# Property rights and hold-up in international shipping

Abiy Teshome*

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**Abstract**

This paper demonstrates that the division of delivery-related tasks between international buyers and sellers constitutes an important margin of trade, and offers the first theoretical analysis of the allocation of control over such tasks. The model describes a sequential production process – consisting of manufacturing and distribution – in an incomplete-contracting environment. Contracts between exporters and importers specify shipping volumes and assign responsibility for delivery to one of the parties. The pair sequentially bargain over the value added by unverifiable efforts at each production stage. Bargaining power initially resides with the exporter, but transfers to the party in charge of distribution at the factory gate, owing to the latter's residual control rights over the output from delivery related activities. Trading partners thus allocate delivery rights to minimize the distortionary effects of these bargaining externalities. The exporter has a strong motive to over-invest in quality, and should thus be deprived of consignment rights unless his effort is particularly important in the delivery process.

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# 1 Introduction

The international trade literature has delved into the mechanisms behind the effects of transportation costs, policy and institutional barriers, and information costs on international trade, surveyed in Anderson and van Wincoop (2004). These trade costs have tangible effects on global value chains, the set of tasks involved in bringing a good or service from its conception to its end use (Global Value Chain Initiative, 2017). Modern supply chains (manufacturing and distribution processes) are more susceptible to such barriers, given the surge in offshoring and just-in-time production, which require several interrelated shipments to accomplish previously straightforward tasks. The viability of supply chain technology improvements therefore depends on the relative magnitudes of the cost savings from "unbundling" production across borders and the sum of trade costs incurred at each interface.

Trade policy intervention has unmistakably alleviated some of these costs. For example, many countries offer duty drawbacks, refunding import duties on intermediate productions upon the exportation of the resulting goods.[1] However, it is unrealistic to expect silver-bullet policies that address all possible impediments to supply chains. This chapter studies the distribution component of supply chain management, which has long taken a back seat in the minds of policy makers, who often focus on the organization of the manufacturing phase. However, distribution physically links one manufacturing phase in the supply chain to the next, and successful distribution relies on executing various costly and often unpredictable logistical and administrative tasks. It is incumbent upon buyers and sellers, interacting across national borders, to coordinate these tasks when sending goods from the seller's location to their intended final destination.

I focus on trade costs arising from the *organization of distribution in global supply chains,* defined as the allocation of delivery-related tasks between buyers and sellers party to international transactions. This allocation matters whenever trading partners differ in their ability to execute the various tasks, and cannot directly compensate each other for their efforts towards smooth logistical operations. Such scenarios abound outside the present setting, with parties often resorting to indirect mechanisms to encourage valuable effort. For example, they may link payment to observable outcomes affiliated with the underlying productive effort. Applying this insight to distribution, buyers and sellers may condition payments on the state of the shipment at the destination. However, it may be difficult to verify shipment quality in all but the extreme cases when goods are damaged beyond repair, or worse, lost in

[1] However, despite plaudits for historically low tariffs, Bown and Crowley (2016) conclude that non-tariff barriers like quantitative restrictions, antidumping regulations, temporary trade barriers, and "behind-the-border" policies (national subsidies and taxes, labour and environmental standards, and antitrust regulations) still present significant policy-based barriers.

transit. To compound the problem, sellers may attribute goods that arrive in poor condition to the unpredictability of long-distance shipping.

This chapter studies a potential workaround to such two-sided moral hazard problems in an extreme contracting environment where parties can only contract on the volume of shipment, the allocation of delivery tasks, and an ex-ante payment. Despite their limitations, such contracts encourage the desirable but otherwise unverifiable behaviour because responsibility for a given distribution-related task often confers valuable rights over the shipment for the duration of the task. The allocation of tasks and the associated power therefore offers buyers and sellers an alternative means to encourage productive efforts in the absence of quality–contingent contracts.

Does the organization of distribution have observable implications for trade flows? If so, what determines the allocation of tasks? I use Colombian transaction data to demonstrate that this allocation is a relevant margin of trade, explaining around 2 percent of the variation in firm-level trade, even after controlling for buyer, seller, and product characteristics. I then build an incomplete-contracting model of production and delivery, where contracts between exporters and importers specify the shipment volume, and designate one of the parties as consignor. The party in charge of delivery then signs a freight contract that affords them the right to modify delivery following unforeseen events, ultimately determining the shipment's fate. Once this auxiliary contract is in place, the exporter incorporates an unverifiable level of quality into the agreed-upon volume of goods. The buyer and seller then bargain over the value added during manufacturing, proceeding to the delivery phase only if they come to a mutually beneficial agreement.

I assume that the exporter possesses all the bargaining power in the first phase of production, thus sidestepping the decision to integrate production and sales into a single firm (see, for example, Antràs, 2003). Instead, I focus on the optimal allocation of control over delivery-related activities. This assignment directly affects buyer and seller behaviour during distribution, and, as we will see, also affects the forward-looking seller's manufacturing decisions. After manufacturing, delivery requires some "maintenance" activity by at least one of the parties. Again, such efforts are unverifiable and thus prone to hold-up. The parties therefore bargain over the value added by their joint efforts. Armed with the rights to dictate the ultimate fate of the goods, the party in charge of distribution may threaten to take possession of the shipment and put it to some alternative use. Foreseeing these control-dependent bargaining externalities, the exporter and importer allocate these scarce rights to minimize overall distortions from their first-best levels.

This chapter contributes to the literature at the intersection of International Trade and Organizational Economics. While existing work covers areas as diverse as owner-

ship/integration and sourcing (Antràs (2003), Antràs and Helpman (2004); Grossman and Helpman (2002); McLaren (2000); and Schwarz and Suedekum (2014) for theoretical contributions; Feenstra and Hanson (2005) for empirical tests) and the internal organization of firms (Marin and Verdier, 2003), I am the first to study the organization of *distribution* in international trade logistics.

I also contribute to the emerging literature on contractual frictions in sequential production processes. Fally and Hillberry (Forthcoming) consider the tradeoffs between arms-length transaction costs and in-house coordination costs in determining the complexity of global supply chains. I present a model similar in its property-rights foundations to work by Antràs and Chor (2013) and Alfaro, Antràs, Chor and Conconi (Forthcoming). These papers focus on independent agents acting at each stage, and describe the effects of investment in upstream stages on subsequent investment decisions. In contrast, and motivated by the observation that international distribution requires joint efforts, I allow multiple parties to undertake productive actions at a given stage. This departure introduces strategic interactions *within* a given stage.

In a broader sense, my work is related to research on the determinants of vertical integration, surveyed in Lafontaine and Slade (2007) and Klein (2008). The Industrial Organization literature traditionally stresses economies of scale and scope, foreclosure, and double marginalization as the main reasons to integrate activities. Such motives are bound to play some role here. For example, as Malfliet (2011) notes, it is reasonable to assign greater responsibility to the larger or more experienced of the two trading parties, with the hope of leveraging its buyer power to earn quantity discounts from the carrier. While such direct costs play a role, this interpretation downplays the indirect costs of allocating control among parties, as highlighted by the incomplete contracting literature.

# 2 Institutional background and motivation

Although there are several ways to allocate roles to each party, most international transactions fall under one of the International Chamber of Commerce's *International Commerce Terms (INCOTERMS).* Widely adopted in international transactions, these *delivery terms* reduce shipping-related confusion by outlining each party's rights and obligations during the delivery process. Conveniently, any two terms can be ranked in terms of the exporter's responsibility. At one extreme, the exporter is a passive observer, and assumes an additional role under each subsequent step. These are (in order): arranging for carriage to the port ("pre-carriage"), customs clearance at the origin, loading the shipment onto the vessel, international freight and insurance, unloading at the destination port, customs clearance at the

destination, and carriage to the importer's premises ("on-carriage"). There terms are usually classified into four groups, *E*, *F*, *C*, and *D*, ranked in increasing order of exporter burden. To avoid confusion, I recode the terms so that *E, F, C,* and *D* correspond to the 1st, 2nd, 3rd, and 4th broad groups.

The first group consists of the *Exworks (EXW)* term, where the exporter simply packs the goods and makes them available at his factory's gate. In some cases, he may help with loading (at the importer's risk), and/or obtaining customs clearance. Given the bureaucratic hurdles sometimes associated with customs clearance, the importer may be at the exporter's mercy despite trading under this term. The importer can certainly lower this dependence by hiring agents or obtaining some other presence at the origin, but often finds it easier to rely on the exporter's effort in ensuring compliance with local regulations.

The second group consists of two terms, *Free Carrier (FCA)*, and *Free on Board (FOB)*. Under FCA, the exporter loads the goods at his premises, arranges inland freight to the port, and clears the goods through customs.[2] Under FOB, the exporter assumes the additional role of loading the goods on board the vessel. The importer arranges the remaining portions of the trip (international carriage and insurance, and customs clearance and on-carriage). It is crucial that the two parties coordinate the handover if they are to avoid any costs associated with delays, such as extra storage until any errors are corrected. Such coordination requires some effort, especially in countries with poor external support from dedicated freight-forwarders or "door-to-door" services.

The third group also consists of two terms: *Carriage Paid To (some port of destination) (CPT)*, and *Cost, Insurance and Freight (CIF)*. Under these terms, the exporter assumes the extra responsibility of arranging international carriage to the destination port. The importer obtains import clearance and arranges inland freight at the destination. The parties' efforts in finding reliable and affordable carriers can make all the difference when deciding between the second and third delivery term groups. First, as Malbon and Bishop (2014) explain, shippers have little bargaining power when negotiating carriage contracts with carriers, unless they ship exceptionally large quantities and have built a history with a particular carrier. Second, entrusting shipments to reliable carriers goes some way to preventing future hassle, given the uncertain nature of international freight.

Finally, the fourth class consists of *Delivered at Terminal (DAT)*, and *Delivered Duty Paid (DDP)*. Relative to the third group of terms, DAT extends the exporter's responsibility to unloading the goods at the destination port, leaving import clearance and inland freight to the importer. The DDP term places the greatest burden on the exporter, requiring that he also clear the goods through customs at the destination, effectively rendering the importer

[2] In some cases, the exporter delivers the shipment at some point before the port.

a spectator in the delivery process.

By delineating the various delivery-related tasks, INCOTERMS indicate that at least one of the parties must exert some costly effort to ensure successful delivery. With this background in hand, the remainder of this section uses the universe of Colombian firm-level transaction data from 2009 to 2013 to establish that variation in delivery terms constitutes a relevant margin of trade. I observe the date that each shipment was cleared through Colombian customs, the associated delivery term, the contents of the shipment (quantities and FOB values of each 10-digit HS product code), a unique tax identifier tied to the Colombian exporter, and, in some cases, the name of the foreign importer. For most of the analysis, I aggregate trade flows to the exporter-product-year level. I also include importer identities for the subset of transactions destined for Spain.

Table 1 shows the popularity of the various arrangements among Colombian exporters using exports at the transaction level. The last row shows that a nontrivial fraction of shipments involve customized delivery terms. According to Ramberg (2011), buyers and sellers sometimes make minor modifications to the standard delivery terms either because of standard practice in the industry, or to accommodate one party's exceptional needs. Among the standard delivery terms, the second group, where the exporter's responsibility ends at the origin port, is by far the most popular, accounting for no less than three quarters of annual export values.

**Table 1:** Delivery term popularity

| Term group: Final exporter task | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| 1: None | 0.8 | 0.5 | 0.4 | 0.4 | 0.5 |
| 2: Origin port | 74.2 | 78.4 | 82.2 | 82.1 | 80.8 |
| 3: Destination port | 11.6 | 12.6 | 7.2 | 7.7 | 7.3 |
| 4: Inland at destination | 4.3 | 3.8 | 5.6 | 6.0 | 6.5 |
| N/A | 9.1 | 4.8 | 4.5 | 3.8 | 5.0 |

*Notes:* Aggregate shares of annual export values under each of the delivery term groups. The first column indicates the group of terms (1E, 2F, 3C, 4D) and the final exporter task (also the additional exporter task relative to the preceding group). For example, the exporter assumes responsibility for getting the goods to the destination port in moving from group 2 to group 3. Transactions in the "N/A" row involve custom arrangements and do not fall under any of the four traditional commerce terms.

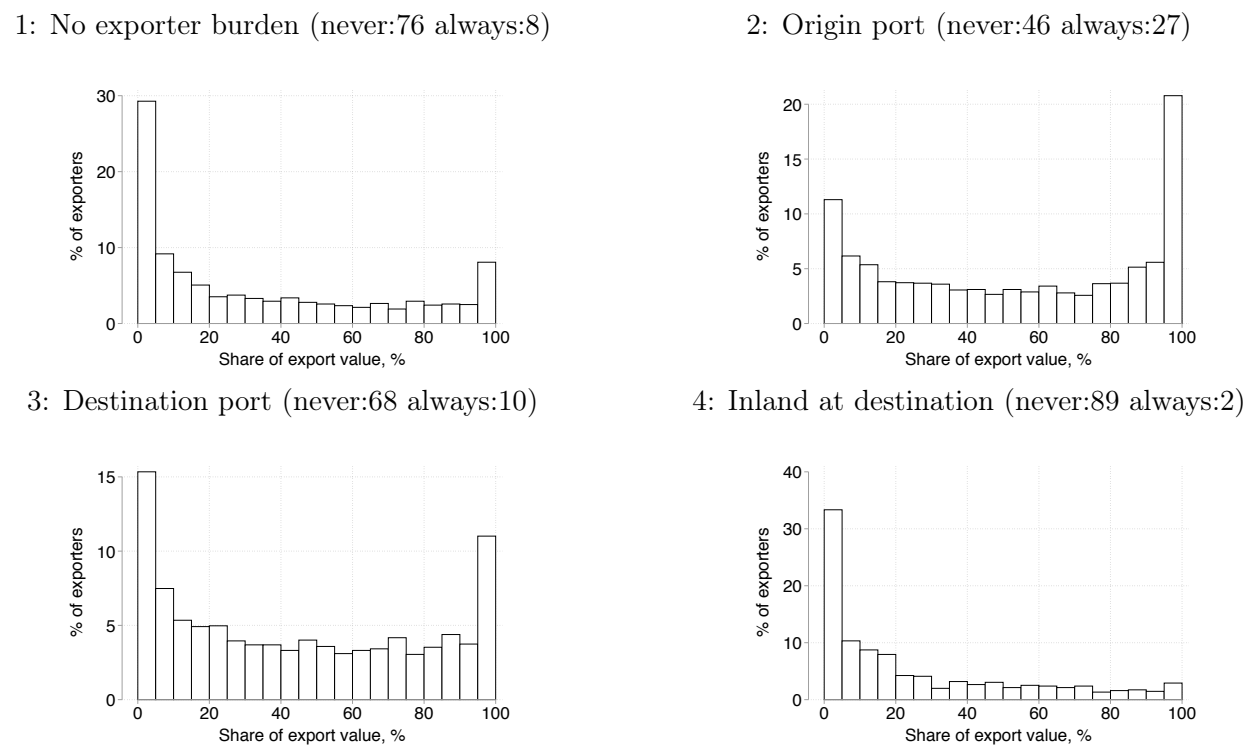
Table 1 masks variation in delivery-term choice across exporters. Consider a Colombian firm, $x$, exporting $\texttt{exports}_{x,\mathcal{O}}$ worth of goods to the rest of the world under a delivery term

in group $\mathcal{O} = 1, 2, 3, 4, \text{N/A}$ in 2013 (this is representative of other years). Let

$$\texttt{share}_{x,\mathcal{O}} \equiv \texttt{exports}_{x,\mathcal{O}} \Big/ \sum_{\mathcal{O}'=1,2,3,4,\text{N/A}} \texttt{exports}_{x,\mathcal{O}'}, \tag{2.1}$$

denote the firm-level share of 2013 export values under term $\mathcal{O}$.

