)	(0.049)	(0.087)
log R&D/Sales	0.020***	0.021***	0.021***	0.019***	0.022***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
log (Skill/Unskilled)	0.017	0.019*	0.024*	0.031**	0.002
	(0.011)	(0.010)	(0.014)	(0.013)	(0.014)
log (Capital Struct/Labor)	-0.022**	-0.023**	-0.004	-0.025*	-0.036***
	(0.010)	(0.010)	(0.015)	(0.013)	(0.013)
log (Capital Equip/Labor)	0.062***	0.062***	0.051***	0.063***	0.070***
	(0.009)	(0.009)	(0.012)	(0.011)	(0.013)
Contractibility	-0.067***	-0.067***	-0.081***	-0.062***	-0.058***
	(0.016)	(0.016)	(0.020)	(0.019)	(0.020)
IV British legal origin:		-0.561***	-0.495*	-0.648***	-0.519***
		(0.179)	(0.257)	(0.176)	(0.168)
IV French legal origin:		-0.607***	-0.584**	-0.694***	-0.531***
		(0.152)	(0.235)	(0.142)	(0.144)
IV German legal origin:		0.249	0.503***	0.089	0.176
		(0.178)	(0.187)	(0.209)	(0.213)
Observations	30,210	30,210	9,421	10,307	10,482
R-squared	0.077	0.059	0.039	0.060	0.069
F-stat first stage		9.91	16.01	11.27	7.47
Sargan Test (p-val)		0.631	0.738	0.683	0.611

Notes: The dependent variable is the US intra-firm import share of importing industry i in year t. Manufacturing sectors only. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. The first column presents results on a pooled OLS regression. Column (2) presents IV results using a pooled regression and legal origin as an instrument. Columns (3), (4), and (5) present cross-sectional IV results for 2000, 2005, and 2010 respectively, using legal origin as an instrument. Heteroskedasticity-robust standard errors clustered by country are reported in parentheses. $***$, $**$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively.

To recover the time dimension in our data, we need to introduce a time-varying instrument for IPR. Following Auriol et al. (2015), we use a measure of outward migration of students. This yearly measure represents the number of students leaving their home country to study in foreign democracies (as defined by the Freedom House Indicators).[18] The idea is that foreign students migrating to democratic destinations, while preserving the link with their home country, can influence their home country's attitudes towards institutions such as IPR, and promote technological progress. The size of student outward migrations in a given country should then have an impact on that country's attitude towards IPR enforcement. The empiri-

[18]Data are taken from Spilimbergo (2009).

cal literature supports the idea that migrant students have an impact on institutional reforms. Spilimbergo (2009) shows that individuals educated in foreign democratic countries can promote democracy in their home country. Additionally, this literature highlights a positive effect of student migrations on technological transfers. For instance, Dominguez Dos Santos and Postel-Vinay (2003) and Dustmann et al. (2003) stress the positive effects of natives that decide to return to their home country.

Student migrations could be related not only to the attitudes towards IPR, but also to trade flows, which would cast doubt on the validity of our approach. However, what is required is that student migrations have no direct effect on the *composition* of import flows. Although cultural links related to student migrations might affect the general tendency to import from a country, there are no particular reasons to think that this should directly impact the choice to source these imports from vertically integrated as opposed to independent firms. Nevertheless, to further reduce endogeneity concerns, we construct a measure of outward migration which takes the average number of students leaving from the neighboring countries, excluding the country of interest. Specifically, we use the bilateral distances as weights to generate a single indicator for each country and each period: for each country c the instrument is built as the weighted sum of migrating students leaving from country's c neighboring countries to study abroad, where weights are given by the bilateral distances between c and each other country. This measure should reduce the risk of direct correlation of the instrument with country c local conditions, which could weaken the exogeneity of the instrument. Additionally, this measure is lagged five and fifteen years.

The IV estimates are reported in Table 3. Column (1) presents results for the OLS regression of equation (25). Column (2) presents IV results using our weighted measure of student migration lagged five years. Columns (3) presents IV results adding legal origins. Column (4) shows results using average students migrations lagged 15 years and legal origins. The coefficients of the excluded instruments in the first-stage equations explaining IPR are reported in the bottom part of the table. The sign of the coefficient of the lagged number of students leaving from neighboring countries is negative. This suggests that when country's c neighboring countries have more students leaving to study abroad, this decreases the incentives of country c to protect IPR. One possible interpretation is that when neighboring countries increase IPR protection and attract foreign technology, this might induce a substitution effect and reduce the incentive for higher IPR protection in country c. When we add the legal origins, we find that IPR are strongest in Scandinavian legal origin countries, followed by English legal origin countries, and then French legal origin countries. In the top panel of Table 3 we report the second-stage estimates. From column (3), we show the results for the test of over-identification restrictions. All IV estimations confirm the benchmark case in column (1). To carefully address this issue of identification, Table 10 in Appendix reports IV results where we exclude some potentially endogenous variables, i.e. the industry covariates, which are certainly correlated with the error term. First, in columns (1) and (2), we eliminate industry level covariates. Then, in columns (3) and (4) we use industry and industry-year fixed effects respectively.[19] These results confirm our findings in Table 3.

