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Abstract

This paper examines the impact of intellectual property rights (IPR) enforcement on multinationals' choice of input suppliers and industry profits in a host economy. The framework consists of suppliers with heterogeneous capabilities who must engage in a relation-specific investment to customize intermediate inputs upon a transfer payment by final producers. An outsourcing contract with better technologically-endowed suppliers requires a lower transfer and generates a higher surplus. Stronger IPR enforcement leads firms to self-select into better quality suppliers on average by reducing their outside option. Weak legal institutions instead make it possible for a larger range of suppliers, including the less capable ones, to form partnerships by granting them a larger outside option. A better IPR environment is more likely to harm lagging countries where the technology distribution is characterized by less capable suppliers.

J.E.L. Classification: O34; L24; F21; F23; O32; L22; D23.

Keywords: International outsourcing; Supplier heterogeneity; Relation-specific investment; Intellectual property rights enforcement; Outside option; Customization; Technological capability.

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1 Introduction

The organization of production and innovation in global supply chains has been subject to recent intense research among trade economists.[1] The complex contractual relationships between the upstream and downstream firms in international markets have particularly been under the spotlight in studying the organizational decisions of firms, relation-specific investments, and consequences for the economy. A good example used to study supply arrangements has been the *Keiretsu* models in the Japanese industries, where suppliers undertake relation-specific investments directed at customizing a product to make it more valuable to a particular partner, but not to other potential (rival) buyers. Applications of the *Keiretsu* models have been brought into the ambit of international trade by Qiu and Spencer (2001,2002). This type of relationship between assemblers and suppliers is especially prevalent in the Japanese automotive sector (Ahmadijan and Oxley, 2006, 2013).

This paper constitutes one of the first attempts to introduce supplier heterogeneity into a model of global sourcing, a step deemed necessary both from a theoretical and an empirical perspective in the literature of firm organization (Antràs, 2014). Indeed, the business and economic literature has to a great extent treated first-tier suppliers as being similar in nature. A closer look within industries, however, reveals a different reality, and more so after the 21st century trends towards the globalization of outsourcing strategies. Suppliers are heterogeneous in several respects. An immediate first feature that distinguishes suppliers from one another is their prototyping facilities and R&D capabilities in customizing components to meet the standards required by their customers.[2] Superior knowledge and technology make some suppliers more attractive and of higher competitive significance to manufacturers in the global market. However, they could also pose a bigger threat under a weak intellectual property rights (IPR) environment. Linkages with multinational enterprises can also have consequences for the domestic economy as a whole by affecting competition and the quality of the supply chain, which in turn depends on the firm's choice of suppliers.

Yet, how do multinationals decide their global sourcing strategy and select suppliers for the procurement of their relation-specific inputs? Do they always rely on the best few first-tier suppliers in each country or do they behave differently in different environments when choosing their subcontractor? This research aims to provide a theory in order to explain the patterns of outsourcing relationships between multinational firms and suppliers. Suppliers are heterogeneous in terms of their technological capability in host countries that are characterized by their legal institutions. By introducing supplier heterogeneity in the upstream market, we can investigate the decisions of firms in the formation of outsourcing contracts with assorted suppliers. We emphasize differences (or improvements) in institutional quality to explore how IPR enforcement may influence the supplier

[1] See Helpman (2006) for a thorough overview.

[2] See Kamath and Liker (1994) for a more detailed explanation regarding the Japanese and American automotive industry based on a survey of auto-part suppliers to Toyota, Nissan, Mazda, General Motors, Ford, and Chrysler.

mix and examine the effect of supplier choice on the domestic economy.

More specifically, final producers source to a continuum of suppliers that are heterogeneous with respect to their ability in undertaking relation-specific investments. Suppliers must commit to make an investment that can be interpreted as a customization (or R&D) cost, the extent of which depends on their ability to carry out the relation-specific task. Less technologically-endowed suppliers are required to make a larger investment to satisfy the multinational's needs. After finding a partner, final producers are bound to make a payment to their supplier to cover a part of the necessary investment, in order to minimize hold-up problems in the upstream-downstream relationship. The more technologically capable the suppliers are, the lower that the required payment is. Consequently, a higher joint surplus is generated within the relationship.

The framework adds a further important feature often overlooked in the literature when assessing multinationals' links with the most capable suppliers: the outside option of suppliers in outsourcing relationships.[3] By adding supplier heterogeneity, we are able to identify suppliers who differ in their outside options according to their customization or R&D capability. Multinationals on average tend to outsource to suppliers with better R&D capabilities in countries with stronger IPR institutions. IPR enforcement ensures adequate relation-specific investment by lowering the supplier's outside option and hence the probability of defection. By contrast, when the IPR environment is weak, supplier technology plays a less important role and buyer-supplier relations are also formed with less capable suppliers. This is because weak legal institutions provide them with an outside option that increases their chances of survival in the market.

Introducing heterogeneity among suppliers also allows us to make predictions regarding the consequences of IPR enforcement for the host economies. The results suggest that the impact of increasing R&D efficiency in the intermediate sector by creating a more stringent IPR environment in the home economy is ambiguous. An enhancement in the average technology of rivals in the economy lowers average profits and makes it harder for less capable suppliers to survive in the market. On the one hand, less competition increases the profitability of the most technologically capable suppliers in the intensive margin. On the other hand, a reduced number of active suppliers lowers the number of firms and hence aggregate profits on the extensive margin. The effect of IPR enforcement is more likely to be negative for technologically lagging host countries with a fat right tail distribution of suppliers with inferior technologies. A shrinking upstream sector serving foreign producers caused by better quality IPR institutions can in this case be harmful to the economy.

The rest of the paper is organized as follows. Section 2 discusses the related literature and evidence. Sections 3 and 4 introduce the basics of the model. Section 5 solves the equilibrium and presents the results. Section 6 concludes.

[3]The few previous works that have touched upon the issue include Andrabi, Ghatak and Khwaja (2006), Lin and Saggi (2007) and Assche and Schwartz (2010).

2 Related Literature and Evidence

The organization of firms was first incorporated into trade theory by McLaren (2000) and Grossman and Helpman (2002). These papers also studied the degree to which suppliers decide to customize intermediate products to the needs of their intended buyer. This is the emphasis of Grossman and Helpman (2003), who use the transaction cost approach to find that better contract enforcement increases the fraction of firms that engage in outsourcing.[4] Grossman and Helpman (2005), however, show that in a general equilibrium setting an improvement in the contractual environment in the South can raise or lower the volume of outsourcing there. Antràs and Helpman (2008) turn the page to the property-right theory to show that improvements in the contractibility of components provided by suppliers in the South increases the relative prevalence of FDI over outsourcing.