**Figure 1:** Distribution of delivery-term popularity, $\texttt{share}_{x,\mathcal{O}}$, at the exporter-level




*Notes:* Panel headers indicate the standard delivery term labels, the corresponding final exporter responsibility, the percentage of exporters that never used a term in a given group, and the percentage of exporters that exclusively used a given term in 2013. For example, 76% of exporters performed *some* delivery-related task in all their transactions in 2013, while 8% did not help with delivery in any of their transactions. The histogram in Panel $\mathcal{O}$ is the distribution of $\texttt{share}_{x,\mathcal{O}} \equiv \texttt{exports}_{x,\mathcal{O}} / \sum_{\mathcal{O}'=E,F,C,D,N/A} \texttt{exports}_{x,\mathcal{O}'}$ among exporters with $0 < \texttt{share}_{x,\mathcal{O}} < 1$ for the $\mathcal{O}$ in question. When computing the shares, the base includes exports under unknown delivery terms (the "N/A" column in Table 1); results are similar if I exclude unclassified transactions.

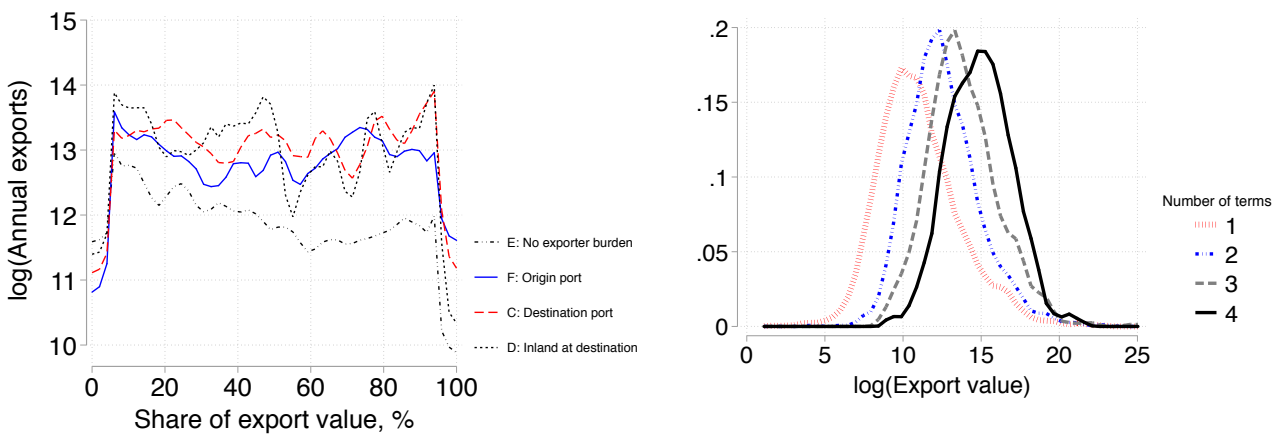
Panel $\mathcal{O} = 1, 2, 3, 4$ of Figure 1 presents the intensive-margin distribution of $\texttt{share}_{x,\mathcal{O}}$ for exporters that use at least one other term in 2013. The panel headers show the share of exporters that entirely avoid a given term, and those that trade exclusively under the term. At one extreme of exporter burden, 76 percent of exporters were involved in some aspect of distribution in each of their transactions, while 8 percent did not take part in any such

tasks at any point in 2013. At the other extreme, only 2 percent of exporters undertook all delivery-related tasks in all their transactions, while 89 percent never ventured beyond the destination port at any point during the year.

**Figure 2:** (Exporter-level) total exports, $\texttt{exports}_x$

**a.** Average annual exports by term popularity

**b.** $\texttt{exports}_x$ conditional on number of delivery terms




*Notes:* Panel (a) plots a local polynomial approximation of the conditional mean of total exports conditional on each term's share of exports, $\mathbb{E}\left[\log\left(\texttt{exports}_x\right)|\texttt{share}_{x\mathcal{O}}\right]$. Each exporter appears in each of the four regressions. Unlike Figure 1, the conditional means includes all exporters, not just those with intermediate shares ($0 < \texttt{share}_{x,\mathcal{O}} < 1$). Letting $\texttt{numterms}_x$ denote the number of terms used by $x$ in 2013 (i.e., those $\mathcal{O}$ with $\texttt{exports}_{x\mathcal{O}} > 0$), Panel (b) plots the density $f\left(\log\left(\texttt{exports}_x\right)|\texttt{numterms}_x\right)$ of (log) exports conditional on the number of terms. Each exporter appears in exactly one distribution. Figures are representative of other years in the 2009-2013 window, and similar patterns emerges if I include the unclassified term as a fifth option.

Turning to the intensive margin within each panel, the share distributions for all terms are bimodal, with most exporters employing a given term either very rarely, or very often. However, Figure 2 shows that such firms account for a small fraction of annual exports. The vertical axis in Panel (a) measures the (log of) annual firm exports, while the horizontal axis measures the fraction of the value these flows that were traded under a particular delivery term. The four curves trace sample means of firm-level annual exports, conditional on the fraction of annual exports under a given delivery term. Regardless of delivery term, exporters with less diverse delivery term portfolios (those at either end of the horizontal axis) have below-average annual exports. Setting aside the particular deliver term, Panel (b) shows the distribution of annual exports, conditional on the *number* of delivery terms used in a given year. Distributions associated with more "diverse" exporters dominate those using fewer

delivery terms.

These figures offer a cursory glance at the data, and the remaining part of the introduction offers a more formal analysis, decomposing the variation in (i) annual trade, and (ii) the popularity of predominantly exporter-controlled trade into various effects. To ease comparison with work predating Melitz (2003), I begin by decomposing the variation in annual trade flows into product, destination, and delivery term effects. I then introduce exporter effects, before using matched exporter-importer data on sales from Colombia to Spain to explore the explanatory power of importer effects. Finally, I repeat the analysis, this time decomposing the variation in the share of trade under the two terms with the greatest exporter burden.

Table 2 decomposes the variation in aggregate exports into the variance attributable to 10-digit HS product categories, destinations, and delivery terms. In particular, consider an arbitrary transaction characteristic, $g$, which may denote a single attribute like exporter identity, or a composite like an exporter-product pair. Given $g$, consider the following models for the value of exports of product $p$ to destination $d$ under delivery term $\mathcal{O}$:

$$\begin{array}{llcllll} (1)\ \text{Raw} & : \texttt{exports}_{\mathcal{O}pd} & = & \alpha^1_g & & + & u^1_{\mathcal{O}pd} & \left(R^2_{\text{only } g}\right) \\ (2)\ \text{Exclude}_g & : \texttt{exports}_{\mathcal{O}pd} & = & & \alpha^2_{\mathcal{O}pd-g} & + & u^2_{\mathcal{O}pd} & \left(R^2_{\text{except } g}\right) \\ (3)\ \text{Joint} & : \texttt{exports}_{\mathcal{O}pd} & = & \alpha^3_g + & \alpha^4_{\mathcal{O}pd-g} & + & u^3_{\mathcal{O}pd} & \left(R^2_{\text{full } g}\right). \end{array} \tag{2.2}$$

The first model projects annual exports on a set of $g$ fixed effects, the second explains this variation using fixed effects for the remaining observation characteristics, while the last model includes both pairs of fixed effects. The *semi-partial R-squared for characteristic* $g$ is the difference $R^2_{\text{full } g} - R^2_{\text{except } g}$ in the explained variation between the model that includes both sets of fixed effects, and that including the remaining characteristics. This statistic offers a rough measure of the explanatory power of transaction characteristics included in $g$.

**Table 2:** Explaining variation in aggregate exports

| $g$ | Raw effect | $R^2_{\text{full } g}$ | $R^2_{\text{except } g}$ | Isolated effect |
|---|---|---|---|---|
| Product | 0.37 | 0.46 | 0.11 | 0.34 |
| Destination | 0.05 | 0.57 | 0.50 | 0.07 |
| *Delivery terms* | *0.03* | *0.62* | *0.60* | *0.02* |

*Notes:* The raw effect is $R^2_{\text{only } g}$ in (2.2), the R-squared from the regression of $\texttt{exports}_{\mathcal{O}pd}$ on a set of $g$-fixed effects. The semi-partial R-squared, $R^2_{\text{full } g} - R^2_{\text{except } g}$, is the difference between the $R^2$'s of regressions of $\texttt{exports}_{\mathcal{O}pd}$ (i) on $g$ fixed effects and fixed effects for the remaining characteristics; and (ii) on just the remaining characteristics. See equations (2.2).

Of the three individual effects, product classifications have the greatest explanatory

power, with delivery terms accounting for a small fraction of the variation in annual exports. Table 3, which adds exporter effects, confirms that some of the variation initially attributed to delivery terms in Table 2 is actually due to exporter-level variation.

**Table 3:** Explaining variation in exporter-level exports

| $g$ | Raw effect | $R^2_{\text{full } g}$ | $R^2_{\text{except } g}$ | Isolated effect |
|---|---|---|---|---|
| Exporter | 0.40 | 0.70 | 0.55 | 0.15 |
| Product | 0.36 | 0.68 | 0.56 | 0.12 |
| Destination | 0.04 | 0.74 | 0.71 | 0.03 |
| *Delivery terms* | *0.02* | *0.77* | *0.76* | *0.01* |

*Notes:* $R^2_{\text{only } g}$ is the R-squared from the regression of $\texttt{exports}_{\mathcal{O}xpd}$ on a set of $g$-fixed effects. The semi-partial R-squared, $R^2_{\text{full } g} - R^2_{\text{except } g}$, is the difference between the $R^2$'s of regressions of $\texttt{exports}_{\mathcal{O}pd}$ (i) on $g$ fixed effects and fixed effects for the remaining characteristics; and (ii) on just the remaining characteristics.

This implies that delivery terms constitute a small but significant margin of trade at the aggregate, and exporter levels. However, it is entirely plausible that importer-level heterogeneity also explains the volume of trade. Indeed, (Bernard, Moxnes and Ulltveit-Moe, 2018) document exactly such a phenomenon. With this in mind, Table 4 summarizes the role of differences across importers. I interpret these results with caution, since we lose the destination dimension by focusing on Colombian exports to a single destination, Spain. Nonetheless, importer-level differences explain some of the variation in trade, confirming results in Bernard et al. (2018). More importantly for our purposes, delivery terms retain their explanatory power.

**Table 4:** Explaining variation in exporter-importer trade

| $g$ | Raw effect | $R^2_{\text{full } g}$ | $R^2_{\text{except } g}$ | Isolated effect |
|---|---|---|---|---|
| Exporter | 0.61 | 0.76 | 0.60 | 0.16 |
| Importer | 0.56 | 0.78 | 0.73 | 0.05 |
| Product | 0.61 | 0.80 | 0.58 | 0.22 |
| *Term* | *0.09* | *0.89* | *0.87* | *0.02* |
| Exporter-importer | 0.61 | 0.82 | 0.62 | 0.19 |
| Exporter-product | 0.72 | 0.78 | 0.56 | 0.22 |
| *Exporter-term* | *0.62* | *0.78* | *0.63* | *0.15* |

*Notes:* $R^2_{\text{only } g}$ is the R-squared from the regression of $\texttt{exports}_{\mathcal{O}xmp}$ on a set of $g$-fixed effects. The semi-partial R-squared, $R^2_{\text{full } g} - R^2_{\text{except } g}$, is the difference between the $R^2$'s of regressions of $\texttt{exports}_{\mathcal{O}xmp}$ on (i) on $g$ fixed effects and fixed effects for the remaining characteristics; and (ii) on just the remaining characteristics.

### Margins of delivery-term choice

In this section, I decompose the variation in $\texttt{share}_{i,\mathcal{O}}$, where $i$ is the level of observation. Given the paucity of trade flows under terms at either extreme of the exporter-burden spectrum, I group terms so that

$$\texttt{share\_expcontrol}_i \equiv \sum_{\mathcal{O}=3,4} \texttt{share}_{i,\mathcal{O}} \tag{2.3}$$

is the share of predominantly exporter-controlled $i$-transactions (where the exporter controls port-to-port distribution). I begin by decomposing variation in $\texttt{share\_expcontrol}_i$ into exporter, product, destination, and year effects, before considering the importer dimension (again, at the expense of the destination effects).

**Table 5:** Explaining variation in share of exporter-controlled transactions

| $g$ | Raw effect | $R^2_{\text{full } g}$ | $R^2_{\text{except } g}$ | Isolated effect |
|---|---|---|---|---|
| Exporter | 0.48 | 0.65 | 0.38 | 0.27 |
| Product | 0.17 | 0.88 | 0.87 | 0.01 |
| Destination | 0.07 | 0.63 | 0.62 | 0.01 |
| Time | 0.00 | 0.83 | 0.83 | 0.00 |
| Exporter-product | 0.58 | 0.61 | 0.09 | 0.52 |
| Exporter-destination | 0.73 | 0.76 | 0.21 | 0.55 |
| Exporter-year | 0.57 | 0.69 | 0.36 | 0.34 |

*Notes:* $R^2_{\text{only } g}$ is the R-squared from the regression of $\texttt{share\_expcontrol}_{xpdt}$ on a set of $g$-fixed effects. The semi-partial R-squared, $R^2_{\text{full } g} - R^2_{\text{except } g}$, is the difference between the $R^2$'s of regressions of $\texttt{share\_expcontrol}_{xpdt}$ (i) on $g$ fixed effects and fixed effects for the remaining characteristics; and (ii) on just the remaining characteristics.

Table 5 shows the resulting R-squared statistics using unmatched exporter-importer data, where $i$ is an exporter-destination-product-year. Restricting attention to individual effects, exporters-level heterogeneity best explains the variation in the share of exporter-controlled trade. This suggests that any model explaining the choice of delivery terms should, at the very least, allow for differences across exporters along some dimension. Turning to joint effects, we see that augmenting either a product or destination dimension substantially improves the model fit. Finally, allowing exporter-product-destination level heterogeneity results in a semi-partial R-squared statistic of 0.83.[3]

[3]Since we observe trade at the exporter-destination-product-year level, the results from the individual time effects imply $R^2_{\text{full } xpd} = R^2_{\text{full } t} = 0.83$, and $R^2_{\text{except } xpd} = R^2_{\text{only } t} = 0.00$.

**Table 6:** Explaining variation in share of exporter-controlled transactions (exporter-importer trade)

| $g$ | Raw effect | $R^2_{\text{full } g}$ | $R^2_{\text{except } g}$ | Isolated effect |
|---|---|---|---|---|
| Exporter | 0.69 | 0.89 | 0.66 | 0.23 |
| Importer | 0.73 | 0.94 | 0.79 | 0.15 |
| Product | 0.37 | 0.97 | 0.96 | 0.01 |
| Time | 0.00 | 0.87 | 0.87 | 0.00 |
| Exporter-importer | 0.86 | 0.91 | 0.43 | 0.47 |
| Exporter-product | 0.74 | 0.94 | 0.83 | 0.11 |
| Exporter-year | 0.82 | 0.95 | 0.77 | 0.18 |

*Notes:* $R^2_{\text{only } g}$ is the R-squared from the regression of $\texttt{share\_expcontrol}_{xmpt}$ on a set of $g$-fixed effects. The semi-partial R-squared, $R^2_{\text{full } g} - R^2_{\text{except } g}$, is the difference between the $R^2$'s of regressions of $\texttt{share\_expcontrol}_{xmpt}$ on (i) on $g$ fixed effects and fixed effects for the remaining characteristics; and (ii) on just the remaining characteristics.