Finally, in column (5) we replicate column (4), but focusing on our sample of less developed economies. The results are consistent with our previous findings. Due to the size of the sample used in column (5), which is slightly more than half of our initial sample, our time-varying instrument, student outward migrations lagged 15 years, is not significant in the first stage regression. We thus confirm the difficulties highlighted in the previous literature when focusing on sub-samples of countries (see Lin and Lincoln, 2017, and Palangkaraya et al., 2017 among others). Nevertheless, these results comfort our findings.[20]

[19]Industry fixed effect are at the 6 digit. But then, to overcome the problem generated by the too many dummies in constructing the industry-year fixed, we aggregate industry at the 3 digit.

[20]Following Lin and Lincoln (2017), we also replicate our results using a sub-sample of less developed countries with a sufficient level of IPR variation over time. The IPR variation should reflect the adoption by these countries of important country-reforms. Results remain consistent.

Table 3: Instrumenting IPR

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV less DEV
IPR	0.093***	0.145***	0.151***	0.151***	0.071**
	(0.008)	(0.032)	(0.022)	(0.023)	(0.028)
WTO member	0.058***	0.026	0.022	0.022	0.045**
	(0.019)	(0.033)	(0.030)	(0.031)	(0.018)
log R&D/Sales	0.021***	0.021***	0.021***	0.021***	0.019***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
log (Skill/Unskilled)	0.017**	0.020**	0.020**	0.020**	0.005
	(0.008)	(0.009)	(0.008)	(0.008)	(0.009)
log (Capital Struct/Labor)	-0.020**	-0.020**	-0.020**	-0.020**	-0.009
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
log (Capital Equip/Labor)	0.058***	0.058***	0.058***	0.058***	0.054***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Contractibility	-0.068***	-0.068***	-0.068***	-0.068***	-0.094***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.013)
Country FE	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes
IV migrants (L5/L5/L15):		-5.322***	-4.299***	-3.831***	2.273
		(0.967)	(1.020)	(1.136)	(1.404)
IV British legal origin:			-0.328***	-0.401***	-0.831***
			(0.123)	(0.121)	(0.126)
IV French legal origin:			-0.503***	-0.566***	-0.797***
			(0.107)	(0.103)	(0.103)
IV German legal origin:			0.394***	0.364***	-0.269***
			(0.128)	(0.122)	(0.183)
Observations	29,354	29,354	29,354	29,354	19998
R-squared	0.075	0.061	0.057	0.058	0.03
F-stat first stage		30.29	30.43	28.74	21.49
Sargan Test (p-val)			0.540	0.541	0.233

Notes: The dependent variable is the US intra-firm import share of importing industry i in year t. Manufacturing sectors only. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. The first column presents results from OLS regression of equation (25). Column (2) presents IV results using average students migration lagged 5 years. Columns (3) presents IV results using average students migration lagged 5 years and legal origin. In column (4) we lag average students migration 15 years. Heteroskedasticity-robust standard errors clustered by country-year are reported in parentheses. $***, **$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively. Column (5) uses migrants lagged 15 years, but result are preserved also for L5.

7.3 Robustness and Sensitivity Analysis

In this section we run some robustness checks to overcome other possible limitations of the analysis. Firstly, using IO2002 six-digit industry data as in the above sections, we explore the role of differences in industry-level sensitivity to IPR. In our model, IPR favor vertical integration because they protect property rights on intangibles, thus reinforcing the advantages of integration. In practice, IPR ensure full control over intangibles and knowledge goods by protecting patents and trademarks. Industries that for exogenous/technological reasons depend strongly on patents (as opposed to industries which rely on industrial secrets or on non-patented knowledge) should thus benefit more from stricter IPR enforcement. Following this economic reasoning, we expect a positive sign for the interaction between IPR and patent sensitivity. The use of this interaction is inspired by Rajan and Zingales (1998), who test whether financial development facilitates economic growth. To identify the effect of financial development, they investigate whether industrial sectors that are relatively more dependent on external financing develop faster in countries with better-developed financial markets. To do that, they study the interaction between the industry-level dependence of external financing and country-level indicators of financial development. Our reasoning is similar. We want to test if stronger IPR favor intra-firm trade. In our model, IPR favor vertical integration because they protect property rights on intangibles, thus reinforcing the advantages of integration. In practice, IPR ensure full control on intangibles and knowledge goods by protecting patents and trademarks. Thus, we should expect a stronger effect of IPR for industries that are patent-sensitive.

