Trade Liberalisation and Vertical Integration*

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June 2, 2016

Abstract

We build a three-country model of international trade in final goods and intermediate inputs and study the relation between four different types of trade liberalisation and vertical integration. Firms are heterogeneous with respect to both productivity and factor (headquarter) intensity. Final-good producers face decisions on exporting, vertical integration of intermediate-input production, and whether the intermediate-input production should be offshored to a low-wage country. We find that the fractions of final-good producers that pursue either vertical integration, offshoring, or exporting are all increasing when intermediate-input trade or final-goods trade is liberalised. Finally, we provide guidance for testing the open-economy property rights theory of the firm using firm-level data and surprisingly show that the relationship between factor (headquarter) intensity and the likelihood of vertical integration is nonmonotone.

Keywords: International Trade; Firm Heterogeneity; Incomplete Contracts; Vertical Integration; Offshoring; Exporting

JEL Classifications: D23; F12; F61; L23

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1 Introduction

We develop a three-country model of trade in final goods and intermediate inputs in order to investigate the relation between vertical integration and liberalisations of international trade in final goods and intermediate inputs. The relationships between final-good producers and intermediate-input suppliers are characterised by incomplete contracts. Final-good producers face a joint decision on the three activities: vertical integration, offshoring, and exporting.[1] Our analysis of these three activities is partly motivated by the observation that almost half of U.S. imports is made up by intra-firm imports (Díez, 2014). A clear understanding of vertical integration and its relation to trade liberalisation may therefore be important for understanding importing and offshoring. Moreover, recent evidence indicates that the decisions to import and export are mutually dependent. More on this later.

The model is characterised by firm-level complementarities between the three activities: vertical integration, offshoring, and exporting, in the sense that undertaking one of these activities raises the gains from undertaking the others. The complementarities arise naturally under standard assumptions. Our main contribution is to derive a series of strong results that illustrate how these complementarities have clear implications for the industry composition. In particular, we find that the fractions of final-good producers that pursue either vertical integration, offshoring, or exporting—i.e., the prevalences of the three activities—are all increasing when intermediate-input or final-goods trade is liberalised. Meanwhile, one observes individual firms shifting away from either vertical integration, offshoring, or exporting when trade is liberalised. This observation is compatible with rising prevalences of the three activities because some low-productivity firms, which do not undertake any of the three activities, endogenously shut down due to fiercer competition induced by trade liberalisation.

These main findings relate to the ongoing discussion about the relationship between trade liberalisation, or more generally competition, and vertical integration. While elements of the popular press and the studies by McLaren (2000) and Antràs and Helpman (2004) (henceforth AH) have accentuated a negative relation between trade liberalisation and vertical integration, other contributions like Grossman and Helpman (2004), Ornelas and Turner (2008),

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[1]We define vertical integration (outsourcing) as the acquisition of an intermediate input from an affiliated (unaffiliated) supplier. Offshoring refers to the phenomenon that production of this intermediate input takes place in the low-wage South.

Conconi et al. (2012), and Díez (2014) have shown that the relationship between trade liberalisation and vertical integration is ambiguous in general. In relation to this, Grossman and Helpman (2002), Aghion et al. (2006), and Acemoglu et al. (2010) show that the relation between competition and vertical integration is ambiguous in general. This paper relates to all these studies by unveiling a clear positive relationship between four different types of trade liberalisation and the prevalence of vertical integration. We also show that this finding at the industry level is compatible with reverse movements at lower levels of aggregation. On the one hand, some firms shift away from vertical integration in the wake of trade liberalisation since the induced increase in competition makes it more difficult to cover the higher fixed costs of vertical integration. This relates to the recent work by Alfaro et al. (2016) who find a negative firm-level relation between trade liberalisation and vertical integration. On the other hand, the fraction of firms undertaking vertical integration domestically decreases when intermediate-input trade is liberalised.

Our model builds on the two prominent models of international trade by Melitz (2003) and AH. In fact, we provide a synthesis of these two models. In an important and simplifying departure from AH, we accentuate a natural complementarity between the activities vertical integration and offshoring.[2] In addition, our model serves as a natural extension of AH. First, the trade-offs governing the integration and offshoring decisions in AH, which does not include a possibility of exporting final goods, can reasonably be expected to depend on the export activity we introduce. One reason is a complementarity between the activities offshoring and exporting for which Amiti and Davis (2012), Bas (2012), and Kasahara and Lapham (2013) provide tentative evidence.[3] Another reason is that the export decision partly determines the scale of the firm which is likely to affect the decision to vertically integrate.[4] Consistent with these speculations, Kohler and Smolka (2011) note that Spanish exporters are more likely than nonexporters to pursue vertical integration and offshoring.

Second, and more importantly, we extend the AH model to allow firms

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[2]The underlying forces behind this complementarity are present in AH but are obscured by the desire to generate a rich equilibrium sorting pattern.

[3]Bernard et al. (2012) note that across U.S. industries, there is a positive correlation (0.87 and significant) between the fraction of exporters and the fraction of offshoring firms.

[4]Acemoglu et al. (2010) note that vertically integrated firms are larger than non-integrated firms.

within the same industry to be heterogeneous with respect to headquarter intensity as well as productivity. Headquarter intensity refers to the elasticity of output with respect to headquarter services which are one input into production. Allowing for within-industry heterogeneity in headquarter intensity is a direct modelling response to the empirical findings of for instance Corcos et al. (2013). These authors reveal that factor intensities like capital and skill intensity—commonly used empirical proxies for headquarter intensity, cf. Antràs (2014)—exhibit considerable variation across firms within narrowly defined industries. In fact, these authors reveal that the capital and skill intensities of production exhibit much more variation within than across French industries.[5] Moreover, Corcos et al. (2013) show that firm-level capital and skill intensities are important determinants of the decision to vertically integrate since the probability of intra-firm importing of intermediate inputs increases in these firm-level intensities conditional on firm productivity and importing. These new empirical observations indicate a need for extending the influential open-economy property rights theory of the firm, pioneered by Antràs (2003) and AH and building on the work of Grossman and Hart (1986), to include firm-specific headquarter intensities. Our contribution is a first attempt in this regard. As mentioned by Corcos et al. (2013) and Antràs (2014), this extension should make the open-economy property rights model more suitable for future analyses based on the firm-level sourcing data which are starting to appear.[6]

An interesting and reassuring aspect of our model is that the sorting of firms into activities based on productivity and headquarter intensity is consistent with two key empirical findings of Corcos et al. (2013) when the trade cost adjusted wage difference across countries is not too big. However, we also illustrate that one has to be very careful when applying a conventional intuition about the relation between headquarter intensity and vertical integration, known from Grossman and Hart (1986), to a firm-level analysis

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[5]More than eighty percent of the total standard deviation of capital and skill intensity comes from within-industry variation as opposed to between-industry variation. Bernard et al. (2003) also argue that industry is a poor indicator of firm factor intensity. Within-industry variation in factor intensity is even more pronounced than within-industry variation in productivity (Corcos et al., 2013).

[6]Empirical tests of the open-economy property rights theory of the firm have broadly provided empirical support to the model but mostly been based on industry-level data on intra-firm trade; see e.g. Yeaple (2006), Nunn and Trefler (2013), and the survey by Antràs (2014).

in an open-economy context. For instance, we reveal that the likelihood of choosing intra-firm importing or vertical integration may not, as previously thought, increase in headquarter intensity since the decision to vertically integrate interacts with the potential cost savings from offshoring. These are also affected by headquarter intensity and importantly also by the levels of trade costs relevant for offshoring. This important finding leads to a second connection between trade liberalisation and vertical integration. Furthermore, our findings clearly illustrate the importance of deriving firm-level predictions from scratch. Starting from scratch is important since the traditional positive industry-level relation between headquarter intensity and intra-firm importing, known from AH, is shown to be potentially misleading when it comes to theoretically guiding an empirical analysis at the firm level.

Despite the apparent complexity of our model, it remains surprisingly tractable. The main reason is the firm-level complementarities inherent in our model. Drawing on the analyses of Mrazova and Neary (2016) and Bache and Laugesen (2015), these complementarities allow us to keep track of both the sorting of firms into activities as well as comparative statics. Our paper relates to the recent strand of literature which applies the monotone comparative statics techniques of Topkis (1978) to international trade. This literature comprises contributions by e.g. Costinot (2007), Costinot (2009), and Mrazova and Neary (2016). We relate to Costinot (2007) by also using monotone comparative statics techniques to analyse the AH model. However, our methods and the variables of interest differ substantially. Our paper also relates to Díez (2014) who shows asymmetric effects of tariffs on intra-firm trade in a slightly extended AH model where offshoring occurs through assembly in the low-wage South. One key finding of Díez (2014) is that the industry-level effects of trade liberalisation on intra-firm trade and vertical integration depend on the type of trade liberalisation. Our analysis differs from the one in Díez (2014) for instance because we focus on very different tariffs and allow for firm-specific headquarter intensities. Finally, our model is related to Defever and Toubal (2013) who analyse sorting in a simplified Antràs and Helpman (2008) model where productivity and the intensity of relationship specific inputs vary across firms.

The paper is structured as follows. Section 2 presents the model and describes the inherent complementarities at the firm level. Section 3 presents comparative statics at the industry and firm levels of analysis. Section 4 focuses on the cross-section of firms in a given equilibrium. This section provides guidance for testing the open-economy property rights theory of

the firm using firm-level data and surprisingly reveals that the likelihood of choosing vertical integration may not increase in headquarter intensity. Section 5 discusses robustness. Finally, Section 6 concludes.

2 Model

We build a three-country heterogeneous-firms trade model with two symmetric northern (N) countries that interact through intra-industry trade in differentiated final goods.[7] In addition to a differentiated-goods industry, which is monopolistically competitive, each northern country contains a perfectly-competitive homogeneous-good industry. Our analysis shall focus on the former. The third country is South (S) which does neither demand nor produce differentiated goods.[8] While South also has a perfectly-competitive industry producing the homogeneous good, South basically serves as a possible production site for intermediate inputs to production. Offshoring denotes the phenomenon that a northern final-good producer decides to let its production of intermediate inputs take place in South. The attraction of producing in South is its perfectly elastic supply of labour at the relatively low wage, w_S. The northern wage is normalised to unity, $w_N = 1$, such that $w_S < 1$ is also the relative wage. In equilibrium, this wage gap between North and South is justified by a difference in labour productivity in the production of the freely-traded homogeneous good, q_0, which is produced and consumed in all three countries. Labour is the only factor of production.

The preferences of the representative consumer in each N country are represented by the utility function,

$$U = q_0 + \log \left[\int_{i \in \omega} q(i)^\alpha \, \mathrm{d}i \right]^{1/\alpha}, \quad 0 < \alpha < 1,$$

where $q(i)$ denotes the quantity consumed of variety i of the differentiated goods. Each final-good producer produces a single unique variety and ω denotes the endogenous measure of available varieties. Demand for variety i is given by the demand function,

$$q(i) = Ap(i)^{-\sigma},$$

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[7] As mentioned, our model effectively merges the models of Melitz (2003) and AH.

[8] To our knowledge, the idea of a North-North-South three-country setup owes to Yeaple (2003).

where $p(i)$ is the price, $\sigma = 1/(1-\alpha)$, and the demand level, $A > 0$, is taken as given by firms while being endogenous in the aggregate.

2.1 Firm Entry

Prospective final-good producers in N pay f_E units of local labour in order to enter the monopolistically-competitive industry and to draw a productivity, θ, from a known Pareto distribution with c.d.f. $F(\theta)$. Simultaneously with the realisation of θ, firms also realise their idiosyncratic characteristic η which also affects their technology of production.[9] We refer to η by the term headquarter intensity. η is independently distributed from θ according to the c.d.f. $G(\eta)$ which is strictly increasing on its domain, $\eta \in (0,1)$.[10] All distributional assumptions on $F(\theta)$ and $G(\eta)$ are completely redundant during the firm-level analysis in Section 4.

