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International Sourcing, Product Complexity and Intellectual Property Rights

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Abstract

In this paper, we propose the technological complexity of a product and the level of Intellectual Property Rights (IPRs) protection to be the co-determinants of the mode through which multinational firms purchase their goods. We study the choice between intra-firm trade and outsourcing given heterogeneity at the product- (complexity), firm- (productivity) and country- (IPRs) level. Our findings suggest that the above three dimensions of heterogeneity are crucial for complex goods, where firms face a trade-off between higher marginal costs in the case of trade with an affiliate and higher imitation risks in the case of sourcing from an independent supplier. We test these predictions by combining data from a French firm-level survey on the mode choice for each transaction with a newly developed complexity measure at the product-level. Our fractional logit estimations confirm the proposition that although firms are generally reluctant to source highly complex goods from outside the firm's boundaries, they do so when a strong IPR regime in the host country guarantees the protection of their technology.

Keywords: Sourcing decision, product complexity, intellectual property rights, fractional logit estimation

JEL: F12, F23, O34

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1. Introduction

'The intellectual property issue remains the most complicated thing we have to deal with,' says Pat Toole, general manager of I.B.M. Engineering and Technology Services. 'If we can all figure it out, farming out design will be a common model in the future. If we can't, it won't.' (New York Times, 30 December 2004). The appraisal matches the results of a survey conducted by the Economist Intelligence Unit (EIU) in the same year, in which 84% of all executives state that they perceive the lack of Intellectual Property Rights (IPRs) protection in emerging markets as a challenge when outsourcing their R&D. In stark contrast to the emphasis the business world puts on IPR protection when outsourcing upper parts of the value chain, the issue has attracted little attention in the economic literature. This paper tries to fill this gap by analyzing how IPR protection determines the mode through which firms source complex products. The topic naturally connects two research strands.

First, it relates to a range of studies investigating the impact of IPRs on Foreign Direct Investment (FDI)(see e.g. Glass and Saggi, 2002, Glass, 2004 and Branstetter et al., 2007).[1] While the results in these papers directly hinge on the capacity and the costs of imitation in a destination country, Glass and Wu (2007) show how the phenomenon could also depend on the type of innovation. More closely related to our argument, Nicholson (2002) studies the mode choice of international sourcing and claims the fear of loosing a proprietary asset to be the main consideration when deciding between FDI and licensing. At low levels of IPR protection, technologically sophisticated firms tend to internalize. A more stringent IPR regime, however, mitigates the imitation risk and may induce a shift towards licensing. As these models do not make a reference to product heterogeneity, their propositions have been tested empirically using aggregate data.

Second, a series of influential papers shift the argument to the choice between purchasing from an affiliate, or from an independent supplier, where the latter gives rise to a hold-up problem when contracts are incomplete (Antràs and Helpman, 2004, 2008).[2] A recent branch of this literature in particular highlights the role of technological intensity in creating hold-up problems in an outsourcing relationship. Acemoglu et al. (2010) find that the technology intensity of the final good producer has a positive effect on the probability of vertical integration (while the opposite is true for the technological intensity of the intermediate good supplier).[3] Grover (2007) interacts the intensity of the sourced input with technology transfer costs and confirms the results from Antràs and Helpman (2004, 2008) to only hold for a certain range of technological complexity of the input. More in line with the approach, Costinot et al. (2011) reinterpret the source of contractual frictions as arising from the non-routineness of tasks. Since these cannot be fully specified ex-ante, ex-post adaptation becomes necessary. Due to better communication and less opportunistic behavior among affiliated parties, outsourcing only takes place for tasks below a certain complexity threshold. Focusing on the relation between technology and the outsourcing decision, the message is clear: Higher technology complicates the relation with the supplier and makes it optimal to vertically integrate. Yet, the role of IPR protection remains absent in these studies.

In this paper, we combine the two strands of literature above starting at the insight that the technological complexity of an intermediate or final good is an alternative determinant of a multinational

[1] See Saggi (2002) for a review of the early literature on FDI and technology transfers.

[2] Among the few studies testing these predictions at the firm-level, Defever and Toubal (2007) and Kohler and Smolka (2009) confirm the existence of an interaction between input intensity and firm productivity which shapes the organizational form of international production.

[3] Without referring to the property rights theory, Abramovsky and Griffith (2006) come to the opposite conclusion. Past investments in information and communication technologies enable firms to purchase business service inputs from independent suppliers abroad as they lower transaction and adjustment costs.

firm's choice between in-house production and outsourcing. Antràs and Rossi-Hansberg (2009) suggest that past literature has focused too much on hold-up inefficiencies as the main drivers of the internalization decision and underline the importance of the effects of the nonappropriable nature of knowledge on the internalization decision of firms. In contrast to the existing studies, we depart from the hold-up problem but emphasize the interaction between the complexity of the sourced good and the IPR protection prevailing in the host country. We build a theoretical framework in which heterogeneous firms tend to outsource low complex goods. As complexity rises, firms are confronted with a trade-off between higher marginal costs in the case of trade with a related party and higher imitation risks in the case of sourcing from an independent supplier. Stronger IPR protection in the source country reduces costs associated with the imitation risk, while a higher endowment of skills (absorptive capacity) reduces the costs of technology transfer. Moreover, firms endowed with better technologies are clearly in a better position to face the extra costs associated with outsourcing. We show that a three-dimensional heterogeneity, namely complexity at the product-level, productivity at the firm-level, and IPR protection at the country-level, build up the decision of a multinational whether to outsource a product or acquire it through intra-group trade.

We test these propositions using data from a French survey which provides information on import transactions at the product-level of multinational firms and their sourcing mode by country. This information is merged with balance sheet and income statement data from which we compute firm-level productivity. The French data have the advantage to deal with firms that are part of a multinational network. This allows us to model the decision of firms with a related party in a given country whether or not to acquire their inputs from a foreign outside supplier. We argue that this choice is influenced by the level of IPR and the level of complexity of the sourced products.

We derive the complexity of a product group by merging three different data sets, (i) ratings of occupations by their intensities in 'problem solving' from the U.S. Department of Labor's Occupational Information Network, (ii) employment shares of occupations by sectors from the Bureau of Labor Statistics Occupational Employment Statistics and (iii) French make tables from Eurostat. We use a fractional logit model to account for the fact that our response variable is bounded between one and zero. The estimation results confirm the model's prediction that the probability of outsourcing increases with the productivity of a firm and decreases with the complexity of the good. The imitation risk of the source country matters as better IPR protection increases the probability of outsourcing. Likewise, better absorptive capacity increases the propensity to outsource by decreasing the costs of technology transfer. A sample split confirms IPR protection to only be relevant when firms outsource highly complex products.

The closest work to ours is Berkowitz et al. (2006), which shows higher quality legal institutions located in the exporter's country to enhance international trade in complex products. They argue this to be due to a production cost effect, assuming the production of complex products to contain some degree of outsourcing, and hence depend on contracts. Better institutions enable the exporting country to cheaply and quickly enforce contracts and resolve business disputes by reducing the likelihood of hold-up on the production chain and will therefore also lower the production costs of complex products. Since these issues are less important for simple goods, better legal institutions enhance a country's comparative advantage in complex goods.[4] While Berkowitz et al. (2006)

[4]Ivus (2010, 2011) takes the opposite perspective and investigates the impact of improved IPRs in the destination country on exports. At the extensive margin, stronger IPRs encourage Northern firms to start exporting which expands the range of goods industries involved in trade. At the intensive margin, exports in industries with the highest risk of imitation rise, while exports in other industries may fall (Ivus, 2011). Developed countries' exports in patent-sensitive industries increases thereby the most in industries that rely heavily on patent protection (Ivus,

study the general impact of institutions on international trade in complex products, we explore the importance of a specific institution for *the type of trade* (intra- versus extra-group) undertaken by a firm with an exporting country. In addition, we use a specific measure of product complexity more adequate for our aim to differentiate products with respect to their technology content, whereas Berkowitz et al. (2006) use the Rauch (1999) classification to distinguish between simple and complex products. Finally, we base our study on the imitation risk faced by a multinational firm instead of contract-related issues, which has served as the basis of the outsourcing decisions in the previous literature.