As for the effect of contract enforcement on the economy, another branch of the literature uses a measure of contract dependence to show that countries with well-functioning contractual institutions will be net exporters of contract-intensive goods. Acemoglu et al. (2007) show that greater contractual incompleteness leads to the adoption of less-advanced technologies with a more pronounced effect when there is greater complementarity among intermediate inputs. Costinot (2009) derives the result that countries with better contracting institutions have a comparative advantage in more complex sectors. Levchenko (2007) and Nunn (2007) suggest measures of contract dependence related to the costs of contracting between upstream and downstream producers and provide empirical evidence that a country's comparative advantage is partly determined by contracting institutions.

Despite the vast literature on outsourcing and incomplete contracts, the role of IPR enforcement in the outsourcing decision of multinationals remains to a large extent unexplored in economic literature. On this regard, Antràs and Rossi-Hansberg (2009) emphasize the effects of the non-appropriable nature of knowledge on the organizational decision of firms, suggesting that past literature has concentrated too much on hold-up inefficiencies as the main drivers of outsourcing decisions. As for evidence on multinational activities, Branstetter, et al. (2006) show that technology transfer by US multinationals to their affiliates increase after IPR reforms. Ivus (2010) finds that increasing IPRs in developing countries raises the value of developed countries' exports in patent-sensitive industries. Canals and Şener (2014) show that US firms substantially expand their intra-industry offshoring activities in high technology industries as a response to IPR reforms in the host countries. Naghavi, et al. (2014) further show that technology-sharing outsourcing of more sophisticated goods by French multinationals take place in countries with better IPR enforcement. Despite clear evidence on technology transfer, however, controversies on the appropriateness of IPR protection in the developing and emerging world persist. Lai and Qiu (2003) debate the suitability of North's IPR standards for the South, whereas Chu, et al. (2014) argue the relevance of the stage of development for the protection of IPRs.

[4] See Defever and Toubal (2013) among others for evidence that supports this hypothesis.

In this paper, we focus on the impact of the quality of IPR institutions on industry profits in the supply chain in the destination country. In particular, we follow Grossman and Helpman (2005) to explore the location decision of firms that have already decided to engage in international outsourcing and its impact on the supplier market and subsequently the host economy. Opening an economy translates into more intensive competition, limiting the number of local suppliers that can serve the multinationals' needs. As a result, only the most qualified suppliers enjoy technology transfer through the outsourcing partnership because multinationals tend to focus their supplier development efforts on their key (most technologically capable) suppliers.[5] Globalization has therefore weakened the position of less efficient suppliers in host developing economies and made it more difficult for them to survive. We argue that the quality of IPR enforcing institutions in a host country decides the magnitude of this effect.

The lack of firm-level data on suppliers and the choice of multinationals between suppliers of different capabilities makes it difficult to carry out an empirical investigation of our theoretical prediction. The closest attempt has been a comprehensive survey of Japanese firms performed by the Research Institute of Economy, Trade and Industry (RIETI) through *The Survey of Corporate Offshore Activities* on large firms (above 50 employees) conducted in 2006 across all manufacturing industries in Japan. A very novel and valuable feature of this survey is the disaggregation of offshore outsourcing activities by geographical destinations and information on the factors that influence their location choice. In addition, firms are asked to communicate their perception of the enforcement of intellectual property rights for each country when making their choice. Ito, Eiichi and Wakasugi (2007) for instance show that the perception of enforcement in China has a score of 2.3 (out of 5), while the corresponding scores for the US and Europe are 4.4 and 3.8, respectively. Given the results of our model we expect outsourcing firms to go to more productive firms in the US and Europe, while this is less the case when outsourcing to China. Indeed, the results of the survey exhibited in Ito, Eiichi and Wakasugi (2007) show that 16% of firms that have started to engage in offshore outsourcing in the last 5 years to China list suppliers' high technology levels or superior human capital quality as a factor influencing their location choice, while 28% of firms do so for the US and Europe. The region *Other Asia* lies between the two, with 18% listing the above characteristic of suppliers as the factor that attracted them and an enforcement score of 2.8. The figures are in line with our finding that firms that engage in international outsourcing tend to go to more technologically capable suppliers on average, in countries with strong IPR enforcement.

[5] Although we only study the case of international outsourcing, it is important to keep in mind that foreign firms tend to be in a different position from local firms: they come from a world market where firms enjoy established suppliers aware of their technical/quality needs. As a result, it would only be worthwhile for multinationals to go to the best available suppliers.

3 The Model with Heterogeneous Suppliers

The economy consists of two countries, North and South. We focus on an industry that produces an endogenous number of differentiated consumer goods. The goods are designed and assembled in the North, whereas the production of the required intermediate goods is outsourced to the South. The goods specifically target consumers in the North. The South therefore plays the role of a production site. We can think of a reduced form explanation, where final producers are multinationals and outsource the production of their intermediates to a host country. We are interested in studying the interaction between multinational firms and input suppliers, and the impact of outsourcing to *heterogeneous suppliers* on the host economy given that the outsourcing decision has already taken place for motives such as lower wages or the higher efficiency of intermediate specialists.

We assume that the only factor needed for the production of the intermediate good is labor. Production of the final good in turn uses these inputs, in such a way that one unit of the intermediate good is required to produce one unit of the final good. Moreover, because of the differentiated nature of final goods, suppliers must customize their intermediate good perfectly so that it can only be used by that particular producer. Customization costs in our model take into account the explicit form of learning costs that an input supplier has to incur to acquire the necessary technology, management and marketing techniques to compete in the world market. The final producer can provide support for part of the training and technology transfer costs through a payment to partially reimburse the investment.

The amount of the transfer depends on the technological capability of the supplier. We assume suppliers to be heterogeneous in terms of fixed customization/R&D costs, but all face the same marginal costs once they start producing. The proposed formulation implies that some suppliers adapt faster than others to final producers' requirements and hence need less external support to achieve the targeted customization. The more technologically-endowed that the supplier is prior to the partnership, the lower that the required payment to guarantee the desired quality of standards is. More capable suppliers therefore yield a higher surplus, which makes them a more attractive target.