Upon the realisation of (θ, η), final-good producers make their optimal decisions, klx, where $k \in \{O, V\}, l \in \{N, S\}, x \in \{D, X\}$, or exit the industry. The decision comprises three sub-decisions or activities. First, a make-or-buy decision concerning procurement of an intermediate input, m. This determines the ownership structure, k, which can be either vertical integration (henceforth integration), V, or outsourcing, O. Second, an offshoring decision concerning the location of the production of the intermediate input. Through offshoring, the input m may be produced in S and used in final-good production in N. This determines $l \in \{N, S\}$ where $l = S$ under offshoring and $l = N$ otherwise. Because of (unmodelled) trade costs, the intermediate input will never be shipped between northern countries in equilibrium. Third, we have a decision about exporting of final goods. The export status, x, can either be X for exporter or D for nonexporter or domestic firm. If no choice of klx entails positive profits, the firm exits the industry and forfeits its cost of entry.

2.2 Production

Production of final-good variety i is given by

$$q(i) = \theta(i)\zeta(i)h(i)^{\eta(i)}m(i)^{1-\eta(i)}, \tag{1}$$

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[9]The idea of multi-dimensional firm heterogeneity in formal models of international trade goes back to the working paper versions of Hallak and Sivadasan (2013).

[10]One can dispense with a strictly increasing $G(\eta)$ at the cost of some slightly weaker propositions. We discuss how various assumptions can be relaxed in Section 5.

where $\zeta(i) \equiv \eta(i)^{-\eta(i)}(1 - \eta(i))^{-(1-\eta(i))}$. $h(i)$ and $m(i)$ denote investments in headquarter services and the intermediate input, respectively.[11] In the following, we focus attention to a given final-good variety and drop the index i. Investments in headquarter services, h, are undertaken by the particular final-good producer (a principal), H, itself. Investments in intermediate inputs, m, are undertaken by an intermediate-input supplier (an agent), M. Due to a perfectly elastic supply of homogeneous M in all countries, matching is always unproblematic for H. One unit of either input, h or m, is produced from one unit of local labour in the country of its production. In contrast to m, h can only be produced in the N country where H entered.

Trade in both final goods and intermediate inputs is costly. Iceberg costs of international final-goods trade are $\tau > 1$. We include the intermediate-input iceberg trade costs, $\tau_m > 1$, in w_S such that $w_S \equiv \tilde{w}_S \tau_m < 1$ where $\tilde{w}_S < 1$ is the relative southern wage net of trade costs that we pin down by the homogeneous good, q_0. During the comparative statics, we will investigate the effects of a change in the trade cost adjusted relative wage rate, w_S. It is irrelevant whether $\tilde{w}_S$ or τ_m is the source of change. A liberalisation of intermediate-input trade through a decrease in τ_m decreases w_S. An increase in the relative labour productivity of South, when it comes to q_0, increases w_S via an increase in $\tilde{w}_S$. Finally, production implies fixed costs, f_{klx}, where

$$f_{klx} = f_k + \mathbb{1}_S(l)f_S + \mathbb{1}_X(x)f_X. \tag{2}$$

The assumption $0 < f_O < f_V$ has been used extensively in the previous literature ranging from Grossman and Helpman (2002) and AH to Antràs and Chor (2013) and we simply follow suit. $\mathbb{1}_S(l)$ and $\mathbb{1}_X(x)$ are indicator functions for offshoring and exporting, respectively.[12] As in Amiti and Davis (2012), offshoring and exporting both imply discrete and separable increases in fixed costs since $f_S, f_X > 0$.[13] All fixed costs are denominated in northern labour.

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[11] Following AH, we use the term headquarter intensity for $\eta(i)$ since $\frac{\partial q(i)}{\partial h(i)} \frac{h(i)}{q(i)} = \eta(i)$. Skill, R&D, capital, and advertisement intensities have earlier been used as empirical proxies for $\eta(i)$.

[12] That is, $\mathbb{1}_S(S) = \mathbb{1}_X(X) = 1$ and $\mathbb{1}_S(N) = \mathbb{1}_X(D) = 0$.

[13] While the assumed linearity in (2) is overly restrictive, it simplifies the notation. For all results, it suffices that f_{klx} is increasing in the integration, offshoring, and exporting activities, and, furthermore, f_{klx} is submodular in the same three activities. Kohler and Smolka (2014) conclude that their results provide empirical support for the assumptions that fixed costs are higher under integration relative to outsourcing and under offshoring relative to nonoffshoring.

2.3 The Decision

Under exporting, the final-good production is distributed across the two northern markets. The final-good producer, H, faces the following problem of maximising total revenue for a given level of production,

$$R(\theta, \eta, h, m, x; A) = \max_{q_D, q_X} A^{1/\sigma} \left[q_D^\alpha + \mathbb{1}_X(x) \left(q_X/\tau \right)^\alpha \right]$$

$$\text{s.t.} \quad q_D + q_X \leq \theta \zeta h^\eta m^{1-\eta},$$

where q_D and q_X denote the quantities produced for, respectively, the domestic and the export markets when only q_X/τ units of final goods arrive for sale on the export market. The optimal allocation entails a revenue of

$$R(\theta, \eta, h, m, x; A) = A^{1/\sigma} \theta^\alpha h^{\alpha\eta} m^{\alpha(1-\eta)} \zeta^\alpha (1 + \tau^{1-\sigma})^{\mathbb{1}_X(x)(1-\alpha)}. \qquad (3)$$

The next step is to analyse the equilibrium investments in h and m. To this end, we impose an assumption of complete asset specificity meaning that the inputs, h and m, are completely tailored to the production of the particular variety under scrutiny and useless elsewhere. Importantly, we assume that only the decision, klx, and not the subsequent production of h and m, is contractible.[14] After klx is chosen, H and M simultaneously and noncooperatively determine their investments, h and m, while foreseeing future Nash bargaining over final-good revenue. Through a process of Nash bargaining, H reaps the fraction β_k of equilibrium revenue while M reaps the complementary fraction. Following Antràs (2003) and Antràs and Yeaple (2014), we assume that

$$\beta_V > \beta_O.$$

Integration entails more extensive property rights for H and thus improved bargaining power. Notice that β_k does not depend on l. This assumption together with the formulation of f_{klx} in (2) allow us to obtain a clear-cut complementarity between integration, offshoring, and exporting.[15] When choosing their investments in h and m, H and M foresee the fractions of

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[14] AH assume that k and l are contractible sub-decisions. We assume that parties can contract on export status as well since exports usually leave a paper trail. This trail is e.g. created from dealings with customs and shipping agencies.

[15] This approach relates to the work of Grossman et al. (2005) who emphasise an industry-level complementarity between outsourcing and offshoring in a model with a very different sorting pattern.

the revenue, (3), they will receive as a consequence of the Nash bargaining. Hence, by backwards induction, the optimal decision, klx, solves the programme,

$$\max_{k\in\{O,V\},l\in\{N,S\},x\in\{D,X\}} R(\theta,\eta,h_{klx},m_{klx},x;A) - h_{klx} - w_l m_{klx} - f_{klx} \qquad (4)$$

$$\text{s.t.} \quad h_{klx} = \arg\max_h \ \beta_k R(\theta,\eta,h,m_{klx},x;A) - h,$$

$$m_{klx} = \arg\max_m \ (1-\beta_k)R(\theta,\eta,h_{klx},m,x;A) - w_l m.$$

In (4), we have implicitly used that H extracts all rents from M through a participation fee which assures that M is left at its outside option of zero. Consequently, the decision simply maximises joint bilateral profits. By combining (3) with the Nash equilibrium input investments from the constraints in (4) and the fixed costs of production in (2), we arrive at joint bilateral profits,

$$\pi_{klx}(\Theta,\eta;A) = A\Theta\psi_k(\eta)\gamma_l(\eta)(1+\tau^{1-\sigma})^{\mathbb{1}_X(x)} - f_{klx}, \qquad (5)$$

where $\Theta = \theta^{\sigma-1}$, $\gamma_l(\eta) = w_l^{(1-\eta)(1-\sigma)}$, and

$$\psi_k(\eta) = \frac{1 - \alpha[\beta_k\eta + (1-\beta_k)(1-\eta)]}{[\frac{1}{\alpha}\beta_k^{-\eta}(1-\beta_k)^{-(1-\eta)}]^{\sigma-1}}.$$

Immediately upon entry and the realisation of (θ,η), H chooses the decision, klx, that maximises (5) given that these profits are positive. In case optimal profits,

$$\pi^*(\Theta,\eta;A) = \max_{klx} \ \pi_{klx}(\Theta,\eta;A), \qquad (6)$$

are negative, H exits the industry and forfeits the fixed cost of entry, f_E. We assume that, for all η, at least some low-productivity firms choose not to produce. In equilibrium, the following free-entry condition holds since the pool of potential entrants is unbounded.

$$f_E = \iint \max\{0, \pi^*(\Theta,\eta;A)\} \, dF(\theta) \, dG(\eta). \qquad (7)$$

The industry's demand level, A, is implicitly determined by (7) as a function of all parameters.[16]

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[16]Given the implicit restriction on the Pareto distribution of productivities that expected profits are finite, the existence and uniqueness of an equilibrium and A follow from the continuity and strict monotonicity of (6) in A, $\pi^* < 0$ when $A = 0$, $\pi^* \to \infty$ when $A \to \infty$, and the intermediate value theorem.

2.4 Input Sourcing and Headquarter Intensity

How does headquarter intensity affect the attractiveness of offshoring and integration when one takes an all else equal perspective? First, we notice that variable profits, $A\Theta\psi_k(\eta)\gamma_l(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x)}$, are always increasing in offshoring because $\gamma_S(\eta) > \gamma_N = 1$. The reason is that offshoring lowers the marginal cost of the intermediate-input production. Offshoring therefore involves a trade-off between higher fixed costs and lower marginal costs for all values of η. All else equal, the gains from offshoring are higher the smaller is η since a lower η implies that the intermediate input becomes more important in the production of the final good. Formally, $\gamma_S(\eta)/\gamma_N$ is continuous and strictly decreasing in η with $\gamma_S(\eta)/\gamma_N \to 1$ as $\eta \to 1$. We will refer to this observation as the offshoring effect.

Next, we discuss the make-or-buy decision. The equilibrium input investments in h and m are always suboptimally low compared to the perfect-contracting input investments. This holds because H and M each cover the full marginal costs of their investments while they reap only a fraction of the marginal gains from these investments; see (4). The result is that either ownership structure obtains only a fraction of the variable profits that would arise under perfect contracting. The factor $\psi_k(\eta)$ in variable profits represents the efficiency of the relationship between H and M. $\psi_k(\eta)$ depends on k since integration assigns H a larger fraction of revenue and M a smaller fraction compared to outsourcing. Thus, integration improves H's incentive to invest in h but worsens M's incentive to invest in m. Consequently, integration provides a more efficient relationship than outsourcing when η is high but a less efficient relationship than outsourcing when η is low. This is the intuition behind the following lemma from Proposition 3 and its proof in Antràs and Helpman (2008).

Lemma 1. *$\psi_V(\eta)/\psi_O(\eta)$ is continuous and strictly increasing in η. Further, there exists a unique headquarter intensity, $\eta^* \in (0,1)$, where $\psi_O(\eta^*) = \psi_V(\eta^*)$. Thus, $\eta > \eta^* \Leftrightarrow \psi_V(\eta) > \psi_O(\eta)$ and $\eta < \eta^* \Leftrightarrow \psi_V(\eta) < \psi_O(\eta)$.*

Hence, a higher η increases the relationship efficiency of integration relative to outsourcing. All else equal, the gains from integration thus increase in η. We will refer to this observation as the property-rights effect. Notice that integration only involves a trade-off between higher relationship efficiency and higher fixed costs for $\eta > \eta^*$. Thus, no firms with $\eta \leq \eta^*$ choose to integrate.

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2.5 Complementarities

As in Amiti and Davis (2012), offshoring and exporting are complementary activities. This is because exporting involves additional sales and offshoring effectively reduces the marginal cost. Higher sales are worth more when the goods are produced more cheaply and vice versa.[17] Next, consider the interaction between integration and the two other activities. Whenever integration is considered (for $\eta > \eta^*$), it is because integration lets the firms obtain a larger fraction of the variable profits that would arise under perfect contracting. Increasing this fraction through integration is worth more when variable profits are higher. This is the case under both offshoring and exporting. Formally, this follows from the observation that variable profits are scaled up by $\gamma_S(\eta) > \gamma_N = 1$ under offshoring and by $1 + \tau^{1-\sigma} > 1$ under exporting. By similar arguments, it follows that, for $\eta > \eta^*$ where $\psi_V(\eta) > \psi_O(\eta)$, the gains from undertaking offshoring and exporting are higher when a firm integrates. In total, whatever the η, the activities that firms actually consider are complementary.[18]

The three activities integration, offshoring, and exporting are not only complementary to each other, they are also complementary to productivity. Integration (for $\eta > \eta^*$) and exporting are complementary to productivity for the same reason that these activities are complementary to offshoring: lower marginal costs increase the gains from these activities. Offshoring is complementary to productivity since the isoelastic demand function means that scaling down marginal costs by a given factor, as implied by offshoring, is worth more when productivity is high.[19]

The complementarities among activities and between activities and productivity greatly simplify the equilibrium sorting of firms into activities based on productivity and headquarter intensity. Before we elaborate, we make an additional assumption. Following AH, we assume that, for all η, the least

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[17]The studies by Amiti and Davis (2012), Bas (2012), and Kasahara and Lapham (2013) provide tentative evidence for this particular complementarity.

