Intangible Assets and the Organization of Global Supply Chains*

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Abstract

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1 Introduction

Modern value chains are becoming more and more global in nature, as they are increasingly characterized by the participation of suppliers located across different countries. Incomplete contracts and contract enforcement continue to be a central issue in this context when studying the integration versus outsourcing decision of firms.[1] The two familiar approaches to confront the issue of incomplete contracts are the transaction cost theory (Williamson, 1971, 1975, 1985) and the property right theory (Grossman andHart, 1986; Hart and Moore, 1990). The literature has by now established how specific features of different production locations such as contract enforcement affect the organizational decision of firms. Under the transaction cost approach, better contracting institutions reduce hold-up problems associated with outsourcing and facilitate the exploitation of specialization gains from outsourcing. With the property rights approach, better contracting institutions mitigate the need to create investment incentives through outsourcing and enable a firm to reap a larger share of the revenue through integration. Empirical studies starting from Corcos *et al.* (2013) all the way up to the very recent work of Eppinger and Kukharskyy (2017) have found strong evidence for the property right theory as opposed to the transaction cost theory evincing that better institutional quality increases incidences of integration over outsourcing. Defever and Toubal (2013) instead put forward some evidence in the direction of the transaction cost theory, by showing an increase in the propensity of outsourcing for more productive firms due to higher organizational costs associated with outsourcing.

A recent seminal paper by Antràs and Chor (2013) introduces the sequential dimension of production along the supply chain into the argument, showing how the position of and the inter-relation between the stages of production impact firms' organizational decision through the structure of incentives for suppliers. In their model, if supplier investments are sequential complements, prior upstream investment by a given supplier would increase marginal returns to investment by the suppliers performing the next stages of production, whereas in the case of sequential substitutes it would reduce the marginal revenue of further investment in subsequent stages. They show therefore that upstream (downstream) stages are outsourced (integrated) when stages are sequential complements and integrated (outsourced) when they are sequential substitutes. This mechanism works under the property right approach, where outsourcing, i.e. giving a larger share of the pie to a supplier, encourages investment by that particular supplier. A follow-up to this strand of literature is the study by Alfaro *et al.* (2015), who incorporate the notion of contractibility from Antràs and Helpman (2008) into Antràs and Chor (2013) and interestingly show that better contractibility in the upstream part of the production tends to increase the firm's propensity to integrate in the case of sequential complementarity, whereas it increases outsourcing in case stages are sequential substi-

[1] See the vast literature on international trade and the boundaries of firms (Antràs, 2003, 2005; Antràs and Helpman, 2004, 2008; Grossman and Helpman, 2002, 2003, 2005).

tutes. The argue that the intuition behind this regularity stems directly from the property right theory: "the higher the contractibility of inputs, the less firms need to rely on outsourcing as a way to reverse the distortions associated with inefficient investment by upstream suppliers."

This paper introduces the concept of intangible assets in sequential global supply chains and the importance of their appropriability in the organizational decision of firms. The focus shifts from property rights to intellectual property rights (IPR), which on top of the hold-up problem between a supplier and the final producer entails an additional risk of imitation as technology may leak to competing producers in the market. The quality of IPR institutions in the location of a supplier can therefore play a crucial role in determining the decision of a final good producer whether to outsource or integrate a particular stage of production. The analysis is performed with Antràs and Chor (2013) in the background, where the position of the input along the supply chain, i.e. its upstreamness, and sequential complementarity/substitutability across stages of production influence the organizational strategy of firms through the incentive structure of supplier investment. Our findings show that introducing intangible assets in sequential supply chain may have the opposite effect of contractibility on outsourcing decision, where only tangible property rights are considered. We argue therefore that the risk of imitation is a relevant feature that needs to be taken into consideration in the incomplete contract literature. Regardless of the vast literature on trade, firm organization and property rights, the focus of all existing works has so far been contract enforcement and the "tangible" perception of property rights. Antràs and Rossi-Hansberg (2009) mention that the literature has concentrated on hold-up inefficiencies as the main drivers of the internalization decision of firms and underline the importance of missing research on how the non-appropriable nature of knowledge affects firm organization.

The argument takes even more importance when talking about stages along the supply chain within a firm. On this, Atalay, Hortacsu and Syverson (2014) emphasize the importance of intangible inputs within a firm by providing evidence for an alternative rationale behind vertical integration and its role in promoting efficient intra-firm transfers of intangible inputs such as marketing know-how, intellectual property, and R&D capital. In other words, they show, in line with the property right theory, that integration is not a tool to insure a smooth flow of physical inputs from upstream towards downstream activities, but rather a strategy to secure efficient transmission of technology across stages along the chain. A fundamental lesson learned from the work of Atalay, Hortacsu and Syverson (2014) is the importance of distinguishing intangible assets from tangible ones, and the critical role of firm organization in their movement along the supply chain. Indeed, there are no existing studies to our knowledge regarding the impact of institutions and firm organization on the transfer of intangible assets at the different stages of a sequential supply chain. This paper takes a step in this direction by building on the sequential production model of Antràs and Chor (2013) and investigating how the integration decision might be affected by the strength of IPR enforcement in the country where the production stage is performed.

In this context, the lack of effective IPR protection implies a higher risk of an imitation shock at that stage of production, reducing profits for the final good producer as well as that of other suppliers within the chain. The supply chain is less likely to reach later stages because technology can leak at any stage as production moves down along the chain. To elucidate the concept of imitation in our model, think of a supply chain with each stage of production requiring a blueprint shared between the firm and the supplier. The likelihood for the technology at a given stage to leak depends solely on the IPR environment and with the same arrival rate for all stages, but moving downstream increases the probability of the supply chain being exposed to imitation. Suppose an intermediate stage of production takes place in a country with low IPR protection. The blueprint in that stage is therefore more likely to diffuse out of the supply chain (thereby allowing for imitation of the final product) under both outsourcing and integration. This decreases the value of supplier investments for the entire supply chain, *ex-ante*, that is at the moment when the firm decides the optimal allocation of property rights before production starts. Following the literature, we consider investments to be for customization purposes with no intrinsic value outside the relationship. The interaction between a supplier and the firm is therefore not affected by imitation as we are dealing with a supply chain and inter-related technologies rather than a one-to-one buyer-supplier relationship.

In line with Atalay, Hortacsu and Syverson (2014) our findings shed light on the importance of the flow of intangible assets along the supply chain. Notably, imitation in our framework is embedded into the property right theory, where inefficiencies caused by contract incompleteness in terms of underinvestment into relation-specific inputs are present both within firm boundaries and in arm's length transactions. This mechanism works in parallel to Antràs and Chor (2013) and Alfaro *et al.* (2015) to produce novel results in the case of non-appropriability of intangible assets. Although integration may not be used to enhance interaction among stages in a supply chain, we show that the lack of the protection of "intellectual" property rights induces firms to opt for integration when inputs are sequential complements. Under a sound IPR regime firms are instead more likely to engage in outsourcing to create supplier incentives. Additionally, the degree of IPR protection tends to play a more important role in shaping the organization of the supply chain in the relatively more downstream parts of the production process. In contrast to the property right notion of contractibility in which stronger enforcement encourages integration and intra-firm trade, IPR protection shows a shifting of strategy towards international outsourcing by final good producers. This approach reveals a remarkable difference between tangible versus intangible assets within the property rights approach to firm boundaries and sheds light on how the non-appropriable nature of knowledge may impact the organization of global supply chains. To this end, the paper delivers clear theoretical predictions that are tested on firm-level data using a comprehensive dataset on Slovenian firms.

We use Slovenian firm level data in the 2002-2009 period and merge transaction-level trade data on Slovenian firms together with their FDI and financial data. The firm's decision to integrate suppliers in a certain market, i.e. the firm's propensity to transact inputs in a particular source country within firm boundaries, is defined based on outward FDI in a particular market. Since we can observe input imports by the core activity of a firm (the identity of the purchasing industry is known), we are able to identify the position of imported inputs in the value chain of a concrete firm's output industry. Hence, we use industry-pair specific measures of upstreamness in a manner of Alfaro *et al.* (2015) to calculate the firm-sourcing country specific measure. To distinguish between the case of sequential substitutes and that of sequential complements, we follow the approach adopted in Antràs and Chor (2013) and Alfaro *et al.* (2015), tracing substitutes/complements based on low/high value of import demand elasticities for each product category. In our case, we use import demand elasticities estimated for core products exported by Slovenian firms obtained from Kee, Nicita, and Olarreaga (2008) following the "production-based GDP-function" approach. Finally, the IPR enforcement index it retrieved from Park (2008).

The empirical findings are in full support of the underlying hypothesis behind our analysis. To validate the data, the estimates first look at the inter-relationship between stage characteristics and in accordance to Antràs and Chor (2013) find that for sequential complements, upstream stages are outsourced whereas downstream stages are integrated. Adding the concept of imitation into the argument reveals striking results. Interacting the results with stronger IPR enforcement in a country where the supplier is located decreases the positive effect of downstreamness on the integration decision of a firm in control of the supply chain. In other words, the threshold stage after which the firm integrates shifts to the right, resulting in outsourcing along a larger range of stages. The underlying mechanism derives from imitation creating uncertainty about the future of the supply chain, making outsourcing a less meaningful tool to create investment incentives for suppliers located further downstream. The final producer therefore chooses to hold on to a larger share of revenues and integrates that stage. As a result, integration occurs at an earlier (more upstream) stage of production. Improving IPRs recovers the sequential investment mechanism of Antràs and Chor (2013) and encourages outsourcing by blocking this imitation channel.

Another key contribution of the paper is to introduce a novel proxy for complementarity and interdependence between stages within a supply chain by measuring the degree of inputs differentiation (the extent to which they are spread across diverse industries). The results are fully robust and resemble those using import demand elasticity, reinforcing the crucial role of IPRs for the organizational mode along "complementary" stages. However, we observe both theoretically and empirically that differently from Alfaro *et al.* (2015), the institutional variables of interest (in our case, imitation risk and the protection of IPRs) tend to be a less relevant argument when stages are sequential substitutes. Conceptually, this is because the static and the dynamic effects of the organizational mode on supplier investments reinforce each other under sequential complements, whereas they counteract each other with sequential substitutes.[2] This finding reinforces our conception regarding the importance of the degree of differentiation between inputs as a measure of complementarity/substitutability of stages in the context of intangible assets and imitation, rather than the mere measure of import demand elasticity, which was the main argument in the context of contractibility of tangible assets in Alfaro *et al.* (2015).

The rest of the paper is organized as follows. Section 2 provides a brief background on our baseline theoretical framework that is essentially derived from Antràs and Chor (2013) and Alfaro *et al.* (2015). In Section 3 we introduce the presence of intangible assets and the possibility of imitation into the model. Section 4 introduces the data and provides a detailed description of the measures used in our specifications. The empirical results are shown in Section 5 along with a discussion of the findings and how they compare with the underlying theory. Section 6 further checks the robustness of the core results and the evidence obtained. Section 7 concludes and discusses avenues for further research.

2 Theoretical Background

For expositional convenience, we introduce the theoretical framework by considering, first, the baseline model, which basically corresponds to the model of Antràs and Chor (2013) in its simplest version. After having acquainted the reader with the mechanisms at work in this type of setting, we will then extend the model in Section 3, by introducing and modelling the risk of imitation and by illustrating how this innovation will affect the main theoretical results.

2.1 The baseline model: key-assumptions

We consider an economy in which the final good is available in many differentiated varieties, each one manufactured by a monopolistically competitive producer. Preferences are described by a standard CES utility function, thereby each producer (the *firm*) faces a demand for its variety given by

$$q = Ap^{-\frac{1}{1-\rho}} \ , \tag{1}$$

where $A > 0$ is a demand shifter that the firm treats as exogenous; p is the profit-maximizing price for the variety, set by the firm; and $\rho \in (0, 1)$ is a measure of elasticity of the final demand, since it is positively related to $1/(1 - \rho)$, i.e. the degree of substitutability among varieties.

While the representation of demand side of the economy is stripped-down, the supply side features more complexity. In order for a unit of each variety to be produced, there is a continuum of stages

[2] By static we intend the impact of outsourcing/integration on incentives for supplier investment in the same stage, and by dynamic on all the upcoming stages along the supply chain.

of production that must be completed in a precise order, dictated by technology. Each stage is therefore indexed by $z \in [0,1]$, where $z = 0$ is the first stage to be performed (the most *upstream*), whereas $z = 1$ is the last one (the most *downstream*). To make the model easier, we consider the case in which all stages are symmetric except for their position along the production line.

At the end of each stage z, a (quality-adjusted) quantity of intermediate good $x(z)$ is delivered to the next stage of production for further reprocessing. Hence, at each stage of production, the intermediate input gets closer to the final good variety. A key-feature of the model is that, at any stage z, the intrinsic value of the variety can be increased by means of a stage-specific investment, with marginal cost $c > 0$, which is intended to raise the level of customization of the intermediate good.[3] It follows that the quality-adjusted volume of the final good production is a function of all the stage-specific investments in input services undertaken along the value chain, i.e.

$$q = \theta \left(\int_0^1 x(z)^{\alpha} I(z)\, dz \right)^{1/\alpha} , \tag{2}$$

where θ is a productivity parameter, which reflects heterogeneity among firms; $\alpha \in (0,1)$ is the degree of physical input complementarity; and $I(z)$ is an indicator function which report us whether stage z has been completed or not. This feature makes the production process inherently sequential, since downstream stages are useless unless inputs from upstream stages have been delivered.

We assume that, albeit in control of the whole production process, the firm is unable to complete any single stage of this process without cooperating with a dedicated supplier. Hence, for each stage z, there is a bundle of *suppliers* endowed with the skills or the know-how required for performing stage z by customizing the product; we also assume that suppliers have a strong preference for staying into the relationship with the firm, their outside option being normalized to zero. As a result, at all stages of production, a supplier engages into a stage-specific contractual relationship with the firm for the procurement of a fully customized input $x(z)$, which is of worthless for alternative buyers. We can thus interpret $x(z)$ in equation (2) as a measure of the level of investment by supplier z.

The last ingredient to be added in the model is contract incompleteness. We assume that none of the aspects of input production can be disciplined by means of a comprehensive *ex-ante* contract, which obviously may give rise to a standard hold-up inefficiency in form of suppliers' under-investment. In particular, we consider the case in which the initial contract specifies only whether the supplier appointed at stage z will be integrated within the firm's boundaries or will remain independent as stand-alone entity. For further details about the key-assumptions of the model, please refer to the original work of Antràs and Chor (2013) or Alfaro *et al.* (2015).

[3]Both the firm and its suppliers are assumed to be capable of producing a non-customized input at a zero marginal cost, which allows for the continuation of the production process but does not add any value to final-good production.

2.2 The baseline model: equilibrium

The timing of the model is therefore the following. The firm posts contracts for suppliers for each stage $z \in [0,1]$, stating the organizational mode (integration or outsourcing), and then chooses for each z one supplier among the applicants. Production then takes place sequentially. The supplier appointed for stage z is handed the semi-finished good completed up to that stage in production, and is supposed to deliver its intermediate input to the immediate downstream supplier. Because of incomplete contracts, supplier z is free to choose the volume of input services $x(z)$ that maximizes its profits, conditional on the value of the intermediate good that has been delivered to it.

This choice is based on two considerations. The first concerns the organizational mode chosen by the firm at stage z. Under vertical integration, the firm is in control of the physical assets used in the production of the intermediate input, which allows it to extract more surplus from the stage-specific investment in input customization. We model this aspect by assuming that, when the supplier is integrated within the firm boundaries, the firm appropriates of a large share of the value of supplier z's incremental contribution to the total revenue, this share being denoted by $\beta_V \in (0,1)$. At the opposite, under outsourcing strategy, the firm receives only a share $\beta_O < \beta_V$ of that surplus, while the rest accrues to the supplier. It stands to reason that, foreseeing a lower return to their investments, integrated suppliers will under-invest relatively more than stand-alone ones.

The second determinant of the supplier investment decision is represented precisely by the value of its incremental contribution to the firm total revenue, i.e. by size of the surplus over which the supplier and the firm engage in a generalized Nash bargaining.[4] This incremental contribution can be proved to be

$$r'(z) = \frac{\rho}{\alpha}\Big(A^{1-\rho}\theta^{\rho}\Big)^{\frac{\alpha}{\rho}} \cdot \big[r(z)\big]^{\frac{\rho-\alpha}{\rho}} \cdot \big[x(z)\big]^{\alpha} \ , \tag{3}$$

which is the derivative in z of the revenue function valued at stage z, namely

$$r(z) = A^{1-\rho}\theta^{\rho}\left(\int_0^z x(s)^{\alpha}\, ds\right)^{\frac{\rho}{\alpha}} \ .$$

According to equation (3), the marginal contribution of supplier z can be either increasing or decreasing in the revenue secured up to a stage z, i.e. in the amount of prior upstream investments, summarized in $r(z)$. Indeed, everything depends on the relative size of parameters ρ (the final demand elasticity) and α (the degree of physical input complementarity). If $\rho > \alpha$, then higher investments by upstream suppliers increase the marginal return of supplier z's own investment. Following Antràs and Chor (2013) and Alfaro *et al.* (2015), we will refer to this case as the *complements* case, given that investment choices turn out to be sequential complements along the production line.