The framework presented below is a variant of Grossman and Helpman (2003, 2005). The novelty of our model lies in the heterogeneous nature of suppliers in the targeted country. Heterogeneity makes it possible for final producers to rank suppliers according to their technology. This generates a sorting of suppliers according to their technology, and the division between subcontractors who do and do not serve multinationals. It will be seen that the R&D capability also gives suppliers a larger outside option, which is in turn influenced by the IPR enforcement environment.

3.1 Consumers

The consumption of the final good takes place in the North. Households share the same preferences with their utility defined over the consumption of a horizontally differentiated good C, where

$$C = \left[\int_0^n c_j^{\alpha} dj \right]^{\frac{1}{\alpha}} \tag{1}$$

is a CES quantity index in which c_j is the consumption of variety j, n is the number of varieties produced, and α is an inverse measure of the degree of product differentiation between varieties. Households maximize consumption subject to the following constraint

$$E = wL_N = \int_o^n p_j c_j dj \tag{2}$$

where p_j is the price of variety j, and the expenditure consumers incur on output from the industry, E, equals aggregate income, wL_N, with L_N representing total labor used in the industry under the common assumption of an infinite supply of labor at an exogenously set market wage rate, $w > 1$.

The utility maximizing profit results in the demand for the j^{th}variety of the form

$$c_j = A p_j^{-\sigma} \tag{3}$$

where A is the aggregate demand associated with the quantity index C and is defined as

$$A = \frac{E}{\int_0^n p_j^{1-\sigma} dj}, \tag{4}$$

and σ is the elasticity of substitution.

3.2 Firms

Upon payment of an entry fixed cost, f_e, intermediate suppliers draw a technology level ζ from a distribution $g(\zeta)$ with a continuous cumulative distribution $G(\zeta) \in [0, 1]$ where $G(0) = 0$, $G(\infty) = 1$. With ζ^* as a threshold capability above which suppliers find it profitable to enter, $1 - G(\zeta^*)$ represents the range of existing suppliers in the market. The parameter ζ can also be interpreted as the firm's marginal capacity of technology absorption. It determines a cost in terms of the level of labor effort they have to make in order to adapt to the technological needs of the representative final producer. Once (potential) suppliers learn their customization capabilities, they go to the market where they negotiate contracts with final firms. They must pay a fixed cost k_s in terms of Southern labor to start producing, where the market wage in the host country is normalized to one. Whenever a partnership is successful, production starts. Once in business, all suppliers need one unit of labor to produce one unit of the intermediate good, irrespective of ζ.

Final firms in turn engage in production upon payment of a fixed cost wk_f in terms of Northern labor. They then look for a supplier and upon success propose their desired prototype, and begin the two-step negotiation. In general, they will have to incur costs that relate to a customization payment or know-how transfer. We will see that this required payment will decrease in ζ. Final firms that have managed to form a successful partnership compete in a typical Dixit-Stiglitz manner: each pair of firms is a monopolist in the production of a differentiated good. They pay a fixed cost each period and use the intermediate good to produce and market their variety. Thus we assume that final producers have no variable costs and can therefore consider them to be homogeneous in terms of productivity for the purposes of this paper.

4 Contracts

Any active firm in this economy is part of a partnership composed of a supplier of customized intermediate inputs and a final producer in charge of the assembly, marketing and distribution of (differentiated) final goods. Prior to commencing production, firms meet in pairs and negotiate the terms of their future relations. Any supplier is *a priori* capable of customizing inputs to any formulation required. Moreover, even though final producers manufacture differentiated goods, the cost of building the right prototype is the same for all goods.

The negotiation takes place after the two parties meet under the assumption that pairs are always formed (no search frictions). Following Grossman and Helpman (2005), such a negotiation can be thought of as being composed of two stages. Assume that the final producer owns all the know-how about its particular product. In the first stage, it transmits the information about the exact type of intermediate input it requires to the (prospective) supplier. We may call this stage the investment contract, where we make explicit that the supplier needs to incur an investment cost in order to close a deal. This contract commits the supplier to undertake the investment in customization so that an acceptable prototype is created. The contract stipulates a payment to which the supplier is entitled if the prototype is satisfactorily developed.

Once the supplier has undertaken the required investment to manufacture the required prototype, the two parties move on to the second stage of the negotiations. The two firms write an order contract through which they stipulate the quantities that the final producer will demand and the associated price. Incentives are fully aligned at this stage as both firms have sunk investments, and the only plausible source of income available to them is the joint surplus that arises from their relationship. Thus, the order contract will be the joint profit maximizing one and the quantity stipulated will be the quantity of inputs needed to produce the demand for final goods in the market. In turn, the price of the intermediate good will be at its lowest possible level, i.e., the marginal cost of the supplier.[6]

4.1 The Order Contract

The order contract determines the surplus arising from a successful partnership. As discussed before, the optimum strategy at this stage is to maximize joint variable profits (revenue), since all fixed costs are already sunk. Recall that firms are monopolists in the production of their own j^{th} variety, and so they pick the optimum price facing a downward-sloping demand curve derived from the consumer's maximization problem. We further denote the profit share that accrues to the supplier and the final producer by $[1-\omega]$ and ω, respectively.

The j^{th} partnership maximizes

$$R_j = \pi_f + \pi_s = p_j y_j - x_j \tag{5}$$

where $y_j = c_j$ is the demand and x_j is the quantity of the intermediate good. This is divided according to the bargaining power of each side so that a share $[1-\omega]$ goes to the final producer:

$$\pi_f = [1-\omega](p_f y_j - x_j), \tag{6}$$

and ω goes to the intermediate supplier:

$$\pi_s = \omega(p_f y_j - x_j). \tag{7}$$

By the assumption that one unit of intermediate goods is required to produce one unit of final goods and with iceberg costs on intermediate goods $\tau > 1$, we have $y_j = \frac{x_j}{\tau}$. Thus, we may rewrite

$$R_j = p_j \frac{x_j}{\tau} - x_j = (\frac{p_j}{\tau} - 1)x_j = \tau A p_j^{-\sigma}(\frac{p_j}{\tau} - 1) \tag{8}$$

The first-order condition yields $p_j = \tau\frac{\sigma}{\sigma-1}$, and hence a price

$$p_j = \tau\frac{\sigma}{\sigma-1} = \frac{\tau}{\alpha}, \tag{9}$$

where $\frac{1}{\alpha} = \frac{\sigma}{\sigma-1}$ is the mark-up over marginal cost resulting from the monopoly position of a firm in the production of its specific variety. As usual, this mark-up is inversely related to the elasticity of substitution: $\frac{\partial 1/\alpha}{\partial\sigma} < 0$, that is, it is positively related to the degree of product differentiation. The more that the pair of goods are substitutes, the less the market power that each firm has and thus the lower the price that it charges.