[18]Imposing the partial ordering, $V > O$, $S > N$, and $X > D$, the complementarities follow from the profit function being supermodular in lx for $\eta \leq \eta^*$ and in klx for $\eta > \eta^*$.

[19]See Mrazova and Neary (2016) for a discussion of the complementarities between integration and productivity and offshoring and productivity in AH. The complementarity between productivity and either offshoring or exporting is seen from the profit function having increasing differences in $(l, x; \theta)$ when we use the partial ordering in footnote 18. The complementarity between productivity and integration follows from the profit function having increasing differences in $(k; \theta)$ for $\eta > \eta^*$.

productive active firms choose the decision $klx = OND$. This resonates with the empirical findings of Federico (2010), Kohler and Smolka (2011), and Antràs and Yeaple (2014) that firms with the decision OND are the least productive. This assumption, which implicitly restricts the sizes of various parameters, together with the monotonicity theorem of Topkis (1978), and the unbounded support of $F(\theta)$ gives rise to the following lemma.

Lemma 2. *For all η, there exist productivity thresholds for offshoring and exporting such that all firms with higher (lower) productivities undertake (do not undertake) that particular activity. For $\eta > \eta^*$, there exists a similar productivity threshold for integration.*

By Lemma 2, the three activities will each be associated with a productivity premium consistent with empirical studies.[20] The intuition is that the gains from either integration (for $\eta > \eta^*$), offshoring, or exporting each increase in productivity while the complementarities among these three activities further reinforce this mechanism. The sorting pattern implied by Lemma 2 contrasts the sorting pattern in AH. In AH, some firms are indifferent between VND and OSD in the benchmark headquarter-intensive industry where all firms share the same $\eta > \eta^*$. When integration and offshoring are complementary activities, this is not possible, cf. Lemma 2. It follows that, if $G(\eta)$ becomes degenerate such that all firms within the industry share the same $\eta > \eta^*$, the sorting pattern in the present model differs from the pattern in AH. This also holds if we abstract from the exporting activity.

As indicated, integration and offshoring are not complementary activities in AH. Complementarity between these two activities shrinks the maximum number of organisational forms, present in the industry equilibrium in AH, from four to three given the simplified sorting pattern implied by Lemma 2. This may be undesirable given the wide diversity in organisational forms observed by e.g. Tomiura (2007) and Kohler and Smolka (2011). However, as the discussion above makes clear, a complementarity between integration and offshoring arises quite naturally when focusing on the essence of these

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[20]There is a productivity premium associated with integration in data; see Tomiura (2007), Federico (2010), Kohler and Smolka (2011), and Antràs and Yeaple (2014). Importers of intermediate inputs are more productive than nonimporters; see Bernard et al. (2012) who also discuss the well established exporter productivity premium. For evidence on causality, see e.g. Bernard and Jensen (1999), De Loecker (2007), Fariñas and Martín-Marcos (2010), Wagner (2011), and Kohler and Smolka (2014).

two activities. In the present paper, we generate the desired diversity of observed organisational forms by letting the sorting of firms into activities differ across the different η's which are present in a given industry. This will be graphically illustrated in Section 4.

3   Comparative Static Analysis

Before the comparative statics in the centrepiece Proposition 1, we introduce one final assumption which can be waived at the cost of only slightly weaker comparative static results. We assume that for η close to 0, the productivity threshold for offshoring is lower than that for exporting, while for η close to 1, the productivity threshold for integration is lower than that for exporting. Exporting is thus sufficiently expensive. This guarantees that we will observe nonexporters which offshore and nonexporters which integrate in equilibrium.[21] Define the prevalence of a given activity as the fraction of all active firms in the industry which choose this activity.

Proposition 1. *i. Reductions in $(f_V, w_S, f_S, \tau, f_X)$ imply that the prevalences of integration, offshoring, and exporting strictly increase. ii. Reductions in (f_V, w_S, f_S, τ) imply that the prevalence of vertical FDI strictly increases.*

Proof. See Appendix A. □

Part i of Proposition 1 illustrates a strong industry-level interdependence—or, in the words of Grossman et al. (2005), industry-level complementarity—among the three activities arising from the firm-level complementarities. In general, increasing the attractiveness of any of the three activities (integration, offshoring, and exporting) makes the industry composition shift towards all three activities becoming more prevalent. These strong results may seem obvious since, for instance, trade liberalisation increases the gains from integration due to the firm-level complementarities among activities. This argument is however only a part of the full story since it holds the level of competition constant. That the results in part i of Proposition 1 are by no means trivial is illustrated below.

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[21] We explain the effects of waiving this assumption in Section 5.

Proposition 2. *Reducing the costs associated with any one of the three activities integration (f_V), offshoring (w_S, f_S), or exporting (τ, f_X) induces some firms to shift away from the other two activities.*

Proof. See Appendix B. □

Proposition 2 follows from a combination between the sorting pattern and the fact that any possible decrease in (f_V, w_S, f_S, τ, f_X) induces a decrease in the demand level, A, as explained in Appendix B. This is equivalent to an increase in the level of competition. To see how Propositions 1 and 2 are compatible, consider for instance trade liberalisation. By Proposition 2, all kinds of trade liberalisation covered by Proposition 1 imply shifts (for at least some η) towards outsourcing at the firm level. This is because the induced increase in competition tends to reduce the size of firms and thereby discourages integration for the firms which are not directly affected by the trade liberalisation, i.e., the nonoffshorers and nonexporters.[22] Such a mechanism lies behind Proposition 2. This mechanism is reminiscent of a quite similar mechanism through a post trade liberalisation price decrease in Alfaro et al. (2016). However, in our model, trade liberalisation and the induced increase in competition also forces the least productive firms, which outsource, to shut down. The Pareto distribution of productivity assures that the mass of exiting outsourcing firms is sufficient for an increasing prevalence of integration despite the firm-level shifts towards outsourcing. In other words, what the Pareto distribution assures is that the indirect effect of trade liberalisation on the prevalence of integration (via the increase in competition) does not dominate the direct increase in the gains from integration due to the firm-level complementarities among activities. Propositions 1 and 2 relate to the ongoing discussion about the relation between trade liberalisation, competition, and integration. In this strand of literature, the results vary as mentioned in the introduction. Our contribution in this regard is to unveil a clear positive relation between trade liberalisations, competition, and integration at the industry level.[23]

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[22]The complementarity between A and integration follows from the profit function having increasing differences in ($k; A$) for $\eta > \eta^*$ when we use the partial ordering in footnote 18.

[23]It can also be shown that the share of total industry revenue going to integrated firms (including integrated exporters from abroad) is decreasing in (f_V, τ, w_S). More information is available upon request.

Part i of Proposition 1 is not in accordance with a finding of AH. AH find that the prevalence of outsourcing rises when w_S decreases. This incongruity depends on the difference in sorting patterns mentioned in Section 2.5. Further, note that an increase in the relative labour productivity of South when it comes to the homogeneous good, q_0, increases w_S via an increase in $\tilde{w}_S$. The relatively recent increase in outsourcing, mentioned by for instance Helpman (2006), may thus, according to part i of Proposition 1, be due to North-South technology diffusion. The intuition is simple. Technology diffusion within the homogeneous-good industry increases w_S implying that offshoring, and hence also integration, becomes less prevalent at the industry level. Next, let us discuss part ii of Proposition 1. This result squares with the increases in the prevalences of integration and offshoring in part i of Proposition 1. Since the highest-productivity firms with $\eta > \eta^*$ undertake vertical FDI in both AH and in the present context, the prevalence of vertical FDI decreases in w_S in both models.

Proposition 2 makes it clear that the strong and positive industry-level relation between trade liberalisation and integration in Proposition 1 is not necessarily at odds with the negative firm-level relation found in the models without entry and exit by McLaren (2000) and Alfaro et al. (2016).[24] Another case in point is that the prevalence of domestic integration (the strategy VNx, $x \in \{D, X\}$) decreases as offshoring becomes more attractive when (w_S, f_S) decreases. This result, which is also proved in Appendix A, is in accordance with a finding of AH. These insights together reveal that complementarities at the firm level may manifest themselves more clearly at higher levels of aggregation during comparative statics.

4   Cross-Sectional Analysis

We start by showing that the sorting of firms into activities is consistent with two key empirical findings of Corcos et al. (2013) when the trade cost adjusted North-South wage gap is not too big (w_S is not too small). These

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[24]Industry- and firm-level predictions often point in different directions in trade models with entry and exit. Take for instance an increase in market size in the closed-economy Melitz and Ottaviano (2008) model. This implies that all firms strictly reduce their percentage markups. However, the equilibrium distribution of percentage markups across firms, and hence also the average markup, is constant when productivities are Pareto distributed.

authors use French firm-level import data to investigate the determinants of the choice between intra-firm and arm's-length importing of intermediate inputs. First, they show that, conditional on firm-level headquarter intensity (proxied by capital and skill intensity) and offshoring, higher firm-level productivity makes intra-firm importing, i.e, vertical integration and vertical FDI, more likely relative to arm's-length importing. Second, they show that, conditional on firm-level productivity and offshoring, higher firm-level headquarter intensity makes intra-firm importing more likely relative to arm's-length importing. Corcos et al. (2013) interpret these two empirical results as firm-level support for the key predictions of the open-economy property rights theory of the firm concerning intra-firm importing.

The first empirical finding of Corcos et al. (2013) squares perfectly with the threshold rule described in Lemma 2 and the implied sorting pattern in the productivity dimension: as earlier mentioned, vertical FDI will be undertaken by the most productive firms with $\eta > \eta^*$. This is also in line with the empirical evidence in Tomiura (2007), Federico (2010), Kohler and Smolka (2011), and Antràs and Yeaple (2014).

The compliance of our model with their second empirical finding is more subtle as we show below.

Proposition 3. *i. Among offshoring firms with the same θ, we may observe that one firm outsources while having a higher η than another firm that integrates. ii. Among integrating firms with the same θ, we may observe that one firm undertakes offshoring while having a higher η than another firm that does not undertake offshoring.*

Proof. See text and Figures 1 and 2 below. □

To understand part i of Proposition 3, consider first the choice of integration conditional on offshoring. By Lemma 1, a higher η increases the relationship efficiency of integration relative to outsourcing which works in favour of intra-firm importing. The size of this property-rights effect depends on the difference between β_V and β_O: the property-rights effect attenuates when the difference between β_V and β_O becomes smaller. This is because the ownership structure k becomes less important. Importantly however, a higher η also decreases the attractiveness of offshoring through a decrease in $\gamma_S(\eta)/\gamma_N$ which indirectly reduces the incentive to integrate via the complementarity between integration and offshoring. If this offshoring effect is sufficiently strong relative to the property-rights effect, it is indeed possible that

a higher η means that firms with a given productivity shift from intra-firm importing to arm's-length importing of intermediate inputs.[25] Technically, the reason behind part i of Proposition 3 is that the productivity threshold for integration may be increasing in η for some η's when this threshold lies above the threshold for offshoring. We illustrate this later.

Notice that the offshoring effect is smaller when the (trade cost adjusted) North-South wage gap, $1 - w_S$, decreases due to technological catchup in the South or a higher τ_m. In this case, $\gamma_S(\eta)/\gamma_N$ becomes less decreasing in η meaning that the offshoring effect is less likely to dominate the property-rights effect. Hence, the sorting pattern in our model is more likely to resonate perfectly with the second empirical finding of Corcos et al. (2013)—and standard theoretical reasoning based on the closed-economy model by Grossman and Hart (1986)—when the North-South wage gap is small relative to the difference between β_V and β_O. Part ii of Proposition 3 is also based on the interplay between the property-rights and the offshoring effects. If the property-rights effect is sufficiently strong relative to the offshoring effect, the possibility in part ii of Proposition 3 occurs.[26] This possibility is less likely to occur when the North-South wage gap increases and $\beta_V - \beta_O$ decreases since this strengthens the offshoring effect and attenuates the property rights effect. Notice that the possibility in part ii of Proposition 3 is less likely to occur when the possibility in part i of Proposition 3 is most likely to occur and vice versa.