To distinguish between patent-sensitive and insensitive manufacturing industries, we follow Table 1 in Cohen et al. (2000) which shows the mean percentage of product and process innovations, by ISIC3 industry, for which each appropriability mechanism was judged to be effective. Cohen et al. (2000) report that firms in most industries rely upon more than one mechanism to protect their innovations. To capture patent-sensitivity, we use the third column of Table 1 in Cohen et al. (2000), and take those industries with an appropriability index in terms of patents higher than the mean, 36 percent. Specifically, we generate a dummy variable that takes the value 1 for the following ISIC3 industries: Papers, Chemicals, Basic Chemical, Miscellaneous Chemicals, Rubber or Plastic, Metal Products, General Purpose Machinery, Special Purpose Machinery, Machine Tools, Computers, TV or Radio, Medical Equipment, Car or Truck, and Autoparts.[21] Then, we interact IPR with the patent-sensitivity dummy. This interaction enables us to consider the additional effect of IPR on patent-sensitive industries.

Table 4 reports the results obtained including industry-level sensitivity. In column (2) we replaced industry controls with industry year fixed effect. Columns (3) to (6) use the same industry level controls as in Table 1. Results in Table 4 show a stronger effect of IPR on the intra-firm share of patent-sensitive industries. All the other results highlighted in Table 1 are preserved.

[21] We then use a correspondence to translate ISIC3 to NAICS classification.

Table 4: IPR and Patent Sensitivity

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1)	(2)	(3)	(4)	(5)	(6)
IPR	0.021**	0.023**	0.022**	0.021**	0.019*	0.034***
	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
IPR*PAT	0.026**	0.026**	0.008***	0.010***	0.010***	0.012***
	(0.011)	(0.011)	(0.002)	(0.002)	(0.002)	(0.002)
WTO member	-0.020	-0.022	-0.018	-0.018	-0.014	-0.034**
	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)
log R&D/Sales			0.024***	0.021***	0.021***	0.018***
			(0.003)	(0.003)	(0.003)	(0.003)
log (Skill/Unskilled)			0.016*	0.011	0.011	0.003
			(0.009)	(0.009)	(0.009)	(0.010)
log (Capital Struct/Labor)			-0.039***	-0.035***	-0.035***	-0.024**
			(0.010)	(0.010)	(0.010)	(0.011)
log (Capital Equip/Labor)			0.057***	0.061***	0.061***	0.044***
			(0.010)	(0.010)	(0.010)	(0.010)
Contractibility				-0.075***	-0.075***	-0.075***
				(0.014)	(0.014)	(0.015)
Rule of law					-0.041***	-0.033**
					(0.015)	(0.015)
log Imp t0						0.022***
						(0.001)
Observations	17,057	17,057	17,057	17,057	17,057	14,463
R-squared	0.229	0.231	0.179	0.181	0.181	0.227
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	No	Yes	No	No	No	No

Notes: The regressions are OLS estimations of equation (25) and controlling for patent-sensitive industries. The dependent variable is the US intra-firm import share of importing industry i in year t. Manufacturing sectors only. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. Heteroskedasticity-robust standard errors clustered by country-year are reported in parentheses. $***, **$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively.

Secondly, following Hu and Png (2013), we also build an alternative IPR index to better account for the effective enforcement of IPR. In fact, the Ginarte and Park (1997) index captures only *de jure* enforcement, and might not be sufficient to accurately account for the *de facto* state of patent rights. Therefore, our alternative index, called *Effective IPR*, is obtained by combining the index built by Ginarte and Park (1997) with an index proposed by the Fraser Institute, which measures the quality of the legal system and security of property rights.[22] In line with Hu and Png (2013), the *Effective IPR* is constructed in two ways: as a

[22] The Fraser index is reported on a scale of 0 to 10 for up to 141 countries on a yearly basis from 1970 to 2016. For the purpose of our study, we only consider information for 2000, 2005, and 2010. Additional information on the data from the Fraser Institute are available here: https://www.fraserinstitute.org/studies/economic-freedom.

geometric mean of the IPR and Fraser indexes, or as an average of the two indexes.[23] This new variable should account for the complementarity between patent law and enforcement. Table 5 reports results using this alternative measure of IPR. All the results are similar to those in Table 1. The coefficient of *Effective IPR* is positive and statistically significant. Therefore, it appears that both law and enforcement make a contribution to the increase in imports of intermediate goods that is associated with vertical integration.