The rest of the paper is organized as follows: Section 2 presents the proposed theory, Section 3-6 introduce the data, the empirical methodology, the descriptive statistics, and estimation results respectively. Section 7 concludes.

2. Theoretical Framework

We start by developing a simple theoretical framework, which helps us pinning down the main idea. Consider a world with J countries, in which a multinational firm already active in a country $j \in \{1..J\}$ can procure intermediate or final goods from a related party (insource) or outsource production to an independent supplier: $X \in \{V, O\}$. Three different sources of heterogeneity drive the selection of firms into the different organizational modes: Firms are heterogeneous in the spirit of Melitz (2003) with respect to their technology, φ, products are heterogeneous with respect to their complexity, z, and countries are heterogeneous with respect to their protection of IPRs, λ, and their absorptive capacity, δ.

2.1. Consumption

The consumption of imports is subject to a Constant Elasticity of Substitution (CES) utility function,

$$U = \left[\int_{\omega \in \Omega} \left(z_\kappa(\omega)^\gamma x(\omega) \right)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $x(\omega)$ refers to the quantity and $z_\kappa(\omega)$ refers to the technological complexity of variety ω. Subscript $\kappa \in (L; H)$ distinguishes between simple (non-complex) products, and more technologically sophisticated ones that maintain a continuous measure of complexity. In the rest of the paper, we normalize the basic level of complexity to one, i.e. $z_L(\omega) = 1$. Referring to the literature on product quality (see Hallak, 2006, Hallak and Sivadasan, 2009 and Crozet et al., 2009), the parameter $\gamma \in (0; 1)$ captures consumer preferences for more technologically sophisticated products. This gives a complexity-augmented demand for imports of

$$x(\omega) = \frac{E}{P} z_\kappa(\omega)^{\gamma(\sigma-1)} \left(\frac{p(\omega)}{P} \right)^{-\sigma} \tag{2}$$

with E as the expenditure and $P = \left[\int_{\omega \in \Omega} \left(\frac{p(\omega)}{z_\kappa(\omega)^\gamma} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$ as the price-complexity index.

2010).

2.2. Production

Multinational firms operate under monopolistic competition. Suppliers in country j transform homogeneous labor, the only factor of production, into intermediate or final goods that are sold to multinational firms at a price equal to marginal costs. Basic goods production involves only wage costs, w_j. Under insourcing (V), the multinational firm owns its supplier and has to pay – in line with empirical findings – a wage premium, $\alpha = \frac{w}{w_j} > 1$, over the wage level in country j. Outsourcing (O) implies marginal cost savings, where independent suppliers pay local wages, hence, $\alpha = 1$. Since basic goods production does not involve any fixed cost, sourcing from independent suppliers involves a (variable) cost advantage and is, generally, preferred over that from related parties.

We parameterize the costs associated with imitation risk as

$$r_j(\omega) = z_\kappa(\omega)^{\frac{1}{\lambda_j}} \tag{3}$$

where $0 < \lambda_j \leq 1$ denotes the level of IPRs with a higher λ_j indicating stronger protection. Notice that for simple goods $r_j(\omega) = z_L(\omega)^{\frac{1}{\lambda_j}} = 1$, which implies the irrelevance of IPRs when products do not contain sophisticated technologies to be imitated. On the other hand, imitation costs are increasing in the level of complexity, $\frac{\partial r_j(\omega)}{\partial z_H} > 0$, and decreasing in IPR protection, $\frac{\partial r_j(\omega)}{\partial \lambda_j} < 0$. Inequality $\frac{1}{\lambda_j} \geq 1$ accounts for the fact that highly complex products are especially sensitive and require more protection. An increase in IPR protection lowers the imitation risk outsourcers face in country j, and this effect is stronger for complex products.[5] Multinationals own the property rights over the available technology in their affiliate. Insourcing therefore does not confront them with the risk of being imitated, hence $r_j(\omega) = 1$.[6]

Complex goods production also involves a fixed technology transfer cost $T(\delta_j)$, which can be thought of as an effort to achieve a better fit of the independent supplier's production to the multinational firm's needs. We assume zero technology transfer costs under integration. δ_j denotes the absorptive capacity in country j, where a higher δ_j indicates more advanced local skills, hence better capacity by an independent supplier to learn and perform the customization required by a multinational. Technology transfer costs are therefore decreasing with absorptive capacity, $\frac{\partial T(\delta_j)}{\partial \delta_j} < 0$. Since this cost is sunk, outsourcers are confronted with the risk of their transferred technology being imitated.

The production technology is described through a Cobb-Douglas cost function,

$$c_j(\omega) = \frac{1}{\varphi}(\alpha w_j)^\mu (r_j(\omega))^{1-\mu} \tag{4}$$

with φ as the productivity a firm draws from a common distribution $G(\varphi)$. Multinational firms charge prices with a mark-up over marginal costs,

$$p_j(\omega) = \frac{\sigma}{\sigma - 1}\frac{1}{\varphi}(\alpha w_j)^\mu (r_j(\omega))^{1-\mu}. \tag{5}$$

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[5] This can be seen from the partial derivative $\frac{\partial r_j(\omega)}{\partial \lambda_j} = -\frac{z_\kappa(\omega)^{\frac{1}{\lambda_j}} \log(z_\kappa(\omega))}{\lambda_j^2}$.

[6] Note that $\lim_{\lambda \to 1} r_j(\omega) = 1$, hence, the assumption that multinational firms fully control their intellectual property within firm boundaries is equivalent to country j providing full IPR protection.

Specifying the mark-up adjusted demand level as $A = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} EP^{\sigma-1}$ and using equations (2), (4) and (5), we derive the profits under both modes:

$$\pi_v\left(\varphi, z\right) = A\left(\frac{\alpha w_j}{\varphi}\right)^{1-\sigma} z_\kappa(\omega)^{\gamma(\sigma-1)}\sigma^{-1}, \tag{6a}$$

$$\pi_o\left(\varphi, z\right) = A\left(\frac{w_j z_\kappa(\omega)^{\left(\frac{1}{\lambda_j}\right)}}{\varphi}\right)^{1-\sigma} z_\kappa(\omega)^{\gamma(\sigma-1)}\sigma^{-1} - T(\delta_j). \tag{6b}$$

While both profit functions are increasing in productivity level, φ, profits under outsourcing (insourcing) increase faster if $z_\kappa(\omega)^{\left(\frac{1}{\lambda_j}\right)} < \alpha \left(z_\kappa(\omega)^{\left(\frac{1}{\lambda_j}\right)} > \alpha\right)$. $T(\delta_j)$ ensures the existence of a product-country specific productivity cut-off that is given by equating (6a) and (6b):

$$\widehat{\varphi} = \left(\frac{A}{\sigma T(\delta_j)}\right)^{\frac{1}{1-\sigma}} \frac{w_j\left(z_\kappa(\omega)^{\left(\frac{1}{\lambda_j}\right)} - \alpha\right)}{z_\kappa(\omega)^\gamma}. \tag{7}$$

The cut-off is decreasing in α and increasing in $z_\kappa(\omega)$, as long as the cost parameters associated with complexity exceed the consumers' strength of preference for complexity. Note that productivity of a firm is not a relevant factor in the outsourcing decision for simple products as $z_L(\omega)^{\left(\frac{1}{\lambda_j}\right)} - \alpha = 1 - \alpha < 0 \Rightarrow \widehat{\varphi} < 0$. The probability that a firm with complex products decides to outsource is then given by the probability that it draws a productivity above the product- and country-specific cut-off,

$$\Pr(O=1) = \Pr\left\{\varphi \geq \left(\frac{A}{\sigma T(\delta_j)}\right)^{\frac{1}{1-\sigma}} \frac{w_j\left(z_H(\omega)^{\left(\frac{1}{\lambda_j}\right)} - \alpha\right)}{z_H(\omega)^\gamma}\right\}. \tag{8}$$

The above equation suggests that a higher mark-up adjusted demand level, A, lower competition, σ, lower relative marginal cost advantage in the form of a high α, and higher absorptive capacity, δ_j, decrease the productivity cut-off and thereby increase the probability that a multinational sources a product from independent suppliers.