Table 6 shows the analogous results from matched Spanish data, where $i$ is an exporter-importer-product-year. As with the unmatched dataset, differences across exporter are the best single predictors of variation in the share of predominantly exporter-controlled shipments. However, the matched data demonstrates that importer-level heterogeneity also accounts for a substantial fraction of the variation in `share_expcontrol`. Turning to joint effects, differences across exporter-importer pairs accounts for more variation than either set of individual effects, suggesting that interactions between exporter and importer characteristics are important in explaining the choice of delivery term. Lastly, allowing exporter-importer-product level heterogeneity results in a semi-partial R-squared statistic of 0.87.[4]

To summarize, the delivery-term margin accounts for a significant share of the variation in both aggregate and firm-level trade, even in the presence of previously studied margins. Further, the popularity of various delivery terms depends, at the very least, on buyer, seller, and product characteristics. These results motivate the upcoming model, which studies buyer-seller pairs that self-select into delivery terms based on their distribution capabilities and the nature of the product being traded.

# 3 Model

This section describes consumer demand for final goods, the supply chain technologies, and the buyer-seller contracting problem.

[4]Since observations are at the $xmpt$ level, the results from the time effects imply $R^2_{\text{full } xmp} = R^2_{\text{full } t} = 0.87$, and $R^2_{\text{except } xmp} = R^2_{\text{only } t} = 0.00$.

## Demand for final goods

Each market consists of $L$ consumers, who spend their income across various industries, with each industry consisting of a variety of differentiated products. Following Antoniades (2015), the representative consumer derives sub-utility

$$\begin{aligned} U_d &= q_0^c + \int \alpha \left(q^c(\omega) + z(\omega)\right) - \frac{\gamma}{2}\left(q^c(\omega)^2 + z(\omega)^2\right) + \gamma z(\omega) q^c(\omega) \, \mathrm{d}\omega \\ &\quad - \frac{\chi}{2}\left(\int q^c(\omega) - \frac{1}{2} z(\omega) \, \mathrm{d}\omega\right)^2 \end{aligned} \tag{3.1}$$

from consuming $q_0^c$ units of a numéraire good and $q^c(\omega)$ units of quality $z(\omega)$ of variety $\omega$ in a given sector. The parameters $\alpha, \chi > 0$ reflect preferences for the differentiated varieties relative to the numéraire, while $\gamma > 0$ measures love-of-variety within a sector. Let $y_d^c$ denote individual consumer income from inelastically supplying a unit of labour. In addition to these labour returns, workers have an exogenous endowment, $\overline{q}_0^c > 0$, of the numéraire. I assume that this endowment is large enough to guarantee positive demand for the numéraire, thereby eliminating any income effects in demand for the differentiated good. Consumers maximize utility $U_d$ subject to the budget constraint

$$q_0^c + \int p(\omega) q^c(\omega) \, \mathrm{d}\omega \leq y_d^c + \overline{q}_0^c.$$

Conditional on quality, these preferences deliver linear inverse-demand and quadratic revenue functions,

$$p(q, z) = A + \gamma z - \frac{\gamma}{L} q, \qquad r(q, z) = \left(A + \gamma z - \frac{\gamma}{L} q\right) q, \tag{3.2}$$

where $A \equiv (\gamma + \chi N)^{-1} (\alpha\chi + \chi N \overline{p} - \gamma\chi N \overline{z}/2) > 0$, which depends on the destination-wide average price, $\overline{p}$, and quality, $\overline{z}$, is an exogenous demand shifter from the perspective of the seller of any given variety. Note that $\gamma$, which measures love-of-variety, also determines the marginal effect of quality on sales revenue, $\partial r(q, z)/\partial z = \gamma q$. This observation will drive many of the subsequent results.

## Supply-chain technology

Having met exogenously, a potential exporter and importer, indexed by $X$ and $M$, work together to serve the $L$ consumers described above. The importer has direct access to the final-goods market, while the exporter owns a manufacturing plant with independent physical-unit-production and quality-creation techniques, in the sense that the marginal product of any given input into quality creation is independent of the scale of production,

and vice versa.

The exporter's factory capabilities are summarized by the pair $(c, \psi_0)$, where $c > 0$ is the marginal cost of producing physical units, and $\psi_0 > 0$ shifts the marginal cost of quality innovation. Specifically, the total cost of producing $q$ units with initial/factory-set quality $z$ is

$$C(q, z) = cwq + \frac{1}{2}\psi_0 z^2, \tag{3.3}$$

where $w$ is the prevailing wage in the source country.

I index shipments by their volume, quality, and location, so that the pair $(q_i, z_i)$ represents $q_i$ units of quality $z_i$ at location $i \in \{0, 1\}$, where $i = 0$ corresponds to the manufacturing plant in the source country, and $i = 1$ is the destination market. Although quality is a vertical characteristic according to consumer preferences in (3.1), I assume that it is suitably tailored to some subset of the population linked to the initial importer $M$. The exporter is therefore subject to hold-up if he produces a bundle with any given importer in mind. Once the exporter produces $(q_0, z_0)$, one of the parties takes possession of the bundle and oversees distribution to the destination.

In addition to transporting the goods across space, delivery may alter their physical characteristics. Throughout, I will assume that the volume of the shipment is fixed at its factory level $q_0$ (let $q$ denote this fixed level), while its quality may change during transit. In particular, $j \in \{X, M\}$ may exert $e_j$ units of unverifiable effort at a cost $\psi_j e_j^2/2$ to improve shipment quality. Individual efforts then combine via the aggregator

$$E(e_X, e_M) = (\eta\, e_X^\rho + (1-\eta)\; e_M^\rho)^{\frac{1}{\rho}}, \qquad \rho \in (0, 1), \tag{3.4}$$

where $\eta \in (0, 1)$ measures the relative importance of exporter effort in quality-maintenance, while $\rho$ is related to the substitutability of individual efforts. For example, large values of $\eta$ may indicate origin-specific regulations that explicitly require exporter participation. Given the partial specificity of quality to $M$'s intended consumers, the marginal product of such maintenance effort depends on the pair's relationship surviving past the distribution phase. In particular, quality at the destination is proportional to a Cobb-Douglas composite of factory-set quality and the aggregate maintenance effort, and is equal to

$$z_1(E|\, z_0) = z_0^{1-\beta} E^\beta, \qquad \beta \in (0, 1), \tag{3.5}$$

if the relationship survives transit-stage bargaining, and $\delta\, z_1(E|\, z_0)$ if the relationship breaks down, where $\delta \in (0, 1)$ measures the "salvage value" of $(X, M)$ −specific quality. The parameter $\beta$ measures the importance of quality maintenance efforts relative to the initial quality

$z_0$, in determining final quality.

## 3.1 First-best contracts

If initial quality and maintenance efforts are verifiable to third parties, the importer proposes a contract $(q, z_0, e_X, e_M, s)$ that specifies the desired physical output, initial quality, each party's maintenance efforts, and a payment $s \in \mathbb{R}$ to the exporter

$$\begin{aligned} \max_{q,z_0,e_X,e_M,s} \; & r\left(q, z_1\left(E\left(e_X, e_M\right)\middle| z_0\right)\right) - \frac{1}{2}\psi_M e_M^2 - s \\ \text{s.t. } \; & s - \left(cwq + \frac{1}{2}\psi_0 z_0^2 + \frac{1}{2}\psi_X e_X^2\right) \geq 0. \end{aligned} \tag{3.6}$$

The importer chooses the transfer $s$ that just secures exporter participation, which implies that the importer maximizes sales revenues net of the joint (across parties) production and distribution costs.

Conditional on the first-best shipping volume and initial quality, $(q_{FB}, z_{0,FB})$, $j$'s optimal maintenance effort is

$$e_{j,FB}\left(q_{FB}, z_{0,FB}\right) = \left(\gamma q_{FB}\, \beta z_{0,FB}^{1-\beta}\, \Phi_{FB}^{\beta-\rho}\right)^{\frac{1}{2-\beta}}\; \phi_{j,FB}, \tag{3.7}$$

where

$$\Phi_{FB} \equiv \left(\eta\, \phi_{X,FB}^{\rho} + (1-\eta)\; \phi_{M,FB}^{\rho}\right)^{\frac{1}{\rho}}, \qquad \phi_{j,FB} \equiv \left(\frac{\eta_j}{\psi_j}\right)^{\frac{1}{2-\rho}}. \tag{3.8}$$

The term $\Phi_{FB}$ is a share-weighted index of individual distribution capabilities, $\phi_{j,FB}$, itself a share-weighted measure of $j$'s marginal efficiency. Large values of $\phi_{j,FB}$ indicate that $j$'s effort is particularly important, and/or cheaper on the margin. Returning to (3.7), first-best individual efforts are increasing in shipment volume, $q_{FB}$, consumer love-of-variety, $\gamma$, and, if $\beta > \rho$, in the exporter-importer pair's joint capabilities, $\Phi_{FB}$. The first two effects follow from the fact, alluded to when discussing consumer preferences, that $\gamma q$ measures the marginal returns to quality (in terms of higher sales revenue).

Given the CES effort aggregator, $j$'s effort, relative to $-j$'s, and to the aggregate, are

$$\frac{e_{j,FB}}{e_{-j,FB}} = \frac{\phi_{j,FB}}{\phi_{-j,FB}} = \left(\frac{\eta_j}{1-\eta_j}\frac{\psi_{-j}}{\psi_j}\right)^{\frac{1}{2-\rho}}, \qquad \frac{e_{j,FB}}{E_{FB}} = \frac{\phi_{j,FB}}{\Phi_{FB}}. \tag{3.9}$$

All else equal, $j$ contributes relatively more if their effort is more important ($\eta_j > 1/2$), or they are more efficient at the margin ($\psi_j/\psi_{-j} < 1$).

While individual efforts are of interest in their own right, we are ultimately interested

in aggregate effort, which combines with factory-set quality, $z_0$, to determine final quality. Substituting (3.7) into (3.4), the first-best aggregate effort,

$$E_{FB}\left(q_{FB}, z_{0,FB}\right) = \left(\gamma q_{FB}\, \beta z_{0,FB}^{1-\beta}\, \Phi_{FB}^{2-\rho}\right)^{\frac{1}{2-\beta}}, \tag{3.10}$$

is increasing in the shipping volume $q_{FB}$, initial factory quality, $z_{0,FB}$, and aggregate productivity, $\Phi_{FB}$. This follows from two simple observations. First, the marginal return to aggregate effort ultimately derives from the resulting increase in sales revenue due to higher quality goods at the destination, $\gamma q$. Second, aggregate effort and initial quality are complements in the production of final quality, so that $z_{0,FB}$ increases the marginal returns to aggregate effort.

Having established the optimal maintenance efforts conditional on $(q_{FB}, z_{0,FB})$, we now turn to initial quality. Simplifying,

$$z_{0,FB}\left(q\right) = \Theta_{z0,FB}\, \gamma q, \qquad \Theta_{z0,FB} \equiv \beta^{\frac{\beta}{2}} \left(1-\beta\right)^{\frac{2-\beta}{2}} \left(\frac{1}{\psi_0}\right)^{\frac{2-\beta}{2}} \Phi_{FB}^{\frac{\beta(2-\rho)}{2}} > 0. \tag{3.11}$$

The term $\Theta_{z0,FB}$ summarizes the role of the supply chain technology. Holding the shipment volume constant, higher quality goods leave the factory whenever quality creation is particularly cheap (low $\psi_0$), or when the parties are adept at distribution (high $\Phi_{FB}$). Conditional on distribution capabilities, the exporter creates higher quality goods when producing large volumes. Again, this follows from the complementarity between final quality and volume in revenue generation.

Combining the first-best factory quality (3.11) and aggregate effort during transit,

$$E_{FB}\left(q\right) = \Theta_{E,FB}\, \gamma q, \qquad \Theta_{E,FB} \equiv \left(\beta\, \Theta_{z0,FB}^{1-\beta}\, \Phi_{FB}^{2-\rho}\right)^{\frac{1}{2-\beta}}, \tag{3.12}$$

according to the Cobb-Douglas technology (3.5), yields quality-at-destination

$$z_{1,FB}\left(q\right) = \Theta_{z1,FB}\, \gamma q, \qquad \Theta_{z1,FB} \equiv \Theta_{z0,FB}^{1-\beta} \Theta_{E,FB}^{\beta} = \beta^{\beta} \left(1-\beta\right)^{1-\beta} \left(\frac{1}{\psi_0}\right)^{1-\beta} \Phi_{FB}^{\beta(2-\rho)} > 0, \tag{3.13}$$

which, like initial quality and aggregate maintenance effort, is linear in the shipment volume, and increasing in the (first-best) joint distribution capabilities $\Phi_{FB}$.

Finally, the first-best shipping volume is the unique $q$ that equates the marginal revenue and marginal cost of output. From (3.2), an increase in shipment volumes changes revenues by $A - (2\gamma/L)\, q$, and, operating through the final quality given in (3.13), further raises

revenue by $(z_{1,FB} + q\,\partial z_{1,FB}/\partial q)\,\gamma$.[5] Similarly, the marginal cost of output consists of the marginal cost of producing the physical units, $cw$, and the induced marginal costs of factory-quality, $(\partial/\partial q)\left\{\psi_0\, z_{0,FB}^2/2\right\}$, and distribution efforts, $(\partial/\partial q)\left\{\sum_j \psi_j e_{j,FB}^2/2\right\}$. Again, (3.11) and (3.10) imply that the last two terms are both positive because larger volumes result in higher levels of factory- and transit-efforts.

At this stage, it is worth comparing the current setup to Antoniades (2015), which assumes that quality is fixed at the factory level (equivalent to letting $\beta \to 0$). Subsequently, the marginal return to output in that paper is simply $A - (2\gamma/L)\,q - cw$. Whether shipment volumes differ from this benchmark depend on the sign of the quality-mediated effect, which is summarized in Lemma 1.

**Lemma 1.** *Setting aside the standard net return to volume, $A - (2\gamma/L)\,q - cw$, the* net quality-mediated marginal gain to shipping volumes *simplifies to*

$$\begin{aligned}\left(z_{1,FB} + q\frac{\partial z_{1,FB}}{\partial q}\right)\gamma - \frac{\partial}{\partial q}\left\{\frac{\psi_0}{2}z_{0,FB}^2 + \sum_j \frac{\psi_j}{2}e_{j,FB}\right\} \\ = \underbrace{\beta^\beta\,(1-\beta)^{1-\beta}\,(1/\psi_0)^{1-\beta}\,\Phi_{FB}^{\beta(2-\rho)}}_{\equiv 2\Theta_{q,FB}}\gamma^2 q,\end{aligned} \tag{3.14}$$

*which is*

1. *always positive;*
2. *increasing in $\gamma$, which measures the marginal effect of quality on sales revenue;*
3. *decreasing in the marginal cost of quality-creation, $\psi_0$;*
4. *increasing in the trading pair's joint distribution capability $\Phi_{FB}$.*

*Proof.* See Section A.1. □

The first part of Lemma 1 implies that first-best quantities in this paper exceed those in Antoniades (2015). Specifically, the first-best shipment volume solves

$$\underbrace{A - \frac{2\gamma}{L}q - cw}_{\text{Antoniades (2015)}} + \underbrace{2\gamma^2\Theta_{q,FB}q}_{\text{through quality choice}} = 0 \quad\Longleftrightarrow\quad q_{FB} = \frac{L}{2\gamma}\frac{A - cw}{1 - L\gamma\Theta_{q,FB}} \tag{3.15}$$

[5] It is clear from (3.13) that this additional term is positive.