Table 5: IPR and Fraser Index

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1) Geometric Mean	(2) Geometric Mean	(3) Mean	(4) Mean
Effective IPR	0.015*	0.025***	0.011*	0.019***
	(0.008)	(0.008)	(0.006)	(0.006)
WTO	-0.021	-0.036**	-0.021	-0.037**
	(0.018)	(0.018)	(0.019)	(0.018)
log R&D/Sales	0.020***	0.019***	0.020***	0.019***
	(0.002)	(0.002)	(0.002)	(0.002)
log (Skill/Unskilled)	0.020**	0.015*	0.020**	0.015*
	(0.008)	(0.008)	(0.008)	(0.008)
log (Capital Struct/Labor)	-0.022***	-0.007	-0.022***	-0.007
	(0.008)	(0.008)	(0.008)	(0.008)
log (Capital Equip/Labor)	0.061***	0.036***	0.061***	0.036***
	(0.007)	(0.007)	(0.007)	(0.007)
Contractibility	-0.063***	-0.063***	-0.063***	-0.063***
	(0.011)	(0.011)	(0.011)	(0.011)
Rule of law	-0.018	-0.018	-0.018	-0.017
	(0.013)	(0.013)	(0.012)	(0.013)
log Imp t0		0.022***		0.022***
		(0.001)		(0.001)
Observations	29,811	25,554	29,811	25,554
R-squared	0.182	0.229	0.182	0.229
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: The regressions are OLS estimations of equation (25). The dependent variable is the US intra-firm import share of importing industry i in year t. Manufacturing sectors only. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. In columns (1) and (2), *Effective IPR* is computed as a geometric mean, while in columns (3) and (4), as an average. Heteroskedasticity-robust standard errors clustered by country-year are reported in parentheses. $***$, $**$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively.

[23] The geometric mean is computed as (IPR index*Fraser Index)$^{0.5}$. The average is computed as (IPR index + 0.5*Fraser Index). In this latter measure, the Fraser index is multiplied by 0.5 so that it varies over the same range as the IPR index, i.e. between 0 and 5.

8 Conclusion

Intellectual property rights can have non-trivial effects on the ownership structures of multinational firms. In this paper, we provide a theoretical and empirical evidence of the role of intellectual property rights in affecting the relative attractiveness of vertical integration with respect to outsourcing. Our model embeds the property rights approach in a global value chains context, stressing the role of intangible and knowledge goods. We extend the existing literature on global sourcing by assuming that production in the South exposes multinational firms to a risk of imitation from the manufacturer. Our model shows that stronger IPR increase the profitability of multinationals under both ownership structures. Additionally, we find that, under reasonable parameter restrictions, higher levels of IPR have a relatively stronger effect on vertical integration than they do on outsourcing. Since in our model technological transfers are higher under vertical integration, this implies that a vertically integrated firm is more exposed to the threat of imitation when IPR are weak. In our model, this leads to the result that, by a larger extent, stronger IPR encourage the imports of intermediate goods through vertical integration.

Our results are tested using US intra-firm trade from the US Census Bureau's Related Party Trade Database. According to the estimates, an increase in IPR enforcement is more valuable for vertically integrated firms. To correct for the potential endogeneity of the strength of IPR protection, we propose a two-stage instrumental variable approach. As a first instrument, we use difference in countries' legal origins: the underlying idea is that legal origin is an important determinant of national institutions. Then to exploit the panel dimension of the data, we also add a time varying instrument: the lagged number of students leaving from neighboring countries to study abroad. We expect migrating student, through different links with the home countries, can also influence the attitude toward institutions, as well as have an impact on technological diffusion. All specifications confirm the main finding that an increase in IPR protection increases the relative share of intra-firm imports. Finally, we assess the sensitivity and robustness of our results to alternative specifications. All specifications confirm our benchmark results.