Testable Implications 1. *For simple products, product-level complexity, firm-level productivity, and country-level IPRs are irrelevant in the mode through which a multinational firm acquires a product. Firms are generally less inclined to outsource production of complex goods to independent suppliers, but are more likely to do so for (i) higher levels of IPR protection in the host country, (ii) higher levels of firm productivity, (iii) higher levels of absorptive capacity in the host country.*

Proof Follows directly from equation (8) and the properties of product complexity $z_L(\omega) = 1$. ∎

3. Data

We test the above developed hypothesis with data on the trade organization of French firms. The rich product and geographical breakdown of the data allows us to match it with a complexity measure at the product-level and an IPR index at the country-level.

3.1. Sourcing Mode

To capture the share of intra- and extra-group trade, we rely on information from a confidential firm-level survey, the French National Institute of Statistics and Economic Studies (INSEE) conducted in 1999. The survey provides information on the trade organization of French firms.[7] It is addressed to all French multinational firms which trade more than one million Euro and which are owned by manufacturing groups that control at least 50% of the equity capital of a foreign affiliate.

The survey provides a detailed geographical breakdown of French firms' imports at the product-level (HS4 or CPA) as well as their sourcing modes – through independent suppliers and/or related parties. There are 2514 firms in the baseline sample. A French intra-group transaction is defined as trade with a related party which is either directly controlled by the firm (firm's affiliates) or controlled by the group to which the firm belongs (group's affiliates). Both types of intra-group transactions are treated as 'insourcing' in our theoretical framework and imply no risk of imitation.

3.2. Product Complexity

Our measure of product complexity is similar to Costinot et al. (2011) and Keller and Yeaple (2009). The U.S. Department of Labor's Occupational Information Network (O*NET) provides expert information on the importance and the level of complex problem solving skills for 809 eight digit occupations as defined in the Standard Occupational Classification (SOC). Each occupation, o, embodies a complexity of

$$z_o = i_o^{\alpha} + l_o^{\beta} \tag{9}$$

where the weights, α and β, give the contributions of the two complexity components, importance $i \in [1,5]$ and level $l \in [0,7]$.[8]

In line with Costinot et al. (2011), we assume that every country in the sample uses the same technology and rely therefore on employment information from the U.S. Bureau of Labor Statistics' Occupational Employment Statistics (OES). The 1999 data contains the number of employees by occupation in every three digit industry k (according to the Standard Industrial Classification (SIC)).[9] The occupational intensity, b_o^k, of each industry is then given by

$$b_o^k = \frac{L_o^k}{\sum_o L^k}, \tag{10}$$

where L_o^k is the employment level of occupation o in industry k. Although the SIC gathers data on those organizations, which work with or produce the same product or service under the same industry heading, it does not relate atypical products. By exploiting information on primary and secondary outputs of the French 1999 make table from Eurostat, we derive a precise product complexity measure,[10]

[7] *échanges internationaux intra-groupe.*

[8] We tried different weights that have been used in the literature (see Blinder, 2009 and Jensen and Kletzer, 2010). We normalized the different scales of the complexity components to a $[0,1]$ scale using the min-max method, $I = \frac{i_o - \min(i)}{\max(i) - \min(i)} \left(L = \frac{l_o - \min(l)}{\max(l) - \min(l)} \right)$.

[9] Crop production, animal production and private households are not surveyed. After matching the O*NET data to the OES data, 695 occupations remain in the sample.

[10] Since direct concordance tables of the NACE Rev. 1.1 classification and the SIC 1987 classification are not available, correspondence is achieved via the NAICS 2002 classification.

$$z_{\kappa}(\omega) = \frac{x^k(\omega)}{\sum_k x(\omega)} \left(z_o b_o^k \right), \tag{11}$$

where $\frac{x^k(\omega)}{\sum_k x(\omega)}$ gives the share of industry k in the production of each product. Table A.1 summarizes the 32 product categories in our sample ranked according to their complexity.

3.3. Other Explanatory Variables

The SESSI[11] survey does not provide information on firms' characteristics. We retrieve the information necessary to compute firm-level Total Factor Productivity (TFP) from the EAE[12] database. The data can be merged directly with the SESSI data thanks to a common firm identifier. The EAE contains information on the balance sheets and income statements of all firms located in France that have more than 20 employees from 1996 to 1999. It has firm-level information on sales, capital, labor and intermediates use, as well as the four digit *NAF700* sector classification of the firm.[13] We calculate TFP following the semiparametric approach of Olley and Pakes (1996), which corrects for the endogeneity of firms' input choices.

We restrict our analysis to manufacturing sectors. However, we do not consider the manufacture of food products, beverages and tobacco because the EAE has no information for these sectors. We exclude firms active in the manufacture of coke, refined petroleum products and nuclear fuel since the sourcing modes in this industry are likely to be determined by factors such as national sovereignty (Antràs, 2003).

We have a measure of IPR protection from Park (2008) for the destination country. This measure of IPR protection is the updated version of the worldwide used Ginarte and Park index (Ginarte and Park, 1997). It incorporates the effects of the TRIPS agreements of 1995 and it takes into account the revisions in national patent laws required to conform to international and regional agreements (such as the North American free trade agreement (NAFTA), European patent convention (EPC), African Regional industrial property organization (ARIPO), Cartagena agreement, among others). All the technical details related to the construction of the index are in Park (2008). We measure the strength of IPR protection in 1995 (and 2000) which is available for 64 countries of the sample. Table A.2 summarizes the information for the countries of our sample.

Information on the population share with completed secondary education for 1995 comes from Barro and Lee (2010) and serves as a proxy for a country's absorptive capacity. As outlined in Section 2.2, we assume that higher absorptive capacity reduces the sunk technology transfer costs since it facilitates the training of the supplier. We calculate the wage premium affiliates pay as the difference between French wages and source country wages by industry in 1998. Both variables are taken from the CEPII Trade, Production and Bilateral Protection Database. We additionally employ a range of gravity variables, such as distance, GDP, the existence of a common official language or a common legal origin. All these variables are provided by CEPII.

[11] *Service des Études et des Statistiques Industrielles.*
[12] *Enquête d'Annuelle d'Entreprises*: annual French firm-level survey.
[13] *Nomenclature d'Activité Française*: nomenclature of French activities.

4. Empirical Methodology

We start with the observation that not all firms in our sample entirely rely on one or the other sourcing strategy. In 13.06% of all cases, firms use mixed strategies even for sourcing the same product from the same country. To account for this, we use the share of an input that is imported by a multinational from an independent supplier located in a foreign country as the dependent variable. This share lies within the $[0; 1]$ interval. Because many values are still at the boundaries, we use a fractional response model as in Papke and Wooldridge (1996).

The next issue to resolve is that the SESSI survey includes multinational firms, which by definition, have at least one related party located abroad. This does not exclude the possibility that firms may only engage in outsourcing in a given country without having a related party there. However, our model aims at comparing the 'proportion' of business undertaken through an existing related party (intra-group trade) with that outsourced to a foreign supplier, given the complexity of the sourced product and the IPR protection level prevailing in the source country. The relevant measure of comparison is therefore the proportion of outsourcing versus intra-group trade, only when the firm has an already existing related party in a given country.

To correct for this, we follow Defever and Toubal (2010) and implement a two-stage estimation procedure. In the first stage, we analyze the likelihood of having a related party in the foreign country. This methodology is only valid if we can identify determinants of the binary selection variable outside the estimating equation, which explain the probability of having a related party. We identify two firm-level variables that are correlated with the presence of a related party and not with the sourcing choice: the number of French related parties, and a dummy variable that indicates whether a firm is owned by an Ultimate Benefial Owner (UBO).[14] Our specification also includes gravity determinants such as market size (GDP), distance, border, official language and common legal origin.[15] Furthermore, we add measures of trade and FDI openness from the Heritage Foundation and an entry cost variable in line with Djankov et al. (2002). We also control for the firm's TFP. The second stage estimates on the sourcing choice include the inverse Mills ratio from the first stage.