The $(X, M)$ pair trade whenever

$$\begin{aligned} &\text{Positive margin :} && c < A/w \\ &\text{Limited quality-scope :} && L\,\gamma\,\Theta_{q,FB} < 1. \end{aligned} \tag{3.16}$$

As in Melitz and Ottaviano (2008), the first condition determines trade participation – given demand conditions $A$ and labour costs $w$, the exporter/manufacturer must be sufficiently productive for exporting to be profitable. The second condition ensures declining marginal revenue, thus curbing the forces that generate sufficiently steep "quality ladders" in Antoniades (2015), where firms are more likely to innovate in quality if they face low innovation costs (low $\psi_0$), markets are large ($L$ large), varieties are sufficiently differentiated ($\gamma$ large). In contrast, the (3.11) and (3.13) guarantee quality innovation regardless of market size, exporter capabilities, or consumer preferences. However, the trade condition (3.16) limits the joint magnitude of $L$, $\gamma$, and $\Theta_{q,FB}$ (the analogue to $\psi_0$ in Antoniades (2015)).[6]

## 3.2 Holdup and the role ownership

In this section, I assume that maintenance costs and the value of the goods are unverifiable to outside parties, so that the exporter and importer cannot sign quality-contingent contracts. Further, suppose the parties cannot commit to a revenue-sharing scheme. Instead, the contract between $X$ and $M$ simply specifies the desired level of physical output, $q$, the consignor, $\mathcal{O}$, and some initial payment, $s$, from the importer to the exporter.

Figure 3 illustrates the order of play. First, the importer proposes a contract $(q, \mathcal{O}, s)$.[7] The exporter accepts the contract if his expected payoff from the ensuing production and distribution stages exceeds his reservation utility, which is normalized to zero. Substituting the binding participation constraint, and letting $z_{0,\mathcal{O}}$ and $e_{j,\mathcal{O}}$ denote the equilibrium (volume-contingent) levels of initial quality and maintenance by party $j$, the second-best contract solves

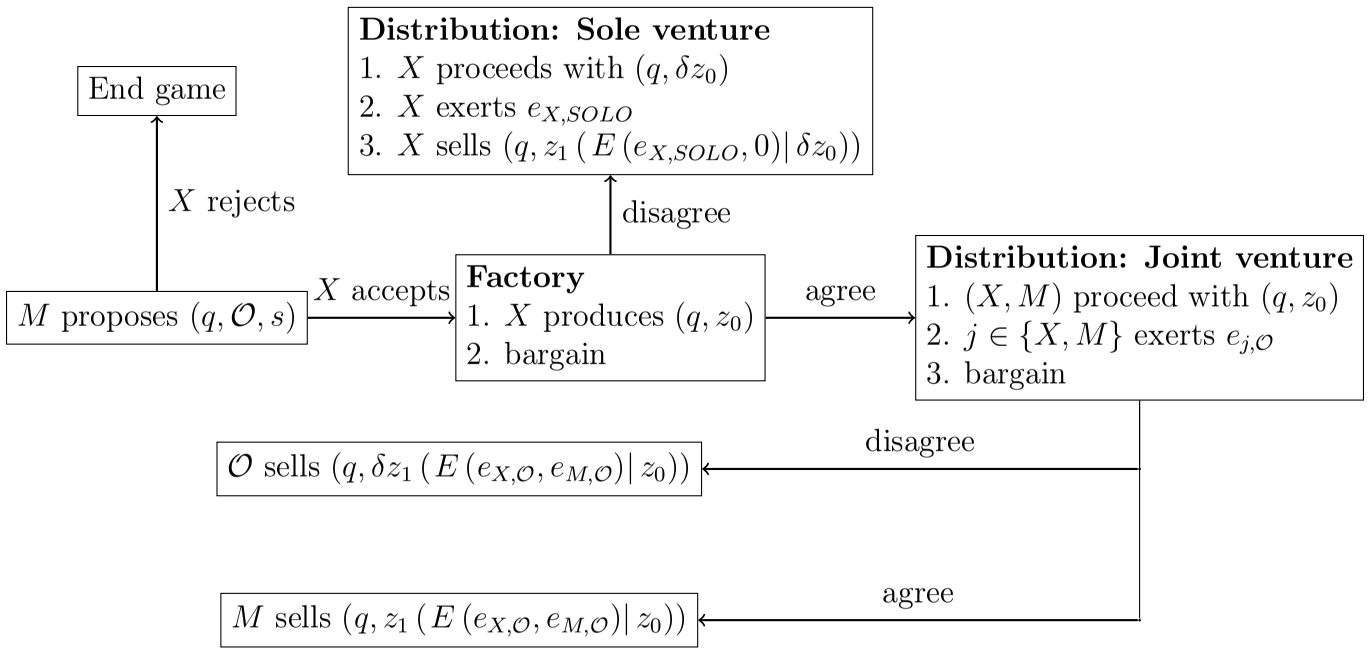
$$\max_{q,\mathcal{O}} \quad r\left(q, z_1\left(E\left(e_{X,\mathcal{O}}, e_{M,\mathcal{O}}\right)\middle| z_{0,\mathcal{O}}\right)\right) - \left(cwq + \frac{1}{2}\psi_0 z_{0,\mathcal{O}}^2 + \sum \frac{1}{2}\psi_j e_{j,\mathcal{O}}^2\right). \tag{3.17}$$

Unlike the first-best (3.6), the importer cannot decree that the parties take particular unverifiable actions. Instead, she must induce the exporter (and herself) to choose the desired levels of these unverifiable inputs in a manner consistent with their selfish interests.

[6] I show in Section A.2 that (3.15) delivers the Antoniades (2015) equilibrium, which assumes that quality is fixed at the factory level ($\beta \to 0$).

[7] The Principal's identity is irrelevant if we assume that both parties have quasilinear preferences and unlimited wealth.

**Figure 3:** Order of play



Combined with the diminished value of the existing bundle to alternative buyers, this contractual incompleteness implies that the parties potentially bargain twice over any potential surplus from maintaining their relationship. They first bargain *after* the exporter has hired the $l = cq$ workers consistent with the desired output and sunk the initial effort $z_0$, but *before* $z_0$ has been incorporated into the $q$ units. For example, the importer, well aware that outside parties value only a fraction $\delta$ of the initial quality $z_0$, may want to renegotiate the terms of trade after the exporter has already exerted some effort towards $z_0$. If the parties arrive at a mutually beneficial arrangement, they initiate the delivery stage with the bundle $(q, z_0)$. However, if they disagree on the terms of trade, the relationship is terminated, and the exporter proceeds independently with the bundle $(q, \delta z_0)$.[8]

### 3.2.1 Distribution phase

If they maintain their relationship beyond the factory, the exporter and importer exert some maintenance effort towards $(q, z_0)$. However, just as with the exporter's quality *creating* effort, the parties bargain over some unforeseen contingency after exerting maintenance effort but before incorporating these efforts into the factory-set bundle $(q, z_0)$. If the relationship survives this second round of bargaining, the parties produce $(q, z_1(E|\, z_0))$, which the importer sells for

$$r^{IN}(E|\, q, z_0) \equiv r(q, z_1(E|\, z_0)) = \left(A + \gamma z_1(E|\, z_0) - \frac{\gamma}{L} q\right) q. \tag{3.18}$$

Unlike the factory-bargain, their disagreement payoffs depend on consignor's identity. Let $v^1_{j,\mathcal{O}}(E|z_0, q)$ denote $j$'s disagreement payoff when $\mathcal{O}$ controls delivery, taking the aggregate maintenance effort, $E$, and initial quality and volume, $(z_0, q)$, as given. Control over distribution determines disagreement outcomes because most contracts of carriage grant the party in charge the right to decide how to proceed following unforeseen events during shipment. For example, Marcet and de Ochoa Martínez (2006) note that such *residual rights of control* stem from the carriers' obligation – when reasonable – to await the consignor's instructions "when transportation cannot be carried out, or impediments to the delivery arise." These freight contracts also effectively confer ownership over the shipment, as carriers must obey the consignor's wishes as to the intended recipient. Freight contracts therefore grant the consignor many of the rights typically associated with ownership. With this in mind, I refer to the party controlling delivery as the consignor or owner.

Because some of the effort is lost if the parties fail to reach an agreement, $j$'s disagreement

[8] I do not consider factory integration; see the vast literature on vertical integration in the face of holdup.

payoff, gross of the sunk maintenance cost, is

$$v^1_{j,\mathcal{O}}\left(E|q,z_0\right) = \mathbb{1}_{\mathcal{O}=j}\, r^{OUT}\left(E|\, q,z_0\right) \equiv \mathbb{1}_{\mathcal{O}=j}\left(A+\gamma\,\delta z_1\left(E|\, z_0\right)-\frac{\gamma}{L}q\right)q, \tag{3.19}$$

where $\mathbb{1}_{\mathcal{O}=j}$ indicates that $j$ controls distribution. That is, $\mathcal{O}$ earns the sales revenue from a bundle embodying a fraction $\delta$ of the aggregate maintenance effort, while the non-controlling party is left empty-handed. Consumer demand (3.2) implies that higher initial quality renders the consignor's outside option more valuable in proportion to the shipment volume. However, larger volumes do not necessarily imply a more valuable outside option – the final salvageable quality must be sufficiently large, exceeding the threshold $z_1^{MIN} = 2q/L - A/\gamma$, an exceedingly difficult task when shipping in more differentiated sectors or to smaller markets.

The property rights literature in the tradition of Grossman and Hart (1986) and Hart and Moore (1990) stresses the distortionary effects of control rights in environments where parties make ex-ante non-contractible investments, as I assume here. Several variations of these models focus on environments where parties undertake too little of some productive activity (relative to the first-best) because they anticipate earning but a fraction of the marginal value of their investments. As we will see, the exporter and importer may *over*-invest, owing to the exporter's ability to influence future outcomes through his factory-based choices.

**Definition 1.** The *transit-stage renegotiation surplus under $\mathcal{O}-$control* is the difference between the value of reaching an agreement during transit-stage bargaining and the joint disagreement payoffs

$$\begin{aligned} R^1\left(E|q,z_0\right) &= r^{IN}\left(E|\, q,z_0\right) - r^{OUT}\left(E|\, q,z_0\right) \\ &= (1-\delta)\cdot\gamma q\cdot z_1\left(E|\, z_0\right). \end{aligned} \tag{3.20}$$

This surplus is the difference between the value added through maintenance efforts during transit within and outside the relationship. Inspecting the revenue function (3.2), the marginal return to quality is proportional to $\gamma q$. The parties are thus more eager to reach an agreement when shipping large volumes, and this effect is magnified when the goods in question are highly differentiated.

Further, the transit surplus is increasing in $1-\delta$, the specificity of effort to the particular exporter-importer pair. The surplus approaches the entire valued added in transit as these efforts become increasingly specialized to $M$'s consumer base. At the other extreme, there is nothing at stake during bargaining if quality is just as valuable outside the relationship ($\delta = 1$).

Lastly, recall that $z_1\left(E|\, z_0\right) \equiv z_0^{1-\beta}E^{\beta}$ measures destination quality, given factory quality

$z_0$ and aggregate transit efforts $E$. As a result, bargaining is pointless if initial quality, $z_0$, is zero, or if neither party performs maintenance ($E = 0$). In contrast, the renegotiation surplus is large whenever high-quality bundles leave the factory, and/or the parties exert a great deal of effort before bargaining. Gathering these observations yields the following sufficient condition for "successful" transit-stage bargaining.

**Proposition 1.** *The parties reach an agreement during transit-stage bargaining whenever (i) maintenance effort is partially-specific to the relationship; (ii) the shipment embodies positive quality levels upon leaving the factory; and (iii) at least one party exerts effort towards transit-stage quality maintenance.*[9]

Under simple Nash bargaining over the transit pie, $j$ earns their disagreement payoff, plus half of the renegotiation surplus. Taking the other party's choice as given, $j$ anticipates earning

$$u^1_{j,\mathcal{O}}\left(e_X, e_M | q, z_0\right) = \mathbb{1}_{\mathcal{O}=j} \cdot r^{OUT}\left(E | \, q, z_0\right) + \frac{1}{2} R^1\left(E | q, z_0\right) - \frac{1}{2}\psi_j e_j^2, \tag{3.21}$$

from choosing choosing $e_j$.

Since the marginal returns to quality on both the owner's outside option and the surplus is $\gamma q$, the exporter's best-response solves

$$\mu_{j,\mathcal{O}}\, \gamma q\, \beta z_0^{1-\beta} E\left(e_X, e_M\right)^{\beta-\rho}\, \eta_j e_j^{\rho-1} = \psi_j e_j, \qquad \mu_{j,\mathcal{O}} \equiv \mathbb{1}_{\mathcal{O}=j}\, \delta + \frac{1}{2}\left(1-\delta\right) \tag{3.22}$$

In equilibrium, $j$ equates the marginal cost of maintenance to their share of value added during transit, adjusting for ownership rights by $\mu_{j,\mathcal{O}}$. This adjustment factor ranges from a high of $\frac{1}{2}\left(1+\delta\right)$ when $j$ controls delivery, to a low of $\frac{1}{2}\left(1-\delta\right)$ when the other party is in charge. Delivery rights encourage owner effort at the expense of the other party's efforts. Finally, if quality maintenance is entirely relationship-specific ($\delta = 0$), then $\mu_{j,\mathcal{O}} = \frac{1}{2}$ does not vary across parties or ownership structures.

It is worth highlighting the differences between the current setup and Antràs and Chor (2013), who also model sequential production. In their model, each stage – analogous to our "factory" and "delivery" phases – is operated by a distinct agent. In their baseline model, each agent only considers the effect of its investment on final sales revenue, so that effort at a given stage depends only on effort in preceding stages.[10]

In contrast, this paper recognizes the fact that both the exporter and importer may enhance the shipment's quality. This observation introduces *within*-stage strategic inter-

[9] While parts (ii) and (iii) seem to rely on the particular functional form for $z_1\left(E | \, z_0\right)$, the result follows given our demand function provided $\delta < 1$ and $z_1\left(\cdot | \, z_0\right)$ is increasing.

[10] They do consider an extension to agents who internalize the effect of their choice on downstream production, but drive this forward-looking behaviour to zero by considering a continuum of stages.

actions. Specifically, individual maintenance efforts interact via the CES effort aggregator $E(e_X, e_M)$. If $\beta = \rho$ , then the parties have dominant strategies, so that the analysis follows à-la-Grossman and Hart (1986). Setting aside this knife-edge case, best responses are upward sloping whenever $\beta > \rho$, and downward sloping otherwise.