To formally prove Proposition 3, let us consider an example where τ tends to infinity. This simplification, which makes Proposition 3 easier to visualise graphically, implies that the analysis becomes qualitatively similar to the analysis of a two-country North-South model where firms decide on kl. Thus, this example essentially analyses the AH model with within-industry heterogeneity in η and a complementarity between integration and offshoring. Alternatively one could analyse the present three-country model with no fixed cost of exporting (such that all firms export), or one could simply remove the exporting activity from the choice set of firms.[27] The analysis would be

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[25]This finding is at variance with theoretical prediction 1 in Corcos et al. (2013) since these authors do not emphasise the offshoring effect and its implications for the likelihood of integration.

[26]Technically, the reason is that the productivity threshold for offshoring may be decreasing in η for some η's when this threshold lies above the productivity threshold for integration.

[27]Section 5 will argue that the allowance for exporting and several other assumptions

qualitatively similar. The various areas in Figures 1 and 2 provide us with the pairs (η, θ) where a given decision klx is chosen. Demarcation lines are given by productivity thresholds. The parameter values and productivity thresholds behind Figures 1 and 2 are given in Appendix C.
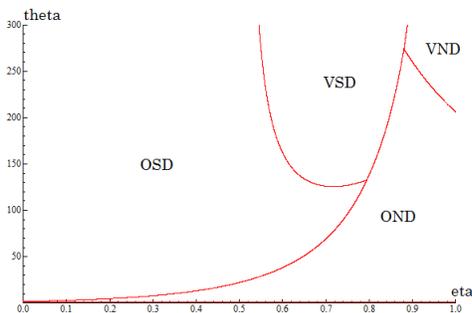

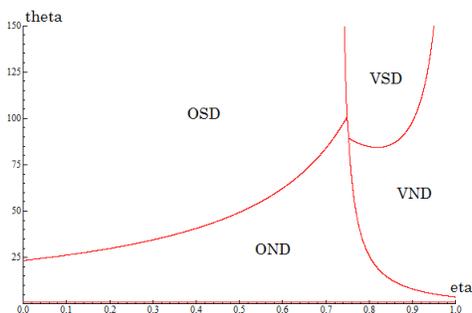Figure 1: Plot in the (η, θ) space. $\beta_V = 0.51$, $\beta_O = 0.50$, and $w_S = 0.3$.

Figure 2: Plot in the (η, θ) space. $\beta_V = 0.85$, $\beta_O = 0.50$, and $w_S = 0.95$.

Figure 1 illustrates part i of Proposition 3. Let us emphasise that the North-South wage gap is relatively large and the difference between β_V and β_O is relatively small. In Figure 1, part i of Proposition 3 follows from the observation that the productivity threshold between OSD and VSD is nonmonotonic and not at least upward-sloping for some η's. Figure 2 illustrates part ii of Proposition 3. Now, the North-South wage gap is relatively small and the difference between β_V and β_O is relatively large. Part ii of Proposition 3 follows from the observation that the productivity threshold between VND and VSD is nonmonotonic and not at least downward-sloping for some η's.[28] We emphasise that Proposition 3 only presents possibilities

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are superfluous for the propositions of the present section.

[28]Note that Figure 2 is in line with the two empirical findings of Corcos et al. (2013)

which may or may not occur depending on parameter values. We accentuate these possibilities because analysis based on many different calibrations of the model (not shown) reveals that these possibilities cannot be neglected. This holds not at least because the empirical distribution of (η, θ) across firms is unknown implying that the two possibilities in Proposition 3 could be important for many firms. Anyway, both possibilities are also easily avoided.[29] Next, we present a proposition which holds regardless of parameter values.

Proposition 4. *Over an interval of η, either the productivity threshold for offshoring is decreasing in η or the productivity threshold for integration is increasing in η.*

Proposition 4 is also illustrated in Figures 1 and 2. The proposition follows since the productivity threshold between ONx_1 and VSx_2, $x_1, x_2 \in \{D, X\}$, always is relevant for an interval of η. This is formally shown and used in Appendix A.[30] The threshold productivity level between ONx_1 and VSx_2 comprises the threshold productivities for both integration and offshoring. When η increases, this threshold is affected both via the property-rights effect and via the offshoring effect. Only in the impossible case, where this threshold is constant in η, we do not have the result in Proposition 4. In Figures 1 and 2, the threshold productivity levels between OND and VSD are increasing and decreasing in η, respectively. This implies that, in Figure 1, the productivity threshold for integration, Θ_V, is increasing in η. In Figure 2, the productivity threshold for offshoring, Θ_S, is decreasing in η. Moreover, these observations also hold for the parts of Figures 1 and 2 that we used to prove Proposition 3. These observations illustrate Proposition 4 and, importantly, provide additional reasons why (for a given θ) the likelihood of integration and offshoring may decrease and increase in η, respectively.

Propositions 3 and 4 together reveal that one has to be very careful when applying the industry-level results of AH about the relationships between η and integration and η and offshoring to the firm level of analysis. Like in Section 3, the results vary across levels of analysis. This is made further clear from the following industry-level proposition, where part i resembles a result

mentioned in the beginning of Section 4.

[29] The possibilities become much harder to avoid when one allows the least productive active firms with some η's to choose other decisions than $klx = OND$.

[30] If this is not the case, some firms in Figures 1 and 2 would be indifferent between the strategies OSD and VND. This cannot hold under Lemma 2. Note also that $x_2 \geq x_1$ (using the partial ordering in footnote 18) which follows from Lemma 2.

from an across-industry analysis in AH, and where part ii can be perceived as symmetrical to part i.

Proposition 5. *i. Among offshoring firms with the same η, the fraction that integrate increases in η. ii. Among integrating firms with the same $\eta > \eta^*$, the fraction that offshore production decreases in η.*

Proof. See Appendix E. □

The analysis above has shown that the macro environments and the sizes of e.g. τ_m, β_V, and β_O are decisive for the sorting pattern as Figures 1 and 2 illustrate. The identities of both the North and the South thus matter for empirical testing. Interestingly, Kohler and Smolka (2011) reveal that offshoring by Spanish firms mainly appears through imports of intermediate inputs from high-wage countries belonging to the European Union. If the same holds for French firms, one could argue that the second empirical finding of Corcos et al. (2013), mentioned above, does not surprise given that France can be argued to be the high-wage North, and given that the difference between β_V and β_O is not too small. Moreover, trade liberalisation through τ_m and North-South technology transfer can affect the sorting pattern through e.g. the relation between integration and η. This illustrates another important connection between trade liberalisation and integration. These points are worth keeping in mind when one tries to construct a firm-level test of the open-economy property rights theory of the firm.

To provide the theoretical background and hypotheses for a firm-level test of the open-economy property rights theory of the firm, we suggest that one graphs the sorting of firms into activities when model parameters are chosen to fit key properties of the data. Properties of the resulting sorting pattern can then be tested empirically. One potential benefit of this empirical strategy is that the approach could add some statistical power to a firm-level test of the open-economy property rights theory of the firm. This is because sorting patterns like those above seem hard to reconcile with competing theories like for instance transaction cost economics.[31] Unfortunately, model parameters such as β_V and β_O are hard to measure. In addition, Appendices D and E reveal that subtle parameters like f_S and f_V may also affect the sorting

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[31]This is potentially important given that existing tests of the open-economy property rights theory of the firm have relatively low statistical power (Antràs, 2014).

pattern in important and complex ways.[32] Certain properties of the sorting pattern are, however, independent of parameter values. Two examples are the sorting in the productivity dimension when $\eta < \eta^*$ and the location of the VSx area in Figures 1 and 2. Note also that the effect of an increase in productivity on the likelihood of integration is only positive for $\eta > \eta^*$.[33]

Federico (2010) and Kohler and Smolka (2011) find that the productivity ranking of the strategies OSx and VNx is empirically unclear. Figures 1 and 2 are consistent with this finding. Further, Kohler and Smolka (2011) also find that (when a firm can belong to more than one bin in their empirical test) the productivity premia on VSx, VNx, and OSx relative to ONx are not significantly different. This finding is also consistent with Figures 1 and 2. Overall, we conclude that the sorting of firms into activities in the present model seems quite consistent with the empirical evidence that we are aware of.

5 Robustness

Let us briefly discuss how certain assumptions can be relaxed. First off, relaxing the assumption that $G(\eta)$ is strictly increasing means that we cannot be sure that the effects in Proposition 1 are strictly positive. Nevertheless, we still know that they are nonnegative, cf. the proof in Appendix A.[34] Further, Proposition 2 critically hinges on this assumption. If one alternatively assumes that outsourcing always results in symmetric Nash bargaining, i.e., $\beta_O = 1/2$, such that ψ_O and the exit productivity threshold do not depend on η, Proposition 1 still holds if one assumes that log-productivities are distributed with nonincreasing hazard rate.[35]

Dispensing with the assumption that some firms with high and low η integrate and offshore, respectively, without exporting simply means that we cannot be sure that the effects of reducing f_X on the prevalences of integration and offshoring are strictly positive in Proposition 1. Nor can we be

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[32]Since many different parameters affect the properties of the sorting pattern, it is very hard to determine a parameter space where the possibilities in Proposition 3 certainly occur.

[33]This last point has also been made by Kohler and Smolka (2015) in a model where η differs across industries instead of across firms.

[34]As explained in Appendix A, this also holds when $G(\eta)$ is degenerate at $\eta > \eta^*$.

[35]See Bache and Laugesen (2015). Log-productivities are distributed with constant hazard rate when $F(\theta)$ is Pareto.

sure that the effect on the prevalence of exporting of reducing (f_V, w_S, f_S) is strictly positive in Proposition 1. These effects will however still be non-negative while all other strict results still hold, c.f. Appendix A. Dispensing with the same assumption also means that we cannot be sure that reductions in (τ, f_X) lead some firms to shift away from integration and offshoring in Proposition 2.

It should also be noted that, if one removes one of the activities integration, offshoring, or exporting from the choice set of firms, Proposition 1 is still valid for the remaining activities and the relevant cost reductions (of the remaining activities). This can be shown by repeating the steps of the proof in Appendix A ignoring one of the activities and the relevant cost reductions associated with this activity. Hence, if one removes the exporting activity throughout, reductions in (f_V, w_S, f_S) will imply that the prevalences of integration, offshoring, and vertical FDI strictly increase. This is shown graphically in Appendix D. Thus, the strong industry-level interdependence of e.g. integration and offshoring implied by Proposition 1 is not lost by not allowing firms to export.

Finally, let us discuss the robustness of Propositions 3 and 4. It is important to note that the allowance for exporting is innocuous for these results. The same can be said about the assumption that some firms with high and low η integrate and offshore, respectively, without exporting. It also turns out that all distributional assumptions on $F(\theta)$ and $G(\eta)$, including independence, are completely redundant for Propositions 3 and 4. These observations follow from the proofs behind these propositions.

6 Concluding Remarks

Our main contribution is to obtain strong results about the interdependencies among integration, offshoring, exporting, and vertical FDI at the industry level of analysis. Of particular interest in light of the existing literature is the clear positive relationship between four types of trade liberalisation and the prevalence of vertical integration. Notably, these results are compatible with ambiguities and reverse movements at lower levels of aggregation. Central to our analysis are the firm-level complementarities we identify. Apart from the introduction of exporting, our model is a natural extension of AH to the case where firms within the same industry are heterogeneous with respect to both productivity and headquarter intensity. This is a response to recent empirical

evidence which reveals that industry is a poor indicator for headquarter intensity and that firm-level headquarter intensity is an important determinant of the decision to vertically integrate. Allowing for within-industry heterogeneity in headquarter intensity is shown to be relatively uncomplicated even for a general distribution of headquarter intensities. Like other authors, we believe that the inclusion of firm-specific headquarter intensities makes the open-economy property rights theory of the firm more suitable for future empirical tests based on the firm-level data sets with input-sourcing information which are starting to appear. These data sets provide an interesting new playground for testing theories of the firm. However, our results also make it clear that firm-level predictions are needed given that industry- and firm-level predictions can potentially point in different directions. Hence, the present paper also aims at providing guidance for testing at the firm level and we mention a few conceivable pitfalls. Most notably, the conventional intuition about the positive relation between headquarter intensity and vertical integration known from Grossman and Hart (1986) may break down in an open-economy context. This is because the relationship between headquarter intensity and the likelihood of vertical integration is nonmonotone in general. Reassuringly, we obtain a sorting pattern broadly in line with Corcos et al. (2013) and other empirical studies. The important task of further testing the open-economy property rights theory of the firm is left to future work.