Since the dependent variable is measured at the transaction-level, while our main variables of interest are measured at the product- (complexity) and at the country- (IPR) level, the i.i.d. assumption is unlikely to hold. We correct the standard errors by employing two-way clustering at the product- and country-level (see Cameron et al., 2006).

5. Descriptive Statistics

This section presents descriptive statistics based on the sample of the second stage, i.e. including transactions only if firms have a choice between relying on a related party or an outside supplier in a given country.

Table 1 shows the means (main values) and the standard deviations (values in parentheses) of the key variables of interest. In order to compare the two sourcing modes, we assign the value of 1 if the outsourcing share is ≥ 0.5 (*outsourcing*) and the value of 0 (*insourcing*) otherwise.

The descriptive statistics confirm that the average complexity level of a sourced product is higher in intra-group than in outsourcing relations. Further, outsourcing takes place, on average, more with

[14] We retrieve this information from the LIFI data, merged using a common firm identifier.

[15] The distance and border variable are computed using the location of the firm in France.

Table 1: Summary statistics

	Intra-group trade	*Extra-group trade*	Total
Complexity	0.272	0.268	0.270
	(0.0603)	(0.0574)	(0.0585)
IPR	4.145	4.274	4.227
	(0.656)	(0.477)	(0.553)
Abs. capacity	23.80	24.75	24.40
	(11.75)	(11.15)	(11.39)
TFP, lag	5.351	5.468	5.425
	(0.908)	(0.965)	(0.946)
Wage diff.	1.736	1.546	1.625
	(1.136)	(1.057)	(1.094)

Note: This table presents descriptive statistics for the sample of firms with group affiliates in the source country. The main statistics are the means of the explanatory variables by mode. Standard deviations are in parentheses.

Source: Own calculations.

suppliers from countries that exhibit better IPR enforcement and superior absorptive capacity. Finally, the average outsourcing transaction involves firms that are more productive compared to those that purchase from affiliates. These summary statistics are in line with our theoretical predictions that suggest IPR, absorptive capacity and productivity to be particularly relevant for outsourcers, which face higher imitation risks and technology transfer costs, than firms dealing with related affiliates.

Table 2: Correlation matrix

	Complexity	IPR	Abs. capacity	TFP, lag	Wage diff.
Complexity	-	0.0678	0.0086	-0.0120	0.0225
IPR	0.2057	-	0.1829	-0.0392	-0.5979
Abs. capacity	0.0561	0.1997	-	-0.0658	0.1788
TFP, lag	-0.0606	-0.1043	-0.0613	-	-0.0280
Wage diff.	-0.0427	-0.5168	0.2477	0.0152	-

Note: This table presents correlations between the main explanatory variables for the sample of firms with group affiliates in the source country. The correlations are calculated by mode. The upper triangle gives the correlations for intra-group trade-firms, the lower triangle gives the correlations for extra-group trade firms.

Source: Own calculations.

Table 2 displays the correlations among the main explanatory variables, separately for firms that source from within (upper triangle) and outside (lower triangle) firm boundaries. We observe a positive correlation between IPR and complexity and between absorptive capacity and complexity, especially in the case of outsourcing. This strengthens our predictions about the impact of these variables: Firms appear to source technologically intensive goods from independent suppliers only in locations where high IPR protection lowers their risk of being imitated and where a high educational level lowers their costs of transferring technology. Absorptive capacity and TFP are negatively correlated, suggesting that productive firms can afford to source from countries with less human capital.

Figure 1 depicts the positive correlation between the IPR level and the outsourcing share. The upward sloping fitting line indicates that the outsourcing share is, on average, higher in countries

Figure 1: IPR protection and outsourcing share

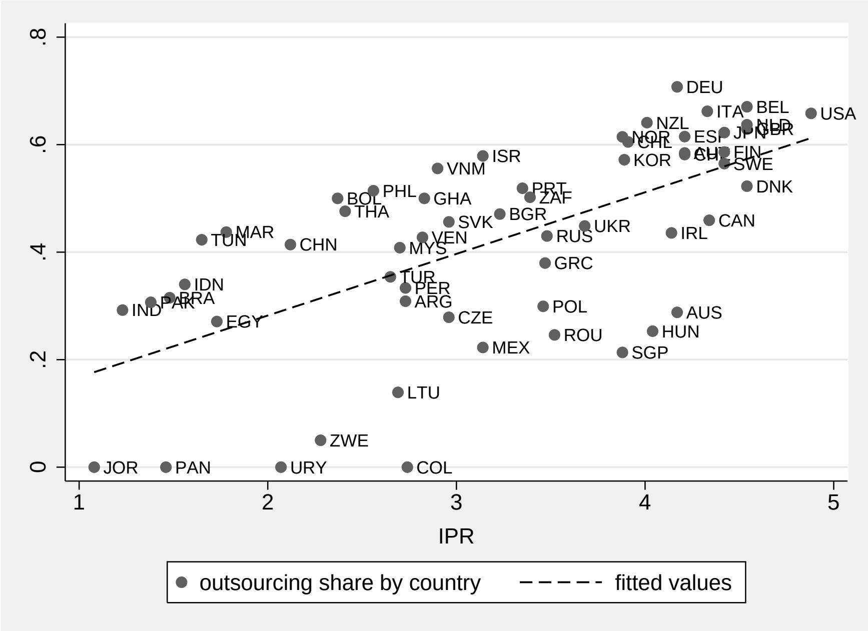
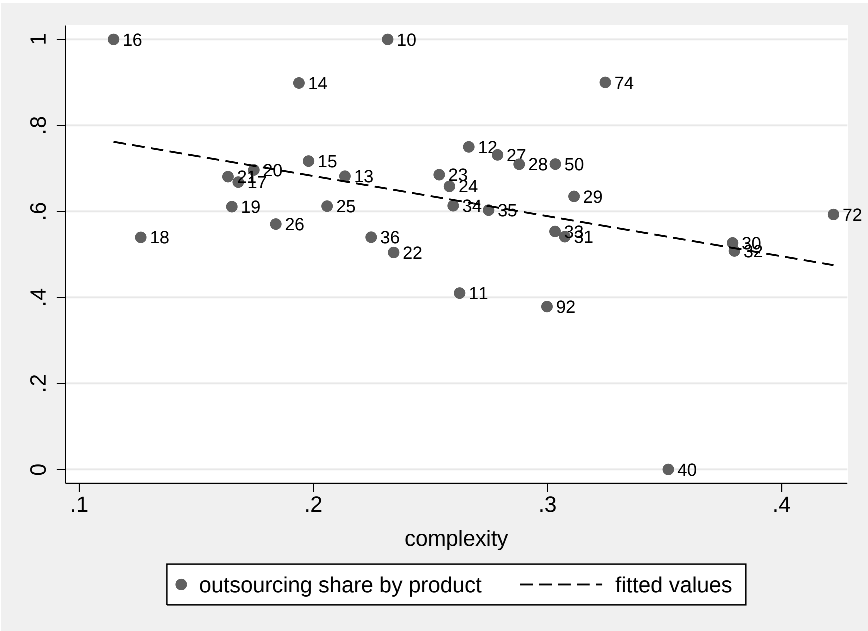


Figure 2: Complexity and outsourcing share



Note: 10: Coal & lignite; peat; 11: Crude petrol. & natural gas; services incidental to oil; 12: Uranium & thorium ores; 13: Metal ores; 14: Other mining & quarrying products; 15: Food products & beverages; 16: Tobacco products; 17: Textiles; 18: Wearing apparel; furs; 19: Leather & leather products; 20: Wood & products of wood & cork (excp. furniture); artic; 21: Pulp, paper & paper products; 22: Printed matter & recorded media; 23: Coke, refined petroleum products & nuclear fuels; 24: Chemicals, chemical products & man-made fibres; 25: Rubber & plastic products; 26: Other non-metallic mineral products; 27: Basic metals; 28: Fabricated metal products, except machinery & equipment; 29: Machinery & equipment n.e.c.; 30: Office machinery & computers; 31: Electrical machinery & apparatus n.e.c.; 32: Radio, television & communication equipment & apparatus; 33: Medical, precision & optical instruments, watches and clocks; 34: Motor vehicles, trailers & semi-trailers; 35: Other transport equipment; 36: Furniture; other manufactured goods n.e.c.; 40: Electrical energy, gas, steam & hot water; 50: Trade, maint. & repair services of motor vehicles & mtr; 72: Computer & related services; 74: Other business services; 92: Recreational, cultural & sporting services.

with stronger IPR protection. Countries, which receive high shares of outsourcing (e.g. Germany, Belgium, USA), are also among the countries that rank highest according to the Park index. By contrast, French multinationals highly rely on related parties when sourcing from countries with lower IPR levels (e.g. India, Jordan).