[4] The actual payment to each supplier is negotiated bilaterally only after that the corresponding stage has been completed, and the terms of exchange are not renegotiated at a later stage. Moreover, this negotiation is treated as independent from bilateral negotiations that take place at other stages of production.

At odds, if $\rho < \alpha$, higher investments by upstream suppliers reduce the marginal return of investment by supplier z; we will refer to this occurrence as the *substitutes* case, since investment decisions become sequential substitutes along the value chain.[5]

Hence, at the beginning of each stage z, the supplier is handed the intermediate product completed up to that stage and learns about the value of this product, i.e. $r(z)$ in equation (3). Based on this, and based on the share $\beta(z) = \{\beta_O, \beta_V\}$ chosen by the firm at stage z, the supplier determines its optimal input level, namely $x(z)$, solving the following problem:

$$\max_{x(z)} \; (1 - \beta(z))r'(z) - cx(z) \; .$$

The equilibrium of the game implied by the model can be solved by backward induction. Knowing the suppliers' optimal investment choice conditional on the organization mode, the firm can determine the pattern of ownership rights along the supply chain that maximizes its own profits. The firm's problem therefore consists of finding, for each $z \in [0, 1]$, the optimal value of share $\beta(z)$ between β_O and β_V, thereby determining whether the contract relative to any input z will be associated with integration or outsourcing. In formal terms, the problem can be written as

$$\max_{\beta(z)\in\{\beta_O,\beta_V\}} \pi = \Phi \int_0^1 \beta(z)\big(1-\beta(z)\big)^{\frac{\alpha}{1-\alpha}} \Big[\int_0^z \big(1-\beta(s)\big)^{\frac{\alpha}{1-\alpha}} \, ds\Big]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} dz \; , \qquad (4)$$

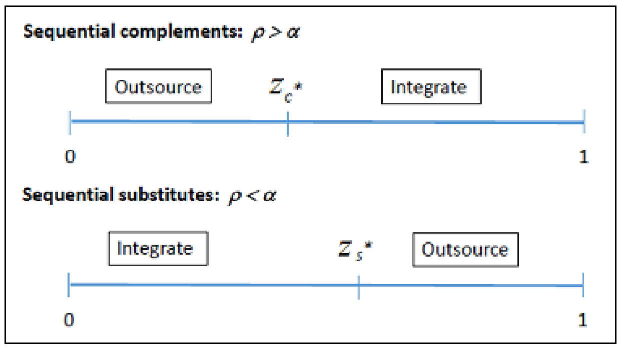
where Φ is a constant term. We refer the reader to Antràs and Chor (2013) for a detailed derivation of the solution to this problem, which identifies the optimal organizational structures represented in Figure 1. In the complements case ($\rho > \alpha$), there exists a unique cut-off stage $z^*_C \in (0, 1]$, such that all earlier stages are outsourced, and all later stages are integrated within firm boundaries. At the opposite, in the substitutes case ($\rho > \alpha$), the unique cut-off is represented by a production stage $z^*_S \in (0, 1]$ such that all upstream stages are retained within firm boundaries, whereas all stages located downstream are associated with outsourcing.

In Figure 2 we provide a graphical representation of the key-insight behind these patterns, by considering a relaxed version of the firm's problem, in which the optimal share $\beta(z)$ is not constrained to be either β_V or β_O, but can take any real value (we only require $\beta(z)$ to be a piece-wise continuously differentiable real-valued function of z). As shown in the figure, in the complements case the optimal share $\beta^*(z)$ is an increasing function of z, which means that integration gets more appealing to the firm, the more production moves downstream. Since supplier investments are sequential complements, a virtuous cycle of investments may be triggered by incentivizing upstream investments

[5]Given $\alpha \in (0, 1)$, supplier investments are always (weakly) complementary from a purely technological standpoint, which makes the *complements* case intuitively clear. However, under some circumstances, supplier investments (in quality-adjusted terms) may turn into sequential substitutes, as a result of a revenue effect large enough to dominate the physical input complementarity effect. This occurs for sufficiently low value of $\rho \in (0, 1)$ (the final demand elasticity), which makes the firm's revenue function highly concave in quality-adjusted output; large upstream investment levels therefore significantly reduce the value of undertaking downstream investments.

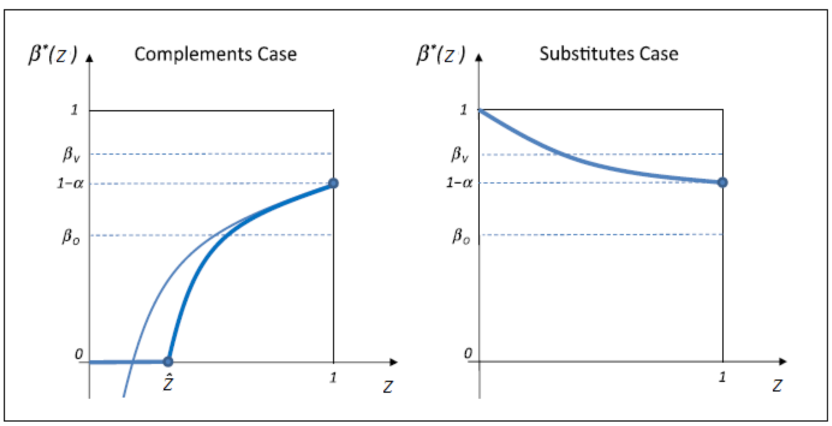
by means of outsourcing. At a given stage of production, the marginal return to investments will be so high that suppliers will keep investing even if integrated, thus the firm will focus on the rent-extraction motive for integration. This pattern is no longer consistent when suppliers investments are sequential substitutes, since large upstream investments (secured by arm's length arrangements) would dampen the incentives for downstream suppliers. The optimal pattern of ownership rights is then reversed, in compliance with $\beta^*(z)$ being a decreasing function of z.

Figure 1: Optimal pattern of ownership along the value chain (baseline model).



Source: Alfaro *et al.* (2015).

Figure 2: Profit-maximizing division of surplus for stage z (baseline model).



Source: Supplement to Antràs and Chor (2013).

3 Non-appropriability of Intellectual Assets

In this Section we propose an extension of the baseline model in which firms are exposed to the risk of their final-good variety being imitated by potential competitors, thereby highlighting how the optimal firm-boundary choices along the value chain might be affected by the degree of appropriability of intellectual assets. In so doing, we introduce a completely new element in the analysis, represented by the intangible dimension of production within modern supply chains and, consequently, by the role of intellectual property rights (IPR) protection.

3.1 The generalized model: introducing the risk of imitation

We consider a supply chain in which completing each stage of production with a fully customized input requires a two-way transfer of a different blueprint between the firm in control of the whole production process and the supplier appointed at that stage. Every blueprint contains (least part of) the relevant technology for developing that stage in production, or the know-how developed as a result of the investment in customization undertaken by the supplier. If the institutional environment in which production occurs were characterized by incomplete contracts but full IPR enforcement, the technology transfer would be smooth, safe and complete; the output of the final good q would be realized with the accomplishment of stage z=1 and the total revenue from the sale of each variety would be collected by the corresponding firm. The organizational structure of the supply chain would therefore be the one described in Section 2.2.

Consider now the case in which contract incompleteness combines together with the lack of full IPR protection. In this setting, a potential competitor of the final-good producers can come up with a copy of one of the varieties available in the market, and can start supplying this product without incurring in sanctions or penalties. Think of this competitor as an agent who is able to produce only a *subpar* version of the final good (of zero value for the market) since it misses the relevant technology for customizing the inputs and thereby creating its own differentiated variety. If intellectual property is not adequately protected, during the technology transfer among the firm and one of its suppliers, part of the content of the blueprint might somehow be diffused outside the relationship, in form of leaks or disclosure of relevant information or, more simply, of evidence about the intrinsic characteristics of the product. Based on this, the potential competitor can infer or acquire the know-how for reproducing the original production process, imitating the final good variety and thereby inflicting a dead-weight loss to the original producer (the firm) and all its suppliers.[6]

We assume that imitation is costless for the potential competitor and is independent of the firm-boundary choices along the value chain, thereby excluding that one specific organizational mode might be used strategically by the firm to reduce the risk of its variety being imitated. In our model the economic value is indeed generated across production stages by overlapping investments in input customization, which stem from the fruitful cooperation between the firm and the suppliers,

[6] In this paper, we do not characterize the equilibrium in the final-good market in the presence of imitation, our interest being on the way according to which firms strategically modify the organizational structure of the supply chains to internalize their exposure to the risk of imitation. It suffices to say that imitation is always beneficial for the potential competitor, whatever is the division of the market with the original producer, whereas it is always detrimental for the firm and for all its suppliers, reducing their surplus necessarily due to the loss of exclusivity of the manufactured product.

regardless of whether the latter are independent or not. Hence, even allowing for product imitation, we assume that the outside option of each supplier remains zero, on the ground that a stand-alone blueprint has no intrinsic value for the supplier outside the relationship with the firm.

A key-feature of our variant of Antràs and Chor (2013) is that we treat imitation as an exogenous shock that can occur at any stage of production, according to a standard Poisson process with arrival rate $\mu > 0$. Intuitively, this rate is inversely related to the strength of IPR protection in the location in which production occurs (in addition to other intrinsic characteristics of the technology of production): the higher is the level of safeguard of intellectual property, the more μ approaches to zero, thereby restoring the baseline version of the model without imitation. Notice that the arrival rate of the shock is here assumed to be independent of the level of investment of each individual supplier and, more in general, to be homogeneous across stages. In principle, one could think of the blueprint transferred at given stage z as more relevant for allowing imitation of the final product, as compared to the blueprint transferred at any other stage of the supply chain. However, modeling this aspect would entail specifying the location (upstream or downstream) of the "relevant" stage, i.e. a feature of the technology of production that might vary from one industry to another one. Assuming a constant μ across stages therefore appears as the most neutral assumption that can be put forth in order to capture the effect that we are mostly interested in.

Once the shock has arrived, i.e. imitation has occurred, none of the participants in the original value chain are willing to invest in the process any longer. Given the properties of the Poisson process, the expected value of supplier investments at stage z is therefore

$$e^{-\mu z}x(z) + (1 - e^{-\mu z})0 = e^{-\mu z}x(z) \ ,$$

where $e^{-\mu z}$ is the probability that, up to the moment in which supplier z enters the production line, imitation has not occurred and the whole production process is still in place.

Based on these assumptions, we can derive a particular statistical representation for the (quality-adjusted) value of production *ex-ante*, i.e. at the moment (corresponding to stage 0) at which the firm has to decide the optimal allocation of property rights along the value chain. This is a modified

version of equation (2), and precisely

$$q = \theta \left(\int_0^1 [e^{-\mu z}x(z)]^\alpha I(z)\, dz \right)^{1/\alpha} \ . \tag{5}$$

Notice that, according to the above specification, the *ex-ante* value of the input services declines as far as we consider more downstream suppliers. It is important to stress that this is simply the result of their position along the supply chain, which increases the probability for their contribution to be zero, given that imitation will be more likely to have occurred by the time at which their contribution is required. Hence, the expected value of investments by downstream suppliers only depends on the engineering order of their participation to the supply chain, and not on their lower propensity to invest in input customization (conditional on imitation not having occurred).

The other elements of the model remain the same as in the baseline version, particularly the interaction between the supplier and the firm. Indeed, introducing non-appropriability of intellectual assets does not alter this type of interaction, as long as we deal with sequential production processes and inter-related technologies, rather than one-to-one buyer-supplier relationships.

3.2 The generalized model: equilibrium

We now characterize the optimal organizational structure of the supply chain for the case of our generalized version of the model. While we discuss here the main insights behind our results, Appendix A reports a more detailed derivation of the solution of the generalized firms' problem, where the latter corresponds to the following program:

$$\max_{\beta(z)\in\{\beta_O,\beta_V\}} \pi = \Phi \int_0^1 \beta(z)\left[e^{-\mu z}\left(1-\beta(z)\right)\right]^{\frac{\alpha}{1-\alpha}} \left[\int_0^z \left[e^{-\mu s}\left(1-\beta(s)\right)\right]^{\frac{\alpha}{1-\alpha}} ds\right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} dz \,. \quad (6)$$

Consider Figure 3, which is the counterpart of Figure 2 for the extended model with risk of imitation. The function $\beta^*(z)$ reported in the figure is then the solution to a relaxed version of program (6), in which the optimal share $\beta(z)$ is not necessarily chosen in the pair of values β_O and β_V, but can take any value in the interval $[0, 1]$. In analogy with the baseline model, $\beta^*(z)$ is an increasing function of z in the complements case ($\rho > \alpha$), while it is a decreasing function of z in the substitutes case ($\rho < \alpha$). The two patterns identified in Section 2.2 are therefore still valid: even under risk of imitation, the firm will outsource upstream and integrate downstream in the first case; and will integrate upstream and outsource downstream in the second.[7]

However, Figure 3 reveals a crucial aspect which differentiates the case of non-appropriable intellectual assets (low IPR protection, i.e. $\mu > 0$) with respect to the baseline model (where $\mu = 0$, because of full IPR protection). In the complements case, at any stage z the optimal value of $\beta(z)$ is indeed higher in case of non-appropriable intellectual assets (dashed line) than in the case with full appropriability (solid line); thus, the non-appropriability of intellectual assets increases the overall appeal of the integration strategy along the supply chain. At odds, in the substitutes case, a weak IPR regime tends to decrease the incidence of integration; for any $z \in [0, 1]$, the optimal value of $\beta(z)$ is indeed lower in the event of $\mu > 0$ (dashed line) than in the baseline model, where $\mu = 0$ (solid line). Based on this, we can derive the following predictions, illustrated in Figure 4.

[7] As in Antràs and Helpman (2004, 2008), the solution to the relaxed problem is used to establish whether the firm will choose outsourcing or integration at the very beginning of the supply chain, selecting the higher (β_V) or the lower (β_O) value of $\beta(z)$ at $z = 0$. As regard to the baseline model, Antràs and Chor (2013) provide a clear treatment of the conditions under which (i) integration and outsourcing coexist along the value chain and (ii) the set of stages under a common organizational form (integration or outsourcing) is a connected interval in [0,1]. The same conditions apply to the our variant of the model (see Appendices A-2, A-3 and A-4).

Figure 3: Profit-maximizing division of surplus for stage z (generalized model).

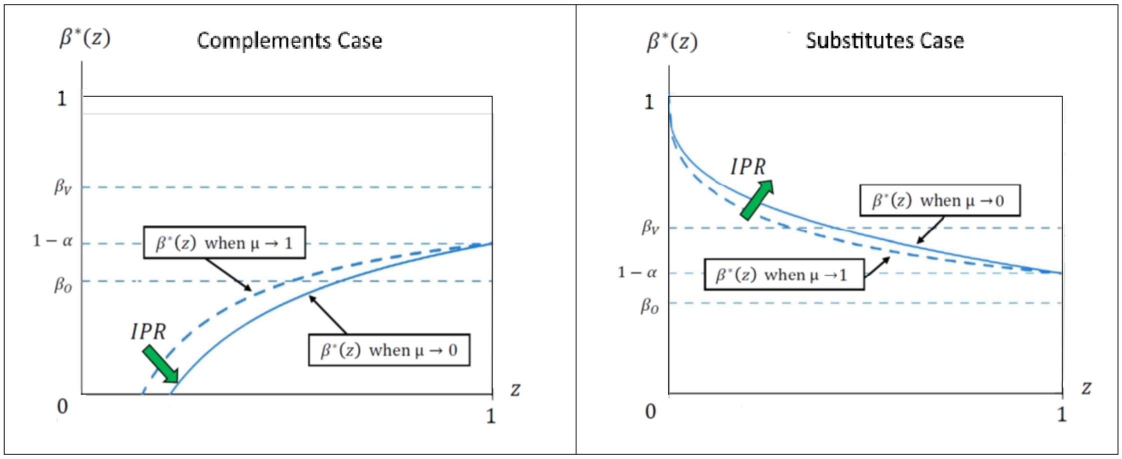
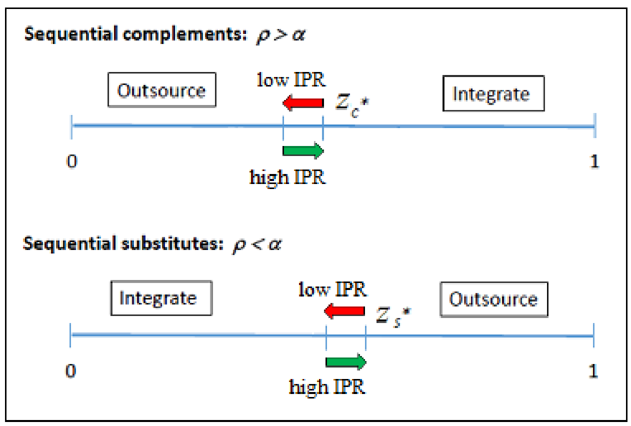


Figure 4: Optimal pattern of ownership along the value chain (baseline model).