From a policy perspective, our findings highlight the importance of concentrating on the share of intra-firm imports (which accounts for both vertical integration and outsourcing) to determine the role of IPR on the optimal organization of the global value chain. Our results show that IPR have a positive impact on FDI, and shape MNF in favor of vertical integration. This finding is relevant when considering policies aimed to attract FDI and when trying to evaluate the global impact of strengthening IPR protection. It is important to keep in mind that the measure used for IPR might suffer from several limitations. For instance it might not measure accurately *de facto* enforcement, and it is a composite index, which does not allow to study the relative importance of the different dimensions of IPR protection. In future research, it would be interesting to uncover the role of other aspects of IPR protection that matter for trade flows decisions. In this direction, Palangkaraya et al. (2017) investigate the role of foreign bias, i.e. the extent to which patent offices are more likely to grant applications from their own local applicants compared with foreign inventors and to use citations of prior inventions from their own jurisdictions to deny patent protection to foreign firms. They show that differential treatment of foreign patents in the destination country can have a negative impact on exports. Accounting for different aspects of IPR regulations and practices should foster our understanding of the relationship between IPR reforms and import-sourcing decisions of multinational firms.

References

Acemoglu, D., Johnson, S., 2005. Unbundling institutions. Journal of Political Economy, 113(5), 949-995.

Antràs, P., 2003. Firms, contracts, and trade structure. Quarterly Journal of Economics, 118(4), 1375–1418.

Antràs, P., 2014. Grossman-Hart (1986) Goes Global: Incomplete contracts, property rights, and the international organization of production. Journal of Law, Economics and Organization, 30(1), 118–175.

Antràs, P., 2015. Global Production: Firms, Contracts, and Trade Structure. Princeton University Press.

Antràs, P., Chor, D., 2013. Organizing the global value chain. Econometrica, 81(6), 2127–2204.

Antràs, P., Helpman, E., 2004. Global sourcing. Journal of Political Economy, 112(3), 552–580.

Auriol, E., Biancini, S., Paillacar, R., 2015. Intellectual property rights protection and Trade. CEPR Discussion Paper.

Bernard, A., Fort, T., 2004. Factoryless goods producing firms. American Economic Review Papers and Proceedings, 105(5), 518-23.

Blomström, M., Sjöholm, F., 1999. Technology transfer and spillovers: does local participation with multinationals matter? European economic review, 43(4), 915–923.

Bolatto, S., Naghavi, A., Ottaviano, G. I., 2017. Intangible assets and the organization of global supply chains. Quaderni - Working Paper DSE N.1105, Bologna.

Branstetter, L., 2006. Is foreign direct investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States. Journal of International economics, 68(2), 325–344.

Branstetter, L., Fisman, R., and Foley, C. F., 2006. Do stronger intellectual property rights increase international technology transfer? Empirical evidence from US firm-level panel data. The Quarterly Journal of Economic, 121(1), 321–349.

Branstetter, L., Fisman, R., Foley, C. F. and Saggi, K., 2011. Does intellectual property rights reform spur industrial development? Journal of International Economics, 83(1), 27–36.

Broda, C., and Weinstein, D.E., 2006. Globalization and the Gains From Variety Quarterly Journal of Economics, 121(2), 541–585.

Cohen, W.M., Nelson, R.R., Walsh, J.P., 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not), NBER Working Paper no.7552.

Corcos, G., Irac, D. M., Mion, G. and Verdier, T., 2013. The determinants of intrafirm trade: Evidence from French firms. Review of economics and statistics, 95(3), 825-838.

De Rassenfosse, G, Grazzi, M, Moschella, D, Pellegrino, G, 2019. The effect of international patent protection on trade., Mimeo.

Dominguez Dos Santos, M., Postel-Vinay, F., 2003. Migration as a source of growth: the perspective of a developing country. Journal of Population Economics, 16(1), 161–175.

Dustmann, C., Fadlon, I., Weiss, Y. 2003. Return migration, human capital accumulation and the brain drain. Journal of Development Economics, 95(1), 58-67.

Elmer, M., Lewis, S., 2010. Where to win: patent-friendly courts revealed, No. 202 Managing Intellectual Property, 34.

Ginarte, J. C., and Park, W. G., 1997. Determinants of patent rights: A cross-national study. Research policy, 26(3), 283-301.

Glass, A. J., and Saggi, K., 1998. International technology transfer and the technology gap. Journal of development economics, 55(2), 369-398.

Görg, H., and Strobl, E., 2005. Spillovers from foreign firms through worker mobility: An empirical investigation. The Scandinavian Journal of Economics, 107(4), 693-709.

Grossman, S. J., Hart, O. D., 1986. The costs and benefits of ownership: A theory of vertical and lateral integration. Journal of political economy, 94(4), 691-719.

Hu, A.G.Z., Png, I.P.L., 2013. Patent rights and economic growth: Evidence from cross-country panels of manufacturing industries. Oxford Economic Papers, 65(3), 675-698.

Helpman, E., Melitz, M.J., Yeaple, S.R., 2004. Exporting and FDI with heterogeneous firms. American Economic Review, 94(1), 300–16.