The correlation between complexity and the average outsourcing share by product group is negative as Figure 2 shows. Basic products, such as tobacco (16), are generally imported from independent suppliers, whereas complex products, such as IT- and telecommunication-related products (30, 32, 72) are largely, sourced from related suppliers.

6. Estimation Results

We start our empirical analyses with presenting the baseline results on the entire sample before splitting the sample to test for the proposed non-linearities in product complexity. We complement our analyses with various robustness checks.

6.1. Preliminarily Results

In Section 2.2, we have modeled the imports of intermediate inputs as a decision between two sourcing modes. Firms can import an intermediate input from a given country using an outside foreign supplier or from their own related party located there. There are, however, some firms that do not face this choice because they do not have a related party in a particular country. This is so because even if all firms in the sample have at least one related party located somewhere abroad, they may still import some products from outside suppliers in a country where they do not have a related party. We expect outsourcing in such countries to be mainly driven by marginal-cost-savings, and imports to involve simple goods making the level of IPRs irrelevant.

In this section, we do not apply the selection methodology and run preliminary regressions on the full sample of 66,935 observations. We pool all types of transactions irrespective of the presence of a related party. The results are reported in Table 3. Indeed, our results show that IPRs do not matter for the location choice across countries when simply deciding where to outsource the production of a given good. The negative and significant correlation between outsourcing and complexity supports our hypothesis that this is because such pure location decisions involve simple goods. Our analysis in the following section therefore takes another step to investigate the importance of IPRs in the choice between acquiring products (of different complexity) from a related party or an outside supplier in a given country.

6.2. Baseline Results

Table 4 reports the marginal effects of the two stage approach. In the first stage, we report the estimates of a probit model that analyzes the likelihood of finding a related party in a given foreign country. In the second stage, we analyze the effects of IPR and product complexity on the share of outsourcing and include the inverse Mills ratio from the first stage in the different models. The sign on the inverse Mills ratio indicates the nature of the correlation between the errors in the selection equation and the second stage equation. In our case, it is negative and highly significant irrespective of the estimated specification. This suggests that those firms most likely to have a foreign related party are also less likely to source from an independent supplier.

The estimates of the first stage equation reveal that the presence of a related party is determined by the number of French related parties and the nationality of the UBO. As expected, both covariates

Table 3: Basic results without selection (marginal effects presented).

Variables	(S1)	(S2)	(S3)	(S4)	(S5)	(S6)	(S7)
IPR	-0.018		-0.018	-0.019	-0.019	0.007	0.031^b
	(-1.270)		(-1.304)	(-1.424)	(-1.323)	(0.555)	(2.405)
Product complexity		-0.353^a	-0.354^a	-0.356^a	-0.389^a	-0.402^a	-0.410^a
		(-3.149)	(-3.057)	(-3.070)	(-3.285)	(-3.424)	(-3.033)
Abs. Capacity				0.008	0.008	-0.004	-0.012
				(1.5)	(1.484)	(-0.455)	(-0.959)
TFP, lag					0.027^a	0.027^b	0.041^a
					(2.593)	(2.518)	(2.906)
Investment risk						-0.017^b	-0.01^c
						(-2.322)	(-1.709)
Corruption						-0.002	-0.012^b
						(-0.434)	(-2.196)
Wage difference							0.003
							(0.059)
Obs.	66,935	66,935	66,935	66,935	66,935	66,917	23,745
Pseudo R^2	0.0236	0.0242	0.0247	0.0249	0.0269	0.0286	0.0309

Robust standard errors adjusted for clustering around the country and product identity in the second stage. *t*-statistics in parentheses. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

enter significantly and positively in the selection equation. The estimate of firm's TFP is small and statistically insignificant. This suggests that the decision of setting up a related party in a certain country is not taken by the firm itself but rather by the group to which the firm belongs. With the exception of GDP and distance, most gravity determinants are insignificant. We find, however, that policies towards FDI, as captured by the FDI openness variable, affect the probability of having a foreign related party positively. The entry costs variable shows the expected negative impact.

The results of the second stage equation are reported in columns (S1) to (S7). The estimates of the IPR and complexity variables are particularly robust across the different specifications. They are both in line with our theoretical expectation. In particular, we find a positive and significant impact of IPR on the outsourcing share with a marginal effect of 0.05 in specification (S6). The estimate of the complexity variable is also significant. The marginal effect is negative and ranges from -0.374 to -0.439.[16]

In column (S4), we introduce the absorptive capacity of a country. This variable, measured as the percentage of a country's population that has completed at least secondary schooling, is an approximation of the costs incurred by the ex-ante technology transfer. The marginal effect is positive and significant. This finding is in line with equation (6) which suggests that the technology transfer costs to customize the input to the multinational firm's needs accrue only in the case of outsourcing. A higher absorptive capacity lowers this cost and favors thereby outsourcing.[17]

In column (S5), we add the one-year lagged TFP level of the French multinational. The marginal effect is positive and significant. It suggests that most productive multinational firms are more

[16]Column (S7) is an exception since it includes wage differences and is for this reason, estimated for a substantially reduced sample.

[17]The result is in line with previous studies: Bernard et al. (2010) report empirical evidence that a country's greater skill abundance reduces the share of intra-firm trade of US firms. Grover (2007) develops a theoretical model according to which intra-firm trade falls relative to extra-firm trade as absorptive capacity rises.

Table 4: Impact of complexity and IPR regimes on the sourcing choice (marginal effects presented).

Variables	(First Stage)	(Second Stage)						
		(S1)	(S2)	(S3)	(S4)	(S5)	(S6)	(S7)
IPR	0.072^a	0.036^b		0.035^b	0.032^b	0.033^b	0.05^a	0.079^b
	(6.08)	(2.384)		(2.288)	(2.215)	(2.319)	(2.681)	(2.112)
Product complexity	0.345^a		-0.389^a	-0.374^a	-0.382^a	-0.425^a	-0.439^a	-0.61^a
	(3.015)		(-3.404)	(-3.314)	(-3.340)	(-3.758)	(-3.873)	(-3.665)
Abs. Capacity	0.001				0.023^a	0.023^a	0.014^c	0.003
	(0.148)				(3.809)	(3.731)	(1.696)	(0.147)
TFP, lag	0.001					0.034^b	0.034^b	0.057^a
	(0.058)					(2.053)	(2.049)	(3.326)
GDP	0.050^a							
	(9.388)							
Distance	-0.045^a							
	(-6.020)							
Adjacency	-0.018							
	(-0.506)							
Official Language	-0.007							
	(-0.436)							
Common legal origin	0.016							
	(1.032)							
Trade openness	-0.001							
	(-1.316)							
Investment openness	0.004^a							
	(4.751)							
Entry costs	-0.015^a							
	(-5.385)							
No. of French related parties	0.164^a							
	(16.756)							
UBO, foreign group	0.259^a							
	(10.149)							
Investment risk							-0.013^b	-0.004
							(-1.997)	(-0.427)
Corruption							-0.002	-0.02^b
							(-0.296)	(-2.389)
Wage difference								-0.016
								(-1.019)
Inverse Mills		-0.3^a	-0.336^a	-0.308^a	-0.317^a	-0.313^a	-0.315^a	-0.321^a
		(-10.04)	(-12.19)	(-9.976)	(-11.37)	(-10.94)	(-10.99)	(-9.447)
Obs.	66,935	39,636	39,636	39,636	39,636	39,636	39,635	14,978
Pseudo R^2	0.166	0.0525	0.0524	0.0534	0.0548	0.0571	0.0578	0.0697

Robust standard errors adjusted for clustering around the country and product identity in the second stage. The standard error are clustered at firm level in the first stage equation. t-statistics in parentheses. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

likely to outsource. In line with our theoretical framework, productive firms find it easier to overcome the technology transfer costs and tend to outsource a higher share of their international activities.