Proposition 1 *In the complements case ($\rho > \alpha$), the cut-off stage $z_C^* \in (0,1]$, such that all upstream stages are outsourced, and all downstream stages are integrated, is decreasing in μ, and therefore increasing in the level of appropriability of intellectual assets (i.e. the strength of IPR protection in the location in which production occurs).*

Proposition 2 *In the substitutes case ($\rho < \alpha$), the cut-off stage $z_S^* \in (0,1]$, such that all upstream stages are integrated, and all downstream stages are outsourced, is increasing in μ, and therefore decreasing in the level of appropriability of intellectual assets (i.e. the strength of IPR protection in the location of production).*

We can rationalize Proposition 1 as follows. When supplier investments are sequential complements, the preferred option at the beginning of the chain is outsourcing, to secure a large amount of upstream investments that will raise incentives for downstream suppliers. Under risk of imitation, the positive dynamic effect of upstream investment is increasingly offset along the supply chain by a higher probability of disruption of the production process. This induces firms to focus on rent extraction therefore increasing its propensity to integrate as production moves downstream. The firm will therefore anticipate the stage at which integration occurs. Enforcing IPRs (i.e. lower μ) tends to restore the original cut-off that characterizes the baseline version of the model, extending the range of stages that are outsourced.

A similar argument can be used also for Proposition 2. In the substitutes case, upstream stages are associated with integration, thereby avoiding the negative effect on incentives for downstream suppliers that would be generated by outsourcing and therefore by large upstream investments. Under imitation, a lower probability of survival works against the negative dynamic effect that outsourcing exerts on investment at more downstream stages. One can think of such uncertainty bringing forward the final stage of production in view of the firm, rendering a larger pie at any given stage through outsourcing more attractive. The negative effect of outsourcing on investment at future stages is mitigated as the production process is less likely to reach the next stage. As a result, outsourcing becomes more appealing as a strategy at relatively earlier stages of production, as compared to the baseline model. Also in this case, enforcing IPR has the effect to restore the original cut-off even though, in this case, by reducing the range of stages that are outsourced.[8]

The last theoretical prediction of the model regards the heterogeneous impact of IPR protection in the case of complements and substitutes. In Appendix A-5 we show that, for a given absolute difference of parameters α and ρ, the derivative of $\beta^*(z)$ with respect to μ is larger when the difference is negative ($\alpha < \rho$) rather than positive ($\alpha > \rho$). This means that a change in level of IPR protection has a larger (lower) effect on the optimal share of ownership at any stage of production, as far as supplier investments are sequential complements (substitutes) along the value chain. We can therefore establish Proposition 3.

Proposition 3 *Ceteris paribus, the choice of the organizational mode at each stage of production is more sensitive to the degree of appropriability of intellectual assets (the strength of IPR protection) in the complements case ($\rho > \alpha$), rather than in the substitutes case ($\rho < \alpha$).*

The intuition behind this result can be illustrated by noticing that a given organization mode, say outsourcing, always exerts two types of effects. One is the "dynamic" effect, i.e. the effect on the incentives for all downstream suppliers, that can be either positive or negative (for outsourcing) depending on whether supplier investments are, respectively, complements or substitutes along the supply chain. The second effect is the "static" effect, which refers to the level of supplier investment at the stage in which this organization mode occurs. In the case of outsourcing, this effect is always positive: *ceteris paribus*, an integrated supplier will underinvest as compared to a stand-alone supplier, regardless of the nature of suppliers investments (complements or substitutes). Under full IPR protection, the dynamic effect is paramount and drives the allocation of property rights across

[8] Both the cut-off stages z^*_C and z^*_S are derived in a closed-form solution in Appendix A-4.

all stages of production, making the "static" effect of each organization mode of limited relevance to this purpose. Under a weak IPR regime, instead, the dynamic effect becomes less relevant as the firm discounts what occurs at the next stages of production by the lower probability that production will still be in place (more and more blueprints are transferred as production moves downstream). We can therefore detect an evident asymmetry between the case of complements and substitutes. In the complements case, the dynamic effect of outsourcing is positive at any stage of production but gets weaker, the weaker is the level of enforcement of IPRs; however, the decision to outsource at a given stage z will always be supported by the positive static effect associated with this particular organization mode. On the contrary, in the substitutes case the dynamic effect of outsourcing is negative for all z; with the lack of IPR protection, this effect gets weaker and finds stronger opposition by the static effect, which is positive. Integration and outsourcing are therefore more interchangeable among each other at all stages of the supply chain, which explains why enforcing or not enforcing IPRs has a weaker impact on organization in this second case.

3.3 Contract Enforcement versus the Protection of Intangible Assets

A helpful point of comparison for our results is the effect of the degree of contractibility on the organizational mode along the supply chain (see Alfaro *et al.* (2015)). This argument explicitly refers to tangible assets. Starting from an incomplete contract environment, reducing the contract frictions initially introduced in the model under the property rights approach allows firms to rely less on outsourcing to compensate for distortions associated with inefficient upstream investment for sequential complements. Consequently, they reduce the set of outsourced stages on the upstream side of the chain, where outsourcing was previously necessary and prevalent. This would move the cut-off stage in Antràs and Chor (2013) to the left. The opposite should hold when inputs are sequential substitutes.

The key conceptual distinction in our framework is that contract incompleteness is present at all times, but what changes is the possibility of imitation of intangible assets by outside competitors, itself determined by the degree of IPR protection in the supplier location. Introducing this feature reveals two notable differences in our results.

The first evident difference from Antràs and Chor (2013) and Alfaro *et al.* (2015) is that the case of substitutable inputs is less relevant when dealing with intangible assets. As described above, sensitivity of β to changes in μ is decreasing in α, that is, the more substitutable are the inputs. As a result, changes in the level of IPR protection should not significantly affect the propensity of firms to integrate leaving the initial incentive structure of supplier investment as the dominant force. This argument also suggests that α, as a real measure of physical or technological substitutability between stages, can be as relevant as the elasticity of demand (ρ) to distinguish between sequential complements/substitutes, particularly when considering intangible assets.

The second major difference arises when looking into the case of complements, where imitation and IPRs do play a role in determining the organizational mode. In fact, we have seen above that when considering intangible assets, outsourcing is the organizational form that prevails for a wider range of production stages when IPR protection is stronger. This is because imitation risk offsets the incentive channel and the positive effect of upstream investment on subsequent stages that are created by outsourcing. This is clearly in contrast to the effect of contract enforcement itself and how this liberalizes firms to enjoy a larger share of the revenues, not having the need to outsource in order to avert inefficient upstream investment. Imitation, on the contrary, blocks this channel of gains from outsourcing, making it optimal for the final good producer to forgo the incentive structure and integrate at an earlier stage. IPR protection reverts this decision and puts the Antràs and Chor (2013) mechanism back in place.[9]

Finally, it is worth mentioning that in our modeling strategy, we have introduced imitation of intellectual property within the context of the property right theory so that it could occur under both outsourcing and integration. Recall first that the imitators in our model are in principle competitors outside the supply chain relationships, hence the organizational choice should not necessarily have an impact on the imitation risk. Nonetheless, if imitation were to be adopted using the transaction cost approach, so that integration could be used to internalize imitation risk and avoid technology leak to competitors that can be more likely under outsourcing, our main results persist and gain strength. This is because assuming that imitation is only viable under outsourcing is an extra constraint that would make integration more attractive under weak IPR protection. We get this result in the absence of such assumption, highlighting the role of imitation on firm organization through the incentive structure channel of supplier investment. This also mitigates concerns that firms could strategically select their location based on the IPR regime in the supplier location, making imitation endogenous in the organizational mode.

3.4 From Theory to Empirics: Testable Predictions

It follows from the model that the strength of IPR protection bears important implications for firm decision on the organization mode at different (sequential) production stages and different degrees of sequential complementarity of its inputs/stages. This result offers an explanation for the observation that when firms source a certain input from (or locate a certain production stage in) more than one country for various reasons, they integrate that input/stage in some markets whereas they may opt for outsourcing in others. It seems that technology and final demand-side factors (e.g. α, ρ, upstreamness) cannot entirely explain the outsourcing/integration decision across different markets and production stages. This paper focuses on the role of IPR protection as one of the crucial market-specific characteristics behind the firms' decision on organization of their global value chains.

[9] Notice that the equilibrium restored by IPR protection is the equilibrium under incomplete contracts.

Based on the propositions of the theoretical model we derive predictions to be tested empirically on the firm-level data about the effects of IPR protection enforcement on firms' outsourcing versus integration decision along their sequential supply chains. As shown by the model, effectiveness of IPR protection in a country where a certain stage of production is performed affects the incidence of internalization of this production stage by a final good producer in that particular market and the impact varies systematically between sequential complements and substitutes.

We formulate three principal testable predictions as follows:

Prediction 1. *In case of sequential complements, enforcing IPR increases the parameter space for the outsourcing strategy.*

Since upstream stages are already outsourced under weak IPR protection enforcement we should observe increased likelihood of outsourcing (decreased likelihood of integration) with improved IPR protection in relatively more downstream stages.

Prediction 2. *In case of sequential substitutes, enforcing IPR increases the parameter space for the integration strategy.*

Since upstream stages are already integrated under weak IPR protection enforcement we should observe increased likelihood of integration (decreased likelihood of outsourcing) with improved IPR protection in relatively more downstream stages.

Prediction 3. *IPR enforcement is more relevant for the organizational decision when inputs are sequential complements..*

To test the above predictions, ideally one would need firm level data on the entire set of inputs sourced from different countries along the entire supply chain together with information on whether a particular input from a particular country is outsourced or provided internally within the firm. Since such a rich and detailed database on the level of firms' trade transactions further disaggregated into intra-firm and arm's lengths type is not readily available, at least for a wider spectrum of industries and firms, our approach exploits the availability of matched firm-level transaction trade data and firms' bilateral foreign direct investment flows. Apart from the firm decision on outsourcing versus integration of different inputs in different markets, empirical testing of the model's predictions requires the identification of the position of a particular input in the value chain, i.e., upstreamness, and distinction between sequential complements and substitutes cases. The approach we follow in the construction of our core variables and data sources are described below.

4 Data and Key Variables

Our core database consists of transaction-level trade data on Slovenian manufacturing firms in the 2002-2009 period, matched with detailed information on direction of firms' direct investment outflows and their balance sheets. Hence, we have on disposal firms' annual export and import flows to/from partner countries disaggregated at 6-digit level of HS product classification and firms outward FDI data at partner country level.

Slovenia is a highly open, small economy from the group of CEE transition economies that since the mid-1990s has been heavily involved in both multilateral liberalization and regional integration processes mostly related to approaching EU membership: (i) accession to the GATT (WTO) in 1994 (1995); (ii) CEFTA membership in 1996; (iii) signing of an Association Agreement with the EU in 1996 and enforcement of an Interim Agreement implementing its trade provisions in January 1997; and (iv) EU accession negotiations between 1998-2002. In year 2004 Slovenia became a full member of the EU and adopted, as the first new EU member state, Euro in 2007. Liberalization processes contributed to increasing involvement of Slovenian companies in global value chains (hereafter GVC). According to the WTO Slovenia is classified among the high-(GVC) participation economies and recorded a GVC participation index of 58.7 in 2011 which is significantly above the average value for developed and developing countries, i.e. 48.6 and 48.0, respectively, mostly on account of strong backward participation (WTO, 2016) as shown in Table B1 of the Appendix. Figures B1 and B2 in the Appendix also show the value-added components of gross exports for Slovenia in 1995 and in 2011, together with the comparison between inward and outward FDI. It is clear from the figure that outward FDI dominates for Slovenia and that the gap between inward and outward FDI has been expanding over the last decade.

These developments support our belief that the comprehensive database of Slovenian firms offers a suitable setting for studying firm organization behavior along international value chains. In our final sample we have 6010 firms that record imports from 171 and/or outward FDI with 37 different partner countries.

4.1 Dependent variable - binary variable on the decision to integrate

We aim to measure the decision to integrate or outsource inputs in different countries at different stages of the value chain. The absence of data on bilateral intra-firm and arm's length trade of inputs at firm level has led empirical studies on the issue to adopt several different approaches. On one hand, some studies exploit the availability of industry-level intra-firm trade data using the share of intra-firm imports in total inputs as an indication of the propensity to transact a particular input within firm boundaries, e.g. Antràs and Chor (2013). On the other hand, some studies define the integration vs outsourcing decision based on the (core) activities of establishments linked via ownership ties (net of subsidiaries of the "global ultimate owner"), e.g. in Alfaro *et al.* (2015). While the former approach gives an industry-level measure and hence requires acceptance of restrictive assumptions regarding the identity (activity) of the buyer, the latter one assumes the set of inputs that are outsourced, e.g. based on Input-Output tables, and, moreover, fails to take into account the sourcing country dimension which is in the focus of this paper.

To overcome this limitation, at least partially, in this paper combine trade and FDI flow firm-level data and define the dependent variable as a firm's decision to integrate suppliers in a certain market; i.e. propensity to transact (part of) inputs in a particular source country within firm boundary. More specifically, our dependent variable d_integr_{ijt} is defined as a binary variable denoting integration by particular firm i in a particular market j based on the existence of outward FDI by firm i in country j in year t. d_integr_{ijt} takes the value 1 for inputs sourced from countries in which firm i has direct investments and value 0 for inputs imported from countries in which the firm has no subsidiaries. This measure has an important advantage of accounting for the market-specific integration decision and computing the average upstreamness of inputs in integrated and non-integrated markets. However, there are several potential concerns with this measure. The first concern relates to the type of the related establishment (subsidiary) in the host country. No information is available in the database on whether a particular affiliate is of horizontal or vertical nature. The second concern relates to the possibility that even in the case of vertically integrated establishment in a certain market, some of the inputs acquired from that country may come through arm's length transactions.

To address the first concern, we use additional database on the performance of the affiliates of Slovenian firms located abroad, which is available for the 2007-2009 sub-period, and which includes information on total export within a firm, total exports, and sales in the local market of the affiliate. Based on that information, we define the share of intra-firm trade in total exports of affiliate/s located in a foreign country and use it to distinguish between vertically and horizontally integrated affiliates. We employ two criteria for vertically integrated affiliates: (i) the existence of positive intra-firm exports of affiliates in a country in a certain year indicating that goods are shifted to other establishments within the firm group, and (ii) a stricter requirement for the share of intra-firm exports to total exports of an affiliate to be greater than 10%. This strategy allows us to exclude horizontal FDI when considering whether or not a Slovenian firm engages in FDI in a given country.

Since data on intra-firm trade broken down at product-market level are not available, we tackle the second concern in a manner adopted in Alfaro *et al.* (2015) by exploiting information on the core activity of a firm's affiliate in a particular host country in the 2007-2009 sub-database. Inputs a firm imports from an affiliate's host country that are classified under the core activity of the affiliate at 4-digit industry level are regarded as integrated, while all other imported inputs from this country are considered as being outsourced. Doing this therefore accounts for the fact that a firm may engage in both integration and outsourcing in a partner country. We link the core activity of an affiliate and imported inputs of the mother company by first adopting Ramon's concordance from 6-digit HS 2002 to 6-digit CPA 2002 classification, and subsequently from CPA 2002 to NACE Rev. 1 at the 4-digit level based on the direct linkage in the structure of these two classifications.[10]

[10]CPA classification is a product classification whose elements are for the goods part based on the HS classification.

4.2 Complementarity/substitutability

To distinguish between sequential substitutes and complements we follow the approach adopted in Antràs and Chor (2013) and Alfaro *et al.* (2015) and trace substitutes/complements based on low/high value of import demand elasticities faced by the buyers of a particular good. We consider import demand elasticity of a firm's core export product, i.e. the product at 6-digit level of HS classification which accounts for the largest share in exports of a particular firm. As stressed by Antràs and Chor (2013), this approach implies the assumption that any existing cross-industry variation in elasticity of technological substitution across firms' inputs is largely uncorrelated with the elasticity of demand. Complements ($d\_compl = 1$) are characterized by above-median import demand elasticity for a firm's core export product and substitutes ($d\_compl = 0$) by below-median demand elasticity. We use import demand elasticities estimated for Slovenia by Kee, Nicita, and Olarreaga (2008) following the production-based GDP function approach. Their estimated import demand elasticities are defined as the percentage change in the quantity of an imported good when the price of this good increases by 1%, holding prices of all other goods, productivity, and endowments of the economy constant.