The equilibrium *aggregate* effort is

$$E_{\mathcal{O}}(q, z_0) = \left(\gamma q \cdot \beta z_0^{1-\beta} \Phi_{\mathcal{O}}^{2-\rho}\right)^{\frac{1}{2-\beta}}, \tag{3.23}$$

where

$$\Phi_{\mathcal{O}} \equiv E(\phi_{X,\mathcal{O}}, \phi_{M,\mathcal{O}}) = \left(\eta\, \phi_{X,\mathcal{O}}^{\rho} + (1-\eta)\, \phi_{M,\mathcal{O}}^{\rho}\right)^{\frac{1}{\rho}}, \qquad \phi_{j,\mathcal{O}} \equiv \left(\mu_{j,\mathcal{O}} \frac{\eta_j}{\psi_j}\right)^{\frac{1}{2-\rho}} \tag{3.24}$$

are the *control-adjusted efficiency index,* and the *individual control-adjusted efficiency.* Like its first-best counterpart (3.8), $\Phi_{\mathcal{O}}$ is a share-weighted average of individual capabilities, with weights corresponding to the importance of a party's maintenance effort. These indices differ in the $\mu_{j,\mathcal{O}}$ terms, which summarize the effects of relationship-specific efforts and ownership on aggregate productivity. Specifically, relative to the first best, $\Phi_{\mathcal{O}}$ scales down individual productivities by the effective contribution to value-added, $0 < \mu_{j,\mathcal{O}} < 1$. Effort non-contractibility is therefore equivalent to a reduction in individual distribution capabilities that disproportionately targets the non-controlling party.

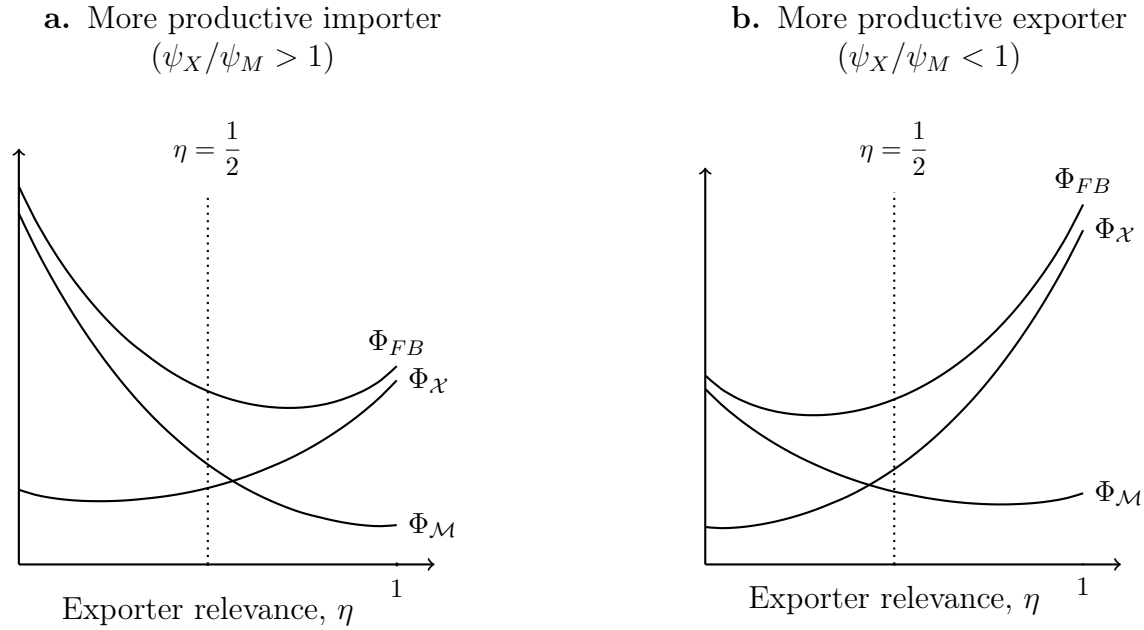
Aggregate efficiency differs across ownership structures depending on the relative importance of exporter effort, the relative exporter marginal cost, and the substitutability of individual efforts. Figure 4 plots the first- and second-best joint capabilities as functions of the exporter's share in aggregate effort. The panels differ in the identity of the relatively more efficient trading partner, with Panel (a) corresponding to a more efficient importer ($\psi_M < \psi_X$).

The first-best aggregate distribution capability exceeds the second-best under either party's control, regardless of the relative importance of exporter effort, $\eta$. Further, the joint capability under exporter-control eventually surpasses that under importer control as exporter effort becomes more important (as $\eta \to 1$). Lemma 2 shows that the critical value of $\eta$ depends on the relative marginal cost of effort and the substitutability of individual efforts.[11]

**Lemma 2.** *The joint distribution capability, $\Phi$, is greater under exporter-control if and only if exporter effort is sufficiently important. Specifically, the exporter's share of aggregate effort, $\eta$, must exceed a threshold, $\eta_{\Phi}^{*} = \eta_{\Phi}^{*}(\psi_X/\psi_M, \rho)$, which*

[11] See A.3.1 for the proof and explicit formula for the cutoff

**Figure 4:** Aggregate productivity and the contracting environment




*Notes:* Aggregate productivity in the first-best, and under exporter ($\Phi_{\mathcal{X}}$) and importer ($\Phi_{\mathcal{M}}$) control. The importer is relatively more productive at the margin in Panel a, while the exporter is more productive in Panel b. First-best aggregate productivity exceeds the second-best under any ownership arrangement, regardless of the value of $\eta$. Second-best aggregate productivity is higher under exporter control when his contribution to aggregate effort, $\eta$, exceeds the threshold defined by the intersection of $\Phi_{\mathcal{X}}$ and $\Phi_{\mathcal{M}}$.

1. *increases in the exporter's relative marginal cost of effort, $\psi_X/\psi_M$, and*

2. *decreases in the elasticity of substitution between individual efforts if the exporter is more efficient ($\psi_X/\psi_M < 1$), and increases in the elasticity of substitution if the importer is more efficient ($\psi_X/\psi_M > 1$).*

*In particular, $\eta^*_\Phi(1, \rho) = 1/2$; if the exporter and importer are equally productive, the pair is better at distribution under exporter control if and only if the exporter makes the more important investment ($\eta > 1/2$).*

All else equal, the gains from transferring ownership to the exporter are increasing in his relative productivity, $\psi_X/\psi_M$. If the exporter is less productive than the importer, then joint capability falls whenever he assumes control, with a more pronounced decline as individual efforts become increasingly substitutable. Intuitively, when $\rho$ is large, transferring ownership to the exporter discourages the importer from exerting that is just as valuable on the margin. Further, $\Phi_{\mathcal{O}}$ is increasing in $\delta$, the fraction of effort valuable outside the relationship, whenever $\mathcal{O}$'s effort is relatively more important. This follows from the complementarity between

$\delta$ and $\Phi_{\mathcal{O}}$ in the salvageable destination quality, $\delta z_1 \left( E_{\mathcal{O}} \middle| z_{0,\mathcal{O}} \right)$. In spite of this, $\Phi_{\mathcal{X}}/\Phi_{\mathcal{M}}$ is independent of $\delta$, so that $\delta$ does not single-handedly determine the ranking of aggregate capabilities across contractual forms. In the extreme case where alternative buyers do not value the pair's particular quality improvements ($\delta = 0$), then $\mu_{j,\mathcal{O}} = \frac{1}{2}$, which renders $\Phi_{\mathcal{O}}$ independent of the contractual form $\mathcal{O}$.

Applying Lemma 2 to the expression for $E_{\mathcal{O}}$ in (3.23) provides a ranking of aggregate effort across ownership structures:

**Proposition 2.** *Aggregate maintenance effort is greater under exporter control if and only if the exporter has a sufficiently large share of aggregate effort.*

Returning to the investment game, individual effort is

$$e_{j,\mathcal{O}}\left(q, z_0\right) = \left(\gamma q \cdot \beta z_0^{1-\beta} \Phi_{\mathcal{O}}^{\beta-\rho}\right)^{\frac{1}{2-\beta}} \phi_{j,\mathcal{O}} \qquad \left(= \frac{\phi_{j,\mathcal{O}}}{\Phi_{\mathcal{O}}} E_{\mathcal{O}}\left(q, z_0\right)\right). \tag{3.25}$$

As with aggregate effort, ownership effectively changes the marginal productivity of effort. Further, in what will become a recurring theme, individual effort is increasing in initial quantity and quality. Finally, note that relative efforts,

$$\frac{e_{j,\mathcal{O}}}{e_{-j,\mathcal{O}}} = \frac{\phi_{j,\mathcal{O}}}{\phi_{-j,\mathcal{O}}} = \left(\frac{\mu_{j,\mathcal{O}}}{\mu_{-j,\mathcal{O}}}\right)^{\frac{1}{2-\rho}} \frac{\phi_{j,FB}}{\phi_{-j,FB}} = \left(\frac{\mu_{j,\mathcal{O}}}{\mu_{-j,\mathcal{O}}}\right)^{\frac{1}{2-\rho}} \frac{e_{j,FB}}{e_{-j,FB}}, \tag{3.26}$$

are pinned down by the relative control-adjusted efficiencies, as shown in Panel (a) of Figure 5. Like the first-best in (3.9), relative equilibrium efforts under $\mathcal{O}$-control lie along a ray through the origin. However, the slopes of the rays under the three regimes (first best, $\mathcal{O} = \mathcal{M}$, and $\mathcal{O} = \mathcal{X}$) differ due to the scarcity of control rights. Assigning ownership to one party necessarily deprives the other of control, so that each party's relative effort is higher when it controls distribution:

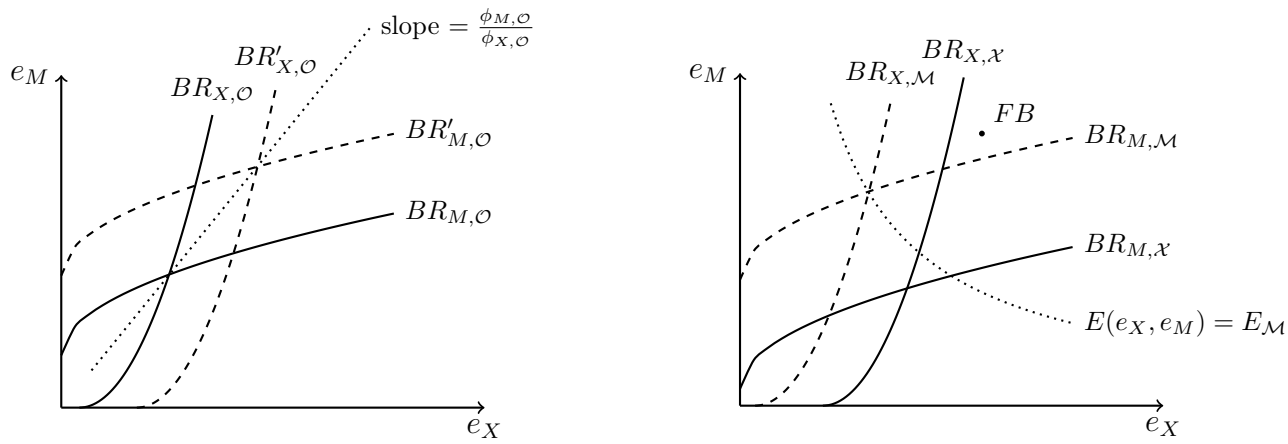
$$\frac{\mu_{M,\mathcal{M}}}{\mu_{X,\mathcal{M}}} > 1 > \frac{\mu_{M,\mathcal{X}}}{\mu_{X,\mathcal{X}}} \quad \Longrightarrow \quad \frac{e_{M,\mathcal{M}}}{e_{X,\mathcal{M}}} > \frac{e_{M,FB}}{e_{X,FB}} > \frac{e_{M,\mathcal{X}}}{e_{X,\mathcal{X}}}. \tag{3.27}$$

Panel (b) of Figure 5 illustrates the first-best, and second best equilibrium efforts under the two control structures, assuming that $\beta > \rho$ (maintenance efforts are strategic complements), $\psi_X = \psi_M$ (the parties are equally productive at the margin), and $\eta < \eta_{\Phi}^{*} < 1/2$ (exporter effort is not important enough to increase aggregate productivity). The solid and broken lines indicate best responses under exporter- and importer-controlled shipments respectively.

Comparing the first-best efforts and the intersections either the broken ($\mathcal{O} = \mathcal{M}$) or

**Figure 5:** Best-response curves when efforts are strategic complements ($\beta > \rho$)

**a.** Changes in $\gamma$, $q$, $z_0$ **b.** Changes in ownership




*Notes:* $BR_{j,\mathcal{O}}$ is $j$'s best response under a $\mathcal{O}-$controlled shipment. Individual efforts are strategic complements when $\beta > \rho$, hence the upward sloping best-response functions. Panel (a) traces equilibrium efforts as the delivery-stage state variables, $q$ and $z_0$, change, holding ownership fixed. Panel (b) illustrates the role of ownership. The downward sloping line traces combinations of exporter and importer efforts that result in the equilibrium level of aggregate maintenance effort under importer control. Aggregate effort is lower under $X$-control because $M$'s effort is more important ($\eta < 1/2$) and $M$ and $X$ are equally productive at the margin ($\psi_X = \psi_M$).

solid ($\mathcal{O} = \mathcal{X}$) lines, the first-best individual efforts exceed their second-best counterparts under either ownership arrangement. Further, comparing the second-best equilibria, exporter control leads to lower importer effort but greater exporter effort. When the importer makes the more important investment, which is the case in the figure, the fall in importer effort outweighs the increase in exporter effort, as shown by the new equilibrium lying below the downward sloping iso-aggregate-effort curve through the initial equilibrium point. In this scenario, there is a clear ranking of *aggregate* effort across the various arrangements : $E_{FB} > E_{\mathcal{M}} > E_{\mathcal{X}}$.

### 3.2.2 Manufacturing phase

This section characterizes the equilibrium factory-set quality, taking shipment volume and the Nash equilibrium in subsequent transit efforts as given. The analysis delivers a control-specific policy rule $z_{0,\mathcal{O}}(q)$, and derives comparative statics with respect to shipment volume $q$ and consignment rights $\mathcal{O}$.

Having accepted the importer's contract, the exporter chooses initial quality, aware that the parties will bargain soon thereafter, and, if successful, proceed to the delivery stage and play the strategies $e_{j,\mathcal{O}}(q, z_0)$ derived in the previous section. The exporter thus chooses $z_0$

to maximize his payoffs across both bargaining stages. Let

$$U^1_{j,\mathcal{O}}(q, z_0) \equiv u^1_{j,\mathcal{O}}\left(e_{X,\mathcal{O}}(q, z_0), e_{M,\mathcal{O}}(q, z_0) \middle| q, z_0\right) \tag{3.28}$$

denote the corresponding equilibrium payoffs from bargaining in transit, where, recall, $u^1_{j,\mathcal{O}}$ in (3.21) is $j$'s objective in the distribution investment game.