The quantity effectively demanded of each good j equals $c_j = Ap_j^{-\sigma} = A\left(\frac{\tau}{\alpha}\right)^{-\sigma}$, which is equal to the demand for the intermediate good. Total revenue is therefore

$$R_j = (1-\alpha)A\left(\frac{\tau}{\alpha}\right)^{1-\sigma}. \tag{10}$$

[6] It will never be optimal for the supplier to charge a higher price, since that would result in a higher marginal cost for the final producer, and a higher-than-optimal price which entails lower joint profits.

The operating profits of a final firm and its input suppliers are

$$\pi_f = [1-\omega](1-\alpha) A \left(\frac{\tau}{\alpha}\right)^{1-\sigma} \tag{11}$$

and

$$\pi_s = \omega (1-\alpha) A \left(\frac{\tau}{\alpha}\right)^{1-\sigma} \tag{12}$$

Using (9), we redefine aggregate demand as

$$A = \frac{E}{n\left(\frac{\tau}{\alpha}\right)^{1-\sigma}}, \tag{13}$$

where the number of varieties n also represents the number of paired suppliers and final producers. Using (13) in (11) and (12), we can rewrite the operating profit of each type of firm in its final form

$$\pi_f = [1-\omega](1-\alpha)\frac{E}{n} \tag{14}$$

and

$$\pi_s = \omega(1-\alpha)\frac{E}{n}. \tag{15}$$

Note that the trade costs disappear as a higher price is offset by a lower demand for the final good.

4.2 The Investment Contract

The investment required for the relation-specific asset, $I(\zeta)$, varies across suppliers andis a decreasing function of ζ such that suppliers that draw a better technology need to devote less effort in terms of labor to create the required prototype, i.e. $\frac{\partial I(\zeta)}{\partial \zeta} < 0$. The supplier also has the outside option of using the know-how provided by final producers for its own benefit by serving the local market, denoted by $O(\zeta, \gamma)$. This implies that similar to final producers, suppliers can convert their inputs into final outputs at a cost that depends on their capability and sell in the domestic economy.[7] Better suppliers face a larger outside option, i.e., $\frac{\partial O(\zeta,\gamma)}{\partial \zeta} > 0$. Yet, the opportunities from defecting are decreasing in terms of the effectiveness of the IPR environment, i.e., $\frac{\partial O(\zeta,\gamma)}{\partial \gamma} < 0$. Finally, the final firm needs to give incentives to the supplier and does so by promising an up-front payment $T(\zeta, \gamma)$ towards the completion of the investment. The profits of the supplier can be written as

$$\Pi_s = \pi_s - \phi(\zeta,\gamma) + T(\zeta,\gamma), \tag{16}$$

where we define $\phi(\zeta,\gamma) = I(\zeta) - O(\zeta,\gamma)$. The final firm's operating profits are in turn

$$\Pi_f = \pi_f - T(\zeta,\gamma). \tag{17}$$

[7] Suppliers would have a hard time selling these goods in the world market (here in the North) if they do not abide by the contract (Antràs, 2014).

The payment comes out of a Nash generalized bargaining process, through which both parts maximize joint profits by anticipating their share of those profits.

By substituting (15) into (16), the surplus for the supplier (net of costs already sunk) is

$$\Pi_s = \omega \frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma) + T(\zeta,\gamma) \tag{18}$$

and the surplus for the producer is found by substituting (14) into (17) to obtain

$$\Pi_f = [1-\omega]\frac{E}{n}(1-\alpha) - T(\zeta,\gamma) \tag{19}$$

To derive the payment, the Nash product is maximized with respect to $T(\zeta,\gamma)$

$$\underset{T(\zeta,\gamma)}{Max}\,\Pi = \left[[1-\omega]\frac{E}{n}(1-\alpha) - T(\zeta,\gamma)\right]^{1-\omega}\left[\omega\frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma) + T(\zeta,\gamma)\right]^{\omega},$$

where $\phi(\zeta,\gamma)$ implicitly contains the outside option of the supplier. By log-linearizing Π we can rewrite

$$\underset{T(\zeta,\gamma)}{Max}\,\ln\Pi = [1-\omega]\ln\left[[1-\omega]\frac{E}{n}(1-\alpha) - T(\zeta,\gamma)\right] + \omega\ln\left[\omega\frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma) + T(\zeta,\gamma)\right]$$

with the FOC

$$\frac{\partial \ln\Pi}{\partial T} = -\frac{1-\omega}{[1-\omega]\frac{E}{n}(1-\alpha) - T(\zeta,\gamma)} + \frac{\omega}{\omega\frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma) + T(\zeta,\gamma)} = 0.$$

This gives us an expression for $T(\zeta,\gamma)$, which in turn depends on ω and $\phi(\zeta,\gamma)$:

$$T(\zeta,\gamma) = [1-\omega]\phi(\zeta,\gamma) \text{ or } 1-\omega = \frac{T(\zeta,\gamma)}{\phi(\zeta,\gamma)}. \tag{20}$$

Lemma 1 *The transfer payment required by a subcontractor that satisfies the Nash bargaining outcome $T(\zeta,\gamma)$ is lower for more capable suppliers because (i) they need less support as their investment costs to customize are lower, and (ii) they invest less within the contract as they enjoy a larger outside option.*

Proof. This follows directly from the Nash bargaining solution (20) together with the definition of $\phi(\zeta,\gamma)$ being an integrated term which is a function of the suppliers' technological capability and their outside option. ■

After replacing $T(\zeta,\gamma)$ in (18) and (19) from (20) we can rewrite the profits functions of each type of firm

$$\Pi_s = \frac{(1-\alpha)\,\omega E}{n} - \phi(\zeta,\gamma) + [1-\omega]\phi(\zeta,\gamma) = \omega\left(\frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma)\right) \tag{21}$$

$$\Pi_f = \frac{(1-\alpha)\,[1-\omega]E}{n} - [1-\omega]\phi(\zeta,\gamma) = [1-\omega]\left(\frac{E}{n}(1-\alpha) - \phi(\zeta,\gamma)\right) \tag{22}$$

for the supplier and the final firm, respectively.