A   Proof of Proposition 1

As an intermediate step in proving part i, we establish that increases in $\nu \equiv (-f_V, -w_S, -f_S, -\tau, -f_X)$ lead to nondecreasing prevalences of integration, offshoring, and exporting. This is done by drawing upon the results, in particular Propositions 2 and 4, of Bache and Laugesen (2015) (henceforth BL).[36] To do so, we adopt the following ranking of the values of the three choice variables in klx: $V > O$, $S > N$, and $X > D$. Remember that the profit function reads

$$\pi_{klx}(\Theta, \eta; A, \nu) = A\Theta\psi_k(\eta)\gamma_l(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x)} - f_{klx}. \tag{8}$$

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[36]We take this approach since it is efficient given the complexity of the model. For a more traditional approach that does not rely on monotone comparative statics techniques, see the complementary proof in Appendix D.

Our assumption that the least productive active firms with any η choose $klx = OND$ means that the productivity threshold for being active,

$$\Theta_{\text{exit}}(\eta; A, \nu) \equiv \inf\{\Theta : \pi_{OND}(\Theta, \eta; A, \nu) > 0\} = \frac{f_O}{A\psi_O(\eta)}, \qquad (9)$$

depends on η (unless $\beta_O = 1/2$), but importantly, is not affected directly by changes in ν but only indirectly through changes in A.

Let $s_j^{\eta \leq \eta^*}$ and $s_j^{\eta > \eta^*}$ be the fractions of active firms with η less than or equal to, or greater than, η^*, respectively, that end up undertaking activity $j \in \{V, S, X\}$. The overall fraction of active firms undertaking activity j, i.e., the prevalence of activity j, is then given by

$$s_j = G(\eta^*)s_j^{\eta \leq \eta^*} + [1 - G(\eta^*)]s_j^{\eta > \eta^*}.$$

Since η^* is importantly not affected by changes in ν, we have shown that s_j is nondecreasing in ν if we can establish that $s_j^{\eta \leq \eta^*}$ and $s_j^{\eta > \eta^*}$ are nondecreasing in ν. Consider first the latter. For $\eta > \eta^*$, the profit function, (8), is supermodular in (k, l, x) and has increasing differences in $(k, l, x; A\Theta)$ and $(k, l, x; \nu)$. Since our setup conforms to all other conditions (including Assumption 2 of BL) for invoking Propositions 2 and 4 of BL for $\eta > \eta^*$, we conclude that $s_j^{\eta > \eta^*}$ is nondecreasing in ν with $j \in \{V, S, X\}$.[37,38] Next, consider $s_j^{\eta \leq \eta^*}$. For these values of η, we know that no firms choose integration and we can treat k as exogenously fixed at $k = O$. Thus $s_V^{\eta \leq \eta^*} = 0$. Further, for $\eta \leq \eta^*$, the profit function with $k = O$ is supermodular in (l, x) and has increasing differences in $(l, x; A\Theta)$ and $(l, x; \nu)$. We can therefore again use Propositions 2 and 4 of BL to conclude that $s_j^{\eta \leq \eta^*}$ with $j \in \{V, S, X\}$ is indeed nondecreasing in ν as well. It follows that s_j is nondecreasing in ν for $j \in \{V, S, X\}$.[39]

The specific setup we analyse in this paper will now allow us to go a step further than BL and show that the prevalences of the three activities we consider are strictly increasing as opposed to nondecreasing. Another innovation relative to BL is to analyse the prevalence of firm strategies that

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[37]Note that Θ is distributed Pareto since θ is distributed Pareto.

[38]It also follows from BL that the same result holds when $G(\eta)$ is degenerate at $\eta > \eta^*$.

[39]The assumption that $G(\eta)$ is strictly increasing is redundant for this intermediate result. The same holds for the assumption that, for η close to 0, the productivity threshold for offshoring is lower than that for exporting, while for η close to 1, the productivity threshold for integration is lower than that for exporting.

combine various activities such as vertical FDI. Finally, in the present paper, we are able to analyse the case where the supermodularity properties of the profit functions vary across firms, i.e., the complementarities vary across firms.

The second step in this proof of part i is to show that s_j, $j \in \{V, S, X\}$, is strictly increasing in ν. For this purpose, we note that, following BL, the effect of the increase in ν on s_j can be split into two parts: the total direct effect of the increase in ν (for a given A) and the total indirect effect due to the change in A. Both of these effects are nonnegative, and in fact, the total indirect effect is zero since θ and Θ are Pareto distributed. This follows from BL and was implicitly used in the first step of this proof. Appendix D illustrates these important observations in a simplified context. We will thus show that the effect of the increase in ν on s_j is strictly positive by arguing that the total direct effect is strictly positive. Since the direct effect of the increase in ν on the productivity threshold for being active is zero for all η as argued above,[40] the total direct effect on s_j is determined by the direct effect on the fraction of all firms (not just active) that undertake activity j, i.e., the direct level effect in the language of BL. This fraction is determined by a threshold, $\Theta_j(\eta; A, \nu)$, giving the threshold productivity for undertaking activity j depending on the headquarter intensity, η.[41] The direct effects of increases in ν on the thresholds $\Theta_V(\eta; A, \nu)$, $\Theta_S(\eta; A, \nu)$, and $\Theta_X(\eta; A, \nu)$ for integration, offshoring, and exporting, respectively, are nonpositive for all η; see e.g. footnote 28 in BL. This is intuitive as an increase in ν (weakly) lowers the costs of integration, offshoring, and exporting and A is held constant. Hence, if we can establish that these effects are strictly negative, each for an interval of η, we are done since $F(\theta)$ and $G(\eta)$ are both strictly increasing.[42]

First, we establish that Θ_V, Θ_S, and Θ_X are continuous functions of η on the intervals $(\eta^*, 1)$, $(0, 1)$, and $(0, 1)$, respectively. We will only provide details on how to show this for Θ_V as showing it for Θ_S and Θ_X will be completely analogous. Let us define Θ_V properly. To do so, let

$$\pi_k(\Theta, \eta; A, \nu) = \max_{lx} \pi_{klx}(\Theta, \eta; A, \nu).$$

Note that π_k is continuous in (Θ, η) since π_{klx} is continuous in (Θ, η). Now,

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[40]In the language of BL, the direct selection effect is zero.

[41]Note that Θ_V is infinite for $\eta \in (0, \eta^*]$. The following discussion of Θ_V will therefore only concern its behaviour on $(\eta^*, 1)$.

[42]If this last step is unclear, decompose the change in H_i from Appendix D in BL along the lines of equation 9 (in Appendix B) in BL.

on $(\eta^*, 1)$, $\Theta_V(\eta; A, \nu)$ is given by

$$\pi_V(\Theta_V, \eta; A, \nu) - \pi_O(\Theta_V, \eta; A, \nu) = 0. \tag{10}$$

Θ_S and Θ_X can be defined through a similar method. Since the LHS of (10) is continuous in (Θ, η) and strictly increasing in Θ,[43] it follows from the implicit function theorem that Θ_V, as determined by (10), is continuous in η.

Next, we establish that $\Theta_V \to \infty$ as $\eta \to \eta^*$ from above and that Θ_V is bounded from above as $\eta \to 1$. Let $\Theta_{V|lx}(\eta; A, \nu)$ be implicitly defined by the equation

$$\pi_{Vlx}(\Theta_{V|lx}, \eta; A, \nu) - \pi_{Olx}(\Theta_{V|lx}, \eta; A, \nu) = 0. \tag{12}$$

Let $\underline{\Theta}_V(\eta; A, \nu) = \min_{lx} \Theta_{V|lx}$. Then for firms with productivities below $\underline{\Theta}_V$, outsourcing is the optimal ownership structure since regardless of the firms' choices of lx, profits are higher under O than under V. This is due to the LHS of (12) being strictly increasing in Θ. Thus, $\underline{\Theta}_V$ represents a lower bound on Θ_V for all η. In a similar fashion, $\bar{\Theta}_V = \max_{lx} \Theta_{V|lx}(\eta; A, \nu)$ is an upper bound on Θ_V. Now, since the LHS of (12) is increasing in lx and Θ by the supermodularity and increasing differences properties of π_{klx}, respectively, we have $\underline{\Theta}_V = \Theta_{V|SX}$ and $\bar{\Theta}_V = \Theta_{V|ND}$.[44] Since the lower bound on Θ_V, $\Theta_{V|SX} \to \infty$ as $\eta \to \eta^*$ from above, the same holds for Θ_V. Further, as the upper bound on Θ_V, $\Theta_{V|ND}$ is bounded from above as $\eta \to 1$, so is Θ_V.[45] By similar lines of arguments, one can establish that $\Theta_S \to \infty$ as $\eta \to 1$, Θ_S is

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[43]That the LHS of (10) is weakly increasing in Θ follows from π_{klx} having increasing differences in $(k, l, x; A\Theta)$ since this implies that π_k has increasing differences in $(k; A\Theta)$. That it is in fact strictly increasing can be seen by writing out (10) to get

$$A\Theta[\psi_V(\eta)\gamma_{l_1}(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_1)} - \psi_O(\eta)\gamma_{l_2}(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_2)}] - (f_{Vl_1x_1} - f_{Ol_2x_2}) = 0, \tag{11}$$

where l_1x_1 and l_2x_2 are the optimal choices of lx under $k = V$ and $k = O$, respectively. Since $V > O$, we have $l_1 \geq l_2$ and $x_1 \geq x_2$. Further, since $\psi_V(\eta) > \psi_O(\eta)$ for $\eta \in (\eta^*, 1)$, the square bracket on the LHS of (11) is strictly positive on $(\eta^*, 1)$ and thus the LHS of (10) is strictly increasing in Θ on $(\eta^*, 1)$.

[44]The intuition for $\min_{lx} \Theta_{V|lx} = \Theta_{V|SX}$ ($\max_{lx} \Theta_{V|lx} = \Theta_{V|ND}$) is that integration is promoted as much (little) as possible by other complementary activities in this case.

[45]Since $\Theta_{V|SX} = \frac{f_V - f_O}{A\gamma_S(\eta)(1 + \tau^{1-\sigma})(\psi_V(\eta) - \psi_O(\eta))}$ and $|\psi_V(\eta) - \psi_O(\eta)| \to 0$ as $\eta \to \eta^*$, it follows that $\Theta_{V|SX} \to \infty$ as $\eta \to \eta^*$ from above. Further, since $\Theta_{V|ND} = \frac{f_V - f_O}{A(\psi_V(\eta) - \psi_O(\eta))}$, $\psi_V(\eta) > \psi_O(\eta)$ for $\eta > \eta^*$, and $\psi_V(\eta)/\psi_O(\eta)$ is strictly increasing in η, $\Theta_{V|ND}$ is bounded from above as $\eta \to 1$.

bounded from above as $\eta \to 0$, and that Θ_X is bounded from above both as $\eta \to 0$ and as $\eta \to 1$.

Our assumption that some firms with η close to 0 choose to offshore without exporting implies that $\Theta_S < \Theta_X$ for η sufficiently close to 0. Further, the assumption that some firms with η close to 1 choose to integrate without exporting implies that $\Theta_V < \Theta_X$ for η sufficiently close to 1. Combined with the properties derived above, an application of the intermediate value theorem implies that Θ_V and Θ_X, Θ_V and Θ_S, and Θ_S and Θ_X intersect in the interior of $(\eta^*, 1)$, $(\eta^*, 1)$, and $(0, 1)$, respectively. This means that V and S share the same threshold productivity for at least one value of η, as does V and X and S and X. The final steps of the proof show that this implies that these joint thresholds must each be relevant for an interval of η, and that for each of the activities, $j \in \{V, S, X\}$, at least one of its joint thresholds is strictly decreasing conditional on A when ν increases.