Since I rule out factory integration, disagreement at this stage leaves the importer empty-handed. That is, her factory-disagreement payoff is $v^0_M(q, z_0) = 0$. In contrast, the exporter can appropriate a fraction $\delta$ of the relationship-specific factory-set quality.[12] Thus, if the parties disagree, the exporter independently initiates the delivery phase with the bundle $(q, \delta z_0)$, eventually offloading the final bundle on a less enthusiastic buyer.[13] In the absence of the initial importer, aggregate transit effort is $E(e_X, 0) = \eta^{1/\rho} e_X$, which implies destination quality of $z_1\left(\eta^{1/\rho} e_X \middle| \delta z_0\right)$. The exporter's disagreement payoff in the factory-based Nash bargaining game is

$$v^0_X(q, z_0) = \max_e \left\{ r\left(q, z_1\left(E(e, 0) \middle| \delta z_0\right)\right) - \frac{1}{2}\psi_X e^2 \right\}, \tag{3.29}$$

the maximized profit from selling the bundle to some alternative buyer. In this branch of play, exporter effort in the transit phase is characterized by a single-agent first-order condition rather than a pair of best-response functions as in (3.22). The optimal "breakaway" transit effort is

$$e_{X,SOLO}(q, z_0) = \left(\gamma q \cdot \beta z_0^{1-\beta} \Phi^{\beta-\rho}_{SOLO}\right)^{\frac{1}{2-\beta}} \phi_{X,SOLO}, \tag{3.30}$$

where

$$\Phi_{SOLO} \equiv \left(\eta \phi^\rho_{X,SOLO} + (1-\eta)\phi^\rho_{M,SOLO}\right)^{\frac{1}{\rho}}, \qquad \phi_{X,SOLO} \equiv \left(\frac{\eta \delta^{1-\beta}}{\psi_X}\right)^{\frac{1}{2-\beta}}, \quad \phi_{M,SOLO} = 0$$

assume the roles of the ownership-adjusted efficiencies $\Phi_{\mathcal{O}}$ and $\phi_{j,\mathcal{O}}$, with $\left(\delta^{1-\beta}, 0\right)$ assuming the role of $(\mu_{X,\mathcal{O}}, \mu_{M,\mathcal{O}})$ in the cooperative outcome. The restriction $\phi_{M,SOLO} = 0$ reflects the importer's inactivity in the exporter's sole venture and the exporter's sole access to the shipment. Like the cooperative maintenance efforts, this threat-point-maximizing effort is increasing in the shipment volume and the degree of product differentiation. Note that

[12] At the cost of extra notation, I could allow the salvageable components of factory and transit effort to differ. All subsequent results are robust to the simplifying assumption in the main text.

[13] For simplicity, I assume that the exporter uses some exogenous delivery system to get the shipment to its alternative buyers, rendering the existing carriage contract worthless.

aggregate effort is

$$E_{SOLO}(q, z_0) = \left(\gamma q \cdot \beta z_0^{1-\beta} \Phi_{SOLO}^{2-\rho}\right)^{\frac{1}{2-\beta}}. \tag{3.31}$$

Having derived the exporter's disagreement payoff, we now turn to the value of cooperation during factory-phase bargaining. If the parties reach an amicable settlement, they proceed to the delivery phase with the higher quality bundle $(q, z_0)$, and then play their equilibrium strategies (3.25), earning $U_{j,\mathcal{O}}^1(q, z_0)$. Letting $e_{j,\mathcal{O}}$ and $E_{\mathcal{O}}$ denote the equilibrium individual and aggregate levels in (3.25) and (3.23), this branch of play earns the parties

$$\begin{aligned} \sum_j U_{j,\mathcal{O}}^1(q, z_0) &= r^{OUT}(E_{\mathcal{O}}|\, q, z_0) + R^1(E_{\mathcal{O}}|q, z_0) - \sum_j \frac{1}{2}\psi_j e_{j,\mathcal{O}}^2 \\ &= r^{IN}(E_{\mathcal{O}}|\, q, z_0) - \sum_j \frac{1}{2}\psi_j e_{j,\mathcal{O}}^2 \end{aligned} \tag{3.32}$$

where I use the fact that transit-phase bargaining is a constant-sum game, in which the exporter and importer divide the sales revenue from maintaining their relationship through delivery, net of the total effort cost.

The threat point (3.29) and the value of cooperation (3.32) define the factory-based bargaining game, where the parties reach a mutually beneficial agreement as long as their joint future payoffs exceed the exporter's immediate outside option.

**Definition 2.** The *factory-stage renegotiation surplus under $\mathcal{O}-$control,* is the difference between the value of reaching an agreement during factory-based bargaining and exporter's immediate outside option:

$$R_{\mathcal{O}}^0(q, z_0) \equiv \sum_j U_{j,\mathcal{O}}^1(q, z_0) - v_X^0(q, z_0) = r^{IN}(E_{\mathcal{O}}|\, q, z_0) - \sum_j \frac{1}{2}\psi_j e_{j,\mathcal{O}}^2 - v_X^0(q, z_0). \tag{3.33}$$

Note that, unlike the distribution-phase surplus (3.20), which is analogous to the surplus in standard single-stage production models, the factory surplus accounts for the joint payoffs from the subsequent delivery stage.

As the unique actor in the factory phase, the exporter has considerable leeway in influencing future play to suit his needs. He considers the effect of his choice of initial quality on his immediate outside option, $v_X^0(q, z_0)$, his future bargaining payoff, $U_{X,\mathcal{O}}^1$, and – with symmetric Nash bargaining – half the value of allowing production to advance to the delivery stage, $\frac{1}{2}\sum_j U_{j,\mathcal{O}}^1(q, z_0)$.

The exporter's payoff from factory-based bargaining, net of the cost of effort, is

$$\begin{aligned} u^0_{X,\mathcal{O}}(q,z_0) &= v^0_X(q,z_0) + \frac{1}{2}R^0_{\mathcal{O}}(q,z_0) - \frac{1}{2}\psi_0 z_0^2 \\ &= \frac{1}{2}v^0_X(q,z_0) + \frac{1}{2}\sum_j U^1_{j,\mathcal{O}}(q,z_0) - \frac{1}{2}\psi_0 z_0^2, \end{aligned} \tag{3.34}$$

where the second line follows from substituting (3.33). The exporter places some weight on the off-the-equilibrium-path event that factory-based bargaining breaks down. Unlike the familiar one-shot production/trade models, the exporter chooses initial quality, $z_0$, to maximize his joint bargaining payoffs across the production and delivery phases. Assuming no discounting, the forward-looking exporter maximizes $u^0_{X,\mathcal{O}}(q,z_0) + U^1_{X,\mathcal{O}}(q,z_0)$, so that his factory-stage objective is a weighted sum of three income streams: (i) his income from a solo venture, $v^0_X(q,z_0)$; (ii) his own payoff in the delivery phase, $U^1_{X,\mathcal{O}}(q,z_0)$; and (iii) the importer's delivery-phase payoff, $U^1_{M,\mathcal{O}}(q,z_0)$. Specifically, using the second line of (3.34),

$$u^0_{X,\mathcal{O}}(q,z_0) + U^1_{X,\mathcal{O}}(q,z_0) = \underbrace{\frac{1}{2}v^0_X(q,z_0)}_{\text{Sole-venture incentive}} + \underbrace{\frac{3}{2}U^1_{X,\mathcal{O}}(q,z_0) + \frac{1}{2}U^1_{M,\mathcal{O}}(q,z_0)}_{\text{Joint-venture incentive}} - \frac{1}{2}\psi_0 z_0^2.$$

The first term on the right-hand side captures the gains accruing from the exporter's immediate outside option, which involves proceeding to the shipping phase alone. The second term measures the gains from sustaining the existing relationship. Adopting the perspective of the exporter (who chooses $z_0$), I refer to $\frac{3}{2}U^1_{X,\mathcal{O}}(q,z_0)$ as the *own-payoff incentive,* and $\frac{1}{2}U^1_{M,\mathcal{O}}(q,z_0)$ as the *rival-payoff incentive.* Ignoring the positive weights unless absolutely necessary, I first sign the own- and rival-payoff incentives, $\mathrm{d}U^1_{X,\mathcal{O}}(z_0,q)/\mathrm{d}z_0$ and $\mathrm{d}U^1_{M,\mathcal{O}}(z_0,q)/\mathrm{d}z_0$ under an arbitrary contractual form, and then describe changes in these incentives as control transfers from the importer to the exporter, $\mathrm{d}\left[U^1_{j,\mathcal{X}}(q,z_0) - U^1_{j,\mathcal{M}}(q,z_0)\right]/\mathrm{d}z_0$.

**Sole-venture effect.** In this branch of play, the exporter opts to terminate the relationship before delivery begins. The marginal return to quality on the exporter's threat point is

$$\frac{\partial v^0_X(q,z_0)}{\partial z_0} = \gamma q \frac{\partial z_1\left(E_{SOLO}(q,z_0)\middle|\,\delta z_0\right)}{\partial z_0} = \gamma q\,(1-\beta)\left(\gamma q \cdot \beta z_0^{1-\beta}\Phi^{2-\rho}_{SOLO}\right)^{\frac{1-\beta}{2-\beta}} > 0,$$

where the envelope theorem allows us to disregard the effects of $z_0$ on $v^0_X$ through the optimally chosen effort, $e_{X,SOLO}(q,z_0)$.

The factory-stage threat point elicits greater initial quality in transactions involving large volumes in differentiated sectors. Note that ownership rights, which only matter if

the relationship survives beyond the manufacturing phase, are irrelevant for the sole-venture channel.

**Joint-venture effect.** The incentives to alter future play depend on the effects of factory-set quality on the transit-stage best responses (cross-stage strategic interactions), and on strategic interactions between individual efforts within the transit stage. Recall that this income stream arises from the exporter appropriating $j$'s transit-stage payoff, where $j = X, M$. The total effect of a change in $z_0$ on $j$'s transit-stage payoff is

$$\frac{\mathrm{d}U^1_{j,\mathcal{O}}(z_0, q)}{\mathrm{d}z_0} = \mu_{j,\mathcal{O}} \cdot \gamma q \left( \frac{\partial z_1 (E_{\mathcal{O}} | z_0)}{\partial z_0} + \frac{\partial z_1 (E_{\mathcal{O}} | z_0)}{\partial e_{-j}} \frac{\partial e_{-j,\mathcal{O}}}{\partial z_0} \right), \tag{3.35}$$

where the envelope theorem eliminates the effect of $z_0$ on $U^1_{j,\mathcal{O}}$ through $j$'s own choice $e_{j,\mathcal{O}}$. The total effect is the sum of the *direct effect* of initial quality on $U^1_{j,\mathcal{O}}$, and the *strategic effect*, mediated by $-j$'s response, $e_{-j,\mathcal{O}}$.

The direct effect combines $j$'s share of value added in transit, the marginal returns to quality, and the marginal returns to effort in quality creation,

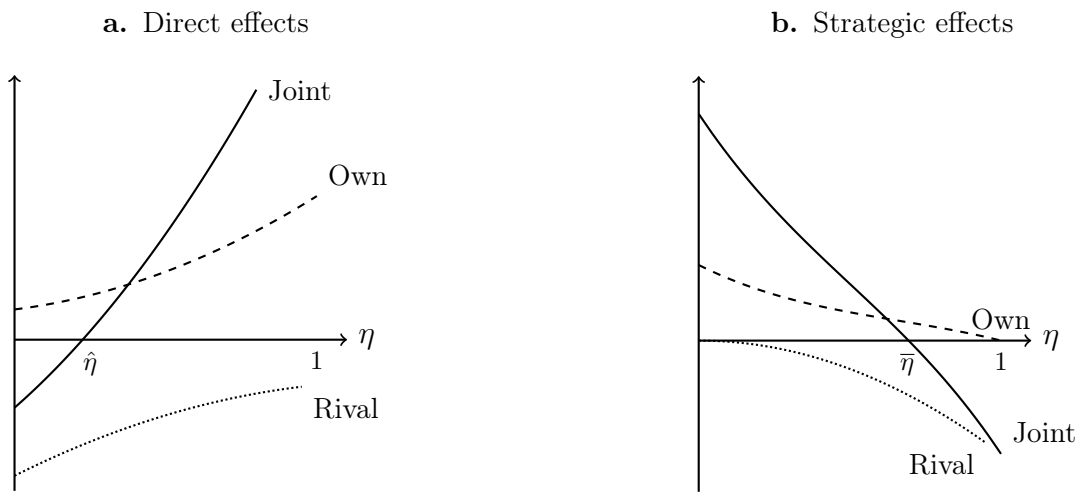
$$\mu_{j,\mathcal{O}} \cdot \gamma q \frac{\partial z_1 (E_{\mathcal{O}} | z_0)}{\partial z_0} = \gamma q \cdot (1 - \beta) \left( \gamma q \cdot \beta z_0^{-1} \Phi_{\mathcal{O}}^{2-\rho} \right)^{\frac{\beta}{2-\beta}} \mu_{j,\mathcal{O}}. \tag{3.36}$$

This effect is unambiguously positive, and stronger when shipping large volumes of differentiated goods. After all, factory effort increases initial quality, which increases sales revenue disproportionately in sectors where consumers enjoy variety. Thus, holding ownership rights fixed, the direct effect encourages the exporter to create high quality goods.

Changes in contractual form affect the direct channel through (i) the pair's joint capability, $\Phi_{\mathcal{O}}$, which, according to Lemma 2, is greater in exporter-controlled shipments whenever exporter effort is particularly useful; and (ii) $j$'s share of value added, $\mu_{j,\mathcal{O}}$, which is greater when $j$ controls delivery. In principle, these effects may oppose each other, with different implications for the own and rival incentives.

Panel (a) of Figure 6 summarizes the effects of transferring consignment rights to the exporter on the direct effect. The own-payoff incentive (dashed line) is unambiguously positive if exporter effort is sufficiently important, that is, if $\eta > \eta^*_{\Phi}$. Transferring control to the exporter raises his incentives to invest, and raises aggregate productivity. Perhaps surprisingly, it remains positive even if exporter effort is not important enough to guarantee that $\Phi_{\mathcal{X}} > \Phi_{\mathcal{M}}$. In other words, the exporter's desire to extract a larger share of the transit-stage surplus, operating through $\mu_{X,\mathcal{O}}$, outweighs potential efficiency concerns. In contrast, the rival-payoff incentive (dotted line) is negative. The importer earns a smaller share of

**Figure 6:** Joint-venture: Changes in quality-creation incentives induced by transfer of ownership




*Notes:* Effects of transferring control to the exporter on (a) the direct (3.36); and (b) the strategic (3.37) channels for initial quality choice. I ignore $\mathcal{O}$-independent terms in these expressions, focusing on changes in $\Phi_{\mathcal{O}}^{\beta(2-\rho)/(2-\beta)}\,\mu_{j,\mathcal{O}}$ in Panel (a), and changes in $\Phi_{\mathcal{O}}^{2(\beta-\rho)/(2-\beta)}\,\mu_{j,\mathcal{O}}\,\eta_{-j}\phi_{-j,\mathcal{O}}^{\rho}$ in Panel (b). The *own-payoff incentive* ($j = X$) is the effect through the exporter's transit-stage payoff, while the *rival-payoff incentive* ($j = M$) operates through the exporter's share of the importer's future payoff. The *joint venture incentive* effect is three times the own incentive, plus the rival incentive.

value-added under exporter control ($\mu_{M,\mathcal{X}} < \mu_{M,\mathcal{M}}$), which compounds the efficiency loss when $\eta < \eta_{\Phi}^{*}$, and outweighs any efficiency gains when $\eta > \eta_{\Phi}^{*}$ (again, the $\mu_{M,\mathcal{O}}$ term, which captures the battle over transit-surplus, dominates). If exporter effort is not too important (less than $\hat{\eta}$ in Figure 6), the direct effect results in lower quality goods leaving the factory under exporter control despite the exporter attaching three times as much weight to the own-payoff incentive than to the rival-payoff incentive.[14]

The strategic effect combines $j$'s share of value added in transit, the marginal returns to quality, and $-j$'s optimal effort,

$$\mu_{j,\mathcal{O}} \cdot \gamma q \frac{\partial z_1\left(E_{\mathcal{O}}|\, z_0\right)}{\partial e_M} \frac{\partial e_{-j,\mathcal{O}}}{\partial z_0} = \frac{\beta\left(1-\beta\right)}{2-\beta} \left(\left(\gamma q \cdot \beta z_0^{-1}\right)^{\beta} \Phi_{\mathcal{O}}^{2(\beta-\rho)}\right)^{\frac{1}{2-\beta}} \gamma q\, \mu_{j,\mathcal{O}}\, \eta_{-j} \phi_{-j,\mathcal{O}}^{\rho}. \quad (3.37)$$

The *own-payoff incentive* requires that the exporter manipulate the importer's future behaviour, while the *rival-payoff incentive* requires that the exporter alter his own future behaviour. The apparent switch in perspective follows from the envelope theorem. When appropriating some of his rivals future payoff $U_{M,\mathcal{O}}^{1}$, the exporter ignores changes in $e_{M,\mathcal{O}}$, leaving only his own action. In any case, the strategic effect is also positive because higher

[14] The cutoff $\hat{\eta}$ is increasing in $\beta$ and $\rho$.

levels of initial quality shift the maintenance best responses outwards ($\partial e_{j,\mathcal{O}}/\partial z_0 > 0$), resulting in higher quality destination goods ($\partial z_1 \left( E \left( e_X, e_M \right) \middle| \, z_0 \right) / \partial e_j > 0$). Intuitively, although I hold the allocation of delivery rights fixed, so that the exporter earns the same share of the surplus, he is better off because the parties now share a larger pie. Yet again, this effect is magnified when shipping large volumes of differentiated goods. Therefore, given an allocation of property rights, the exporter creates higher quality goods than he would without such strategic considerations.