5 Equilibrium

5.1 Supplier Zero Cut-Off Conditions

Suppliers enter into outsourcing relations after paying the production fixed cost, k_s, with the expected gains of a supplier with technology ζ from a partnership being $\Pi_s - k_s$.

Using (21), the zero cut-off condition for the supplier implies that

$$k_s = \Pi_s = \pi_s - \phi\left(\zeta, \gamma\right) + T(\zeta, \gamma) = \omega \left(\frac{E}{n}(1-\alpha) - \phi(\zeta^*, \gamma) \right) \tag{23}$$

The cut-off investment needed, above which a supplier cannot serve the multinational, is

$$\phi(\zeta^*, \gamma) = \frac{E}{n}\left(1-\alpha\right) - \frac{k_s}{\omega}, \tag{24}$$

where ζ^* is the cut-off value of ζ, such that any supplier with $\zeta < \zeta^*$ is required to make an investment it cannot afford.[8] Note that the cut-off investment level below which suppliers find it profitable to enter into a relationship is increasing in ω, which implies that a larger ω tends to create a more favorable condition for suppliers to enter relationship-specific contracts.

The final good producer who enters a partnership with the threshold supplier earns

$$wk_f = \Pi_f \; = \pi_f - T(\zeta, \gamma) = [1-\omega] \left(\frac{E}{n}(1-\alpha) - \phi(\zeta^*, \gamma) \right), \tag{25}$$

where profits are equal to wk_f to satisfy the zero profit condition. By substituting the investment costs of the threshold supplier from (24) into (25) we obtain

$$\frac{wk_f}{k_s} = \frac{1-\omega^*}{\omega^*} \Longrightarrow \omega^* = \frac{k_s}{wk_f + k_s}. \tag{26}$$

Lemma 2 *The profit share going to the threshold supplier ω^* can be interpreted as the industry's (i) inverse measure of market thickness in the upstream intermediate inputs market, and (ii) level of upstream representation or the importance of the role of suppliers in partnerships, being determined by the suppliers' relative fixed costs to produce within the relationship.*

Proof. This follows directly from the condition (26). ■

The value ω^* can be thought of as an initial condition that determines the industry characteristics. It is the minimum share required by suppliers in an industry. More precisely, it is the share paid to the threshold supplier that makes both sides break even. The derivative $\frac{\partial \omega^*}{\partial k_s} > 0$ shows that lower fixed costs encourage more suppliers to enter outsourcing relationships, thereby increasing the thickness in the input market.[9] It can be also interpreted as an industry in which suppliers

[8] Note that if more productive multinationals enter, their fixed costs would be higher than those of a local firm so $\phi(\zeta^*)$ must be lower. As it is tougher to stay in the market, only top suppliers can manage to provide services.

[9] In McLaren (2000), the thicker the market for inputs, the larger is the ex-post share of the surplus obtained by suppliers, which in turn alleviates the hold-up inefficiencies. In Grossman and Helpman (2002) instead, a thicker market for inputs enhances the probability of finding a match, which increases the attractiveness of outsourcing.

have a relatively higher representation or importance in outsourcing relationships (a higher relative production fixed cost) and therefore require a larger share. It will be seen that the positive surplus in outsourcing relations with suppliers above the threshold will be divided according to the bargaining power of each side, which does not play an important role in our results.

We can now rewrite the investment cost of the threshold supplier by substituting ω^* obtained in (26) back into (24):

$$\phi(\zeta^*, \gamma) = \frac{E}{n}(1-\alpha) - wk_f - k_s. \tag{27}$$

Finally, considering a specific functional form $\phi(\zeta, \gamma) = \frac{\gamma}{\zeta}$ for tractability, this would give a cut-off technology level that just compensates for the fixed production costs of both partners:[10]

$$\zeta^*(\gamma) = \frac{\gamma}{\frac{E}{n}(1-\alpha) - wk_f - k_s}. \tag{28}$$

5.2 Final Good Market Entry

Equation (19) infers that there exists a threshold level of supplier capability under which they no longer find it worthwhile to enter a partnership. For any given level of supplier capability, the investment cost that makes the final producer break even can be solved in terms of $\phi(\zeta, \gamma)$ and is

$$\phi(\zeta, \gamma) = \frac{E}{n}(1-\alpha) - \frac{wk_f}{(1-\hat{\omega}_f)}, \tag{29}$$

where $\hat{\omega}_f$ is the share of the surplus paid to the supplier that satisfies the final firms' zero profits condition:

$$\hat{\omega}_f = 1 - \frac{wk_f}{\frac{E}{n}(1-\alpha) - \phi(\zeta, \gamma)}. \tag{30}$$

The supplier share that gives the final producer zero profits is increasing with a supplier's R&D capability and outside option, i.e., $\frac{\partial \hat{\omega}_f}{\partial \phi(\zeta, \gamma)} < 0$ as this requires a lower transfer. This suggests that the better a supplier is (the less investment cost it bears), the higher is the share of the surplus that a final producer can afford to give up and still break even.

5.3 Formation of Outsourcing Relations

As in Melitz (2003), we focus on steady state equilibria. A pair of firms, the supplier in which has the technology level ζ, earn a joint surplus $\Pi(\zeta)$ in each period, until hit by a shock, at which point they exit the market. A pair seeking to start operations expect a discounted value of profits equivalent to:

$$v(\zeta) = \max\left\{0, \sum_{t=0}^{\infty}(1-\delta)^t \Pi(\zeta)\right\} = \max\left\{0, \frac{1}{\delta}\Pi(\zeta)\right\},$$

[10] The important feature of $\phi(\zeta, \gamma)$ is that it is increasing in IPR enforcement and decreasing in technological capability.

where an anticipated negative operating profit makes the two sides exit the potential contract upon observing ζ. We now know there is a unique threshold ζ^* such that $v(\zeta) > 0$ if $\zeta > \zeta^*$.