Consider the joint thresholds for activity V. First off, we have established that for η sufficiently close to, but above, η^*, $\Theta_V > \Theta_S, \Theta_X$ and that for η sufficiently close to 1, $\Theta_V < \Theta_S, \Theta_X$. That is, Θ_V must be equal to respectively Θ_S and Θ_X for at least one value of η. Suppose that Θ_V and Θ_S are not equal on an interval of η. Then there must exist an $\eta = \eta'$ for which $\Theta_V(\eta'; A, \nu) = \Theta_S(\eta'; A, \nu) = \Theta'$ with $\Theta_V > \Theta_S$ for η just below η' and $\Theta_V < \Theta_S$ for η just above η'. First, suppose that $\Theta_X(\eta'; A, \nu) \neq \Theta'$. That is, for (Θ, η) sufficiently close to (Θ', η') all firms choose the same export status, x. Then we must have that $\pi_{VSx}(\Theta', \eta'; A, \nu) = \pi_{ONx}(\Theta', \eta'; A, \nu) = \pi_{OSx}(\Theta', \eta'; A, \nu) = \pi_{VNx}(\Theta', \eta'; A, \nu)$.[46] However, this cannot be the case since $\pi_{OSx} - \pi_{ONx} = 0$ implies that $\pi_{VSx} - \pi_{VNx} > 0$ since $\psi_V(\eta) > \psi_O(\eta)$ for $\eta > \eta^*$. Second, suppose $\Theta_X(\eta'; A, \nu) = \Theta'$. Then we must have that

$$\pi_{VSX}(\Theta', \eta'; A, \nu) = \pi_{OND}(\Theta', \eta'; A, \nu) = \pi_{VNx_1}(\Theta', \eta'; A, \nu) = \pi_{OSx_2}(\Theta', \eta'; A, \nu)$$
$$(13)$$

for some x_1, x_2.[47] But as before, this cannot be true. To see why, suppose (13) holds for $x_1 = D$ and $x_2 = X$. Then $\pi_{OSX} - \pi_{OND} = 0$ implies that $\pi_{VSX} - \pi_{VND} > 0$ and we have a contradiction. If (13) holds for $x_1 = X$ and $x_2 = D$, then $\pi_{VNX} - \pi_{OND} = 0$ implies $\pi_{VSX} - \pi_{OSD} > 0$

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[46]Right at (Θ', η') firms are indifferent between VSx and ONx which gives the first of the equalities. For η just below η', Θ_S gives indifference between ONx and OSx. As Θ_S is continuous, this indifference at Θ_S extends to $\eta = \eta'$ which gives the second equality. The last equality follows from a similar argument using Θ_V for η just above η'.

[47]The argument is completely analogous to before.

and again we have a contradiction. If $x_1 = x_2 = D$, $\pi_{VND} - \pi_{OND} = 0$ implies $\pi_{VSD} - \pi_{OSD} > 0$. But this means that $\pi_{VSD}(\Theta', \eta'; A, \nu)$ is strictly higher than $\pi_{OND}(\Theta', \eta'; A, \nu)$, and due to continuity, firms with $\eta = \eta'$ and Θ just below Θ' find $klx = VSD$ more profitable than $klx = OND$. But these firms should choose OND if $\Theta_V(\Theta', \eta'; A, \nu) = \Theta_S(\Theta', \eta'; A, \nu) = \Theta_X(\Theta', \eta'; A, \nu) = \Theta'$ and we have a contradiction. Finally, if $x_1 = x_2 = X$, then $\pi_{VSX} - \pi_{VNX} = 0$ implies $\pi_{OSX} - \pi_{ONX} < 0$ but by $\pi_{OSX} = \pi_{OND}$, we thus have $\pi_{ONX} > \pi_{OND}$, which, by a similar argument as before, is incompatible with $\Theta_V(\Theta', \eta'; A, \nu) = \Theta_S(\Theta', \eta'; A, \nu) = \Theta_X(\Theta', \eta'; A, \nu) = \Theta'$. Thus, we must have that $\Theta_V = \Theta_S$ holds for an interval of η since otherwise we arrive at a contradiction. Arguments similar to those used above imply that the same must hold for Θ_V and Θ_X and for Θ_S and Θ_X. These observations are also important for Proposition 4.

To conclude the proof of part i of the proposition, note that when $\Theta_S = \Theta_V$, this joint threshold is given by

$$\pi_{VSx_1}(\Theta_V, \eta; A, \nu) - \pi_{ONx_2}(\Theta_V, \eta; A, \nu) = 0 \qquad (14)$$

for some $x_1 \geq x_2$. But the LHS of (14) is strictly increasing in both Θ and $(-f_V, -w_S, -f_S)$ which means that, given A, Θ_V is strictly decreasing in $(-f_V, -w_S, -f_S)$ when $\Theta_S = \Theta_V$. This holds for an interval of η as argued above. As $\Theta_V = \Theta_S$ on this interval of η, the same can be said about Θ_S. Further, when $\Theta_V = \Theta_X$, it is given by

$$\pi_{Vl_1X}(\Theta_V, \eta; A, \nu) - \pi_{Ol_2D}(\Theta_V, \eta; A, \nu) = 0 \qquad (15)$$

for some $l_1 \geq l_2$. As the LHS of (15) is strictly increasing in Θ and $(-f_V, -\tau, -f_X)$, Θ_V and Θ_X are strictly decreasing in $(-f_V, -\tau, -f_X)$, given A, on an interval of η. Finally, when $\Theta_S = \Theta_X$, it is given by

$$\pi_{k_1SX}(\Theta_S, \eta; A, \nu) - \pi_{k_2ND}(\Theta_S, \eta; A, \nu) = 0 \qquad (16)$$

for some $k_1 \geq k_2$. As the LHS of (16) is strictly increasing in Θ and $(-w_S, -f_S, -\tau, -f_X)$, Θ_S and Θ_X are strictly decreasing in $(-w_S, -f_S, -\tau, -f_X)$, given A, on an interval of η. Combining these results leads you to conclude that whenever $\nu \equiv (-f_V, -w_S, -f_S, -\tau, -f_X)$ increases, Θ_V, Θ_S, and Θ_X each strictly decreases on some interval of η given A. As argued above, this proves part i of Proposition 1.

Let us now prove part ii of Proposition 1. That the prevalence of vertical FDI (the fraction of all active firms that undertake both V and S) is strictly

increasing in $(-f_V, -w_S, -f_S, -\tau)$ is quite simple to show at this point. Note that vertical FDI only occurs for $\eta > \eta^*$. Let us define the productivity threshold for vertical FDI,

$$\Theta_{VS}(\eta; A, \nu) = \max\{\Theta_V(\eta; A, \nu), \Theta_S(\eta; A, \nu)\}.$$

This productivity threshold is clearly nonincreasing in $(-f_V, -w_S, -f_S, -\tau, -f_X)$ given A. By the same arguments as above, we need to show that, given A, Θ_{VS} is strictly decreasing in $(-f_V, -w_S, -f_S, -\tau)$ on an interval of η in order to prove part ii of the proposition. We have already established that $\Theta_V = \Theta_S$ on an interval of η for which they are strictly decreasing in $(-f_V, -w_S, -f_S)$ for a given A; see also Appendix D. This means that the same holds for Θ_{VS} on this interval of η. Finally, since $\Theta_V > \Theta_S, \Theta_X$ for all η sufficiently close to, but above, η^*, $\Theta_{VS} = \Theta_{V|SX}$ for these η. It is easy to verify that $\Theta_{V|SX}$ is strictly decreasing in $-\tau$ given A, and we are therefore done with proving part ii of Proposition 1.

Finally, we prove that increasing $(-w_S, -f_S)$ always strictly reduces the prevalence of domestic integration. To do so, consider for the moment the initial equilibrium and note that it follows from Appendix E that Θ_S/Θ_V is monotone increasing in η for $\eta > \eta^*$. Suppose that $\Theta_V < \Theta_S$, then, as in Appendix E,

$$\Theta_S(\eta; A, \nu) = \frac{f_{VSx_1} - f_{VNx_2}}{A\psi_V(\eta)[\gamma_S(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_1)} - (1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_2)}]},$$

for some $x_1 \geq x_2$, and

$$\Theta_V(\eta; A, \nu) = \frac{f_{VNx_3} - f_{ONx_4}}{A[\psi_V(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_3)} - \psi_O(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_4)}]},$$

for some $x_3 \geq x_4$ where $x_2 \geq x_3$. Thus, when $\Theta_V < \Theta_S$, the ratio between these thresholds is given by

$$\frac{\Theta_S}{\Theta_V} = \frac{(f_{VSx_1} - f_{VNx_2})[(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_3)} - \psi_O(\eta)\psi_V(\eta)^{-1}(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_4)}]}{(f_{VNx_3} - f_{ONx_4})[\gamma_S(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_1)} - (1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_2)}]}.$$
(17)

Since $\gamma_S(\eta)$ and $\psi_O(\eta)\psi_V(\eta)^{-1}$ are both strictly decreasing in η, it is obvious that the ratio in (17) is strictly increasing in η for given (x_1, x_2, x_3, x_4). Further, as (17) is continuous at points where (x_1, x_2, x_3, x_4) jumps, (17) is

strictly increasing in η whenever $\Theta_V < \Theta_S$. Thus, if $\Theta_V < \Theta_S$ for some $\eta = \eta''$, we have that $\Theta_V < \Theta_S$ for all $\eta > \eta''$. Let η^{**} be given by

$$\eta^{**} \equiv \inf\{\eta : \Theta_V < \Theta_S\} = \inf\{\eta : 1 < \tfrac{\Theta_S}{\Theta_V}\}.$$

Then we can express the prevalence of domestic integration, s_{VN}, as

$$s_{VN} = \frac{\int_{\eta^{**}}^1 [F((\Theta_S)^{1/(\sigma-1)}) - F((\Theta_V)^{1/(\sigma-1)})] \, \mathrm{d}G(\eta)}{\int_0^1 [1 - F((\Theta_{\mathrm{exit}})^{1/(\sigma-1)})] \, \mathrm{d}G(\eta)}.$$

Next, let us show that η^{**} is strictly increasing in $(-w_S, -f_S)$. By (17), which is valid for $\eta \geq \eta^{**}$, it is obvious that changes in A do not affect η^{**}. Further, given A, increases in $(-w_S, -f_S)$ reduce Θ_S strictly but do not affect Θ_V whenever $\Theta_V < \Theta_S$. It follows that η^{**} must rise strictly in $(-w_S, -f_S)$. This will later be graphically illustrated in Appendix D. Finally, employing the Pareto distribution with shape parameter $z(\sigma - 1) > 0$, s_{VN} can be expressed as

$$s_{VN} = \frac{\int_{\eta^{**}}^1 [(A\Theta_V)^{-z} - (A\Theta_S)^{-z}] \, \mathrm{d}G(\eta)}{\int_0^1 (A\Theta_{\mathrm{exit}})^{-z} \, \mathrm{d}G(\eta)}.$$

Now, note that η^{**} increases strictly in $(-w_S, -f_S)$, that $A\Theta_V$ and $A\Theta_{\mathrm{exit}}$ are unaffected by changes in $(-w_S, -f_S)$ for $\eta > \eta^{**}$, and that $A\Theta_S$ is strictly decreasing in $(-w_S, -f_S)$. Thus, s_{VN} strictly decreases in $(-w_S, -f_S)$. This proves the claim made in Section 3.