We complement the standard measure of distinguishing between sequential complements and substitutes with an original proxy for α, i.e. the degree of input differentiation. We assume that inputs classified within the same industry at certain digit-level of classification exhibit higher technological substitutability compared to inputs classified in different industries at the particular level of aggregation. To reflect substitutability among inputs in this regard we compute a Herfindahl index (H_{it}), which measures how (6-digit) imported inputs by a firm are spread across different (3-digit) industries. Our H_{it} counts 3-digit imported product groups and weights them by the abundance of 6-digit product categories within each 3-digit group:

$$H_{it} = 1 - \sum_{n=1}^{N_{3dig}} \left(\frac{\#(6digitHS)_n}{N} \right)^2 , \tag{7}$$

where n denotes product category at a 3-digit level of HS, N_{3dig} represents number of 3-digit product categories of HS, and N the total number of imported products at 6-digit level of HS. When all imported inputs are classified under same 3-digit industry, i.e. in case of high degree of input substitutability, H is equal to 0, whereas in case each input is classified under a different 3-digit category, $H = (N-1)/N$.

We define complements/substitutes based on below and above median value of the Herfindahl index; in case of a below average value of the index, i.e. relatively high substitutability among inputs, $d\_compl = 0$ which represents substitutes, while for an above average value of the index $d\_compl = 1$. This definition implies the assumption of independence between ρ and α. Therefore we further consider both ρ (import demand elasticity) and α to determine sequential complements/substitutes. More specifically, we take the product of import demand elasticity in absolute terms and the Herfindahl index and then define the dummy variable *d_compl* based on below and above median values of this product. The higher the import demand elasticity in absolute terms (ρ) and the higher the Herfindahl index (inverse α), i.e. the lower the technological substitutability, the more likely it is that $\rho > \alpha$, hence complements.

4.3 Upstreamness/downstreamness

Since we observe imports at the firm, we are able to identify the position of imported inputs in the value chain of a concrete firm's output, which we define by its core export product at 6-digit level of the HS classification. Hence our upstreamness measure ($Upstr_{ijt}$) is industry-pair specific in the same manner as Alfaro *et al.* (2015) and following Fally (2012) and Antràs et al. (2012), and is expressed as the "average" distance of each input h from the final demand in product k, for each pair h, k. Upstreamness of the input suppliers' position in a particular sourcing country is defined as a weighted average upstreamness of inputs a particular firm is sourcing from a particular country with respect to a firm's core export product. For each firm i, we average the upstreamness measure of all imported inputs from a given sourcing country j, to obtain a firm-country specific measure of upstreamness, our main distinction with respect to Alfaro *et al.* (2015). We use 2002 US Input-Output table since the detailed input-output table for Slovenia is not available.

In Table 1 we report descriptive statistics separately for complements and substitutes based on import demand elasticities.

Table 1: Descriptive statistics

	Substitutes (d_compl =0)		Complements (d_compl =1)	
	Mean	Std.Dev.	Mean	Std.Dev
d_OutFDI	0.028	0.165	0.036	0.187
Upstreamness	2.30	0.97	2.26	0.95
IM demand elasticity	0.87	0.19	1.53	3.23
ln_IPR_index	1.49	0.08	1.49	0.08
Age	15.4	7.6	15.5	7.8
Employment	28.8	6.2	29.3	6.3
Ex-Propensity	0.35	0.33	0.35	0.33
K-intensity	30353		29178	
L-productivity	30748		31459	
Debt_assets	0.59	0.25	0.60	0.24

Note: Labor productivity (*L-productivity*) and capital intensity (*K-intensity*) are expressed in EUR.

5 Empirical Specification and Results

5.1 Model Specifications

Baseline specification. The firm's decision to integrate suppliers in a certain market, i.e. its propensity to transact (part of) inputs in a particular source country within firm boundary, is defined based on outward FDI in that market. We base our empirical estimations on the following baseline model specification that corresponds to the Antràs and Chor (2013) model:

$$Pr(d\_integr_{ijt}=1)=\beta_0+\beta_1 Upstr_{ijt-1}+\beta_2 d\_compl_i+\beta_3 Upstr_{ijt-1}*d\_compl_i$$
$$+X'_{ijt}\beta_4+\sum\beta_{5,j}d\_industry_j+\sum\beta_{6,t}d\_country_t+\sum\beta_{7,t}d\_year_t+u_{it}\ , \qquad (8)$$

where subscripts i, j and t refer to firms, countries and years, respectively. Dependent variable d_integr_{ijt} is a binary variable denoting integration of particular firm i in a particular market j based on existence of firm i's outward FDI in that country in year t. Besides the complementarity and upstreamness variables, in the model specification we include vector X_{it} of standard, firm-specific controls: a firm's age, size, capital intensity of production, labor productivity, export orientation and financial leverage measured by the debt-to-assets ratio. In our model, the size of a firm ($size_{it}$) is measured by the number of employees. The variable age_{it} denotes a firm's age counting from the formation year according to the Business Register of the Republic of Slovenia. Further, we include capital-intensity $Kint_{it}$, measured by fixed assets per worker, which according to the Olley and Pakes (1996) model affects the distribution of future plant productivity and may act as a proxy for unobserved sources of efficiency. Productivity is measured in terms of labor productivity defined by value added per employee ($Lproductivity_{it}$). Export orientation is defined as the share of exports in total sales of a firm ($ExPropensity_{it}$) and financial leverage as debt to assets ratio ($Debt\_assets_{it}$).

We include also sets of (i) annual dummy variables to control for macroeconomic shocks, (ii) partner country dummies to take account for country-specific time-invariant effects, and (iii) industry-specific effects, where we define a firms industry participation based on its core export product at 1-digit level of Harmonised System classification.

IPR-augmented specification. The focus of this paper is the role of IPR protection in a sourcing country. In addition to the direct impact of IPR on integration of input suppliers in a certain market we expect that IPRs affect the internalization decision also indirectly by influencing the interaction between input substitutability (sequential complements/substitutes) and upstreamness. Since we have a sourcing-country specific measure of upstreamness for each firm we can test these predictions by augmenting the empirical model specification (1) with the level of sourcing countries IPR protection and its three-way interaction with the $Upstr$ and the d_compl variables:

$$Pr(d\_integr_{ijt}=1)=\beta_0+\beta_1 Upstr_{ijt-1}+\beta_2 d\_compl_i+\beta_3 IPR_{jt}+\beta_4 Upstr_{ijt-1}*d\_compl_i+$$
$$+\beta_5 IPR_{jt-1}*d\_compl_i+\beta_6 IPR_{jt-1}*Upstr_{ijt-1}+\beta_7 IPR_{jt-1}*d\_compl_i*Upstr_{ijt-1}+$$
$$+X'_{it}\beta_8+\sum\beta_{9,j}d\_industry_j+\sum\beta_{10,t}d\_country_t+\sum\beta_{11,t}d\_year_t+u_{it}\ , \qquad (9)$$

where the level of IPR protection (IPR_{jt}) is measured as a continuous measure of IPR protection

($lnIPR_{jt}$) defined as logarithm value of the Park index.

We next introduce our preferred baseline specification, which takes a slightly different form as it separates the sample into sequential complement and sequential substitute inputs based on our two definitions of ρ and α. This allows us to observe and compare the heterogeneous impact of IPRs at different stages of the supply chain for the two cases in a more direct manner. For the split sample between sequential complements and sequential substitutes, the specification then turns to

$$Pr(d\_integr_{ijt} = 1) = \beta_0 + \beta_1 Upstr_{ijt-1} + \beta_2 IPR_{jt} + \beta_3 IPR_{jt-1} * Upstr_{ijt-1} + \\ + X'_{it}\beta_4 + \sum \beta_{5,j} d\_industry_j + \sum \beta_{6,t} d\_country_t + \sum \beta_{7,t} d\_year_t + u_{it} \ . \quad (10)$$

5.2 Empirical Results

In Table 2 we report results of the baseline model where dummy for complements/substitutes is defined based on import demand price elasticities (ρ) in column (1) and based on α in column (2). The negative interaction between complementarity and upstreamness confirms that the Slovenian sample is consistent with Antràs and Chor (2013) in that integration is a more likely outcome for sequential complements at downstream stages. Column (3) brings IPR protection into the picture by first showing its interaction with complementarity and upstreamness and then the double interaction with the two variables. The interaction of IPRs with complementarity is negative and significant suggesting that IPRs on average encourages outsourcing when inputs are sequential complements. The positive and significant double interaction term, in turn, shows that this phenomenon is less likely at upstream stages, and therefore occurs downstream. Bearing in mind that IPR protection is the relevant institution for intangible assets, in columns (5) and (6) we replicate the same exercise for rule of law to see how things fair for contract enforcement in a property right environment. The signs are indeed opposite to those under IPRs, although not statistically significant, showing that imitation and IPRs are important factors in the organizational decision of firms along the supply chain, and that they don't coincide with decisions based on the contractual environment. Recall that under the property right theory for tangible assets we expect contract enforcement to *increase* the prevalence of integration over outsourcing.

Table 3 depicts the results separately for the subsample of sequential complements and substitutes based on import demand price elasticities (ρ) and differentiation of inputs used along the supply chain (α). Columns (1)-(4) show the results for IPRs and columns (5)-(8) repeat the regressions replacing IPRs with the rule of law. Splitting the sample allows us to see that the statistical significance of the coefficients of IPR protection and its interaction with upstreamness are in fact only true for the case of sequential complements. Again, IPRs tend to reduce the propensity to integrate (negative coefficient for IPRs), and this is the case for relatively downstream stages (positive coefficient of the interaction between IPRs and *upstr*). The findings again show the opposite sign for rule of law

Table 2: Heteroskedastic probit model of firm integration decision

	Rho (1)	Alpha (2)	Rho (3)	Alpha (4)	Rho (5)	Alpha (6)
Upstr(-1)	0.009	0.031	-0.279 *	-0.896	0.021	0.032
	(0.011)	(0.021)	(0.166)	(0.921)	(0.013)	(0.023)
d_compl	0.224***	0.195***	1.826***	1.236	0.204***	0.171***
	(0.041)	(0.059)	(0.566)	(1.806)	(0.049)	(0.065)
d_compl * Upstr(-1)						
1	-0.045***	-0.054**	-0.563**	0.253	-0.043**	-0.044*
	(0.016)	(0.023)	(0.255)	(0.928)	(0.020)	(0.025)
lnIPR			-0.059	0.054		
			(0.294)	(1.194)		
d_compl * lnIPR						
1			-1.093**	-0.731		
			(0.384)	(1.201)		
lnIPR X Upstr(-1)						
			0.172	0.615		
			(0.112)	(0.610)		
d_compl * lnIPR * Upstr(-1)						
1			0.367**	-0.214		
			(0.172)	(0.614)		
WGI_rule_law(-1)					0.016	0.008
					(0.105)	(0.115)
d_compl * WGI_rule_law(-1)						
1					0.036	0.027
					(0.045)	(0.071)
WGI_rule_law(-1) * Upstr(-1)						
					-0.025**	-0.01
					(0.012)	(0.027)
d_compl * WGI_rule_law(-1) * Upstr(-1)						
1					-0.003	-0.016
					(0.019)	(0.028)
Age	0.021***	0.019***	0.016***		0.020***	0.019***
	(0.001)	(0.001)	(0.001)		(0.010)	(0.001)
lnSize(-1)	0.300***	0.294***	0.300***	0.301***	0.302***	0.296***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
ExProp(-1)	0.298***	0.297***	0.436***	0.446***	0.308***	0.302***
	(0.025)	(0.023)	(0.029)	(0.029)	(0.026)	(0.024)
lnKint(-1)	0.175***	0.159***	0.145***	0.141***	0.178***	0.161***
	(0.014)	(0.012)	(0.017)	(0.016)	(0.014)	(0.013)
lnLprod(-1)	0.045**	0.085***	0.001	0.071***	0.042**	0.085***
	(0.018)	(0.017)	(0.023)	(0.021)	(0.019)	(0.017)
Debt_assets(-1)	0.160***	0.257***	0.108***	0.282***	0.162***	0.258***
	(0.036)	(0.033)	(0.038)	(0.035)	(0.037)	(0.033)
Time eff.	YES	YES	YES	YES	YES	YES
Country eff.	YES	YES	YES	YES	YES	YES
Industry eff.	YES	YES	YES	YES	YES	YES
Log pse.likelihood	-8793.13	-10690.97	-4821.6	-5974.4	-8486.83	-10334.96
Wald test	chi2(69)= 4353.2***	chi2(70)= 492118***	chi2(64)= 3894.3***	chi2(65)= 4084.1***	chi2(71)= 4259.47***	chi2(72)= 4801.50***
Wald's test for heteroskedasticity (H0: lnsigma2=0)						
lnsigma2	-0.054***	-0.050***	-0.091***	-0.070***	-0.55***	-0.051***
lempllag	(0.007)	(0.006)	(0.024)	(0.007)	(0.007)	(0.006)
chi2(1)	69.43***	70.99***	14.32***	95.08***	68.62***	68.05***
Observations	103246	120862	91788	107539	102413	119898

Note: Robust Std. Err. in round brackets; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

(positive) and the interaction term (negative) even if not or at best slightly significant, reinforcing the hypothesis that things may differ with respect to the organizational decision of firms when studying *intangible* assets under the property rights approach. We can also deduce from these results that our findings are specific to IPR protection and cannot be generalized to other regulatory measure that directly affect contract enforcement. On Table B2 of the Appendix we also report the results for our robustness check of the full sample when unobserved heterogeneities are controlled for.

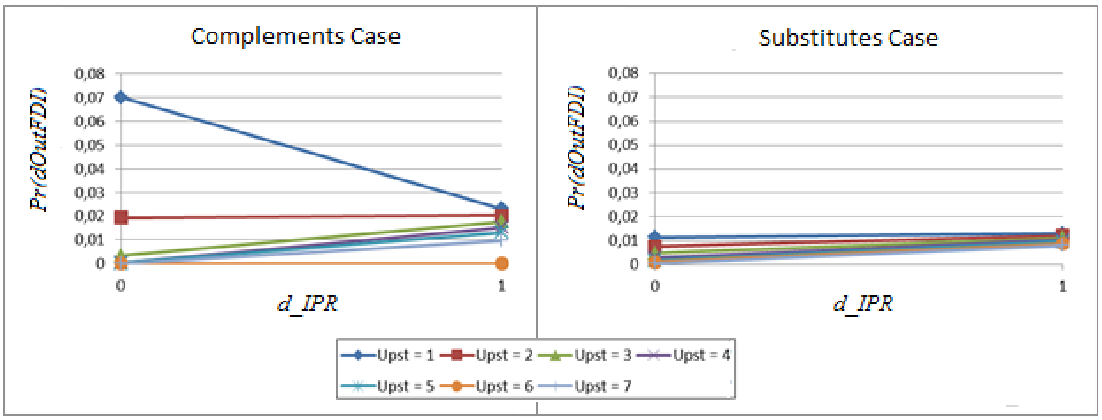
Table 3: Probit model of firm integration decision in a certain market for substitutes and complements

	Rho	Rho	Alpha	Alpha	Rho	Rho	Alpha	Rho
	(1)	(2)	(3)	(4)[1]	(5)[2]	(6)[2]	(7)[2]	(8)[2]
	het probit	het probit	het probit	probit	het probit	het probit	het probit	probit
	compl	subst	compl	subst	compl	subst	compl	compl
Upstr(-1)	-0.850**	-0.243	-0.586***	-1.722	-0.026	0.023	-0.012	0.052
	(0.389)	(0.267)	(0.220)	(1.426)	(0.026)	(0.021)	(0.017)	(0.040)
lnIPR	-0.845*	-0.323	-0.866**	-0.968				
	(0.482)	(0.397)	(0.297)	(1.555)				
lnIPR * Upstr(-1) 1	0.534**	0.149	0.537***	1.134				
	(0.259)	(0.177)	(0.145)	(0.936)				
WGI_rule_law(-1)					0.119	-0.156	0.049	-0.480
					(0.153)	(0.170)	(0.100)	(0.436)
WGI_rule_law(-1) * Upstr(-1) 1					-0.03	-0.027	-0.024*	-0.05
					(0.023)	(0.020)	(0.014)	(0.041)
Age	0.017***	0.015***	0.016***	-0.013	0.022***	0.019***	0.020***	-0.003
	(0.005)	(0.003)	(0.004)	(0.010)	(0.005)	(0.003)	(0.003)	(0.007)
lnSize(-1)	0.332***	0.281***	0.291***	0. 352***	0.324***	0.291***	0.286***	0.373***
	(0.023)	(0.017)	(0.018)	(0.089)	(0.021)	(0.018)	(0.018)	(0.048)
ExPropensity(-1)	0.390***	0.489***	0.392***	1.047***	0.299***	0.336***	0.263***	0.658***
	(0.107)	(0.093)	(0.079)	(0.208)	(0.092)	(0.087)	(0.068)	(0.157)
lnKintensity(-1)	0.100*	0.212***	0.122***	0.280***	0.145***	0.222***	0.148***	0.217***
	(0.062)	(0.052)	(0.062)	(0.077)	(0.049)	(0.049)	(0.034)	(0.053)
lnLproductivity(-1)	0.126**	-0.098	0.051	0.140	0.143**	-0.027	0.0685	0.11
	(0.074)	(0.063)	(0.054)	(0.112)	(0.062)	(0.056)	(0.043)	(0.082)
Debt_assets(-1)	0.165	0.051	0.265**	0.352**	0.204	0.099	0.241**	0.346**
	(0.062)	(0.125)	(0.145)	(0.149)	(0.139)	(0.122)	(0.102)	(0.138)
Time eff. Incl.	YES	YES	YES	YES	YES	YES	YES	YES
Country eff. Incl.	YES	YES	YES	NO	YES	YES	YES	YES
Industry eff. Incl.	YES	YES	YES	YES	YES	YES	YES	YES
Log pse.likelihood	-2372.93	-2292.76	-5586.88	-340.143	-4052.22	-4250.45	-9264.34	-973.31
Wald test	chi2(56)= 837.5***	chi2(52)= 1325.4***	chi2(61)= 846.3***	chi2(26)= 321.5***	chi2(67)= 884.7***	chi2(64)= 1043.8***	chi2(73)= 939.0***	chi2(41)= 774.9***
Wald's test for heteroskedasticity (H0: lnsigma2=0)								
lnsigma2	-0.073***	-0.109***	-0.082***	-0.036	-0.048**	-0.065**	-0.059***	-0.033
lempllag	(0.029)	(0.027)	(0.027)	(0.097)	(0.025)	(0.030)	(0.022)	(0.036)
chi2(1)	6.57***	16.15***	9.02***	0.14	3.89**	4.69**	7.07***	0.86
Observations	37316	52127	87401	19334	42326	57715	95878	16594

Notes: Robust Std. Err. in round brackets, adjusted for firm clusters; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$;
1. Estimation with set of country dummies not possible. Instead, the following partner country controls included: lnDist, lnGDP, lnGDPpc.
2. Specification includes additional WGI controls, and precisely: WGI_voice_account(-1), WGI_pol_stab_violence(-1), WGI_govn_effectiveness(-1), WGI_regul_quality(-1), WGI_control_corrupt(-1).