In the industry equilibrium, we have to solve for the number of paired partners (and varieties) n, and the distribution of the technology of suppliers that are active in the market $\mu(\zeta)$. We try to write all expressions in terms of the cut-off ζ^*. Let us define the weighted average supplier technological capability measure:

$$\tilde{\zeta} = \int_0^\infty \zeta \mu(\zeta) d\zeta, \tag{31}$$

where the conditional distribution of $g(\zeta)$ on $[\zeta^*, \infty]$ is

$$\mu(\zeta^*) = \int_{\zeta^*}^\infty \mu(\zeta) d\zeta = \frac{g(\zeta)}{1 - G(\zeta^*)}$$

from which we can rewrite (31) as

$$\tilde{\zeta}(\zeta^*) = \frac{1}{1 - G(\zeta^*)} \int_{\zeta^*}^\infty \zeta g(\zeta) d\zeta, \tag{32}$$

where $\tilde{\zeta}$ is uniquely derived by ζ^* and the exogenous distribution $g(\zeta)$ and $G(\zeta)$. We can next define the average joint surplus $\bar{\Pi}$. This can be easily calculated by using the share $\hat{\omega}_f$ from (30) to set the profits of the final producers equal to zero and solve for supplier average profits $\bar{\Pi}_s = \Pi_s(\tilde{\zeta}) - k_s$ It is also possible to do the opposite, giving the final producer full bargaining power. By doing so, we obtain the share $\hat{\omega}_s = \frac{wk_s}{\frac{E}{n}(1-\alpha) - \phi(\zeta, \gamma)}$ that sets supplier profits equal to zero and solve for $\bar{\Pi}_f = \Pi_f(\tilde{\zeta}) - wk_f$. The derivations yield the exact same results as the two sides simply maximize joint profits at the order contract stage.[11]

We start by using the ratio technique in the spirit of Melitz (2003), which gives

$$\frac{\phi_1(\zeta_1)}{\phi_2(\zeta_2)} = \left(\frac{\zeta_2}{\zeta_1}\right) \Longrightarrow \phi(\tilde{\zeta}) = \left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right) \phi(\zeta^*).$$

This allows us to calculate the average customization investment for suppliers using the investment under the cut-off technology level in (27):

$$\bar{\phi} = \phi(\tilde{\zeta}) = \left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right) \phi(\zeta^*) = \left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right) \left[\frac{E}{n}(1-\alpha) - wk_f - k_s\right] \tag{33}$$

The average payment, on the other hand, can be found by substituting (33) in (20) and is

$$\bar{T} = [1 - \hat{\omega}_f] \phi(\tilde{\zeta}) = [1 - \hat{\omega}_f] \left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right) \left[\frac{E}{n}(1-\alpha) - wk_f - k_s\right] \tag{34}$$

Relegating the calculations to the Appendix, we can derive the first equation of our system, which simplifies to

$$\bar{\Pi} = \pi_s + \bar{T} - \bar{\phi} - k_s = \left[\frac{E}{n}(1-\alpha) - wk_f - k_s\right] \kappa(\zeta^*), \tag{35}$$

[11] Calculations are not reported to simplify the exposition, but are available upon request.

where

$$\kappa(\zeta^*) = 1 - \left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right). \tag{36}$$

We can see from (35) that since a higher ζ^* increases average capability, it directly increases the average joint surplus. There is, however, also a negative effect because the capabilities of rival firms are also increasing. The latter effect tends to dominate if $G(\zeta)$ has a sufficiently fat right tail so that $\kappa(\zeta^*)' < 0$, making (35) downward sloping in ζ^*.[12] The ex-ante probability of successful entry is

$$\rho_e(\zeta^*) \equiv 1 - G(\zeta^*) \tag{37}$$

Recall that both sides of the relationship make investments wk_f and k_s to enter a partnership when they have an expectation of future positive profits. Let $\bar{v}$ represent the present value of the average flow of the joint surplus:

$$\bar{v} = \frac{1}{\delta}\bar{\Pi}$$

$\bar{v}$ is also the average value of firms, which is conditional upon successful entry into an outsourcing relationship:

$$\bar{v} = \int_{\zeta^*}^{\infty} v(\zeta)\mu(\zeta)d\zeta$$

The net value of entry can be defined as

$$v_e = \rho_e\bar{v} - f_e = \frac{1 - G(\zeta^*)}{\delta}\bar{\Pi} - f_e$$

as

$$\int_0^{\infty} v(\zeta)g(\zeta)d\zeta = \int_{\zeta^*}^{\infty} \frac{1}{\delta}\Pi(\zeta)\mu(\zeta)d\zeta = \frac{[1 - G(\zeta^*)]}{\delta}\int_{\zeta^*}^{\infty} \Pi(\zeta)\mu(\zeta)d\zeta = [1 - G(\zeta^*)]\,\frac{1}{\delta}\bar{\Pi}.$$

Thus, the free entry condition yields the second equation of our system

$$\bar{\Pi} = \frac{\delta f_e}{1 - G(\zeta^*)} = \frac{\delta f_e}{\rho_e(\zeta^*)}, \tag{38}$$

which is increasing in ζ^*.

5.4 Industry Equilibrium and IPR Enforcement

The two equations (35) and (38) together with two unknowns n and ζ^* can now be explicitly solved to close the model. By equating the two equations obtained for $\bar{\Pi}$, we can solve for the number of relations (paired upstream and downstream firms), n, which is also equivalent to the number of varieties:

$$n = \frac{E\,(1 - \alpha)}{\frac{\delta f_e}{\rho_e(\zeta^*)\kappa(\zeta^*)} + wk_f + k_s}, \tag{39}$$

[12] See Melitz (2003).

where we have used definitions (36) and (37). It is easy to see that $\frac{\partial n}{\partial \zeta^*} < 0$. Replacing n from (39) in (28) gives the zero cut-off technology level in its final form and thereby the equilibrium condition:

$$\frac{\zeta^*}{\kappa(\zeta^*)\rho_e(\zeta^*)} = \frac{\gamma}{\delta f_e}. \tag{40}$$

An increase in the RHS of (40) caused by a larger γ or a lower entry cost must be accompanied by an increase in the LHS made possible by a higher ζ^* (given that $\kappa' < (\zeta^*)$ and $\rho_e'(\zeta^*) < 0$) to satisfy the equilibrium condition.