Imbs, J., Mejean, I., 2017. Trade elasticities. Review of International Economics, 25(2), 383-402.

Ivus, O., 2010. Do stronger patent rights raise high-tech exports to the developing world? Journal of International Economics, 81(1), 38-47.

Ivus, O., 2015. Does stronger patent protection increase export variety? Evidence from US product-level data. Journal of International Business Studies, 46(6), 724-731.

Ivus, O., Saggi, K., Park, W., 2016. Intellectual property protection and the industrial composition of multinational activity. Economic Inquiry, 54(2), 1068-1085.

Ivus, O., Saggi, K., Park, W., 2017. Patent protection and the composition of multinational activity: Evidence from US multinational firms. Journal of International Business Studies, 48(7), 808-836.

Javorcik, B. S., 2004a. The composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies. European Economic Review, 48(1), 39-62.

Javorcik, B. S., 2004b. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. The American Economic Review, 94(3), 605-627.

Javorcik, B. S., Spatareanu, M., 2009. Tough love: do Czech suppliers learn from their relationships with multinationals? The Scandinavian Journal of Economics, 111(4), 811-833.

Keller, W., Yeaple, S.R., 2013. Gravity in the knowledge economy. American Economic Review, forthcoming, 103(4), 55.

Kukharskyy, B., 2020. A Tale of Two Property Rights: Knowledge, Physical Assets, and Multinational Firm Boundaries. Journal of International Economics, 122, 103262.

La Porta, R., López-de-Silanes, F., Shleifer, A., Vishny, R., 1999. The quality of government. Journal of Law, Economics and Organization, 15(1), 222-279.

La Porta, R., López-de-Silanes, F., Shleifer, A., 2008. The economic consequences of legal origins. Journal of Economic Literature, 46, 285-332.

Lee, K., Choo, K, Yoon, M., 2016. Comparing the productivity impacts of knowledge spillovers from network and arm's length industries: findings from business groups in Korea. Industrial and Corporate Change, 25(3), 407-427.

Lee, J.Y., Mandsfield, E., 1996. Intellectual Property Protection and U.S. Foreign Direct Investment. Review of Economics and Statistics, 28, 181-186.

Lin, P, Lincoln, J, 2017. Pirate's treasure. Journal of International Economics, 109, 235-245.

Lin, P, Saggi, K, 1999. Incentives for foreign direct investment under imitation. Canadian Journal of Economics, 1275-1298.

Maskus, K. E., Dougherty, S. M., Mertha, A., 2005. Intellectual property rights and economic developement in China. Fink, C., Maskus, K. E., Editors. Intellectual property and development: lessons from recent economic research. World Bank.

Maskus, K. E., 2000. Intellectual Property Rights in the Global Economy. Washington: Peterson Institute for International Economics.

Maskus, K. E., Penubarti, M., 1995. How trade-related are intellectual property rights? Journal of International economics. 39(3), 227–248.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica, 71(6), 1695–1725.

Naghavi, A., Spies, J. and Toubal, F., 2015. Intellectual property rights, product complexity and the organization of multinational firms. Canadian Journal of Economics, 48(3), 881-902.

Nunn, N., 2007. Relationship-specificity, incomplete contracts and the pattern of trade. Quarterly Journal of Economics, 122(2), 569–600.

Nunn, N., Trefler, D., 2008. The boundaries of the multinational firm: an empirical analysis. The organization of firms in a global economy, 55–83.

Nunn, N., Trefler, D., 2013. Incomplete contracts and the boundaries of the multinational firm. Journal of Economic Behavior & Organization, 94(1), 330–344.

Palangkaraya, A., Jensen, P.H., Webster, E., 2017. The effect of patents on trade. Journal of International Economics, 105, 1-9.

Park, W. G., 2008. International patent protection: 1960–2005. Research policy, 37(4), 761-766.

Park, W. G., Lippoldt, D., 2005. International licensing and the strengthening of intellectual property rights in developing countries during the 1990s. OECD Economic Studies, 40, 7-48.

Park, W. G., Lippoldt, D., 2008. Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries. OECD Trade Policy Papers, 62.

Pierce, J.R., Schott, P., 2009. A Concordance Between Ten-Digit U.S. Harmonized System Codes and SIC/NAICS Product Classes and Industries. NBER Working Paper, 15548.

Qian, Y.,2007. Do national patent laws stimulate domestic innovation in a global patenting environment? A cross-country analysis of pharmaceutical patent protection, 1978-2002. The Review of Economics and Statistics, 89(3), 436-453.

Rajan, R.G, Zingales, L.,1998. Financial dependence and growth. The American Economic Review, 88(3), 559–586.