The IPR regime and the decision to source complex inputs may be correlated with some host country characteristics such as the corruption level and the level of investment risk. As Javorcik (2004) points out, multinational firms are less likely to operate with their affiliates in risky and corrupt countries. We include these additional variables in the estimation. The investment risk variable is the 1999 ICRG investment profile. It provides information on contract viability and expropriation, profits repatriation and payment delays.[18] We find that lower investment risk favors outsourcing. The corruption index is the 1999 Transparency International Corruption Perception Index which pools information from ten different surveys of business executives, risk analysts and

[18] A higher index indicates a lower risk of investment.

the general public. The estimate is small and insignificant. The corruption level does not influence the sourcing mode of French multinationals. While the effect of corruption is insignificant, the introduction of the investment risk variable yields a more precise estimation of the IPR estimates.

In column (S7), we additionally control for the wage difference between the home country, France, and the source countries, J. Since the wage difference is positive only for less developed countries whilst the major part of French firms' imports come from well developed countries such as Germany and the US, the inclusion of the variable in logs results in a loss of over 50% of all observations. Although we do not find the predicted positive impact of the wage difference on the outsourcing share, it is interesting to observe that the effects of complexity and the IPR protection level become stronger for this sample.[19] The country's absorptive capacity and the quality of its business environment now turn out to have no impact on the outsourcing share. The corruption variable is negative and estimated with a very low degree of precision.

As shown by Hanson et al. (2005), the trade activities of multinational firms involve intermediate inputs which are a key element of their global production network. We analyze the effect of IPR and complexity on the outsourcing decision of intermediate products. In Appendix B, Table B.1 reports the marginal effects using a sample containing intermediate inputs only. We follow the methodology developed in Defever and Toubal (2007) and identify imported intermediate inputs as purchased inputs registered in an HS3-digit sector other than the one in which the French multinational reports its main activity. The results are qualitatively similar to those reported in Table 4. The marginal effects are, however, estimated with a higher level of precision, suggesting that the sample of intermediate inputs provides a better fit for our analysis.

6.3. Simple vs. Complex Products

We find that the level of complexity has, on average, a negative impact on the outsourcing share. A greater level of complexity should deter outsourcing because complex products are associated with a higher risk of imitation. According to equation (3), the decision to source products with a very high degree of complexity from an outside supplier should be strongly influenced by the level of IPR protection. In Table 5, we investigate the effect of IPR and complexity on the sourcing mode, separately for high and low complex products. Table 5 reports the second stage equation, the estimation of the selection equation is similar to the one presented in Table 4. The sample of high complexity products corresponds to all transactions with a level of complexity which is above the complexity variable median value ($z = 0.279$). The estimated marginal effects are presented in the upper Panel A of Table 5. We report the results of the low complexity sample in the lower Panel B. As in the baseline regressions, we find that the inverse Mills ratios are statistically significant and negative in both subsamples.

The results of Table 5 show striking differences with respect to the effect of IPR on low and high complexity products. While for a high level of complexity, the levels of IPR and complexity are relevant for the sourcing decision, they do not appear to be relevant for low complexity levels. In Panel A, the marginal effects of the IPR variables are significant and vary from 0.05 to 0.073. We additionally find a negative and significant impact of the complexity variable. Interestingly, the marginal effects of the IPR and complexity variables are larger than the ones reported in Table 4. These results suggest that the levels of IPR and complexity are even more important for the sourcing decision of highly complex products. The human capital endowment does not lower technology transfer costs for highly complex products. Notice, that the marginal effect of the IPR

[19] 2/3 of imports in this restricted sample come from Italy, Spain and the United Kingdom.

variable is more important in this specification. As suggested by our testable implications, firms need a certain productivity level to overcome the fixed costs associated with the sourcing of high complex goods from independent suppliers. The positive and significant marginal effect in Panel A confirms this.

Table 5: Outsourcing and the non-linear impact of complexity (marginal effects presented).

Panel A: high level of complexity							
IPR	0.055^a		0.052^b	0.05^b	0.051^b	0.073^a	0.172^a
	(2.644)		(2.486)	(2.512)	(2.558)	(2.995)	(4.489)
Product complexity		-0.686^b	-0.618^c	-0.604^c	-0.688^b	-0.693^b	-1.013^c
		(-2.024)	(-1.815)	(-1.765)	(-1.982)	(-2.000)	(-1.839)
Abs. Capacity				0.021^a	0.021^a	0.012	-0.009
				(3.743)	(3.639)	(1.244)	(-0.532)
TFP, lag					0.037^b	0.037^b	0.052^a
					(2.4)	(2.398)	(2.848)
Investment risk						-0.011	-0.006
						(-1.431)	(-0.487)
Corruption						-0.005	-0.021^b
						(-0.740)	(-2.171)
Wage difference							-0.004
							(-0.193)
Inverse Mills	-0.256^a	-0.304^a	-0.257^a	-0.267^a	-0.255^a	-0.26^a	-0.263^a
	(-6.298)	(-7.747)	(-6.295)	(-6.906)	(-6.479)	(-6.672)	(-5.414)
Obs.	20,961	20,961	20,961	20,961	20,961	20,960	7,744
R^2	0.0691	0.0679	0.07	0.0711	0.0734	0.0742	0.0972
Panel B: low level of complexity							
IPR	0.011		0.013	0.009	0.012	0.024	0.021
	(0.497)		(0.554)	(0.4)	(0.534)	(0.924)	(0.56)
Product complexity		-0.367	-0.378	-0.395	-0.455	-0.473	-1.001^b
		(-1.016)	(-1.045)	(-1.089)	(-1.191)	(-1.248)	(-2.239)
Abs. Capacity				0.025^a	0.025^a	0.016^c	-0.001
				(4.517)	(4.303)	(1.723)	(0.080)
TFP, lag					0.034	0.034	0.063^b
					(1.385)	(1.392)	(2.491)
Investment risk						-0.015	0.003
						(-1.541)	(-0.407)
Corruption						0.002	-0.017^b
						(0.221)	(-2.184)
Wage difference							-0.019
							(-1.188)
Inverse Mills	-0.343^a	-0.358^a	-0.349^a	-0.358^a	-0.357^a	-0.359^a	-0.368^a
	(-10.559)	(-11.818)	(-10.883)	(-12.147)	(-12.309)	(-12.503)	(-9.337)
Obs.	18,675	18,675	18,675	18,675	18,675	18,675	7,234
R^2	0.0461	0.0465	0.0466	0.0482	0.051	0.0518	0.0621

Robust standard errors adjusted for clustering around the country and product identity in the second stage. First stage regression as in Table 4. *t*-statistics in parentheses. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Concerning the results presented in Panel B, we still find a positive and significant effect of the absorptive capacity. A country's endowment with human capital favors the outsourcing of low complex goods. Confirming our testable implications, the productivity of a firm is irrelevant for the sourcing of low complex goods. Since we assume that basic good production does not involve high fixed costs, firms at all levels of productivity can outsource the production of these goods.

Table B.2 in Appendix B reports the marginal effects using the intermediate inputs sample. The results are qualitatively similar and estimated with a higher degree of precision.

6.4. Robustness Checks

We provide two robustness checks: First, we use the Rauch (1999) classification to challenge our measurement of product complexity. Second, we employ the average measure of IPR enforcement for the period under study.