In our discussion of the effects of ownership on the direct channel, we established that the desire to earn a larger share of the transit-stage surplus, operating through $\mu_{j,\mathcal{O}}$, outweighs efficiency concerns. The same reasoning applies in the strategic effect. For example, looking at the own-payoff incentive, we see that transferring ownership to the exporter raises his share of value added, $\mu_{X,\mathcal{X}} > \mu_{X,\mathcal{M}}$, while lowering the importer's efficiency, $\phi_{M,\mathcal{X}} < \phi_{M,\mathcal{M}}$. The key departure from that discussion concerns $-j$'s share-weighted efficiency, $\eta_{-j}\phi_{-j,\mathcal{O}}$, and the effects of changes in overall efficiency.

The $\phi_{-j,\mathcal{O}}$ term, which is greater whenever $-j$ controls delivery, appears because only $-j$'s choice has a first-order effect on $U^1_{j,\mathcal{O}}$. This seemingly presents an additional force, proportional to the importance of $-j$'s effort ($\eta_{-j}$), against the $\mu_{j,\mathcal{O}}$-driven battle over the distribution-phase surplus. Turning to overall efficiency concerns, giving the exporter control of shipping (even when his effort is sufficiently important; $\eta > \eta^*_\Phi$) strengthens the strategic channel if and only if efforts are strategic complements.

Panel (b) of Figure 6 summarizes the effects of transferring control to the exporter for various levels of $\eta$. Note that the rival effect vanishes as $\eta$ approaches zero – if exporter effort has little effect on the aggregate, then the exporter has little incentive to restrict his future behaviour as this will have a negligible effect on the importer's actions. Similarly, the own effect vanishes as $1 - \eta$ approaches zero. If exporter effort is important enough (greater than $\overline{\eta}$ in Figure 6), the strategic effect results in lower quality goods leaving the factory under exporter control. These qualitative properties hold for all values of $\beta$ and $\rho$; that is, regardless of whether maintenance efforts are strategic complements or substitutes as determined by the sign of $\beta - \rho$. Instead, $\beta$ and $\rho$ affect the cutoff $\overline{\eta}$ beyond which the strategic effect leads to lower quality goods under exporter control. In particular, $\overline{\eta}$ is increasing in $\beta$ and decreasing in $\rho$.

To summarize, transferring control to the exporter affects initial quality through direct and strategic channels. The direct channel encourages higher quality goods under exporter control when exporter effort is sufficiently important, while the strategic channel discourages higher quality goods if exporter control is too important. The remainder of this section combines these two counteracting forces, deriving a sufficient statistic for the effect of con-

tractual form on the choice of initial quality. We will see that initial quality is higher under exporter-control regardless of the importance of exporter effort, $\eta$, or the nature of strategic interactions within the delivery stage.

Relegating the details to Section A.4, the first-order condition for initial quality, which equates the marginal cost and benefit of $z_0$, delivers

$$z_{0,\mathcal{O}}(q) = \Theta_{z0,\mathcal{O}}\,\gamma q, \tag{3.38}$$

where

$$\Theta_{z0,\mathcal{O}} \equiv \beta^{\frac{\beta}{2}}(1-\beta)^{\frac{2-\beta}{2}}\left(\frac{1}{\psi_0}\right)^{\frac{2-\beta}{2}}\left(\omega_{SOLO}\Phi_{SOLO}^{\frac{\beta(2-\rho)}{2-\beta}} + \sum_j \omega_{j,\mathcal{O}}\Phi_{\mathcal{O}}^{\frac{\beta(2-\rho)}{2-\beta}}\right)^{\frac{2-\beta}{2}} > 0 \tag{3.39}$$

summarizes the effects of production and distribution technologies. Setting aside $\Theta_{z0,\mathcal{O}}$ for the moment, the exporter responds to higher shipping volumes by raising the initial quantity. Further, initial quality, like all other effort levels we have considered thus far, is higher in differentiated sectors.

Returning to $\Theta_{z0,\mathcal{O}}$, the first three terms, which also appear in the first-best decision rule $\Theta_{z0,FB}$ in (3.11), show that initial quality is decreasing in the marginal cost of quality creation, $\psi_0$. It is comforting to know that this purely technologically-driven conclusion is independent of the contracting environment. The term $\Theta_{z0,\mathcal{O}}$ differs from the first-best $\Theta_{z0,FB}$ through a weighted power mean of the exporter's individual capability, $\Phi_{SOLO}^{\beta(2-\rho)/2}$, and the (ownership-dependent) joint capability, $\Phi_{\mathcal{O}}^{\beta(2-\rho)/2}$. The weights are given by

$$\omega_{SOLO} \equiv \frac{1}{2}\delta^{1-\beta}, \qquad \omega_{j,\mathcal{O}} \equiv \lambda_j\mu_{j,\mathcal{O}}\left(1 + \frac{\beta}{2-\beta}\eta_{-j}\left(\frac{\phi_{-j,\mathcal{O}}}{\Phi_{\mathcal{O}}}\right)^{\rho}\right). \tag{3.40}$$

Here, the term $\omega_{SOLO}$ summarizes exporter incentives due to solo venture effect. It is increasing in the fraction of initial quality useful outside the existing relationship, which, for simplicity, is identical to the fraction of aggregate maintenance effort salvageable in case the relationship breaks down during the transit phase.[15] Holding the value of future cooperation fixed, the exporter creates higher quality goods if he expects to fetch more for the goods in the event of an early break in the relationship.

The value of maintaining the relationship beyond the manufacturing phase affects the choice of initial quality through the ownership-dependent term $\Omega_{\mathcal{O}} \equiv \sum_j \omega_{j,\mathcal{O}}$, where $\omega_{j,\mathcal{O}}$ measures exporter incentives through his share of $U^1_{j,\mathcal{O}}$. The term $\omega_{j,\mathcal{O}}$ comprises the direct effect, which is proportional to $\lambda_j\mu_{j,\mathcal{O}}$, and the strategic effect, which is proportional to

[15] Recall that none of the subsequent results hinge on this simplifying assumption.

$\lambda_j \mu_{j,\mathcal{O}} \frac{\beta}{2-\beta} \eta_{-j} \left( \frac{\phi_{-j,\mathcal{O}}}{\Phi_{\mathcal{O}}} \right)^{\rho}$.

**Lemma 3.** *Ownership affects the choice of initial quality through* $\Omega_{\mathcal{O}} \equiv \sum_j \omega_{j,\mathcal{O}}$*, where* $\omega_{j,\mathcal{O}}$ *is given in (3.40). Regardless of the importance of exporter effort,* $\eta$*, or the nature of transit-phase strategic interactions,* $\operatorname{sign}\{\beta - \rho\}$*, the term* $\Omega_{\mathcal{O}}$ *is*

1. *positive for all ownership arrangements; and*
2. *greater under exporter control.*

Part (1) of this result implies that the prospect of proceeding to the distribution phase with his current partner encourages the exporter to create higher quality goods. This holds despite the observation (Figure 6) that the rival strategic channel may discourage initial quality when exporter effort is particularly important. Part (2) shows that this incentive is greater whenever he controls delivery. Finally, applying Lemma 3 to the second-best initial quality (3.38) provides comparative statics of $z_{0,\mathcal{O}}(q)$ with respect to the contractual form $\mathcal{O}$.

**Proposition 3.** *Conditional on shipment volume,* $q$*, the exporter creates higher quality goods when controlling delivery if and only if his contribution to aggregate effort exceeds some threshold,* $\eta_z^* = \eta_z^*(\psi_X/\psi_M, \rho, \beta, \delta) \in [0, 1)$*. The critical value* $\eta_z^*$ *is*

1. *increasing in* $\beta$*, the sensitivity of final quality to maintenance efforts relative to factory-set quality levels*
2. *zero if final quality is primarily determined by factory-set quality rather than by maintenance efforts during delivery (*$\beta$ *is sufficiently low)*
3. *increasing in* $\delta$*, the fraction of aggregate effort useful outside the existing relationship.*

### 3.2.3 Optimal second-best contract

Having analyzed the the optimal strategies in the manufacturing and distribution subgames, I now return to the optimal contract (3.17), which maximizes sales revenue less total manufacturing and distribution costs. To clarify the analysis, I first describe the dependence between each component of joint welfare and the agreed-upon volume, $q$.

First, sales revenue depends on the contract $(q, \mathcal{O})$ directly through the quantity sold, and indirectly through the optimal final quality. The shipment's final quality, in turn, depends on the induced aggregate effort, now written as a a function of shipping volume by substituting the optimal initial quality (3.38) into (3.23):

$$E_{\mathcal{O}}(q) \equiv E_{\mathcal{O}}(z_{0,\mathcal{O}}(q), q) = \Theta_{E,\mathcal{O}} \gamma q, \qquad \Theta_{E,\mathcal{O}} \equiv \left( \beta \Theta_{z0,\mathcal{O}}^{1-\beta} \Phi_{\mathcal{O}}^{2-\rho} \right)^{\frac{1}{2-\beta}} \tag{3.23'}$$

Substituting $z_{0,\mathcal{O}}(q)$ and $E_{\mathcal{O}}(q)$ into the final-quality production function (3.5) delivers final quality as a function of the agreed shipment volume

$$z_{1,\mathcal{O}}(q) \equiv z_1\left(E_{\mathcal{O}}(q) \middle| z_{0,\mathcal{O}}(q)\right) = \Theta_{z1,\mathcal{O}}\,\gamma q, \qquad \Theta_{z1,\mathcal{O}} \equiv \Theta_{z0,\mathcal{O}}^{1-\beta}\Theta_{E,\mathcal{O}}^{\beta} = \left(\beta^{\beta}\Theta_{z0,\mathcal{O}}^{2(1-\beta)}\Phi_{\mathcal{O}}^{\beta(2-\rho)}\right)^{\frac{1}{2-\beta}}. \tag{3.41}$$

Second, with constant returns to production, manufacturing costs, $cwq$, depend on the exporter-specific marginal cost and the shipment volume. Lastly, quality related costs are

$$\frac{1}{2}\psi_0\left(z_{0,\mathcal{O}}(q)\right)^2 + \sum_j \frac{1}{2}\psi_j\left(e_{j,\mathcal{O}}(q)\right)^2 = \frac{1}{2}\psi_0\left(\Theta_{z0,\mathcal{O}}\,\gamma q\right)^2 + \frac{1}{2}\Psi_{\mathcal{O}} \times \left(\frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}}\gamma q\right)^2, \tag{3.42}$$

where the CES effort aggregator allows us to write total maintenance costs using the index $\Psi_{\mathcal{O}} \equiv \sum_j \psi_j \phi_{j,\mathcal{O}}^2$. This cost index inherits many properties from $\Phi_{\mathcal{O}}$, including

$$\Psi_{\mathcal{X}} \geq \Psi_{\mathcal{M}} \iff \Phi_{\mathcal{X}} \geq \Phi_{\mathcal{M}} \iff \eta \geq \eta^*\left(\psi_X/\psi_M, \rho\right). \tag{3.43}$$

Putting it all together, the optimal contract solves

$$\max_{q,\mathcal{O}} \quad \left\{\left(A + \gamma z_{1,\mathcal{O}}(q) - \frac{\gamma}{L}q\right)q - \left(cwq + \frac{1}{2}\psi_0 z_{0,\mathcal{O}}(q)^2 + \sum \frac{1}{2}\psi_j e_{j,\mathcal{O}}(q)^2\right)\right\} \tag{3.17'}$$

I first characterize $q_{\mathcal{O}}$, the optimal shipping volume conditional on ownership rights, and then describe the optimal allocation of consignment rights, $\mathcal{O}^*$. Relegating the details – which follow the same steps as the first-best solution – to Section A.5, the $\mathcal{O}-$conditional optimal shipping volume is

$$q_{\mathcal{O}} = \frac{L}{2\gamma}\frac{A - cw}{1 - L\gamma\Theta_{q,\mathcal{O}}}, \tag{3.44}$$

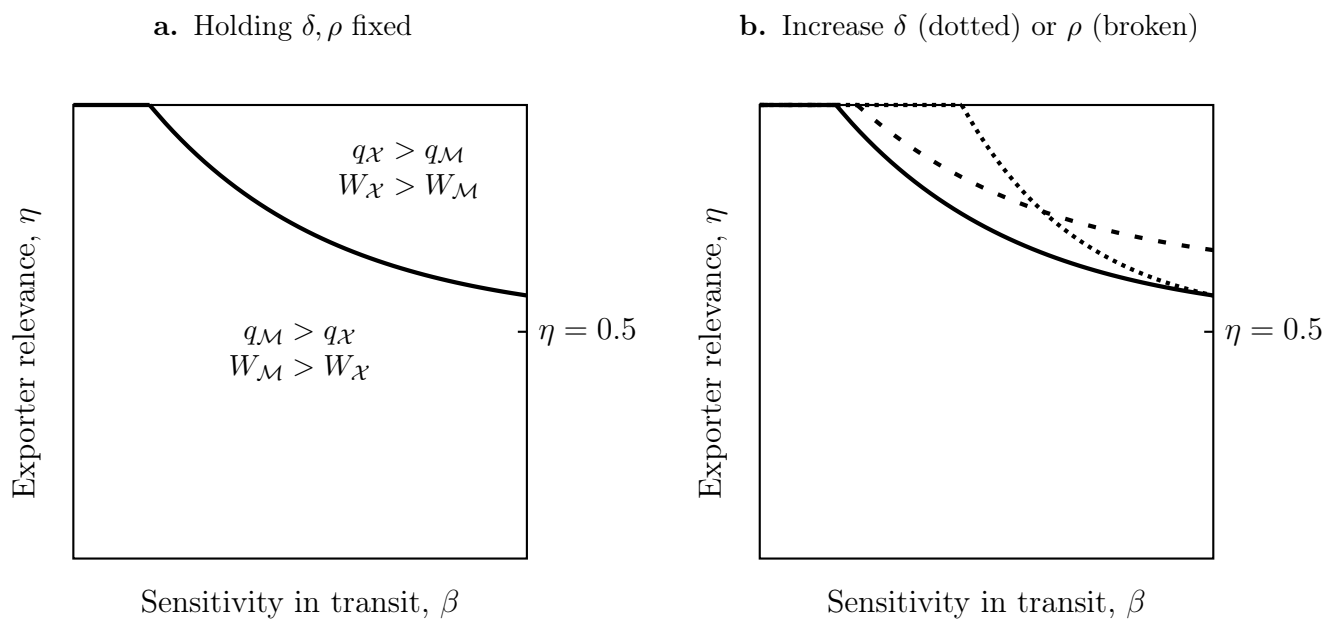
where

$$\Theta_{q,\mathcal{O}} \equiv \underbrace{\Theta_{z0,\mathcal{O}}^{1-\beta}\Theta_{E,\mathcal{O}}^{\beta}}_{\text{Quality–induced increase in revenue}} - \left(\underbrace{\frac{1}{2}\psi_0\Theta_{z0,\mathcal{O}}^2}_{\text{Quality creation costs}} + \underbrace{\frac{1}{2}\Psi_{\mathcal{O}} \times \left(\frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}}\right)^2}_{\text{Quality enhancement costs}}\right) \tag{3.45}$$

is the second-best analogue to the first-best quality-effect of shipping volume defined in (3.14). It summarizes the effect of shipment volume on joint welfare through quality, and has the following properties, which allow us to compare the trade volumes under the first-best and the two ownership arrangements.