Smith, P. J., 1999. Are weak patent rights a barrier to US exports? Journal of International Economics, 48(1), 151–177.

Spilimbergo, A., 2009. Democracy and foreign education. American Economic Review, 99(1), 528–543.

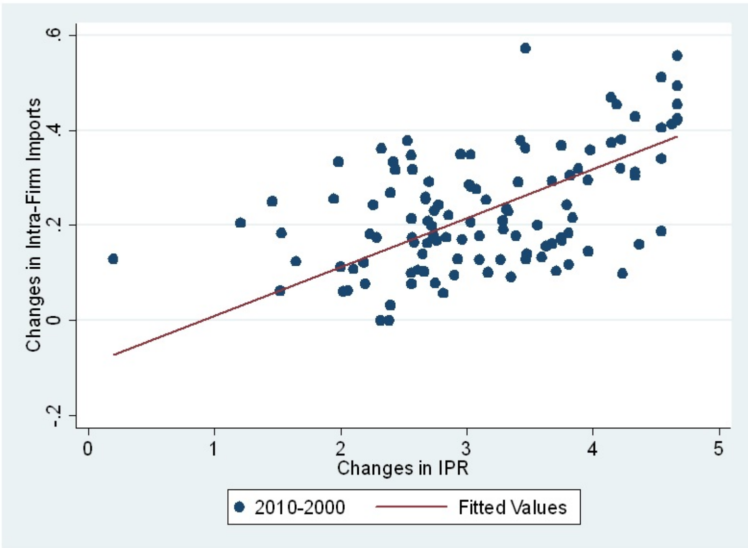
Yang, G., and Maskus, K. E., 2001. Intellectual property rights, licensing, and innovation in an endogenous product-cycle model. Journal of International Economics, 53(1), 169–187.

Wright, G. C, 2014. Revisiting the employment impact of offshoring. European Economic Review, 66, 63–83.

Appendix

This Appendix provides additional details on the data. Figure 2 presents an alternative plot, with respect to Figure 1, where we use changes between 2000 and 2010.[24] Table 6 reports the evolution of the IPR Index for a sub-sample of 35 countries used in our empirical exercise (including US). Table 7 reports in-sample summary statistics related to our 253 sectors, and 115 countries.[25] Table 10 replicates Table 3, but without including industry level covariates.

Figure 2: Share of Intra-firm Imports



Source: Authors' calculation using US Input-Output tables and IPR in changes between 2000 and 2010.

[24]A similar picture can be obtained excluding 2010.

[25]For additional information on the data used see Table B.1 in appendix B in Antràs (2015).

Table 6: Evolution IPR Index

Country	2000	2005	2010
Argentina	3.56	3.56	3.56
Australia	4.33	4.33	4.33
Austria	4.33	4.33	4.33
Banglad.	1.7	1.7	1.58
Belgium	4.67	4.67	4.67
Bolivia	2.97	2.97	2.85
Brazil	3.43	3.43	3.43
Canada	4.54	4.54	4.54
Chile	4.48	4.48	4.68
China	3.09	4.08	4.21
Colombia	3.3	3.43	3.43
Denmark	4.67	4.67	4.54
Finland	4.54	4.67	4.67
France	4.67	4.67	4.67
Germany	4.67	4.67	4.67
H. Kong	3.81	3.81	3.81
India	2.27	3.76	3.76
Indonesia	2.47	2.77	2.77
Japan	4.67	4.67	4.67
Malaysia	3.03	3.48	3.68
Mexico	3.22	3.42	3.75
Morocco	2.89	3.35	3.55
Mozamb.	1.06	2.52	3.02
N. Zealand	3.68	3.68	3.68
Russia	3.68	3.68	3.68
S. Africa	3.75	3.75	3.88
Senegal	2.1	2.77	2.77
Singapore	4.01	4.21	4.21
Taiwan	3.29	3.74	3.74
Tanzania	2.64	2.64	3.1
Thailand	2.37	2.50	3.23
U.K.	4.54	4.54	4.54
U.S.A.	4.88	4.88	4.88
Venezuela	3.15	3.15	2.44
Vietnam	2.65	2.78	3.43

Source: Data from Park (2008) (updated version received by Walter G. Park).

Table 7: In-sample Summary Statistics

	N	Mean	Std. Dev.	Max	Min
Tot Imp. (in million $)	30209	646	5180	365000	1.383
Share Intra-firm Imp.	30209	0.28	0.32	1	0
IPR	30209	3.68	0.77	4.67	0.2
Rule of law	30209	0.44	1.01	1.96	-2.45
nb. sectors	30209	139	62.12	253	1
nb. countries	30209	100	56.05	115	1
Effective IPR (geometric)	29810	4.73	1.09	6.48	0.75
Effective IPR (average)	29810	6.76	1.50	9.16	1.60

Notes: Calculations based on data from Antràs (2015) and Park (2008).