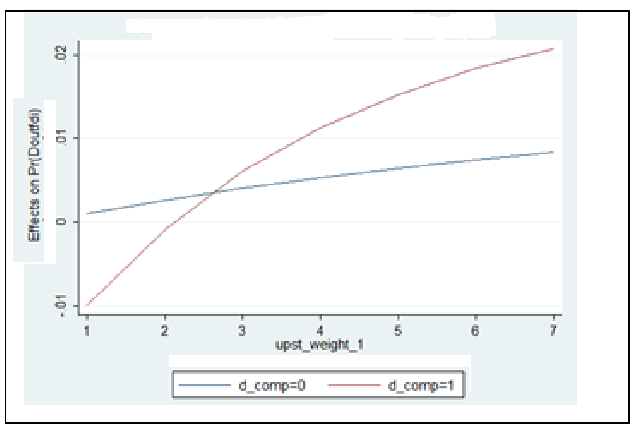
To better visualize the impact of IPRs, Figure 5 plots predicted probabilities of integration for complements and substitutes at different stages along the supply chain in markets with above and below average IPR protection level, while Figure 6 represents average marginal effect of an increase in Park's measure ($lnIPR$) on probability to integrate at different stages along the supply chain for complements and substitutes. Putting the figures alongside the tables with our baseline results suggest that IPR protection bears a heterogeneous impact on producers' propensity to integrate suppliers with respect to their position in the supply chain and sequential complementarity/substitutability of their investments. More specifically, improvement in the level of IPR protection decreases the likelihood of integration of the suppliers in more downstream parts of the production process in industries in which suppliers' investments along the value chain are sequential complements (as depicted by negative values of the marginal effects in Figure 6 and decreasing curve for complements in the downstream stages in Figure 5). We instead observe a weakly positive effect on the propensity to integrate in more upstream stages under sequential complements and at all stages when inputs are sequential substitutes, which explains the insignificant impact of IPRs in the latter case.

Figure 5: Predictive margins



Notes: Based on regression from Table 3, column 1 (Table 2, column 1)

Figure 6: (Average) Marginal effects of the level of IPR protection



Notes: Based on regression from Table 3, column 2; the IPR variable is here expressed as the log of the Park index.

6 Robustness of the Core Findings

Based on the additional information from 2007-2009 sub-sample we perform a more concise analysis to take into consideration several details that are not feasible for the full sample. Initially, we redefine the dependent variable employing a criteria for vertically integrated affiliates, i.e. existence of affiliates intra-firm exports. We also perform a stricter criteria in Table B3 of the appendix that uses the 10% threshold for intra-firm export propensity of affiliates as a robustness check. The idea is to eliminate horizontal FDI from our regressions and also adjusts the upstreamness measure of the inputs sourced by considering only the vertically integrated inputs. The results are illustrated in Table 4. Columns (1) and (2) show the results using the complementarity measure ρ, whereas columns (5) and (6) consider α. The direct effect of IPR remains negative and significant in all cases although at different levels, whereas the interaction remains positive.

Table 4: Probit model of firm integration decision in a certain market (conditioned on existence of affiliates' intra-firm exports)

	Rho	Rho	Rho	Rho	Alpha	Alpha	Alpha	Alpha
	(1)	(2)	(3)[1]	(4)	(5)	(6)	(7)	(8)
	het.probit	het.probit	xtprobit	xtprobit	probit	probit	xtprobit	xtprobit
	compl	subst	compl	subst	compl	subst	compl	subst
Upstr(-1)	-1.046***	-0.579	-3.714**	-1.211	-1.646**	-10.607	-5.520*	-18.505
	(3.103)	(1.041)	(3.237)	(5.499)	(0.796)	(8.327)	(2.875)	(25.018)
lnIPR	-5.893*	-0.512	-7.979**	3.384	-7.007*	-18.424	-6.756*	-0.578
	(3.103)	(3.628)	(0.565)	(8.931)	(3.798)	(11.619)	(3.541)	(31.361)
lnIPR * Upstr(-1)								
1	0.670***	0.387	2.362*	0.767	1.066**	6.756	3.559*	10.498
	(0.239)	(0.685)	(1.385)	(3.669)	(0.523)	(5.407)	(1.936)	(16.568)
Age	0.015***	0.020***	0.065**	0.135***	0.025***	-0.061***	0.105***	-0.381***
	(0.005)	(0.005)	(0.030)	(0.029)	(0.008)	(0.023)	(0.021)	(0.146)
lnSize(-1)	0.358***	0.274***	-0.522	1.315***	0.347***	0.639***	1.343***	3.809***
	(0.027)	(0.023)	(0.600)	(0.192)	(0.047)	(0.185)	(0.145)	(1.063)
ExProp(-1)	0.468***	0.668***	-0.001	4.472***	0.824***	1.171**	3.486***	7.023**
	(0.139)	(0.210)	(2.447)	(1.107)	(0.198)	(0.572)	(0.599)	(3.227)
lnKint(-1)	0.149	0.097	0.585	0.220	0.210**	0.123	0.333*	1.955***
	(0.104)	(0.082)	(0.553)	(0.339)	(0.093)	(0.131)	(0.199)	(0.640)
lnLprod(-1)	0.08	-0.043	-0.073	0.27	0.084	0.146	0.540**	-0.017
	(0.116)	(0.118)	(0.904)	(0.453)	(0.129)	(0.214)	(0.275)	(1.047)
Debt_assets(-1)	0.232	-0.175	1.300	-0.694	0.618**	-0.541	1.899***	-5.380
	(0.205)	(0.243)	(0.987)	(1.238)	(0.290)	(0.702)	(0.663)	(4.356)
lnGDP(-1)			0.380**	-0.014				
			(0.177)	(0.188)				
lnGDPpc(-1)			0.045	-0.376				
			(0.256)	(0.369)				
Time eff.	YES	YES	YES	YES	YES	YES	YES	YES
Country eff.	YES	YES	NO	NO	YES	YES	NO	NO
Industry eff.	YES	YES	NO	NO	YES	YES	NO	NO
Log pse.likelihood	-314.059	-347.681	-274.964	-290.695	-913.4	-54.609	-702.927	-47.438
Wald test	chi2(37)= 1510.5***	chi2(35)= 1196.3***	chi2(18)= 45.9***	chi2(13)= 116.0***	chi2(45)= 992.2***	chi2(18)= 445.9***	chi2(11)= 131.2***	chi2(11)= 39.7***
Wald's test for heteroskedasticity (H0: lnsigma2=0)								
lnsigma2	-0.135***	-0.106*	/	/	-0.035	-0.159	/	/
lempllag	(0.037)	(0.055)			(0.051)	(0.302)		
chi2(1)	13.22***	3.69*			0.48	0.28		
Likelihood-ratio test; rho=0: chi2(1) (Prob¿chi2)								
				284.2***			662.49***	50.67***
Observations	13387	17318	17215	23235	34410	3036	38883	9299

Notes: robust Std. Err. in round brackets are adjusted for firm clusters in heteroskedastic probit specifications.
*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$;
1. Averages of firm-level time-varying regressors included in the specification.

To deal with endogeneity which is caused by unobserved firm-specific effects we employ parameterization of unobserved firm-specific effects by firm-level means of all time-varying independent variables over the sample period in the manner suggested by Mundlak (1978), Chamberlain (1984), Wooldridge (2002). Additionally, we estimate random effects probit model and explicitly exploit panel structure of our data where unit of observation refers to firm-country pair. Since we cannot control for these in the probit logit model, this panel approach allows to control for everything that remains constant during the sample interval with a partner country, i.e. country-firm pair fixed effect. In the random effects model, individual-specific effect (in our case firm-country pair specific effect) is a random variable that is uncorrelated with the explanatory variables. Results are presented in columns (3-4) and (7-8) of Table 4, and show that our findings are fully robust to these more demanding specifications that control for unobserved heterogeneity. Our results remain unchanged with only a slight reduction in the significance of the coefficient of the interaction term.

Table 5: Probit model of firm integration decision at product-market level for complements and substitutes

	Rho	Rho	Rho	Rho	Alpha	Alpha	Alpha	Alpha
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	het probit	het probit	xtprobit	xtprobit	het probit	het probit	xtprobit	xtprobit
	compl	subst	compl	subst	compl	subst	compl	subst
Upstr(-1)	-0.924***	-0.05	-8.457***	-1.392**	-0.665*	-0.064		3.329
	(0.349)	(0.214)	(0.944)	(0.660)	(0.402)	(0.773)		(3.156)
lnIPR	-2.298***	-0.303	-25.254***	-6.946***	-2.059***	-0.100		1.626
	(0.521)	(0.815)	(1.816)	(1.275)	(0.697)	(1.335)		(5.669)
lnIPR * Upstr(-1) 1	0.606***	0.036	5.596***	1.026**	0.444*	0.040		-2.263
	(0.233)	(0.145)	(0.628)	(0.440)	(0.233)	(0.509)		(2.130)
Age	0.010***	0.010**	0.137***	0.071***	0.023***	-0.022**		-0.067*
	(0.004)	(0.004)	(0.051)	(0.003)	(0.006)	(0.011)		(0.037)
lnSize(-1)	0.266***	0.205***	1.988***	0.784***	0.235***	0.494***		2.136***
	(0.026)	(0.024)	(0.049)	(0.018)	(0.031)	0.041		(0.237)
ExProp(-1)	0.178**	0.419***	1.412***	2.171***	0.320**	1.106***		7.283***
	(0.083)	(0.093)	(0.119)	(0.088)	(0.126)	(0.256)		(0.908)
lnKint(-1)	0.131**	0.047	1.357***	0.197***	0.071*	0.083		0.812***
	(0.054)	(0.038)	(0.051)	(0.033)	(0.039)	(0.070)		(0.212)
lnLprod(-1)	-0.013	-0.154**	0.625***	-0.529***	0.012	0.154**		0.474
	(0.056)	(0.064)	(0.077)	(0.054)	(0.070)	(0.075)		(0.323)
Debt_assets(-1)	0.15	0.186	3.502***	2.132***	0.658***	-0.150		-0.936
	(0.205)	(0.234)	(0.201)	(0.118)	(0.183)	(0.257)		(1.072)
lnDist	-0.128***	-0.062	-1.310***	-0.703***	-0.165***	-0.05		-0.112
	(0.042)	(0.040)	(0.069)	(0.042)	(0.052)	(0.040)		(0.261)
lnGDP(-1)	0.150***	0.051	1.653***	0.642***	0.148***	0.012		0.086
	(0.032)	(0.031)	(0.058)	(0.030)	(0.042)	(0.110)		(0.212)
lnGDPpc(-1)	-0.019	0.018	-0.135	-0.142***	-0.028	-0.092		-0.442
	(0.050)	(0.034)	(0.083)	(0.055)	(0.050)	(0.077)		(0.410)
Time eff.	YES	YES	YES	YES	YES	YES		YES
Industry eff.	YES	YES	YES	YES	NO	NO		YES
Log pse. likelihood	-16329.23	-19534.32	-14660.17	-16875.12	-47721.88	-358.49		-303.21
Wald test	chi2(22)= 276.26***	chi2(22)= 353.69***	chi2(22)= 2395.49***	chi2(22)= 3866.53***	chi2(14)= 127.77***	chi2(14)= 516.89***		chi2(19)= 152.11***
Wald's test for heteroskedasticity (H0: lnsigma2=0)								
lnsigma2 lempllag		-0.178***			-0.118***	-0.1278*		
		(0.039)			(0.028)	(0.072)		
chi2(1)		20.98***			17.12***	3.12*		
Likelihood-ratio test; rho=0: chi2(1) (Prob>chi2)			6129.3***	7775.1***				93.65***
Observations	195029	272773	195029	272773	503183	45569		32472

Notes: In heteroskedastic probit specifications robust Std. Err. in round brackets are adjusted for firm clusters; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

We next move down on the level of aggregation to exploit the disaggregated nature of the data. To this end, instead of the firm-year-country level regressions we now use a regression model on the firm-year-product-country level to estimate the likelihood of integration of a particular input from a particular country in a given year by a firm. Here in the spirit of Alfaro *et al.* (2015) we define vertical integration based on the core activity of the affiliate. Another great advantage of estimations at this level is that we can consider the upstreamness of specific input instead of average upstreamness of inputs sourced from a certain country. Table presents the results. Our findings are reinforced and strikingly strong not only under the standard heteroskedastic probit specifications (columns (1-2) and (5-6) for ρ and α, respectively), but also under the random effect probit model when considering unobserved heterogeneities for each country-firm pair that are invariant over time (columns (3-4) and (7-8) for ρ and α, respectively).

Table 6: Random effects tobit and fractional logit model (GLM) of the share of integrated input imports

	Rho	Rho	Rho	Rho	Alpha	Alpha
	(1)	(2)	(3)	(4)	(5)	(6)
	xttobit	xttobit	frac.logit	frac.logit	frac.logit	frac.logit
	compl	subst	compl	subst	compl	subst
Upstr(-1)	-1.403**	-0.701	-6.179*	-3.636	-5.297**	-8.804
	(0.581)	(0.475)	(3.264)	(3.269)	(2.227)	(6.656)
IPR	-2.289***	-0.054	-6.999	1.323	-4.487	-4.185
	(0.820)	(0.745)	(4.640)	(4.088)	(3.635)	(5.071)
lnIPR * Upstr(-1) 1	0.913**	0.446	3.956*	2.265	3.387**	5.832
	(0.390)	(0.318)	(2.210)	(2.209)	(1.505)	(4.287)
Age	0.023**	0.014***	0.0559**	0.0398**	0.0215	-0.0597
	(0.010)	(0.003)	(0.027)	(0.017)	(0.019)	(0.040)
lnSize(-1)	0.207***	0.160***	-0.406	1.070*	-0.0413	0.535
	(0.042)	(0.019)	(0.467)	(0.627)	(0.450)	(0.749)
ExProp(-1)	0.378***	0.422***	3.258***	3.969	2.464	-0.481
	(0.124)	(0.089)	(1.231)	(3.015)	(1.875)	(2.258)
lnKint(-1)	0.170***	0.107***	1.242***	-0.713	0.406	-0.555
	(0.040)	(0.031)	(0.473)	(0.551)	(0.500)	(0.350)
lnLprod(-1)	0.04	-0.009	-0.602	1.061	-0.321	-0.849
	(0.060)	(0.039)	(0.642)	(0.789)	(0.551)	(0.782)
Debt_assets(-1)	0.320**	-0.118	1.270	0.129	1.954	0.733
	(0.166)	(0.118)	(1.278)	(1.381)	(1.747)	(1.684)
lnDist	-0.0001**		0.125	-0.006	0.062	-0.871
	(0.000)		(0.143)	(0.307)	(0.141)	(0.638)
lnGDP(-1)	0.051*	0.003	-0.171	-0.318**	-0.217***	-0.18
	(0.028)	(0.019)	(0.128)	(0.129)	(0.084)	(0.307)
lnGDPpc(-1)	-0.083*	-0.047	-0.312**	-0.626***	-0.431***	-1.105
	(0.047)	(0.035)	(0.148)	(0.186)	(0.131)	(0.682)
Time eff.	YES	YES	YES	YES	YES	YES
Country eff.	NO	NO	NO	NO	NO	NO
Industry eff.	NO	NO	YES	YES	YES	YES
Log likelihood	-730.934	-612.243	-338.967	-249.462	-704.014	-81.367
Wald test	chi2(23)= 40.03**	chi2(22)= 157.82***				
AIC			0.043	0.024	0.038	0.023
BIC			-167009	-232866.8	-403558.4	-83130.15
Observations	17215	23235	16709	22973	37815	8156

Notes: Robust Std. Err. in round brackets (for fractional logit models they are adjusted for firm clusters); averages of firm-level time-varying regressors included in fractional logit specifications; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

In order to look at the outcome at the country level, we aggregate our product-level estimates to define the share of a firm's imports from a partner country that are integrated by estimating the random effects tobit model and the fractional logit model, where the dependent variable defined as such takes a value between 0 and 1. Table presents the results, where columns (1-4) refer to the tobit model and columns (5-8) depict the results for the fractional logit model. Also in this case we only observe significant results for the case of sequential complements. IPRs encourage outsourcing in the relatively downstream stages of the chain.