Berkowitz et al. (2006) and Rajan and Lee (2007) reinterpret Rauch's product classification in terms of product complexity. Rauch (1999) classifies the four digit industries into different trading categories. Some products are quoted on organized exchanges, while others are quoted in trade publications, i.e. they are reference priced. We denote these two categories by homogenous products. Rauch classifies also other goods that are not homogenous. These products are "sufficiently differentiated that prices cannot convey enough of the information relevant for international trade: buyers and sellers must be matched in characteristics space" (Rauch, 2001, p. 1187). Berkowitz et al. (2006) and Rajan and Lee (2007) assume that homogenous products hold a lower level of complexity than differentiated products. We depart a little from their interpretation. The homogenous products category might also exhibit variation in product complexity (from pork to chemicals). But the levels of complexity or IPR for homogenous goods should not influence the choice of sourcing because the goods are standardized and sold to a wider range of firms. The IPR enforcement issue and the level of complexity should be more important for trade in differentiated products. These goods contain many characteristics that are difficult to fully stipulate in a contract and the success of the buyers and sellers match is not guaranteed.

In Table 6, we report the marginal effects of the first and second stage estimations using this classification. Considering the sample of homogenous products, we do not find robust evidence that the levels of IPR and product complexity affect the sourcing choice.[20] We find that the levels of IPR and complexity influence the outsourcing share of differentiated products. The estimated marginal effects are in line with those of the baseline specifications.

The enforcement of the WTO agreement on the trade-related aspects of intellectual property rights (TRIPS) in 1995 may have changed the ranking of countries according to their IPR protection level. Even though the Park (2008) index incorporates these changes, the index for 1995 cannot account for the transition periods that were granted to transition and developing countries (until 2000) and to developed countries (until 1996) in applying TRIPS. Given these delays, it would be desirable to use an IPR index at a later date. Since the Park (2008) index was calculated only every five years prior to 2000, we use the average between 1995 and 2000.[21]

The results are presented in Table B.3 in the Appendix. The introduction of the alternative measure of IPR does not affect the impact of our variables of interest on the outsourcing share. The marginal effects of the complexity level enter negatively and significantly in the second stage equations. We find the average IPR index to have a significant and positive impact on the outsourcing share of

[20] In the reduced sample that includes the wage differences, the level of IPR is significant but only at 10%.

[21] Other popular measures, like the Heritage Foundation and the Kaufmann et al. (2010) index capture the institutional quality of a country in general and are, therefore, not suitable to measure imitation risk.

Table 6: Using the Rauch classification (marginal effects presented).

Variables	(First Stage)	(Second Stage)			
		Homogenous		Differentiated	
IPR	0.072[a]	0.019	0.043	0.053[b]	0.082[b]
	(6.08)	(0.626)	(1.419)	(2.485)	(2.051)
Product complexity	0.345[a]	0.488[c]	0.46	-0.396[a]	-0.546[a]
	(3.015)	(1.678)	(1.222)	(-2.992)	(-2.914)
Abs. Capacity	0.001	0.01	-0.026	0.015	0.011
	(0.148)	(0.974)	(-1.510)	(1.552)	(0.532)
TFP, lag	0.001	-0.004	0.006	0.049[a]	0.077[a]
	(0.058)	(-0.220)	(0.413)	(2.704)	(3.867)
GDP	0.05[a]				
	(9.388)				
Distance	-0.045[a]				
	(-6.020)				
Adjacency	-0.018				
	(-0.506)				
Official language	-0.007				
	(-0.436)				
Common legal origin	0.016				
	(1.032)				
Trade openness	-0.001				
	(-1.316)				
Investment openness	0.004[a]				
	(4.751)				
Entry costs	-0.015[a]				
	(-5.385)				
No. of French related parties	0.164[a]				
	(16.756)				
UBO, foreign group	0.259[a]				
	(10.149)				
Investment risk		-0.019[c]	-0.014[a]	-0.011	0.000
		(-1.719)	(-3.050)	(-1.515)	(0.017)
Corruption		0.003	-0.001	-0.004	-0.026[a]
		(0.437)	(-0.170)	(-0.610)	(-3.207)
Wage difference			-0.01		-0.021
			(-0.549)		(-1.340)
Inverse Mills		-0.296[a]	-0.336[a]	-0.314[a]	-0.307[a]
		(-9.718)	(-7.638)	(-9.143)	(-7.966)
Obs.	66,935	11,004	3,582	30,981	11,992
R^2	0.166	0.0394	0.0539	0.0648	0.0756

Robust standard errors adjusted for clustering around the country and product identity in the second stage. The standard error are clustered at firm-level in the first stage equation. t-statistics in parentheses. [a], [b] , [c] significantly different from 0 at 1%, 5% and 10% level, respectively.

multinational firms. The marginal effect is of an order of magnitude larger than the one found in Table 4. Interestingly, the introduction of the average IPR index renders the absorptive capacity variable insignificant.

7. Conclusions

This paper has investigated the decision of multinational groups to source complex goods from independent or related suppliers. We have developed a theoretical framework that proposes the complexity of a product and the IPR protection level of a country as alternative determinants for a firm's choice between outsourcing and vertical integration.

As measures of the technological intensity at the product-level are not available, we have built a new measure reflecting the complex problem-solving skills involved in the production of a good. The estimations confirm the theoretical presumption that firms use independent suppliers when sourcing non-complex goods. When sourcing complex goods, costly technology transfer exposes firms to the risk of being imitated. This imitation risk increases in the complexity of the imported good and decreases in the level of IPR protection available in the source country.

The study confirms the hypothesis that firms outsource highly complex products to countries where their intellectual property is recognized. While IPR and complexity matter for the mode choice between sourcing from a related party or an outside supplier in a given country, IPR is less relevant for the location choice across countries when deciding from where to import a given simple product. Our findings are robust when considering intermediate goods, when linking the results to a different definition of product complexity, and when using an alternative measure of IPR.

As much as the paper contributes to understanding the internationalization strategy of firms and the differences between intra-firm trade and outsourcing, it bears an important policy conclusion: The results suggest that attracting the upper part of the value chain requires building trust into the protection of IPRs.

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Appendix A. IPR and Complexity Ranking

Appendix A.1. Product Complexity Ranking

Table A.1: Product complexity ranking

Code	Description	Complexity
72	Computer & related services	.4221271
32	Radio, television & communication equipment & apparatus	.3798102
30	Office machinery & computers	.3790194
40	Electrical energy, gas, steam & hot water	.3515674
74	Other business services	.3246673
29	Machinery & equipment n.e.c.	.3113132
31	Electrical machinery & apparatus n.e.c.	.3073564
50	Trade, maint. & repair services of motor vehicles & mtrcls; retail sale of auto fuel	.3033172
33	Medical, precision & optical instruments, watches and clocks	.3031925
92	Recreational, cultural & sporting services	.2997497
28	Fabricated metal products, except machinery & equipment	.2878633
27	Basic metals	.2786216
35	Other transport equipment	.2748125
12	Uranium & thorium ores	.266358
11	Crude petrol. & natural gas; services incidental to oil & gas ext. excl. surveying	.2624262
34	Motor vehicles, trailers & semi-trailers	.2596836
24	Chemicals, chemical products & man-made fibres	.2580898
23	Coke, refined petroleum products & nuclear fuels	.2537238
22	Printed matter & recorded media	.2342544
10	Coal & lignite; peat	.2317005
36	Furniture; other manufactured goods n.e.c.	.2246486
13	Metal ores	.2134478
25	Rubber & plastic products	.205822
15	Food products & beverages	.1978979
14	Other mining & quarrying products	.1938014
26	Other non-metallic mineral products	.1839178
20	Wood & products of wood & cork (excp. furniture); articles of straw & plaiting matls	.1745415
17	Textiles	.167882
19	Leather & leather products	.1651444
21	Pulp, paper & paper products	.1634918
18	Wearing apparel; furs	.1262338
16	Tobacco products	.1146149

Source: Own calculations.