Lemma 3 *The cut-off technology level of suppliers is increasing with stronger IPR enforcement, $\frac{\partial \zeta^*(\gamma)}{\partial \gamma} > 0$, making it less likely for less technologically capable firms, which are deprived of their already low outside option, to lie within the range of technological capabilities governed by a contract.*

Proof. This follows directly from the condition (40). ■

We can therefore state the following proposition:

Proposition 1 *A more stringent IPR environment induces final producers to choose suppliers that are on average more technologically capable as outsourcing partners, i.e., $\tilde{\zeta}'(\zeta^*) > 0$.*

Proof. This follows directly from the equilibrium condition in (40) derived from (39) and (28). Differentiating average supplier capability with respect to ζ^* yields:

$$\tilde{\zeta}'(\zeta^*) = \frac{g(\zeta^*)(\tilde{\zeta} - \zeta^*)}{1 - G(\zeta^*)} > 0.$$

■

Proposition 1 has important implications. The conventional wisdom suggests that final producers tend to choose suppliers with better technologies to pair with. The results show that this is to a greater extent the case in countries with better IPR institutions: the average technology of suppliers is higher in countries with stronger IPR enforcement. A better legal environment reduces the outside option of more capable suppliers, whereas that of the less capable firms is already low. This makes suppliers with better technologies more attractive by inducing them to invest more within the contractual relationship. On the other hand, while more capable suppliers already enjoy a large outside option under weak IPR institutions, less capable ones are provided with a larger outside option enabling them to also enter into outsourcing relationships.

Our final aim is to study the impact of IPR enforcement and in turn the outsourcing decisions by multinationals on the host economy. To do this recall that consumption of the final good takes place in the North. Given that a positive share of the surplus $\omega > 0$ goes to the suppliers and is superior to the pay-off outside the relationship after exiting the market, the total profits earned from economic activities that take place in the industry can be used to measure the industry gains in the

Southern economy that arise from outsourcing relationships.[13] To do so, we multiply Equations (38) and (39) to obtain

$$n\bar{\Pi} = \frac{\delta f_e E(1-\alpha)}{[1-G(\zeta^*)]\left(\frac{\delta f_e}{\rho_e(\zeta^*)\kappa(\zeta^*)} + wk_f + k_s\right)} = \frac{E(1-\alpha)}{\frac{1}{\kappa(\zeta^*)} + \frac{\rho_e(\zeta^*)(wk_f+k_s)}{\delta f_e}}, \tag{41}$$

where we have used the definition for $\rho_e(\zeta^*)$ from (37).[14] Equation (41) immediately reveals that the impact of an upward shift in ζ^* that occurs due to strengthening IPR enforcement is ambiguous and depends on the technology distribution. Since $\kappa'(\zeta^*) < 0$ and $\rho_e'(\zeta^*) < 0$, we observe two effects. The positive effect is due to an increase in the profits of the remaining more technologically capable suppliers in the *intensive margin* brought about by reduced competition, a lower $\rho_e(\zeta^*)$. This occurs as a consequence of protection against the entry of more firms into the market. The negative effect appears due to lower supplier profits on the *extensive margin* that come from a reduced number of active firms in the industry due to stronger rivals in the market, a lower $\kappa(\zeta^*)$.[15]

Proposition 2 *Given $\zeta^{*\prime}(\gamma) > 0$ and $\kappa'(\zeta^*) < 0$, the impact of strengthening IPR enforcement on the host economy is twofold: reduced competition increases the average profits of the remaining more technologically capable firms in the intensive margin, while a reduction in the absolute number of firms on the extensive margin lowers total industry profits.*

Proof. This follows directly from Lemmas 2 and 3, Equations (40) and (41), and the definition of $\kappa(\zeta^*)$ in (36). That is, the derivative of (41) with respect to ζ^* is:

$$\frac{d(n\bar{\Pi}_s)}{d\zeta^*} = \frac{E(1-\alpha)\left[\frac{\kappa'(\zeta^*)}{\kappa(\zeta^*)^2} - \frac{\rho_e'(\zeta^*)(wk_f+k_s)}{\delta f_e}\right]}{\left(\frac{1}{\kappa(\zeta^*)} + \frac{\rho_e(\zeta^*)(wk_f+k_s)}{\delta f_e}\right)^2}. \tag{42}$$

The effect of an increase in ζ^* on aggregate industry profits depends on the sign of $\frac{\kappa'(\zeta^*)}{\kappa(\zeta^*)^2} - \frac{\rho_e'(\zeta^*)}{\delta} \lesseqgtr 0$. We know that $\kappa'(\zeta^*) < 0$ and $\rho_e'(\zeta^*) < 0$. ■

Proposition 2 underlines the significance of IPR enforcement in the home economy. A more technologically capable intermediate sector in the South brought about by better IPR enforcement is expected to have an ambiguous impact on the home economy. More lagged economies that are represented by a fat right tail distribution, where $\kappa'(\zeta^*) < 0$ is large and $\rho_e'(\zeta^*) < 0$ small, are expected to be affected negatively by an improvement in IPR institutions. In this case, losses from facing tougher rivals assume a larger weight and the lack of sufficient benefits in the intensive margin makes a shrinking upstream sector decisively detrimental to the economy.

[13] While condition $L_N = wk_f$ can be used to determine consumption in the North, labor in the South used to produce the intermediate goods in the industry under study is equal to $L_S = n(\bar{x} + \bar{I} + k_s)$. This is however irrelevant for our purpose of studying the gains from outsourcing relations in the South.

[14] This is equivalent to replacing the number of firms in (35) with its equilibrium value from (39) and then multiplying the two equations.

[15] The negative effect, however, disappears in more advanced economies with a large distribution of suppliers with better technologies, where $\kappa'(\zeta^*) > 0$.

Proposition 3 *Given the shape of the distribution function in $\kappa(\zeta^*)$ and $\rho_e(\zeta^*)$, an economy where the distribution of technology leans towards less technologically endowed suppliers is more likely to lose from IPR enforcement. This is due to a smaller positive effect of a change in ζ^* on aggregate profits in the intensive margin and a larger negative effect on the extensive margin.*

Proof. This follows directly from Equation (41) and properties of the technology distribution function in (37) and (36). Looking back at the derivative of (41) with respect to ζ^* in (42), and recalling $\kappa'(\zeta^*) < 0$ and $\rho_e'(\zeta^*) < 0$, the technology distribution in the economy determines the size of each derivative. A poor distribution of technology, i.e. a fat right tail distribution of suppliers, implies a larger $\kappa'(\zeta^*) < 0$ and a smaller $\rho_e'(\zeta^*)$, making it more likely for the expression to be negative. ■

Proposition 3 states that IPR enforcement in technologically lagged economies is more likely to have a negative effect on the upstream supplier market given the attributes of their relationships with downstream multinational firms. Gains from reduced competition in the *intensive margin* are not sufficient to compensate for losses on the *extensive margin* brought about by the exit of less capable suppliers. In such economies, less strict IPR enforcement generates a larger outside option for suppliers and creates gain by allowing more suppliers to operate in the economy and benefit from links to multinational firms.