Finally, even if Slovenian firms are heavily involved in global supply chains and the participation is substantially more backward (meaning firms are more likely to be positioned towards the end of the supply chain), we need to check to see whether our results remain valid when only considering Slovenian producers of the final good. This would mitigate concerns that the firm is located in an intermediate stage of the supply chain importing an upstream input and exporting its production further downstream along the chain. Table tackles this issue by considering only a subsample of firms that have their core export product classified as a final (consumer) good. As expected, the number of observations drops considerably, but the results are fully robust.

Table 7: Probit model of firm integration decision in a certain market for final producer subsample

	Rho	Rho	Alpha	Alpha
	(1)	(2)	(3)	(4)
	het.probit	het.probit	probit	probit
	compl	subst	compl	subst
Upstr(-1)	-1.537**	-0.405	-0.612*	1.434
	(0.666)	(0.456)	(0.328)	(5.812)
lnIPR	-2.975***	-0.389	-0.830*	-17.72
	(1.042)	(0.569)	(0.497)	(19.08)
lnIPR X Upstr(-1)				
1	0.967**	0.248	0.388*	-0.998
	(0.440)	(0.310)	(0.218)	(3.820)
Age	0.012	0.019***	0.015***	0.028
	(0.012)	(0.005)	(0.003)	(0.034)
lnSize(-1)	0.268***	0.277***	0.263***	1.013***
	(0.046)	(0.030)	(0.028)	(0.311)
ExPropensity(-1)	0.212	0.629***	0.483***	2.080***
	(0.254)	(0.159)	(0.150)	(0.572)
lnKintensity(-1)	0.415***	0.273***	0.252***	0.291*
	(0.066)	(0.083)	(0.055)	(0.149)
lnLproductivity(-1)	-0.098	-0.175**	-0.077	0.566**
	(0.099)	(0.086)	(0.071)	(0.230)
Debt_assets(-1)	0.601	-0.142	0.224	0.495***
	(0.389)	(0.201)	(0.153)	(0.186)
Time eff. Incl.	YES	YES	YES	YES
Country eff. Incl.	YES	YES	YES	YES
Industry eff. Incl.	YES	YES	YES	YES
Log pse.likelihood	-519.74	-677.70	-1804.80	-37.04
Wald test	chi2(42)=	chi2(46)=	chi2(50)=	chi2(19)=
	872.8***	1094.8***	919.5***	881.3***
lnsigma2	0.149	-0.121***	-0.104***	0.154
lempllag	(0.112)	(0.029)	(0.031)	(0.460)
chi2(1)	1.79	17.68***	10.90***	0.11
Observations	8041	12348	21455	801

Notes: Robust Std. Err. in round brackets, adjusted for firm clusters; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

7 Conclusion

To be completed.

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Appendix A: Mathematical Appendix

A-1. Derivation of program (6)

This appendix reports some steps which lead to derive the theoretical results introduced and discussed in the main text. As explained in Section 3.3, from a pure mathematical standpoint, our variant of Antràs and Chor (2013) bears a resemblance of that of Alfaro *et al.* (2015), although the two papers focus on completely different aspects of the interaction between institutional environment and organization of a sequential production line. We therefore refer the reader to that paper (and to the original work of Antràs and Chor (2013), of course) for more technical details on the matter, herein restricting ourselves to highlight only the most relevant differences that characterize our framework with respect to theirs.

In deriving program (6) in Section 3.2, for instance, we follow the same procedure that Alfaro *et al.* (2015) use to derive program (8) in their body text. Hence, we first solve the supplier's problem, which consists of finding the optimal amount of investments, namely $x^*(z)$, that maximizes supplier z's surplus, i.e. $(1-\beta(z))r'(z) - cx(z)$, where $r'(z)$ is the derivative in z of the revenue function

$$r(z) = A^{1-\rho}\theta^{\rho}\left(\int_0^z \left[e^{-\mu s}x(s)\right]^{\alpha} ds\right)^{\frac{\rho}{\alpha}} \quad ,$$

and therefore corresponds to

$$r'(z) = \frac{\rho}{\alpha}\left(A^{1-\rho}\theta^{\rho}\right)^{\frac{\alpha}{\rho}} \cdot \left[r(z)\right]^{\frac{\rho-\alpha}{\rho}} \cdot \left[e^{-\mu z}x(z)\right]^{\alpha}.$$

The optimal investment level for supplier z can be proved to be

$$x(z) = \left[(1-\beta(z)) \cdot \rho A^{\frac{(1-\rho)\alpha}{\rho}} \cdot e^{-\alpha\mu z}\left[r(z)\right]^{\frac{\rho-\alpha}{\rho}}\right]^{\frac{1}{1-\alpha}} \quad ,$$

which plugged into the above expression for $r'(z)$ originates a separable differential equation for $r(z)$, namely

$$r'(z) = \frac{\rho}{\alpha}(A^{1-\rho})^{\frac{\alpha}{\rho(1-\alpha)}} \cdot \left[r(z)\right]^{\frac{\rho-\alpha}{\rho(1-\alpha)}} \cdot \left[\rho(1-\beta(z))e^{-\mu z}\right]^{\frac{\alpha}{1-\alpha}} \quad ,$$

with solution

$$r(z) = A\left(\frac{1-\rho}{1-\alpha}\right)^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}}\rho^{\frac{\rho}{1-\rho}} \cdot \left[\int_0^z \left[(1-\beta(s))e^{-\mu s}\right]^{\frac{\alpha}{1-\alpha}} ds\right]^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}} \quad . \tag{A1}$$

With this expression in mind, we now turn to the problem of the final good producer which is in control of the supply chain. This firm has to choose the optimal division of surplus at any stage of production, thereby solving the following profit-maximization program: $\max\limits_{\beta(z)} \pi = \int_0^1 \beta(z) \cdot r'(z)\, dz$.

By differentiating equation (A1), this program can be re-expressed as follows:

$$\max_{\beta(z)} \pi = \Phi \int_0^1 \beta(z)\left[e^{-\mu z}\left(1-\beta(z)\right)\right]^{\frac{\alpha}{1-\alpha}} \left[\int_0^z \left[e^{-\mu s}\left(1-\beta(s)\right)\right]^{\frac{\alpha}{1-\alpha}} ds\right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} dz \ ,$$

where $\Phi \equiv A(\frac{1-\rho}{1-\alpha})^{\frac{\rho-\alpha)}{\alpha(1-\rho)}} \rho^{\frac{\rho}{1-\rho}}$. This exactly corresponds to program (6) in Section 3.2.

A-2. Optimal Ownership Structure for the Substitutes Case

Following the same approach of Antràs and Chor (2013), we solve the firm's problem in our generalized framework by considering a relaxed version of program (6), in which the firm could freely choose the function $\beta(z)$ from the whole set of piece-wise continuously differentiable real-valued functions, rather than from those that only take on values in the set $\{\beta_V, \beta_O\}$. As in their paper, we reformulate the firm's problem in terms of $\upsilon(z)$, a real-valued function of z defined as

$$\upsilon(z) \equiv \int_0^1 \left(e^{-\mu s}\left[1-\beta(s)\right]\right)^{\frac{\alpha}{1-\alpha}} \ ds \ .$$

The problem thus turns into a program of the type

$$\max_{\upsilon(z),u(z)} \pi = \Phi \cdot \int_0^1 \ \left[1 - e^{\mu z} u(z)^{\frac{1-\alpha}{\alpha}}\right] \cdot u(z) \cdot \upsilon(z)^{\frac{\rho-\alpha}{\alpha(1-\rho)}} d\upsilon \ ,$$

in which the control variable, denoted as $u(z)$, is

$$u(z) = \upsilon'(z) = \left[e^{-\mu z}\left(1-\beta(z)\right)\right]^{\frac{\alpha}{1-\alpha}} \ . \tag{A2}$$

The Euler-Lagrange equation associated leads to:

$$\frac{1}{\alpha} e^{\mu z} u^{\frac{1-\alpha}{\alpha}} \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left[\frac{(\rho-\alpha)(1-\alpha)}{\alpha(1-\rho)}\frac{u}{\upsilon} + \mu + \frac{1-\alpha}{\alpha}\frac{u'}{u}\right] = 0 \ ,$$

where $\upsilon = \upsilon(z)$, $u = u(z) = \upsilon'$, and $u' = \upsilon''$. Out of the three type of solutions that can be outlined for the above equation, only one generates strictly positive profits, namely

$$\frac{(\rho-\alpha)(1-\alpha)}{\alpha(1-\rho)}\frac{u}{\upsilon} + \mu + \frac{1-\alpha}{\alpha}\frac{u'}{u} = 0 \ . \tag{A3}$$

The solution to this second-order differential equation is represented by a first-order differential equation, that is

$$u(z) = \upsilon'(z) = C_1 e^{-\frac{\alpha}{1-\alpha}\mu z} \upsilon(z)^{\frac{\alpha-\rho}{1-\rho}} \ , \tag{A4}$$

where C_1 is a positive constant, which embeds the constant of integration.

The first-order differential equation has solution

$$\upsilon(z) = \Big[C_2 - \frac{(1-\alpha)^2 C_1}{\mu\alpha(1-\rho)} e^{-\frac{\alpha}{1-\alpha}\mu z}\Big]^{\frac{1-\rho}{1-\alpha}} \ , \tag{A5}$$

where C_2 is another constant term, inclusive of a second constant of integration.

To find the precise expression of C_1 and C_2, we impose (i) the initial condition, i.e. $\upsilon(0) = 0$; and (ii) the transversality condition, i.e. $1 - \frac{1}{\alpha}\upsilon'(1)^{\frac{1-\alpha}{\alpha}} e^{\mu} = 0$.

Indeed, by combining the initial condition with (A5) evaluated at $z = 0$, we get $C_2 = \frac{(1-\alpha)^2}{\alpha\mu(1-\rho)} C_1$. By combining the transversality condition with (A4) evaluated at $z = 1$, we obtain

$$C_1 = \alpha^{\frac{\alpha}{1-\rho}} \big[\frac{(1-\alpha)^2}{\alpha\mu(1-\rho)}\big]^{\frac{\rho-\alpha}{1-\rho}} (1 - e^{-\frac{\alpha}{1-\alpha}\mu})^{\frac{\rho-\alpha}{1-\rho}} \ .$$

Given the expressions for C_1 and C_2, the value function $\upsilon(z)$ can then be written as follows:

$$\upsilon(z) = \Lambda \cdot (1 - e^{-\frac{\alpha}{1-\alpha}\mu z})^{\frac{1-\rho}{1-\alpha}} \ , \tag{A6}$$

where $\Lambda \equiv \alpha^{\frac{\alpha}{1-\alpha}} \frac{(1-\alpha)^2}{\mu\alpha(1-\rho)} (1 - e^{-\frac{\alpha}{1-\alpha}\mu})^{\frac{\rho-\alpha}{1-\alpha}}$. This implies

$$\upsilon'(z) = \alpha^{\frac{\alpha}{1-\alpha}} \Big(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}}\Big)^{\frac{\alpha-\rho}{1-\alpha}} \cdot e^{-\frac{\alpha}{1-\alpha}\mu z} \ . \tag{A7}$$

In the light of equation (A2), the optimal share at stage z turns out to be:

$$\beta^*(z) = 1 - \alpha \cdot \Big(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}}\Big)^{\frac{\alpha-\rho}{\alpha}} \ . \tag{A8}$$

This solution can be proved to satisfy a sufficient condition for a maximum and can be also characterized as the solution of the firm's problem when $\beta^*(z)$ is constrained to take non-negative values. In the substitutes case ($\rho < \alpha$), the solution to the unconstrained problem, given in (A8), does not violate the constraint $0 \leq \beta(z) \leq 1$; in fact, it can be proved that

$$0 \leq 1 - \alpha \cdot \Big(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}}\Big)^{\frac{\alpha-\rho}{\alpha}} \leq 1$$

holds for any $\rho \in (0, 1)$ and for any $\alpha \in (0, 1)$ such that $\rho < \alpha$. It follows than, exactly as in Antràs and Chor (2013) and Alfaro *et al.* (2015), the solution obtained from solving the unconstrained problem is necessarily also the one which yields the maximum for the constrained problem.

In Figure A1 of Appendix A-3, we plot the optimal share function (A8) for two arbitrary values of ρ and α, such that $\rho < \alpha$. The function is represented as downward-sloping solid line: in analogy with the baseline model, the (unconstrained) optimal share $\beta^*(z)$ is a decreasing function of z whenever supplier investments are sequential substitutes (i.e. $\rho < \alpha$).

A-3. Optimal Ownership Structure for the Complements Case

When $\rho > \alpha$, the optimal share generated by the function that solves the unconstrained problem, namely (A8), violates the constraint $0 < \beta(z) < 1$, since $\left[(1 - e^{-\frac{\alpha}{1-\alpha}\mu z})/(1 - e^{-\frac{\alpha}{1-\alpha}\mu})\right]^{\frac{\alpha-\rho}{\alpha}} > 1$ for some values of $z \in [0, 1]$. For the complements case ($\rho > \alpha$), the solution to the firm's problem must therefore be obtained by solving the constrained version of problem, formulated as follows:

$$\begin{aligned} \max_{\upsilon(z),u(z)} \quad & \Phi \int_0^1 \left[1 - e^{\mu z} u(z)^{\frac{1-\alpha}{\alpha}}\right] \cdot u(z) \cdot \upsilon(z)^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \, d\upsilon \\ s.t. \quad 0 \quad < \quad & e^{\frac{\alpha}{1-\alpha}\mu z} u(z) < 1 \\ \upsilon(0) \quad = \quad & 0 \quad \text{(initial condition)} \end{aligned}$$

where $z \in [0, 1]$ and $\upsilon'(z) = u(z)$, while Φ is the constant term introduced in Appendix A-1. As in the constrained problem, the optimal share at each of production is given by $\beta(z) = 1 - e^{\mu z} \upsilon'(z)^{\frac{1-\alpha}{\alpha}}$.

The Hamiltonian function associated with this problem is therefore

$$H(\upsilon, u, z, \lambda) = \left[1 - e^{\mu z} u^{\frac{1-\alpha}{\alpha}}\right] \cdot u \cdot \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} + \lambda u + \theta(1 - e^{\frac{\alpha}{1-\alpha}\mu z} u) \ ,$$

which implies the following costate equation: $\lambda' = -\frac{\partial H}{\partial \upsilon} = -\frac{\rho-\alpha}{\alpha(1-\rho)} \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left[1 - e^{\mu z} u^{\frac{1-\alpha}{\alpha}}\right] \frac{u}{\upsilon}$.

At the same time, the first-order condition of the firm's problem, namely $\partial H/\partial u = 0$, implies $\lambda = -\upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left(1 - (1/\alpha) e^{\mu z} u^{\frac{1-\alpha}{\alpha}}\right) + \theta e^{\frac{\alpha}{1-\alpha}\mu z}$.[11] According to this, the total derivative of λ turns out to be:

$$\lambda' = -\frac{\rho-\alpha}{\alpha(1-\rho)} \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left[1 - \frac{1}{\alpha} e^{\mu z} u^{\frac{1-\alpha}{\alpha}}\right] \frac{u}{\upsilon} + \frac{1}{\alpha} e^{\mu z} u^{\frac{1-\alpha}{\alpha}} \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left[\frac{1-\alpha}{\alpha} \frac{u'}{u} + \mu\right] + F(z, \theta', \theta) \ .$$

Putting together the above equation and the costate equation, one gets

$$\frac{1-\alpha}{\alpha^2} e^{\mu z} u^{\frac{1-\alpha}{\alpha}} \upsilon^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \left[\frac{\rho-\alpha}{1-\rho} \frac{u}{\upsilon} + \frac{u'}{u} + \frac{\alpha}{1-\alpha} \mu\right] + F(z, \theta', \theta) = 0 \qquad \text{(A9)}$$

When the constraint $u \leq 1$ (i.e. $\beta(z) \geq 0$) does not bite, then $\theta' = \theta = 0$ and equation (A9) delivers exactly the same second-order differential equation of the constrained problem, namely equation (A3), thus the solution is still $u = \upsilon'(z) = C_1 e^{-\frac{\alpha}{1-\alpha}\mu z} \upsilon(z)^{\frac{\alpha-\rho}{1-\rho}}$, i.e. equation (A4).