B   Proof of Proposition 2

For η sufficiently close to 0, the thresholds for offshoring and exporting are given by

$$\pi_{OSD}(\Theta_S, \eta; A, \nu) - \pi_{OND}(\Theta_S, \eta; A, \nu) = 0 \tag{18}$$

and

$$\pi_{OSX}(\Theta_X, \eta; A, \nu) - \pi_{OSD}(\Theta_X, \eta; A, \nu) = 0, \tag{19}$$

respectively. Next, for η sufficiently close to 1, the thresholds for integration and exporting are given by

$$\pi_{VND}(\Theta_V, \eta; A, \nu) - \pi_{OND}(\Theta_V, \eta; A, \nu) = 0 \tag{20}$$

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and

$$\pi_{VNX}(\Theta_X, \eta; A, \nu) - \pi_{VND}(\Theta_X, \eta; A, \nu) = 0, \tag{21}$$

respectively. Now, any possible increase in $(-f_V, -w_S, -f_S, -\tau, -f_X)$ results in a strict reduction in A since entry to the industry is free and since any increase in $(-f_V, -w_S, -f_S, -\tau, -f_X)$ implies an at least weak increase in the profits of all firms when A is held constant. Moreover, some firms experience a strict increase in their profits given A. Consider a reduction in the fixed cost associated with integration, f_V. This does not affect the cutoff conditions (18) and (19) directly but does so indirectly through the decline in A. Since the LHS of both equations are strictly increasing in (Θ, A), the result of the strict decline in A is a strict increase in the thresholds given by (18) and (19) for the relevant η's. That is, some firms shift away from offshoring and exporting. Next, consider a reduction in the costs associated with offshoring, (w_S, f_S). Since the LHS of (20) and (21) are not directly affected by these changes and strictly increase in (Θ, A), the result is a strict increase in the thresholds given by these two equations for the relevant η's. That is, some firms shift away from integration and exporting. Finally, consider a reduction in (τ, f_X). Using the same line of arguments again implies that the thresholds given by (18) and (20) are strictly increasing for the relevant η's. That is, some firms shift away from integration and offshoring. This proves Proposition 2.

C   Figures 1 and 2

We now derive a number of productivity thresholds. These thresholds are used to illustrate the sorting of firms into decisions. Recall that the threshold productivity levels for the marginal active firms can be expressed as

$$\Theta_{\text{exit}}(\eta; A, \nu) \equiv \inf\{\Theta : \pi_{OND}(\Theta, \eta; A, \nu) > 0\} = \frac{f_O}{A\psi_O(\eta)}.$$

In general, we let $\Theta_{k_1 l_1 x_1}^{k_2 l_2 x_2}(\eta; A, \nu)$ solve

$$\pi_{k_1 l_1 x_1}(\Theta_{k_1 l_1 x_1}^{k_2 l_2 x_2}(\eta; A, \nu), \eta; A, \nu) = \pi_{k_2 l_2 x_2}(\Theta_{k_1 l_1 x_1}^{k_2 l_2 x_2}(\eta; A, \nu), \eta; A, \nu).$$

Thus, $\Theta_{k_1 l_1 x_1}^{k_2 l_2 x_2}(\eta; A, \nu)$ represents the level of Θ at which a firm with headquarter intensity η is indifferent between operating under the decisions $k_1 l_1 x_1$

and $k_2 l_2 x_2$ given the demand level, A, and the vector of parameters, $\nu \equiv (-f_V, -w_S, -f_S, -\tau, -f_X)$.

Recall from Section 2.5 and Lemma 2 that the inherent complementarities in the model imply that many potential indifference conditions can be ruled out. It was for instance mentioned that firms with a given η will never be indifferent between the decisions VND and OSD. More generally, we can make the following observations if we use the partial ordering in footnote 18. For $\Theta_{Ol_1 x_1}^{Vl_2 x_2}(\eta; A, \nu)$ it must hold that $l_2 \geq l_1$ and $x_2 \geq x_1$. For $\Theta_{k_1 N x_1}^{k_2 S x_2}(\eta; A, \nu)$ it must hold that $k_2 \geq k_1$ and $x_2 \geq x_1$. Finally, for $\Theta_{k_1 l_1 N}^{k_2 l_2 X}(\eta; A, \nu)$ it must hold that $k_2 \geq k_1$ and $l_2 \geq l_1$. These observations shrink the number of relevant productivity thresholds significantly. The following three equations provide us with twelve threshold expressions.

$$\Theta_{Ol_3 x_3}^{Vl_3 x_3}(\eta; A, \nu) = \frac{f_V - f_O}{A(\psi_V(\eta) - \psi_O(\eta))\gamma_{l_3}(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_3)}}, \qquad (22)$$

$$\Theta_{k_4 N x_4}^{k_4 S x_4}(\eta; A, \nu) = \frac{f_S}{A\psi_{k_4}(\eta)(\gamma_S(\eta) - 1)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_4)}}, \qquad (23)$$

$$\Theta_{k_5 l_5 D}^{k_5 l_5 X}(\eta; A, \nu) = \frac{f_X \tau^{\sigma-1}}{A\psi_{k_5}(\eta)\gamma_{l_5}(\eta)}. \qquad (24)$$

Note that (22) provides us with $\Theta_{OND}^{VND}(\eta; A, \nu)$, $\Theta_{OSD}^{VSD}(\eta; A, \nu)$, $\Theta_{ONX}^{VNX}(\eta; A, \nu)$, and $\Theta_{OSX}^{VSX}(\eta; A, \nu)$. (23) provides us with $\Theta_{OND}^{OSD}(\eta; A, \nu)$, $\Theta_{VND}^{VSD}(\eta; A, \nu)$, $\Theta_{ONX}^{OSX}(\eta; A, \nu)$, and $\Theta_{VNX}^{VSX}(\eta; A, \nu)$. (24) provides us with $\Theta_{OND}^{ONX}(\eta; A, \nu)$, $\Theta_{OSD}^{OSX}(\eta; A, \nu)$, $\Theta_{VSD}^{VSX}(\eta; A, \nu)$, and $\Theta_{VND}^{VNX}(\eta; A, \nu)$. All twelve thresholds in (22), (23), and (24) are based on indifference conditions between starting to undertake just one activity (integration, offshoring, or exporting) or not. Some firms may also—and in fact will—be indifferent between starting to undertake two or three activities at the same time or not. This observation

gives rise to the seven additional thresholds below.

$$\Theta_{OND}^{VSX}(\eta; A, \nu) = \frac{f_V - f_O + f_S + f_X}{A(\psi_V(\eta)\gamma_S(\eta)(1 + \tau^{1-\sigma}) - \psi_O(\eta))},$$

$$\Theta_{OND}^{VSD}(\eta; A, \nu) = \frac{f_V - f_O + f_S}{A(\psi_V(\eta)\gamma_S(\eta) - \psi_O(\eta))},$$

$$\Theta_{OND}^{VNX}(\eta; A, \nu) = \frac{f_V - f_O + f_X}{A(\psi_V(\eta)(1 + \tau^{1-\sigma}) - \psi_O(\eta))},$$

$$\Theta_{OND}^{OSX}(\eta; A, \nu) = \frac{f_S + f_X}{A\psi_O(\eta)(\gamma_S(\eta)(1 + \tau^{1-\sigma}) - 1)},$$

$$\Theta_{VND}^{VSX}(\eta; A, \nu) = \frac{f_S + f_X}{A\psi_V(\eta)(\gamma_S(\eta)(1 + \tau^{1-\sigma}) - 1)},$$

$$\Theta_{OSD}^{VSX}(\eta; A, \nu) = \frac{f_V - f_O + f_X}{A(\psi_V(\eta)(1 + \tau^{1-\sigma}) - \psi_O(\eta))\gamma_S(\eta)},$$

$$\Theta_{ONX}^{VSX}(\eta; A, \nu) = \frac{f_V - f_O + f_S}{A(\psi_V(\eta)\gamma_S(\eta) - \psi_O(\eta))(1 + \tau^{1-\sigma})}.$$

Overall, we thus have twenty threshold expressions to keep track of. However, given that τ tends to infinity in Figures 1 and 2, we can effectively ignore all threshold productivities, $\Theta_{k_1 l_1 x_1}^{k_2 l_2 x_2}(\eta; A, \nu)$, where either $x_1 = X$, $x_2 = X$, or $x_1 = x_2 = X$ when we draw those figures. This leaves us with the six thresholds $\Theta_{\text{exit}}, \Theta_{OND}^{VND}, \Theta_{OSD}^{VSD}, \Theta_{OND}^{OSD}, \Theta_{VND}^{VSD}$, and Θ_{OND}^{VSD} which are used in drawing Figures 1 and 2.

The parameter values behind Figure 1 are $\alpha = 0.8, \beta_V = 0.51, \beta_O = 0.50, f_O = 0.2, f_V = 3.0, f_S = 45$, and $w_S = 0.3$. The parameter values behind Figure 2 are $\alpha = 0.8, \beta_V = 0.85, \beta_O = 0.50, f_O = 0.3, f_V = 4.2, f_S = 1.6$, and $w_S = 0.95$. In Figures 1 and 2, we divide all the relevant productivity thresholds by Θ_{exit} before plotting these thresholds. This is innocuous with respect to our cross-sectional results as Θ_{exit} is independent of η when $\beta_O = 1/2$. The benefit of this scaling is that the scaling allows us to better illustrate the gist of Proposition 1 graphically.

D Illustrating Proposition 1

We now want to illustrate graphically the gist of the comparative statics in Proposition 1. We do this by showing how Figure 2 reacts to changes in (f_V, w_S, f_S). Specifically, our aim is to show graphically that reductions in

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(f_V, w_S, f_S) imply that the prevalences of integration, offshoring, and vertical FDI strictly increase. To guide the reader, we first provide a formal proof which complements the proof in Appendix A.

Like in Figure 2, let us analyse the case of symmetric Nash bargaining where $\beta_O = 1/2$ such that Θ_{exit} is independent of η. Employing a Pareto distribution, $F(\theta)$, with shape parameter $z(\sigma - 1) > 0$, the prevalences of integration, offshoring, and vertical FDI are given by

$$s_V = \frac{\int_{\eta^*}^1 [1 - F((\Theta_V)^{1/(\sigma-1)})]\, dG(\eta)}{1 - F((\Theta_{\text{exit}})^{1/(\sigma-1)})} = \int_{\eta^*}^1 [\frac{\Theta_V}{\Theta_{\text{exit}}}]^{-z}\, dG(\eta),$$

$$s_S = \frac{\int_0^1 [1 - F((\Theta_S)^{1/(\sigma-1)})]\, dG(\eta)}{1 - F((\Theta_{\text{exit}})^{1/(\sigma-1)})} = \int_0^1 [\frac{\Theta_S}{\Theta_{\text{exit}}}]^{-z}\, dG(\eta),$$

$$s_{VS} = \frac{\int_{\eta^*}^1 [1 - F(\max\{(\Theta_V)^{1/(\sigma-1)}, (\Theta_S)^{1/(\sigma-1)}\})]\, dG(\eta)}{1 - F((\Theta_{\text{exit}})^{1/(\sigma-1)})} = \int_{\eta^*}^1 [\frac{\max\{\Theta_V, \Theta_S\}}{\Theta_{\text{exit}}}]^{-z}\, dG(\eta),$$

respectively. Note that η^* is unaffected by changes in (f_V, w_S, f_S). Then for s_V and s_{VS} to be strictly increasing in $(-f_V, -w_S, -f_S)$, we must have that the fractions $\Theta_V/\Theta_{\text{exit}}$ and $\max\{\Theta_V, \Theta_S\}/\Theta_{\text{exit}}$ are nonincreasing in $(-f_V, -w_S, -f_S)$ for all $\eta > \eta^*$. Further, these fractions must be strictly decreasing for an interval of $\eta > \eta^*$. This holds because the only requirement on $G(\eta)$ is that it is strictly increasing. Similarly, for s_S to be strictly increasing in $(-f_V, -w_S, -f_S)$, we must have that the fraction $\Theta_S/\Theta_{\text{exit}}$ is nonincreasing in $(-f_V, -w_S, -f_S)$ for all η and strictly decreasing for an interval of η. Importantly, the fractions $\Theta_V/\Theta_{\text{exit}}, \Theta_S/\Theta_{\text{exit}}$, and $\max\{\Theta_V, \Theta_S\}/\Theta_{\text{exit}}$ are independent of A. This implies that indirect effects via changes in the level of A do not affect the prevalence of a given activity when $F(\theta)$ is Pareto.

Next, note that $\Theta_S/\Theta_{\text{exit}}$ is indeed nonincreasing in $(-f_V, -w_S, -f_S)$ for all η and strictly decreasing in $(-f_V, -w_S, -f_S)$ over e.g. the interval of η where firms are indifferent between ONx_1 and VSx_2, $x_1 \leq x_2$.[48] $\Theta_V/\Theta_{\text{exit}}$ and $\max\{\Theta_V, \Theta_S\}/\Theta_{\text{exit}}$ are also nonincreasing in $(-f_V, -w_S, -f_S)$ for all $\eta > \eta^*$. Moreover, these fractions are also strictly decreasing in $(-f_V, -w_S, -f_S)$ over e.g. the interval of η where firms are indifferent between ONx_1 and VSx_2, $x_1 \leq x_2$. These findings prove that reductions in

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[48]This is intuitive as the increase in $(-f_V, -w_S, -f_S)$ decreases the costs of integration and offshoring and since $\Theta_V = \Theta_S$ over this interval of η. Recall that $\Theta_S/\Theta_{\text{exit}}$ does not depend on A and that Θ_{exit} is not directly (for a given A) affected by the increase in $(-f_V, -w_S, -f_S)$.