Table 8: In-sample Summary Statistics: by year

	Tot Imp. (in million $)	Share Intra	IPR	Rule of law	Eff. IPR (geometric)
	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)
2000	532	0.27	3.52	0.45	4.71
	(3780)	(0.32)	(0.89)	(0.99)	(1.17)
2005	664	0.28	3.72	0.43	4.76
	(4950)	(0.32)	(0.72)	(1.01)	(1.08)
2010	729	0.30	3.78	0.43	4.73
	(6360)	(0.33)	(0.68)	(1.04)	(1.01)

Notes: Calculations based on data from Antràs (2015) and Park (2008). Summmary statistics (mean) of key variables by year. Standard deviations are reported in parentheses.

Table 9: List of Countries

DEV	**Less DEV**	**Less DEV**
AUS	AGO	MEX
AUT	ARG	MLI
BEL	BDI	MMR
CAN	BEN	MOZ
DEU	BFA	MRT
DNK	BGD	MUS
ESP	BGR	MWI
FRA	BOL	MYS
GBR	BRA	NER
GRC	BWA	NGA
IRL	CAF	NIC
ISR	CHL	NPL
JPN	CHN	PAK
LUX	CIV	PAN
MLT	CMR	PER
NLD	COG	PHL
NOR	COL	PNG
NZL	CRI	POL
PRT	CYP	PRY
SWE	CZE	RUS
	DOM	RWA
	DZA	SAU
	ECU	SDN
	EGY	SEN
	ETH	SGP
	FJI	SLE
	GAB	SLV
	GHA	SOM
	GRD	SVK
	GTM	SWZ
	GUY	SYR
	HKG	TCD
	HND	TGO
	HTI	THA
	HUN	TTO
	IDN	TUN
	IND	TUR
	IRN	TWN
	IRQ	TZA
	JAM	UGA
	JOR	UKR
	KEN	URY
	KOR	VEN
	LBR	VNM
	LKA	ZAF
	LTU	ZMB
	MAR	ZWE
	MDG	

Notes: This Table presents the list of countries used in our regressions. The first column reports the list of 20 developed countries used in Table 1 column (7), while columns (2) and (3) show the list of less developed countries, 95, used in Table 1 column (6), and in Table 3 column (5).

Table 10: Instrumenting IPR (without industry controls)

Dep. Var. $\frac{\text{Intra-firm Imp.}}{\text{Total Imports}}$	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV less DEV
IPR	0.152***	0.151***	0.149***	0.147***	0.055*
	(0.023)	(0.025)	(0.027)	(0.026)	(0.032)
Country FE	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes
Sector FE	No	No	Yes	No	No
Sector Year FE	No	No	No	Yes	Yes
IV migrants (L5/L15/L15/L15):	-4.864***	-4.295***	-4.355***	-4.305***	2.041
	(1.043)	(1.191)	(1.155)	(1.185)	(1.527)
IV British legal origin:	-0.154	-0.228*	-0.217*	-0.225*	-0.663***
	(0.125)	(0.126)	(0.122)	(0.125)	(0.138)
IV French legal origin:	-0.343***	-0.405***	-0.380***	-0.401***	-0.632***
	(0.107)	(0.107)	(0.103)	(0.106)	(0.116)
IV German legal origin:	0.508***	0.478***	0.446***	0.472***	-0.293**
	(.145)	(0.141)	(0.139)	(0.141)	(0.146)
Observations	29,354	29,354	29,354	29,354	19,998
R-squared	0.034	0.035	0.039	0.037	0.006
F-stat first stage	24.28	21.37	20.48	21.22	15.36
Sargan Test (p-val)	0.542	0.548	0.466	0.468	0.193

Notes: The dependent variable is the U.S. intra-firm import share of importing industry i in year t. Only manufacturing sectors. Wright (2014) correction for intermediates. Nunn and Trefler (2013) destination countries correction. The first column presents IV results using using average students migration lagged 5 years and legal origin. In column (2) we lag average students migration 15 years. In column (3) and (4) we add industry and industry-year fixed effect respectively. Column (5) replicates column (4) for the sub-sample of less developed countries. All results remain consistent with Table 3. Heteroskedasticity-robust standard errors clustered by country-year are reported in parentheses. $***$, $**$, and $*$ indicate significance at the 1, 5 and 10 percent levels respectively.