Notice that for $\upsilon(z)$ sufficiently small (in particular, in the neighborhood of $z = 0$), and given $\rho > \alpha$, we necessarily have that $e^{\frac{\alpha}{1-\alpha}\mu z} \upsilon'(z) > 1$, which means that the constraint $e^{\frac{\alpha}{1-\alpha}\mu z} \upsilon'(z) \leq 1$ must bind, implying $\theta > 0$. The costate equation implies that $\lambda' = 0$. In light of the first-order condition $\partial H/\partial u = 0$, this in turn implies that θ is a monotonically decreasing function of z as

[11] Notice that this equation for λ delivers the transversality condition for this problem. Provided that the constraint does not bind in $z = 1$, which implies $\theta = 0$ in that point, $\lambda(1)$ has to be equal to 0. With some simple algebra we can therefore derive the transversality condition for this problem, which is $\upsilon'(1)^{\frac{1-\alpha}{\alpha}} e^{\mu} = \alpha$.

long as the constraint binds. We can conclude that, if the constraint binds at some point $\widehat{z} \in (0,1)$, then it necessarily binds (i.e. $\theta > 0$) for any $z < \widehat{z}$. Hence, we have $e^{\frac{\alpha}{1-\alpha}\mu z}\upsilon'(z) = 1$, which means $\beta(z) = 0$ for all $z \in [0, \widehat{z}]$.

Moreover, we can write $\upsilon(\widehat{z}) \equiv \int_0^{\widehat{z}} \upsilon'(z)\,dz = \int_0^{\widehat{z}} u(z)\,dz$, which leads to

$$\upsilon(\widehat{z}) = \frac{1-\alpha}{\alpha\mu}\left[1 - e^{-\frac{\alpha}{1-\alpha}\mu\widehat{z}}\right] \tag{A10}$$

With this expression in hand, we can now solve the first-order differential equation, represented by (A4), albeit limited to $z > \widehat{z}$. The solution is still

$$\upsilon(z) = \left[C_2 - \frac{(1-\alpha)^2 C_1}{\mu\alpha(1-\rho)} e^{-\frac{\alpha}{1-\alpha}\mu z}\right]^{\frac{1-\rho}{1-\alpha}},$$

which is the same equation as (A4). The derivative of $\upsilon(z)$ with respect to z is

$$\upsilon'(z) = C_1 e^{-\frac{\alpha}{1-\alpha}\mu z} \cdot \left[C_2 - \frac{(1-\alpha)^2 C_1}{\mu\alpha(1-\rho)} e^{-\frac{\alpha}{1-\alpha}\mu z}\right]^{\frac{\alpha-\rho}{1-\alpha}}. \tag{A11}$$

By combining equation (A11), evaluated at $z = 1$, with the transversality condition, one obtains a first expression for the constant term C_2. An alternative expression can be derived by combining (A11), evaluated at $z = \widehat{z}$ with the boundary condition, namely $e^{\frac{\alpha}{1-\alpha}\mu\widehat{z}}\upsilon'(\widehat{z}) = 1$. The two expressions, assembled together, lead us to write the constant term C_1 as follows

$$C_1 = \left[\frac{1}{1-\alpha^{-\frac{\alpha}{\rho-\alpha}}} \cdot \frac{(1-\alpha)^2}{\mu\alpha(1-\rho)}\left(e^{-\frac{\alpha}{1-\alpha}\mu} - e^{-\frac{\alpha}{1-\alpha}\mu\widehat{z}}\right)\right]^{\frac{\rho-\alpha}{1-\rho}}. \tag{A12}$$

We now use equation (A10). If combined with (A11) evaluated at $z = \widehat{z}$, this equation delivers a new expression for C_1, namely

$$C_1 = \left(\frac{1-\alpha}{\alpha\mu}\right)^{\frac{\rho-\alpha}{1-\rho}}\left[1 - e^{-\frac{\alpha}{1-\alpha}\mu\widehat{z}}\right]^{\frac{\rho-\alpha}{1-\rho}}. \tag{A13}$$

Equations (A12) and (A13), assembled together, allows for identifying stage $\widehat{z}$, based on the following equation:

$$e^{-\frac{\alpha}{1-\alpha}\mu\widehat{z}} = \frac{e^{-\frac{\alpha}{1-\alpha}\mu} - \left(1-\alpha^{-\frac{\alpha}{\rho-\alpha}}\right)^{\frac{1-\alpha}{1-\rho}}}{1 - \left(1-\alpha^{-\frac{\alpha}{\rho-\alpha}}\right)^{\frac{1-\alpha}{1-\rho}}}. \tag{A14}$$

Plugging equations (A14), (A13), (A12) and the expression for C_2 into (A11), we can finally derive the optimal share function $\beta^*(z)$ for all $z > \widehat{z}$, that is

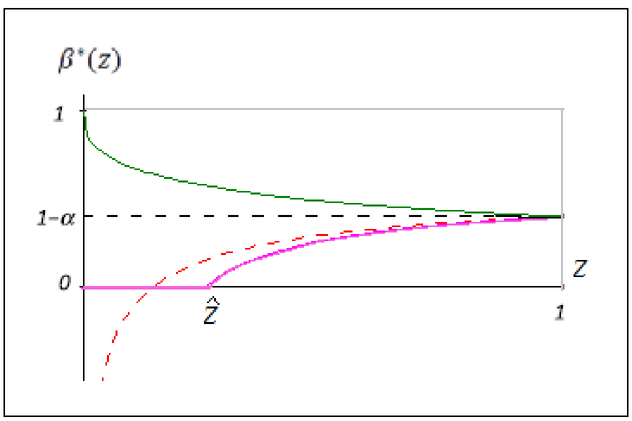
$$\beta^*(z) = 1 - \alpha\left[1 + \chi \cdot \frac{e^{-\frac{\alpha}{1-\alpha}\mu} - e^{-\frac{\alpha}{1-\alpha}\mu z}}{e^{-\frac{\alpha}{1-\alpha}\mu} - 1}\right]^{\frac{\alpha-\rho}{\alpha}}, \text{ where } \chi \equiv \frac{(1-\rho)\left(1-\alpha^{-\frac{\alpha}{\rho-\alpha}}\right) - (1-\alpha)}{(1-\rho)\alpha^{-\frac{\alpha}{\rho-\alpha}}}.$$

Hence, the solution to the constrained problem, which solve the firm's (relaxed) problem in the complements case (i.e. when $\rho > \alpha$) is:

$$\beta^*(z) = \max\left\{0, 1-\alpha\left[1+\chi\cdot\frac{e^{-\frac{\alpha}{1-\alpha}\mu}-e^{-\frac{\alpha}{1-\alpha}\mu z}}{e^{-\frac{\alpha}{1-\alpha}\mu}-1}\right]^{\frac{\alpha-\rho}{\alpha}}\right\}. \tag{A15}$$

In Figure A1, the above solution (solid line, downward-sloping) is plotted together with the solutions to the unconstrained problem for the case $\rho > \alpha$ (dotted line) and $\rho < \alpha$ (solid line, upward-sloping). As in Antràs and Chor (2013), the optimal share $\beta^*(z)$ is a decreasing function of z as long as supplier investments are sequential substitutes (i.e. $\rho < \alpha$). Moreover, as in their paper, $\beta^*(z)$ in the unconstrained problem is higher than in the constrained problem for all stages $z > \widehat{z}$: when upstream suppliers cannot be incentivized by offering them a payoff exceeding their marginal contribution (as it would be optimal, if the constraint were absent), then the firm finds optimal to offer (i) full marginal contribution to a larger measure of suppliers, and (ii) a higher share of their marginal contribution to the remaining suppliers.

Figure A1: Profit-maximizing division of surplus for stage z for the generalized model.



A-4. Cut-off Stages and Proof of Propositions 1 and 2

Propositions 1 and 2 can be proved by considering a particular case of the proof outlined by Alfaro *et al.* (2015) for their Proposition 2, which basically generalizes the proof of Proposition 2 in Antràs and Chor (2013). Indeed, they introduce asymmetries in the marginal product of different inputs' investments (in their case, induced by the different relative contractability of upstream stages versus downstream stages) by means of a stage-specific attribute, namely $\psi(i)$ (where i indexes the stages of production, instead of z). In our framework, $\psi(z)$ takes on a particular interpretation as a discount factor for the value of suppliers investments, motived by the exposure to the risk of the final-good variety being imitated, with a potential loss from imitation that increases over z. Hence, we can follow the same procedure sketched in their Appendix A-1.3, setting $\psi(z) = e^{-\mu z}$ and abstracting away from heterogeneity in the marginal cost of production across stages.

Consider first the complements case ($\rho > \alpha$). Given the solution reported in (A15), outsourcing will prevail at the very beginning of the supply chain, since $\beta^*(z) = 0$ for all stages $z \in [0, \widehat{z}]$ and β_O is lower than β_V. Since the most upstream stages are outsourced, stages to be integrated, if any, will necessarily be located downstream relative to those that are outsourced, which means that it does exist a cut-off stage $z_C^* \in (0, 1]$, such that all stages $z \in [0, z_C^*)$ will be outsourced, whereas all stages $z \in [z_C^*, 1]$ will be integrated integrated within the firm's boundaries. Outsourcing and integration will coexist along the production line, conditional on $z_C^* \neq 1$; otherwise, the whole production process is outsourced.

The existence of this cut-off stage can be established by contradiction, following the line of reasoning of Alfaro *et al.* (2015), thus by considering the case of a stage $\widetilde{z} \in (0, 1)$, such that the firm decides to integrate in the upstream neighborhood of $\widetilde{z}$, and to outsource in the downstream neighborhood of $\widetilde{z}$, thereby violating the pattern described in Proposition 1. Also in our case, it can be proved that this ownership structure would yield lower profits than an alternative organizational mode, such that outsourcing would apply to measurable set of stages located upstream than $\widetilde{z}$, and integration would apply to a measurable set of downstream stages, with the same organizational decision retained for all other stages (consistently with Proposition 1). Hence, deviating from the pattern described in Figure 4 would simply be inconsistent with the principle of profit maximization.

Similar arguments apply also in the substitutes case ($\rho < \alpha$), to fully establish Proposition 2. In this case, the solution to the firm's problem is represented by the function in (A8). Since $\beta^*(z)$ takes value 1 at $z = 0$ and then it monotonically decreases, it stands to reason that integration will be the preferred option at the very beginning of the value chain, given $\beta_V > \beta_O$. The optimal organizational structure is such that we cannot have a positive measure of outsourced stages located upstream relative to the measure of integrated stages. Hence, there exists a cut-off stage $z_S^* \in (0, 1]$, such that integration occurs at all stages $z \in [0, z_S^*)$, while outsourcing occurs at all stages $z \in [z_S^*, 1]$. If $z_S^* \neq 1$, then the two organizational modes will coexist along the supply chain, preventing from full integration. The formal proof of Proposition 2 can be obtained by following the same approach hinted for Proposition 1.

To pin down the level of the cut-offs z_C^* and z_S^*, we proceed as follows. Consider the real-valued function $\widetilde{v}(z) \equiv \left[\int_0^z [e^{-\mu s}(1-\beta(s))]^{\frac{\alpha}{1-\alpha}} \, ds \right]^{\frac{(1-\alpha)\rho}{\alpha(1-\rho)}}$ and its derivative with respect to z, namely $\partial \widetilde{v}(z)/\partial z = \frac{\rho(1-\alpha)}{\alpha(1-\rho)} \cdot [e^{-\mu z} 1 - \beta(z)]^{\frac{\alpha}{1-\alpha}} \cdot \left[\int_0^z [e^{-\mu s}(1-\beta(s))]^{\frac{\alpha}{1-\alpha}} \, ds \right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}}$.

Given this expression, the firm's profit function in (6) can be re-written as

$$\pi = \frac{\alpha(1-\rho)}{\rho(1-\alpha)} \Phi \cdot \int_0^1 \beta(z) \cdot \frac{\partial \widetilde{v}(z)}{\partial z} \, dz \; . \tag{A16}$$

In the complements case ($\rho > \alpha$), Proposition 1 implies that (A16) corresponds to

$$\pi = \Phi \cdot \frac{\alpha(1-\rho)}{\rho(1-\alpha)} \beta_O \cdot (1-\beta_O)^{\frac{\rho}{1-\rho}} \left[\int_0^{z_C^*} e^{-\frac{\alpha}{1-\alpha}\mu s}\, ds \right]^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}} +$$
$$+\Phi \cdot \frac{\alpha(1-\rho)}{\rho(1-\alpha)} \beta_V \cdot \left[(1-\beta_O)^{\frac{\alpha}{1-\alpha}} \int_0^{z_C^*} e^{-\frac{\alpha}{1-\alpha}\mu s}\, ds + (1-\beta_V)^{\frac{\alpha}{1-\alpha}} \int_{z_C^*}^1 e^{-\frac{\alpha}{1-\alpha}\mu s}\, ds \right]^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}} +$$
$$-\Phi \cdot \frac{\alpha(1-\rho)}{\rho(1-\alpha)} \beta_V \cdot \left[(1-\beta_O)^{\frac{\alpha}{1-\alpha}} \int_0^{z_C^*} e^{-\frac{\alpha}{1-\alpha}\mu s}\, ds \right]^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}} .$$

If we maximize π with respect to z_C^*, from the first-order condition of the problem we obtain

$$\frac{\int_0^{z_C^*} e^{-\frac{\alpha}{1-\alpha}\mu s} ds}{\int_0^1 e^{-\frac{\alpha}{1-\alpha}\mu s} ds} = \left\{ 1 + \left(\frac{1-\beta_O}{1-\beta_V} \right)^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{1 - \frac{\beta_O}{\beta_V}}{1 - \left(\frac{1-\beta_O}{1-\beta_V}\right)^{-\frac{\alpha}{1-\alpha}}} \right)^{\frac{\alpha(1-\rho)}{\rho-\alpha}} - 1 \right] \right\}^{-1} . \tag{A17}$$

Notice that the condition for z_C^* to be in the interval $(0,1)$ is the same as in the baseline model of Antràs and Chor (2013), namely $\beta_V(1-\beta_V)^{\frac{\alpha}{1-\alpha}} > \beta_O(1-\beta_O)^{\frac{\alpha}{1-\alpha}}$ (which is the condition for the right-hand-side of equation (A17) to be lower than one). Hence, the degree of appropriability of intellectual assets does not play any role in determining whether outsourcing and integration coexist along the production line.