(f_V, w_S, f_S) imply that the prevalences of integration, offshoring, and vertical FDI strictly increase in the benchmark case of symmetric Nash bargaining under outsourcing.

With this alternative proof underneath our belts, it is rather simple to illustrate the gist of Proposition 1 graphically. This is done in Figures 3, 4, and 5 which show how Figure 2, illustrated by the red broken demarcation lines, reacts to decreases in f_V, w_S, and f_S, respectively. Recall from Appendix C that all productivity thresholds in Figures 1 and 2 are divided by the constant value of Θ_{exit}. Hence, we can apply the approach of the proof above.
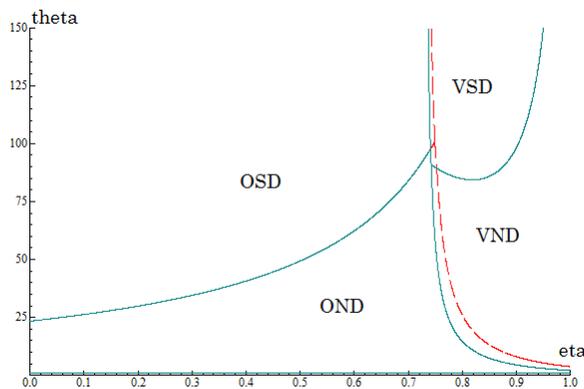

Figure 3: Plot in the (η, θ) space. Comparative statics with respect to f_V which changes from 4.2 to 2.5. All other parameters are kept constant. The blue solid demarcation lines provide the sorting pattern for $f_V = 2.5$.

A few comments are appropriate when it comes to Figure 4. First, note that the offshoring effect becomes stronger because of the increase in the North-South wage gap. This implies that the possibility, mentioned by part ii of Proposition 3 and visible in Figure 2, disappears. This is intuitive and in line with the discussion in Section 4. Second, note that Figure 4 and 5 illustrate the finding of Appendix A that $\eta^{**} \equiv \inf\{\eta : \Theta_V < \Theta_S\}$ strictly increases in $(-w_S, -f_S)$. The increases in η^{**} imply that only the upward-sloping parts of the thresholds between VND and VSD become relevant in Figures 4 and 5. This relates to the discussion at the end of Section 4.
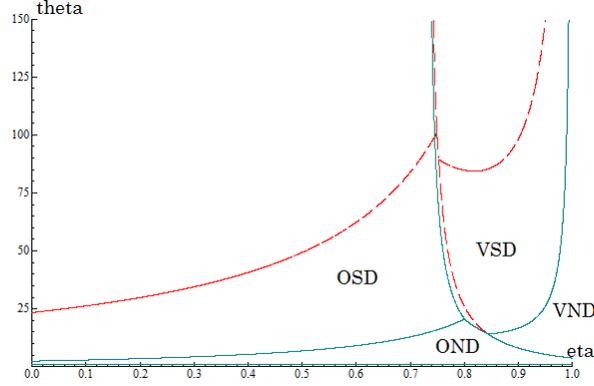
Figure 4: Plot in the (η, θ) space. Comparative statics with respect to w_S which changes from 0.95 to 0.75. All other parameters are kept constant. The blue solid demarcation lines provide the sorting pattern for $w_S = 0.75$.
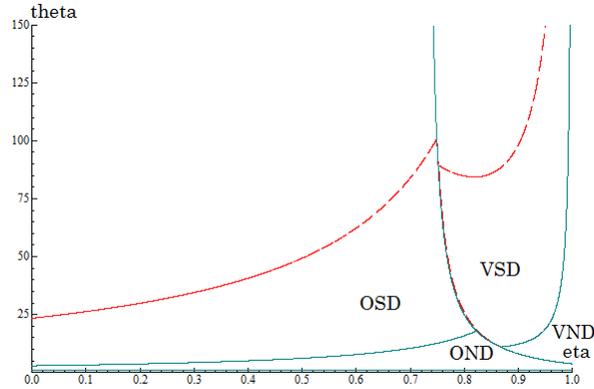

Figure 5: Plot in the (η, θ) space. Comparative statics with respect to f_S which changes from 1.6 to 0.2. All other parameters are kept constant. The blue solid demarcation lines provide the sorting pattern for $f_S = 0.2$.

E Proof of Proposition 5

This proof draws upon some results and definitions from Appendix A. Denote by $s_{V|S}(\eta)$ the fraction of offshoring firms with headquarter intensity η which integrate. Denote by $s_{S|V}(\eta)$ the fraction of integrating firms with headquarter intensity $\eta > \eta^*$ which offshore their production of intermediate inputs. Using again a Pareto distribution with shape parameter $z(\sigma - 1) > 0$

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for F, $s_{V|S}(\eta)$ can be expressed as

$$s_{V|S}(\eta) = \frac{1 - F((\Theta_V)^{1/(\sigma-1)})}{1 - F((\Theta_S)^{1/(\sigma-1)})} = (\Theta_S/\Theta_V)^z,$$

for $\Theta_V \geq \Theta_S$ and $\eta > \eta^*$. Note that $s_{V|S}(\eta) = 0$ for $\eta \leq \eta^*$ and note that $s_{V|S}(\eta) = 1$ for $\Theta_V \leq \Theta_S$. Similarly, $s_{S|V}(\eta)$ can be expressed as

$$s_{S|V}(\eta) = \frac{1 - F((\Theta_S)^{1/(\sigma-1)})}{1 - F((\Theta_V)^{1/(\sigma-1)})} = (\Theta_S/\Theta_V)^{-z},$$

for $\Theta_S \geq \Theta_V$ and $\eta > \eta^*$. Note that $s_{S|V}(\eta) = 1$ if $\Theta_S \leq \Theta_V$ for $\eta > \eta^*$ and note that $s_{S|V}(\eta)$ tends to zero as η tends to 1. Proposition 5 is proved by showing that Θ_S/Θ_V is increasing in η for $\eta > \eta^*$. We do this below.

First, suppose that $\Theta_V > \Theta_S$ for $\eta > \eta^*$, then Θ_V is given by

$$\pi_{VSx_1}(\Theta_V, \eta; A, \nu) - \pi_{OSx_2}(\Theta_V, \eta; A, \nu) = 0$$

for some $x_1 \geq x_2$. This gives us

$$\Theta_V(\eta; A, \nu) = \frac{f_{VSx_1} - f_{OSx_2}}{A\gamma_S(\eta)[\psi_V(\eta)(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_1)} - \psi_O(\eta)(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_2)}]}.$$

Further, Θ_S is given by

$$\pi_{OSx_3}(\Theta_S, \eta; A, \nu) - \pi_{ONx_4}(\Theta_S, \eta; A, \nu)$$

for some $x_3 \geq x_4$ where $x_2 \geq x_3$. This gives us

$$\Theta_S(\eta; A, \nu) = \frac{f_{OSx_3} - f_{ONx_4}}{A\psi_O(\eta)[\gamma_S(\eta)(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_3)} - (1+\tau^{1-\sigma})^{\mathbb{1}_X(x_4)}]}.$$

Thus, when $\Theta_V > \Theta_S$, the relevant ratio between these thresholds is given by

$$\frac{\Theta_S}{\Theta_V} = \frac{(f_{OSx_3} - f_{ONx_4})[\psi_V(\eta)/\psi_O(\eta)(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_1)} - (1+\tau^{1-\sigma})^{\mathbb{1}_X(x_2)}]}{(f_{VSx_1} - f_{OSx_2})[(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_3)} - \gamma_S(\eta)^{-1}(1+\tau^{1-\sigma})^{\mathbb{1}_X(x_4)}]}.$$
$$(25)$$

Since $\psi_V(\eta)/\psi_O(\eta)$ and $\gamma_S(\eta)^{-1}$ are both strictly increasing in η, it is obvious that the ratio in (25) is strictly increasing in η for given (x_1, x_2, x_3, x_4). Further, as (25) is continuous at points where (x_1, x_2, x_3, x_4) jumps (because

Θ_V and Θ_S are continuous in $\eta > \eta^*$), the value of Θ_S/Θ_V is unaffected by these jumps. Just above and below such points, Θ_S/Θ_V is strictly increasing in η. Thus, we can conclude that (25) is strictly increasing in η whenever $\Theta_V > \Theta_S$ for $\eta > \eta^*$.

Next, suppose that $\Theta_V < \Theta_S$ for $\eta > \eta^*$, then Θ_S is given by

$$\pi_{VSx_5}(\Theta_S, \eta; A, \nu) - \pi_{VNx_6}(\Theta_S, \eta; A, \nu) = 0$$

for some $x_5 \geq x_6$. This gives us

$$\Theta_S(\eta; A, \nu) = \frac{f_{VSx_5} - f_{VNx_6}}{A\psi_V(\eta)[\gamma_S(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_5)} - (1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_6)}]}.$$

Further, Θ_V is given by

$$\pi_{VNx_7}(\Theta_V, \eta; A, \nu) - \pi_{ONx_8}(\Theta_V, \eta; A, \nu) = 0,$$

for some $x_7 \geq x_8$ where $x_6 \geq x_7$. This gives us

$$\Theta_V(\eta; A, \nu) = \frac{f_{VNx_7} - f_{ONx_8}}{A[\psi_V(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_7)} - \psi_O(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_8)}]}.$$

Thus, when $\Theta_V < \Theta_S$, the relevant ratio between these thresholds is given by

$$\frac{\Theta_S}{\Theta_V} = \frac{(f_{VSx_5} - f_{VNx_6})[(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_7)} - \psi_O(\eta)\psi_V(\eta)^{-1}(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_8)}]}{(f_{VNx_7} - f_{ONx_8})[\gamma_S(\eta)(1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_5)} - (1 + \tau^{1-\sigma})^{\mathbb{1}_X(x_6)}]}.$$

$$(26)$$

Since $\gamma_S(\eta)$ and $\psi_O(\eta)\psi_V(\eta)^{-1}$ are both strictly decreasing in η, it is obvious that the ratio in (26) is strictly increasing in η for given (x_5, x_6, x_7, x_8). Further, as (26) is continuous at points where (x_5, x_6, x_7, x_8) jumps, (26) is strictly increasing in η whenever $\Theta_V < \Theta_S$ for $\eta > \eta^*$.

From Appendix A we know that $\Theta_V = \Theta_S$ holds for an interval of $\eta > \eta^*$ implying that Θ_S/Θ_V is constant on this interval. From the observation that $\psi_V(\eta)/\psi_O(\eta)$ tends to one as η tends to η^* from above, it follows that $\Theta_V > \Theta_S$ for η tending to η^* from above (see also Appendix A). From the observation that $\gamma_S(\eta)/\gamma_N$ tends to 1 as η tends to 1, it follows that $\Theta_V < \Theta_S$ for η tending to 1. Recall that Θ_S/Θ_V is continuous in $\eta > \eta^*$. Let η^{***} be given by

$$\eta^{***} \equiv \sup\{\eta : 1 > \frac{\Theta_S}{\Theta_V}\}.^{49}$$

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[49]η^{***} strictly decreases in $-f_V$ as also shown in Figure 3. Such a decrease in η^{***} may imply that only the downward-sloping part of the threshold between OSD and VSD becomes relevant in Figure 1. This relates to the discussions at the end of Section 4 and Appendix D.

Recall that η^{**} is given by

$$\eta^{**} \equiv \inf\{\eta : 1 < \tfrac{\Theta_S}{\Theta_V}\}.$$

By the arguments and definitions above, it follows that Θ_S/Θ_V is strictly increasing in η on the interval (η^*, η^{***}) where $\Theta_V > \Theta_S$. It also follows that Θ_S/Θ_V is constant at the value of 1 on the interval $[\eta^{***}, \eta^{**}]$ where $\Theta_V = \Theta_S$ and strictly increasing on the interval $(\eta^{**}, 1)$ where $\Theta_V < \Theta_S$. Hence, Θ_S/Θ_V is monotone increasing in η for $\eta > \eta^*$ and that proves Proposition 5 as argued above.

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