Appendix A.2. List of Countries and IPR Level

Table A.2: List of countries and IPR level

Argentina	2.73	Germany	4.17	Mexico	3.14	Spain	4.21
Australia	4.17	Ghana	2.83	Morocco	1.78	Sri Lanka	2.98
Austria	4.21	Greece	3.47	Netherlands	4.54	Sweden	4.42
Belgium	4.54	Hungary	4.04	New Zealand	4.01	Switzerland	4.21
Bolivia	2.37	India	1.23	Norway	3.88	Tanzania	2.32
Brazil	1.48	Indonesia	1.56	Pakistan (1972-)	1.38	Thailand	2.41
Bulgaria	3.23	Ireland	4.14	Panama	1.46	Tunisia	1.65
Canada	4.34	Israel	3.14	Peru	2.73	Turkey	2.65
Chile	3.91	Italy	4.33	Philippines	2.56	Ukraine	3.68
China	2.12	Jamaica	2.86	Poland	3.46	United Kingdom	4.54
Colombia	2.74	Japan	4.42	Portugal	3.35	United States	4.88
Czech Republic	2.96	Jordan	1.08	Romania	3.52	Uruguay	2.07
Denmark	4.54	Kenya	2.43	Russia	3.48	Venezuela	2.82
Ecuador	2.04	Korea, South	3.89	Singapore	3.88	Vietnam	2.9
Egypt	1.73	Lithuania	2.69	Slovakia	2.96	Zambia	1.62
Finland	4.42	Malaysia	2.7	South Africa	3.39	Zimbabwe	2.28

List of countries in the full sample. Level of Intellectual Property Rights for 1995.

Appendix B. Additional Empirical Results

Table B.1: Impact of complexity and IPR regimes on the sourcing choice intermediate products (marginal effects presented).

Variables	(First Stage)	(Second Stage)						
		(S1)	(S2)	(S3)	(S4)	(S5)	(S6)	(S7)
IPR	0.069^a	0.042^a		0.04^a	0.038^a	0.039^a	0.057^a	0.113^a
	(4.948)	(3.43)		(3.199)	(3.412)	(3.409)	(4.01)	(3.993)
Product complexity	0.379^a		-0.522^a	-0.508^a	-0.518^a	-0.545^a	-0.550^a	-0.623^a
	(3.487)		(-4.649)	(-4.577)	(-4.634)	(-4.925)	(-4.950)	(-3.775)
Abs. Capacity	0.005				0.023^a	0.024^a	0.016^b	0.001
	(0.665)				(5.308)	(5.364)	(2.548)	(0.08)
TFP, lag	0.005					0.037^c	0.037^c	0.063^a
	(0.343)					(1.946)	(1.938)	(3.589)
GDP	0.053^a							
	(8.207)							
Distance	-0.044^a							
	(-5.145)							
Adjacency	0.001							
	(0.038)							
Official language	-0.015							
	(-0.813)							
Common legal origin	0.017							
	(0.969)							
Trade openness	-0.001							
	(-0.496)							
Investment openness	0.003^a							
	(3.465)							
Entry costs	-0.018^a							
	(-5.494)							
No. of French related parties	0.162^a							
	(16.02)							
UBO, foreign group	0.260^a							
	(9.442)							
Investment risk							-0.01^c	-0.006
							(-1.895)	(-0.671)
Corruption							-0.004	-0.015^c
							(-0.831)	(-1.921)
Wage difference								0.003
								(0.224)
Inverse Mills		-0.286^a	-0.331^a	-0.302^a	-0.311^a	-0.304^a	-0.306^a	-0.311^a
		(-8.683)	(-10.68)	(-8.988)	(-10.12)	(-9.496)	(-9.303)	(-8.065)
Obs.	48,343	28,447	28,447	28,447	28,447	28,447	28,447	10,042
R^2	0.164	0.0619	0.0632	0.0645	0.0661	0.0692	0.0699	0.0836

Robust standard errors adjusted for clustering around the country and product identity in the second stage. The standard error are clustered at firm level in the first stage equation. t-statistics in parentheses. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table B.2: Outsourcing of intermediate inputs and the non-linear impact of complexity (marginal effects presented).

Panel A: high level of complexity

IPR	0.053^a		0.052^a	0.05^a	0.049^a	0.069^a	0.163^a
	(2.823)		(2.72)	(2.832)	(2.87)	(3.334)	(3.658)
Product complexity		-0.562^b	-0.502^c	-0.485^c	-0.56^c	-0.557^b	-0.822^c
		(-2.089)	(-1.836)	(-1.729)	(-1.952)	(-1.960)	(-1.728)
Abs. Capacity				0.019^a	0.019^a	0.012	-0.002
				(4.377)	(4.273)	(1.499)	(-0.195)
TFP, lag					0.053^a	0.053^a	0.076^a
					(2.955)	(2.944)	(3.335)
Investment risk						-0.007	0.001
						(-1.011)	(0.039)
Corruption						-0.008	-0.025^a
						(-1.282)	(-2.617)
Wage difference							-0.005
							(-0.203)
Inverse mills	-0.224^a	-0.273^a	-0.226^a	-0.234^a	-0.217^a	-0.219^a	-0.188^a
	(-4.473)	(-5.741)	(-4.505)	(-4.896)	(-4.543)	(-4.518)	(-3.523)
Obs.	14,246	14,246	14,246	14,246	14,246	14,246	5,055
R^2	0.0751	0.0735	0.0757	0.0766	0.0816	0.0824	0.0972

Panel B: low level of complexity

IPR	0.023		0.023	0.021	0.025	0.039^c	0.069^b
	(1.065)		(1.067)	(1.053)	(1.147)	(1.72)	(2.332)
Product complexity		-0.183	-0.220	-0.245	-0.257	-0.255	-0.526
		(-0.729)	(-0.878)	(-0.970)	(-1.003)	(-1.019)	(-1.259)
Abs. Capacity				0.027^a	0.027^a	0.018^c	-0.004
				(3.979)	(4.043)	(1.813)	(-0.231)
TFP, lag					0.029	0.029	0.056^b
					(1.115)	(1.115)	(2.304)
Investment risk						-0.012	-0.008
						(-1.222)	(-1.071)
Corruption						-0.002	-0.013
						(-0.289)	(-1.259)
Wage difference							0.01
							(0.672)
Inverse mills	-0.339^a	-0.354^a	-0.341^a	-0.349^a	-0.346^a	-0.347^a	-0.374^a
	(-10.75)	(-11.37)	(-11.16)	(-12.09)	(-11.82)	(-11.51)	(-10.29)
Obs.	14,201	14,201	14,201	14,201	14,201	14,201	4,987
R^2	0.0602	0.0579	0.0602	0.0624	0.0648	0.0654	0.0807

Robust standard errors adjusted for clustering around the country and product identity in the second stage. First stage regression as in Table B.1. *t*-statistics in parentheses. [a], [b], [c] significantly different from 0 at 1%, 5% and 10% level, respectively.

Table B.3: Alternative measure of IPR (marginal effects presented).

	Average IPR (1995-2000)		
Average IPR	0.084^a	0.062^a	0.089^b
	(5.833)	(3.023)	(2.096)
Product complexity	0.348^a	-0.435^a	-0.603^a
	(3.036)	(-3.840)	(-3.631)
Abs. capacity	0.000	0.012	0.003
	(0.036)	(1.528)	(0.165)
TFP, lag	0.001	0.034^b	0.057^a
	(0.060)	(2.049)	(3.316)
GDP	0.049^a		
	(9.110)		
Distance	-0.046^a		
	(-6.144)		
Adjacency	-0.017		
	(-0.490)		
Official language	-0.008		
	(-0.454)		
Common legal origin	0.014		
	(0.915)		
Trade openness	-0.001		
	(-1.166)		
Investment openness	0.004^a		
	(4.675)		
Entry costs	-0.016^a		
	(-5.589)		
No. of French related parties	0.164^a		
	(16.757)		
UBO, foreign group	0.259^a		
	(10.153)		
Investment risk		-0.013^b	-0.002
		(-1.996)	(-0.171)
Corruption		-0.002	-0.019^b
		(-0.274)	(-2.363)
Wage difference			-0.017
			(-1.103)
Inverse mills		-0.312^a	-0.321^a
		(-11.005)	(-9.686)
Obs.	66,935	39,635	14,978
R^2	0.166	0.058	0.0698

Robust standard errors adjusted for clustering around the country and product identity in the second stage. The standard error are clustered at firm level in the first stage equation. *t*-statistics in parentheses. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

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