With some simple algebra, the cut-off stage can be proved to be

$$z_C^* = \frac{\alpha-1}{\alpha\mu} \log\left(1 + \frac{e^{-\frac{\alpha}{1-\alpha}\mu} - 1}{\Omega_C} \right) \text{ , with } \Omega_C \equiv 1 + \left(\frac{1-\beta_O}{1-\beta_V} \right)^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{1 - \frac{\beta_O}{\beta_V}}{1 - \left(\frac{1-\beta_O}{1-\beta_V}\right)^{-\frac{\alpha}{1-\alpha}}} \right)^{\frac{\alpha(1-\rho)}{\rho-\alpha}} - 1 \right].$$

Consider now the substitutes case ($\rho < \alpha$). In the light of Proposition 2, the profit function (A16) can be re-written in a specular way with respect to the case of sequential complements (with β_O instead of β_V, and vice versa) and the first-order condition with respect to z_S^* delivers the following counterpart of equation (A17):

$$\frac{\int_0^{z_S} e^{-\frac{\alpha}{1-\alpha}\mu s} ds}{\int_0^1 e^{-\frac{\alpha}{1-\alpha}\mu s} ds} = \left\{ 1 + \left(\frac{1-\beta_V}{1-\beta_O} \right)^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{\frac{\beta_V}{\beta_O} - 1}{\frac{1-\beta_V}{1-\beta_O})^{-\frac{\alpha}{1-\alpha}} - 1} \right)^{\frac{\alpha(1-\rho)}{\rho-\alpha}} - 1 \right] \right\}^{-1} . \tag{A18}$$

Also in this case the condition for z_S^* to be in the interval $(0,1)$ is not affected by μ, this condition being $\beta_V(1-\beta_V)^{\frac{\alpha}{1-\alpha}} < \beta_O(1-\beta_O)^{\frac{\alpha}{1-\alpha}}$. The cut-off stage z_S^* turns out to be

$$z_C^* = \frac{\alpha-1}{\alpha\mu} \log\left(1 + \frac{e^{-\frac{\alpha}{1-\alpha}\mu} - 1}{\Omega_S} \right) \text{, with } \Omega_S \equiv 1 + \left(\frac{1-\beta_V}{1-\beta_O} \right)^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{\frac{\beta_V}{\beta_O} - 1}{\left(\frac{1-\beta_V}{1-\beta_O}\right)^{-\frac{\alpha}{1-\alpha}} - 1} \right)^{\frac{\alpha(1-\rho)}{\rho-\alpha}} - 1 \right].$$

A-5. Proof of Proposition 3

We conclude this Appendix with a proof of Proposition 3, which entails re-considering equation (A8), i.e. the solution to the firm's relaxed problem, in its unconstrained version:

$$\beta^*(z) = 1 - \alpha \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}} \right)^{\frac{\alpha-\rho}{\alpha}} .$$

The derivative of $\beta^*(z)$ with respect to μ turns out to be

$$\frac{\partial \beta^*(z)}{\partial \mu} = \frac{\alpha}{1-\alpha}(\rho - \alpha) \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}} \right)^{\frac{\alpha-\rho}{\alpha}} \frac{e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \cdot \left[1 - \frac{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu z}\right) e^{-\frac{\alpha}{1-\alpha}\mu}}{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu}\right) e^{-\frac{\alpha}{1-\alpha}\mu z}} \right] .$$

The image of the entire domain $z \in [0, 1]$ of both the derivative and the primitive function is either defined over the co-domain $\mathbb{R}^+$ or $\mathbb{R}^-$, depending on the sign of $\alpha - \rho$. To make a meaningful comparison among the impact of IPR (i.e. μ) on $\beta^*(z)$ in the two cases of complements and substitutes, we consider the absolute value of the above derivative, for a given absolute difference between parameter α (the degree of physical input complementarity) and parameter ρ (the demand elasticity for the final-good variety).

Let ϵ be the absolute value of this difference, namely $\epsilon = |\alpha - \rho|$.

Hence, for a given value of ϵ, supplier investments are sequential complements if $\alpha - \rho = \epsilon$; and complements if $\alpha - \rho = -\epsilon$. In the substitutes case, the derivative of $\beta^*(z)$ with respect to μ can therefore be written as

$$\left| \frac{\partial \beta^*(z)}{\partial \mu} \right|_{\alpha-\rho=\epsilon} = \left| -\epsilon \cdot \frac{\alpha}{1-\alpha} \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}} \right)^{\frac{x}{\alpha}} \frac{e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \cdot \left[1 - \frac{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu z}\right) e^{-\frac{\alpha}{1-\alpha}\mu}}{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu}\right) e^{-\frac{\alpha}{1-\alpha}\mu z}} \right] \right| =$$

$$= \epsilon \cdot \frac{\alpha}{1-\alpha} \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}} \right)^{\frac{\epsilon}{\alpha}} \frac{e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \cdot \left[1 - \frac{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu z}\right) e^{-\frac{\alpha}{1-\alpha}\mu}}{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu}\right) e^{-\frac{\alpha}{1-\alpha}\mu z}} \right] ,$$

whereas the counterpart for the complements case is

$$\left| \frac{\partial \beta^*(z)}{\partial \mu} \right|_{\alpha-\rho=-\epsilon} = \left| \frac{\alpha}{1-\alpha} \cdot \epsilon \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu}} \right)^{-\frac{x}{\alpha}} \frac{e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \cdot \left[1 - \frac{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu z}\right) e^{-\frac{\alpha}{1-\alpha}\mu}}{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu}\right) e^{-\frac{\alpha}{1-\alpha}\mu z}} \right] \right| =$$

$$= \epsilon \cdot \frac{\alpha}{1-\alpha} \cdot \left(\frac{1 - e^{-\frac{\alpha}{1-\alpha}\mu}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \right)^{\frac{\epsilon}{\alpha}} \frac{e^{-\frac{\alpha}{1-\alpha}\mu z}}{1 - e^{-\frac{\alpha}{1-\alpha}\mu z}} \cdot \left[1 - \frac{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu z}\right) e^{-\frac{\alpha}{1-\alpha}\mu}}{\left(1 - e^{-\frac{\alpha}{1-\alpha}\mu}\right) e^{-\frac{\alpha}{1-\alpha}\mu z}} \right] .$$

It is straightforward to show that

$$\left| \frac{\partial \beta^*(z)}{\partial \mu} \right|_{\alpha-\rho=-\epsilon} > \left| \frac{\partial \beta^*(z)}{\partial \mu} \right|_{\alpha-\rho=\epsilon} .$$

Indeed, the above inequality holds for

$$\left(\frac{1-e^{-\frac{\alpha}{1-\alpha}\mu}}{1-e^{-\frac{\alpha}{1-\alpha}\mu z}}\right)^{\frac{x}{\alpha}} > \left(\frac{1-e^{-\frac{\alpha}{1-\alpha}\mu z}}{1-e^{-\frac{\alpha}{1-\alpha}\mu}}\right)^{\frac{x}{\alpha}},$$

which, in turns, implies $e^{-\frac{\alpha}{1-\alpha}\mu z} > e^{-\frac{\alpha}{1-\alpha}\mu}$. Given $\alpha \in (0,1)$, the last condition is verified as far as $z < 1$, which is always true since $z \in [0,1]$.

We can therefore conclude that, for a given absolute difference between parameters α and ρ, the optimal share $\beta^*(z)$ is more sensitive to changes in μ (the strength of IPR enforcement) in the complements case ($\alpha - \rho = -\epsilon$) rather than in the substitutes case ($\alpha - \rho = \epsilon$), as stated in Proposition 3.

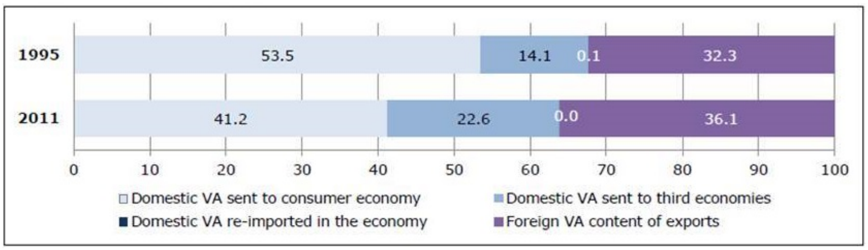
Appendix B: Data Appendix

Table B1: The GVC participation index, Slovenia 2011 (% share in total gross exports).

	Slovenia	Developing countries	Developed countries
Total GVC participation	58.7	48.6	48.0
Forward participation	22.6	23.1	24.2
Backward participation	36.1	25.5	23.8

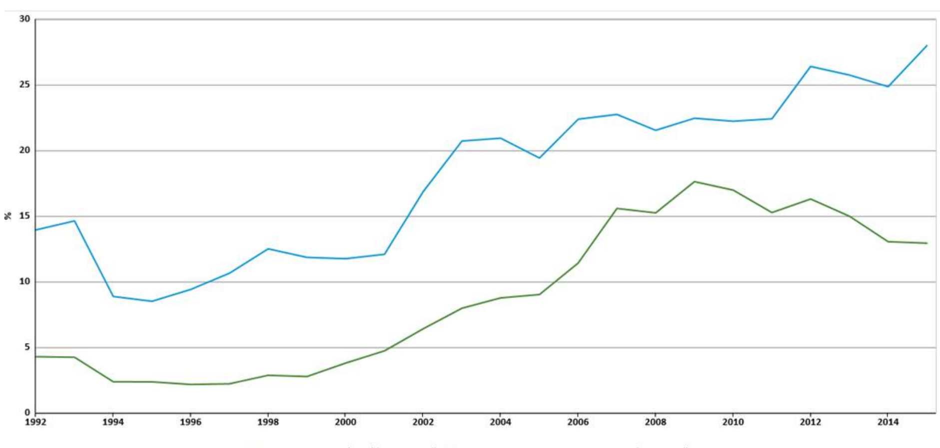
Source: WTO.

Figure B1: The value-added (VA) components of gross exports, Slovenia 1995 and 2011. (% share in total gross export)



Source: WTO.

Figure B2: Slovenian FDI stock (% of GDP)



Source: WTO.

Table B2: IPR protection augmented heteroskedastic and random effects probit model of firm integration decision in a certain market controlled for unobserved heterogeneity

	Rho	Rho	Rho	Rho	Alpha	Alpha	Alpha	Alpha
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	het probit	hetprobit	xtprobit	xtprobit	hetprobit	probit	xtprobit	xtprobit
	compl	subst	compl	subst	compl	subst	compl	subst
Upstr(-1)	-1.007**	-0.397*	-1.950*	0.290	-0.644***	-1.692	-1.002	-3.723
	(0.399)	(0.226)	(1.048)	(1.332)	(0.207)	(1.451)	(0.874)	(5.487)
lnIPR	-1.829**	-0.456	-2.372*	2.658	-1.082***	-0.913	-0.359	2.524
	(0.724)	(0.328)	(1.446)	(2.274)	(0.416)	(1.548)	(1.329)	(7.290)
lnIPR * Upstr(-1)								
1	0.642**	0.252*	1.174*	-0.267	0.404***	1.116	0.576	2.383
	(0.265)	(0.150)	(0.710)	(0.904)	(0.138)	(0.952)	(0.593)	(3.641)
Age	0.017***	0.014***	0.0642***	0.077***	0.0146***	-0.0139	0.0807***	-0.033
	(0.005)	(0.003)	(0.010)	(0.017)	(0.004)	(0.011)	(0.013)	(0.034)
lnSize(-1)	0.136	0.175***	0.757***	1.367***	0.142**	0.0869	1.279***	1.060***
	(0.126)	(0.064)	(0.075)	(0.085)	(0.059)	(0.182)	(0.080)	(0.209)
ExPropensity(-1)	0.335	0.183	1.284***	1.814***	0.061	0.635	1.560***	2.162***
	(0.295)	(0.135)	(0.268)	(0.368)	(0.116)	(0.387)	(0.304)	(0.672)
lnKintensity(-1)	0.143	0.046	0.441***	1.121***	0.0813	0.262**	0.606***	1.099***
	(0.107)	(0.038)	(0.077)	(0.120)	(0.052)	(0.125)	(0.085)	(0.205)
lnLproductivity(-1)	-0.051	0.052	0.0515	0.029	0.016	-0.008	0.360***	0.118
	(0.076)	(0.056)	(0.145)	(0.185)	(0.041)	(0.200)	(0.134)	(0.268)
Debt_assets(-1)	0.004	-0.004	0.263	0.026	0.078	0.263*	1.149***	1.080
	(0.130)	(0.135)	(0.335)	(0.550)	(0.109)	(0.157)	(0.341)	(0.974)
avglnSize	0.199	0.100			0.149**	0.276		
	(0.134)	(0.107)			(0.065)	(0.195)		
avgExPropensity	0.041	0.321*			0.336**	0.486		
	(0.304)	(0.182)			(0.139)	(0.435)		
avglnKintensity	-0.075	0.194***			0.044	0.002		
	(0.102)	(0.064)			(0.063)	(0.129)		
avglnLproductivity	0.252**	-0.205***			0.031	0.196		
	(0.107)	(0.080)			(0.075)	(0.230)		
avgDebt_assets	0.209	0.102			0.253	0.162		
	(0.235)	(0.177)			(0.166)	(0.132)		
lnDist	-0.182***	-0.230***			-0.209***	-0.248**		
	(0.040)	(0.043)			(0.037)	(0.103)		
lnGDP(-1)	0.149***	0.126***			0.136***	0.149		
	(0.032)	(0.024)			(0.025)	(0.091)		
lnGDPpc(-1)	-0.096**	-0.121***			-0.116***	-0.200		
	(0.043)	(0.034)			(0.032)	(0.149)		
Time eff. Incl.	YES	YES	YES	YES	YES	YES	YES	YES
Industry eff. Incl.	YES	YES	NO	NO	YES	YES	NO	NO
Log pse.likelihood	-2508.774	-2441.895	-258.334	-1258.666	5815.627	-337.521	-2707.499	-267.454
Wald test	chi2(32)=	chi2(32)=	chi2(15)=	chi2(15)=	chi2(32)=	chi2(32)=	chi2(15)=	chi2(15)=
	625.1***	846.2***	235.4***	584.1***	618.4***	335.4***	449.2***	64.0***
Wald's test for heteroscedasticity (H0: lnsigma2=0)								
lnsigma2	-0.066**	-0.109***			-0.080***	-0.035		
lempllag	(0.028)	(0.024)			(0.027)	(0.090)		
chi2(1)	5.62**	21.00***			8.98***	0.15		
Likelihood-ratio test; rho=0: chi2(1) (Prob>chi2)								
			2905.4***	2828.2***			7027.8***	176.4***
Observations	39895	55641	40345	56437	90992	19334	92187	21256

Notes: Robust Std. Err. in round brackets, adjusted for firm clusters in heteroskedastic probit models;
*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.;
1. Estimation with set of country dummies not possible; instead, following partner country controls included: lnDist, lnGDP, lnGDPpc.

Table B3: Probit model of firm integration decision in a certain market (threshold at 10% intra-firm export propensity of affiliates

	Rho	Rho	Rho	Rho	Alpha	Alpha	Alpha	Alpha
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	het probit	het probit	xtprobit	xtprobit	probit	het probit	xtprobit	xtprobit
	comp	subst	comp	subst	comp	subst	comp	subst
Upstr(-1)	-1.438	-1.057	-6.103**	-2.574	-1.865*	-1.149	5.528**	-2.428
	(0.965)	(1.363)	(2.720)	(5.147)	(0.992)	(2.107)	(2.796)	(19.265)
lnIPR	-4.257	1.636	-9.263***	-1.314	-3.064	-4.138	-7.094**	1.470
	(3.736)	(4.902)	(3.156)	(7.961)	(4.169)	(5.283)	(3.600)	(23.236)
lnIPR * Upstr(-1)								
1	0.949	0.714	4.047**	1.716	1.217*	0.732	3.639*	0.886
	(0.643)	(0.911)	(1.815)	(3.478)	(0.661)	(1.369)	(1.884)	(12.722)
Age	0.021**	0.020***	0.108**	0.121***	0.030***	-0.034***	0.104***	-0.603***
	(0.009)	(0.007)	(0.049)	(0.031)	(0.008)	(0.011)	(0.021)	(0.163)
lnSize(-1)	0.367***	0.245***	0.994***	1.134***	0.306***	0.444***	1.105***	3.908***
	(0.039)	(0.036)	(0.253)	(0.248)	(0.041)	(0.061)	(0.143)	(0.947)
ExProp(-1)	0.451***	0.866***	2.599***	4.994***	0.8727***	0.739***	3.056***	5.367*
	(0.174)	(0.337)	(0.953)	(1.486)	(0.183)	(0.154)	(0.595)	(3.043)
lnKint(-1)	0.163	0.123	0.467	0.369	0.195*	0.050	0.389**	1.441**
	(0.135)	(0.115)	(0.438)	(0.384)	(0.103)	(0.036)	(0.197)	(0.590)
lnLprod(-1)	0.092	-0.03	0.601	0.113	0.072	0.025	0.350	0.131
	(0.140)	(0.143)	(0.813)	(0.482)	(0.135)	(0.098)	(0.276)	(0.937)
Debt_assets(-1)	0.389	-0.311	2.253***	-0.978	0.617**	0.133	1.950*	-4.939
	(0.254)	(0.310)	(0.830)	(1.384)	(0.290)	(0.355)	(0.657)	(4.123)
Time eff.	YES	YES	YES	YES	YES	YES	YES	YES
Country eff.	YES	YES	NO	NO	YES	YES	NO	NO
Industry eff.	YES	YES	NO	NO	YES	YES	NO	NO
Log pse.likelihood	-263.537	-304.724	-249.794	-253.497	-768.333	-38.841	-624.691	-41.92
Wald test	chi2(35)=	chi2(36)=	chi2(11)=	chi2(11)=	chi2(44)=	chi2(17)=	chi2(11)=	chi2(11)=
	1357.1***	1163.8***	61.3***	76.7***	1060.6***	416.1***	111.3***	35.4***
Wald's test for heteroscedasticity (H0: lnsigma2=0)								
lnsigma2	-0.110**	-0.056	/	/	0.002	-0.352**	/	/
lempllag	(0.046)	(0.069)			(0.058)	(0.152)		
chi2(1)	5.70**	0.66			0.00	5.40**		
Likelihood-ratio test; rho=0: chi2(1) (Prob>chi2)								
				216.80***			487.32***	44.60***
Observations	12884	17423	17408	23566	33237	2006	38883	9299

Notes: heteroskedastic probit specifications robust Std. Err. in round brackets are adjusted for firm clusters; *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.