5.5 Robustness to Alternative Explanations

The results obtained from this framework are robust to several parallel studies in the international trade and IPR literature and can be put into different contexts. To name a few we put our findings next to theory and evidence derived under the topic of imitation, technological complexity, and spillovers.

In the context of imitation, it was mentioned that more capable suppliers have a larger outside option and therefore pose a bigger threat in a contractual relationship. In a weak IPR environment, they are not obliged to respect the rules of the contract and can use their capability to defect and operate outside the relationship. This is parallel to imitation under a weak IPR regime, where licensing contracts are not respected and the licensees defect and use the acquired technology for their own purposes. Arora and Merges (2004) is among a number of papers under this branch of the literature that show how IPR protection may encourage investments in specialized firms with strong capabilities in the area of innovative input supply. IPRs can therefore play a role in determining the location of firm boundaries. This is consistent with evidence by Anand and Khanna (2000) in a study of 1,612 licensing agreements using data from the Strategic Alliance database of the Securities Data Company.

Moving to technological complexity, Acemoglu, Antràs and Helpman (2007) provide a theory to show that contract enforcement stimulates the adoption of more complex technologies through the firms' choice of suppliers. In a similar context, by using French firm-level data Naghavi, at al. (2014) provide evidence that firms outsource more complex technologies to countries that ensure stronger IPR protection. Our work can also be related to this context. Here, we show that stronger IPR enforcement shifts multinationals to form outsourcing relationships with suppliers endowed with better technologies by reducing the probability of defection.

Spillovers are another channel through which linkages between multinationals and local suppliers in a host country create benefits for both sides. Strong linkages with such firms have been associated with fostering production efficiency, productivity growth, and technological or managerial capabilities in supplier firms. Local suppliers therefore self-select into production for multinational firms. In particular Carluccio and Fally (2013) provide a theory that sheds light on how vertical spillovers from foreign firms can generate technology transfer and improve the productivity of upstream firms in the domestic industry. This is in line with evidence collected in an empirical survey by Alfaro and Rodriguez-Clare (2004) on manufacturing firms in Chile, Mexico, Venezuela and Brazil that are distinguished by sector and ownership. Our framework can be compared to this argument as strong IPR enforcement here also increases average technological capability in the supply chain. The channel is however different here as this is made possible by excluding the less capable suppliers from outsourcing relationships. In our framework, the previous findings are made possible through stronger IPR institutions.

6 Conclusion

This paper introduces supplier heterogeneity in the literature on firm organization in order to study the selection mechanism through which multinationals outsource to suppliers. Doing so allows us to study this decision under different IPR environments and highlights the impact of the latter on the host economy. In particular, we study suppliers that are heterogeneous in terms of their ability to make relationship-specific investments to customize the input according to standards required by the multinationals. Suppliers of high value-added and sophisticated products and services are in a better position to benefit from such partnerships than those with simpler processes. They also have a greater scope for exploiting their technological and organizational capabilities outside the outsourcing contracts.

In this setting multinationals provide suppliers with assistance in raising suppliers' technological capabilities and competitiveness to ensure that the inputs procured meet their stringent technical requirements. The extent of the technology transfer depends on the host economy and the level of development of local firms. Higher customization costs, less technologically endowed suppliers, and a weak IPR regime in the host country all increase the required amount of investment by the supplier. A multinational only offers such support when the investment can be expected to yield a reasonable return. They are more likely to source to domestic suppliers when the technological and managerial gaps between them and their local suppliers are not too wide to minimize training and technology transfer costs. In other words, when potential suppliers lack the minimum base of skills and know-how needed to absorb technologies and management practices, it becomes too costly for multinationals to transfer technology and train suppliers to match the required international standards. In countries with less adequate enforcement of IPRs, a higher outside option granted to less capable suppliers enables them to also operate in the customization of inputs and supplying parts to multinationals. Better IPR enforcement diverts attention along with the opportunity to obtain the necessary technical assistance and know-how towards a limited number of first-tier suppliers with relatively better technologies. This is because a better IPR environment reduces the excessive outside option of more technologically capable firms inducing them to invest more within the contractual relationship.

The subsequent elimination of less capable suppliers and an enhancement of the average R&D capability of the supply market also has numerous impacts on the host country. We find that better IPR enforcement has an ambiguous effect on the economy. Reduced competition increases the average profits in the industry in the intensive margin, whereas exit by less capable firms reduces aggregate profits on the extensive margin. Strict IPR enforcement can harm economies not endowed with a favorable distribution of technological capabilities. When a substantial mass of suppliers in the economy are on the low technology side, better IPR enforcement reduces intensive margin gains from lower competition, while increasing the extensive margin losses from a lower number of firms. Our results shed light on why IPR enforcement is given more importance in technologically advanced economies and continues to be neglected in countries such as China, which regardless enjoys an ever increasing share of outsourcing relationships worldwide. We also hope this study can motivate the challenging task of collecting firm-level data that contains information regarding suppliers, in order to make possible a more in-depth analysis of outsourcing relationships between multinationals and subcontractors of different characteristics and attributes.

Appendix

The difference between the average transfer and average investment can be solved and is

$$\bar{T}-\bar{I}=-\hat{\omega}_f\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right].$$

Average net profits can be written in terms of ζ^*:

$$\begin{aligned}
\bar{\Pi}_s &= \pi_s+\bar{T}-\bar{\phi}-k_s=\hat{\omega}_f\left\{\frac{E}{n}(1-\alpha)-\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right]\right\}-k_s \\
&= \left(1-\frac{wk_f}{\frac{E}{n}(1-\alpha)-\bar{\phi}}\right)\left\{\frac{E}{n}(1-\alpha)-\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right]\right\}-k_s \\
&= \left(1-\frac{wk_f}{\frac{E}{n}(1-\alpha)-\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right]}\right) \\
&\quad *\left\{\frac{E}{n}(1-\alpha)-\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right]\right\}-k_s \\
&= \frac{E}{n}(1-\alpha)-\left(\frac{\zeta^*}{\tilde{\zeta}(\zeta^*)}\right)\left[\frac{E}{n}(1-\alpha)-wk_f-k_s\right]-wk_f-ks
\end{aligned}$$

where we have substituted for $\hat{\omega}_f$ from (30) and for $\bar{\phi}$ from (33).

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