**Lemma 4.** *The second-best quality-mediated effect of shipping volume on joint welfare, $\Theta_{q,\mathcal{O}}$,*

**Figure 7:** Optimal volumes, and Joint payoffs under different rights allocations




*Notes:* Threshold in **Panel (a)** divides $(\beta, \eta)$–space according to rankings of shipment volumes, $q_{\mathcal{O}}$ (see (3.44)), and joint payoffs, $W_{\mathcal{O}}$ (see (3.46)), where $\mathcal{O} = \mathcal{X}, \mathcal{M}$ indicates the party in charge of arranging delivery. Remaining parameters: (i) the importer is more efficient at maintenance; $\psi_M < \psi_X$; (ii) $\rho = 0.4$ governs substitutability among exporter and importer efforts; and (iii) $\delta = 0.3$ so that the shipment loses 70% of the relationship–specific quality in secondary markets. All else equal, exporter control is optimal whenever exporter effort is important for in–transit quality improvements. The dotted line in **Panel (b)** traces threshold for higher values of $\delta$, the fraction of quality useful outside the relationship. The broken line plots the threshold at higher values of $\rho$, the substitutability of exporter and importer efforts.

*is*

1. *always positive, regardless of the importance of exporter effort, $\eta$;*

2. *independent of the marginal cost of physical output.*

*Further, $\Theta_{q,\mathcal{X}} > \Theta_{q,\mathcal{M}}$, if and only if exporter relevance, $\eta$, exceeds some threshold $\eta_q^*$.*

Panel (a) of Figure 7 displays the threshold rule as a function of $\eta$, the exporter's importance for aggregate effort, and $\beta$, the relative significance of transit effort for final quality. Here, the importer is more efficient ($\psi_M < \psi_X$), quality–enhancing efforts are sufficiently substitutable ($\rho = 0.4$), and only 30 percent of the relationship–specific quality is valuable in secondary markets ($\delta = 0.3$).

Consider the limiting case as final quality becomes insensitive to enhancements during transit (as $\beta \to 0$). In this case, the parties do not bother exerting effort during delivery (3.23'), and the marginal effect of additional volume simplifies to the increase in sales revenue due to higher factory–set quality, net of the cost the exporter incurs when creating said goods

$$\Theta_{q,\mathcal{O}} \underset{\beta\to 0}{\longrightarrow} \underbrace{\Theta_{z0,\mathcal{O}}}_{\text{Quality–induced increase in revenue}} - \underbrace{\frac{1}{2}\psi_0\Theta_{z0,\mathcal{O}}^2}_{\text{Quality creation costs}} .$$

Substituting for $\Theta_{z0,\mathcal{O}}$ from (3.39) and taking limits, $\Theta_{q,\mathcal{X}} \geq \Theta_{q,\mathcal{M}}$ whenever $\delta \leq 0$, which is impossible.[16] Intuitively, despite quality remaining fixed at its initial level, the exporter is all too eager to create high–quality goods when in control, provided he does not discount his future payoff too heavily. Unfortunately for the trading pair, the increase in sales revenues does not justify the costs of creating such high–quality goods. Subsequently, exporter–control is never optimal when perceived quality is insensitive to enhancements made during delivery.[17]

At the other extreme, if quality at the destination is wholly determined during transit ($\beta \to 1$), the shipment leaves the exporter's factory with zero quality, and the marginal effect of additional volume consists of higher sales revenue due to higher efforts during delivery, net of the joint cost of effort during delivery

$$\Theta_{q,\mathcal{O}} \underset{\beta\to 1}{\longrightarrow} \underbrace{\Phi_{\mathcal{O}}^{2-\rho}}_{\text{Quality–induced increase in revenue}} - \underbrace{\frac{1}{2}\Psi_{\mathcal{O}}\Phi_{\mathcal{O}}^{2(1-\rho)}}_{\text{Quality enhancement costs}} .$$

[16] If the exporter discounts future payoffs by a factor $0 \leq \kappa < 1$, then

$$\Theta_{q,\mathcal{X}} \geq \Theta_{q,\mathcal{M}} \iff \delta \leq 1 - \kappa,$$

so that exporter control is optimal whenever quality is sufficiently relationship specific.

[17] By continuity, importer–control is always optimal for low values of $\beta$.

Exporter control is then optimal if transferring control raises enough revenue to offset any rise in delivery–related costs, which simplifies to

$$\Phi^{\rho}_{\mathcal{X}} - \Phi^{\rho}_{\mathcal{M}} \geq \frac{1}{2}\left(\Psi_{\mathcal{X}} - \Psi_{\mathcal{M}}\right),$$

which is more likely when exporter effort is important ($\eta$ sufficiently large).[18]

Panel (b) of Figure 7 illustrates changes in the threshold rule in response to changes in $\delta$, the fraction of quality valued in secondary markets, and in $\rho$, which indexes substitutability between exporter and importer effort. Compared to the baseline in Panel (a), exporter effort must be even more important for quality enhancement if the importer's effort is otherwise just as good (when $\rho$ is large). Similarly, changes in the salvage value, indexed by $\delta$, raise the $\eta$ cutoff as long as quality is at least partially determined in the factory ($\beta < 1$).

Finally, applying Lemma 4 to the expression for the optimal shipment volume (3.44) yields a familiar result from the vast literature on productivity–based sorting into various activities in international trade.

**Proposition 4.** *Conditional on unit input requirements meeting the export cutoff, more productive (low c) exporters trade larger volumes under any control assignment.*

As Mrázová and Neary (Forthcoming) point out, this result follows from the simple observation that $c$ affects the marginal returns to $q$ solely through the marginal cost of manufacturing the physical units.

Armed with these observations, I know characterize the optimal $\mathcal{O}-$conditional volume of trade, and the optimal contract. Joint welfare under $\mathcal{O}$'s ownership, $W_{\mathcal{O}}$, consists sales revenues, less production and distribution costs:

$$\begin{aligned} W_{\mathcal{O}} &\equiv r\left(q_{\mathcal{O}}, z_{1,\mathcal{O}}\left(q_{\mathcal{O}}\right)\right) - \left[cwq_{\mathcal{O}} + \frac{1}{2}\psi_0 z_{0,\mathcal{O}}\left(q_{\mathcal{O}}\right)^2 + \sum \frac{1}{2}\psi_j e_{j,\mathcal{O}}\left(q_{\mathcal{O}}\right)^2\right] \\ &= \frac{L}{4\gamma}\frac{\left(A - cw\right)^2}{1 - L\gamma\Theta_{q,\mathcal{O}}}. \end{aligned} \tag{3.46}$$

where the equality follows from substituting the optimal shipment volume (3.44) into (3.41) to determine sales revenue, and into (3.42) to determine total costs (see A.6). As a result, the sign of $W_{\mathcal{X}} - W_{\mathcal{M}}$ is determined by the same threshold behind the ranking of shipment volumes across contractual forms (see Figure 7). After all, with linear demand, constant marginal costs, and quadratic quality–creation and quality–upgrading costs, profits from sale of final goods – which coincide with joint welfare – are linear in output.

[18] See section A.6 for details.

**Proposition 5.** *The exporter controls delivery if and only if his effort is sufficiently important, exceeding the same threshold $\eta_q^*$ that determines whether the optimal volume of trade is greater under exporter control.*

In line with the standard result from the property-rights literature, the exporter should assume control of delivery if his effort is sufficiently more important than the importer's.

# 4 Conclusion

This paper studies the organization of international shipping when agents exert unverifiable effort in a sequential production process. It characterizes the optimal contract, and derives optimal production and quality maintenance decisions by self-interested parties subject to hold-up.

Individuals exert greater effort in the second stage when trading large volumes of highly differentiated goods. The exporter, who acts as a Stackelberg leader in the first stage, magnifies this sensitivity to volume and love-of-variety by trying to influence subsequent play in his favour. Both parties then exert too much costly effort, which often outweighs any potential offsetting sales revenue. As a result the exporter is more likely to assume control when effort is especially important in getting the goods to the destination in good condition.

| Symbol | Meaning (First appearance) |
|---|---|
| *Demand* | |
| $A > 0$ | Demand shifter; (Eq. (3.2)). |
| $\gamma > 0$ | Consumer love of variety / proportional to willingness-to-pay for quality (Eq. 3.1). |
| *Technology* | |
| $C(q, z) = cwq + \frac{\psi_0}{2} z$ | Factory costs (Eq. (3.3)). |
| $\frac{\psi_j}{2} e_j$ | Maintenance costs. |
| $E(e_X, e_M) = \left(\eta\, e_X^{\rho} + (1-\eta)\, e_M^{\rho}\right)^{\frac{1}{\rho}}, \quad \rho \in (0,1)$ | Maintenance effort aggregator (Eq. (3.4)). |
| $z_1(E \mid z_0) = z_0^{1-\beta} E^{\beta}, \qquad \beta \in (0,1)$ | Final-quality production function (Eq. 3.5). |
| $\phi_{j,FB} \equiv (\eta_j/\psi_j)^{1/(2-\rho)}$ | Share-weighted first-best individual efficiency. (Eq. (3.8)). |
| $\Phi_{FB} \equiv \left(\eta\, \phi_{X,FB}^{\rho} + (1-\eta)\, \phi_{M,FB}^{\rho}\right)^{\frac{1}{\rho}}$ | First-best aggregate efficiency (Eq. (3.8)). |
| $\phi_{j,\mathcal{O}} \equiv (\mu_{j,\mathcal{O}} \eta_j/\psi_j)^{1/(2-\rho)}$ | Control–adjusted, share-weighted first-best individual efficiency. (Eq. (3.24)). |
| $\Phi_{\mathcal{O}} \equiv \left(\eta\, \phi_{X,\mathcal{O}}^{\rho} + (1-\eta)\, \phi_{M,\mathcal{O}}^{\rho}\right)^{\frac{1}{\rho}}$ | Second-best aggregate efficiency (Eq. (3.24)). |
| *Bargaining* | |
| $r^{IN}(E \mid z_0, q) = \left(A + \gamma \cdot g(E \mid z_0) - \frac{\gamma}{L} q\right) q$ | Value of shipment within relationship (Eq. (3.18)). |
| $r^{OUT}(E \mid z_0, q) = \left(A + \gamma \cdot \delta\, g(E \mid z_0) - \frac{\gamma}{L} q\right) q$ | Value of shipment outside relationship (Eq. (3.19)). |
| $\delta \in (0,1)$ | Fraction of effort valuable outside relationship. |
| $\mu_{j,\mathcal{O}} \equiv \mathbb{1}_{\mathcal{O}=j}\, \delta + \frac{1}{2}(1-\delta)$ | Control–adjustment factor (Eq. (3.22)). |
| $u_{j,\mathcal{O}}^{1}(e_X, e_M \mid z_0, q)\,,\ U_{j,\mathcal{O}}^{1}$ | Ex-ante transit-phase payoff; corresponding value function (Eq. (3.21)). |
| $v_X^0(z_0, q)$ | Exporter's factory-stage outside option (Eq. (3.29)). |
| $W$ | Joint welfare (Eq. (3.46)). |

Commonly used symbols

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# A Mathematical Appendix

## A.1 First-best shipping volume

Recall the first-best destination quality (3.13) is

$$z_{1,FB}(q) = \Theta_{z1,FB}\,\gamma q,$$

and individual efforts

$$e_{j,FB}(q_{FB}) \equiv e_{j,FB}(q_{FB}, z_{0,FB}(q_{FB})) = \left(\beta\,\Theta_{z0,FB}^{1-\beta}\,\Phi_{FB}^{\beta-\rho}\right)^{\frac{1}{2-\beta}}\,\gamma q\,\phi_{j,FB}.$$

Thus, aggregate maintenance costs (conditional on shipping volume $q_{FB}$) are

$$\sum_j \frac{1}{2}\psi_j e_{j,FB}(q_{FB})^2 = \frac{1}{2}\left(\left(\beta\Theta_{z0,FB}^{1-\beta}\,\Phi_{FB}^{\beta-\rho}\right)^{\frac{1}{2-\beta}}\cdot\gamma q_{FB}\right)^2 \sum_j \psi_j\phi_{j,FB}^2.$$

The net marginal benefit of shipping volume on joint first-best welfare equals marginal revenue less production and distribution costs,

$$A - \frac{2\gamma}{L}q - cw + \left[\left(z_{1,FB} + q\frac{\partial z_{1,FB}}{\partial q}\right)\gamma - \frac{\partial}{\partial q}\left\{\frac{\psi_0}{2}z_{0,FB}^2 + \sum_j \frac{\psi_j}{2}e_{j,FB}\right\}\right], \tag{A.1}$$

where

$$\left(z_{1,FB} + q\frac{\partial z_{1,FB}}{\partial q}\right)\gamma = \left(\Theta_{z1,FB}\,\gamma q + q\frac{\partial\Theta_{z1,FB}\,\gamma q}{\partial q}\right)\gamma = 2\Theta_{z1,FB}\,\gamma^2 q, \tag{A.2}$$

and

$$\frac{\partial}{\partial q}\left\{\frac{\psi_0}{2}z_{0,FB}^2 + \sum_j \frac{\psi_j}{2}e_{j,FB}\right\} = \left[\psi_0\left(\Theta_{z0,FB}\gamma\right)^2 + \left(\gamma\beta\Phi_{FB}^{\beta-\rho}\right)^{\frac{2}{2-\beta}}\left(\Theta_{z0,FB}\gamma\right)^{\frac{2(1-\beta)}{2-\beta}}\sum_j \psi_j\phi_{j,FB}^2\right]q. \tag{A.3}$$

Adding (A.2) and (A.3), the term in brackets in (A.1) evaluates to

$$\begin{aligned}&\left(z_{1,FB} + q\frac{\partial z_{1,FB}}{\partial q}\right)\gamma - \frac{\partial}{\partial q}\left\{\frac{\psi_0}{2}z_{0,FB}^2 + \sum_j \frac{\psi_j}{2}e_{j,FB}\right\}\\ &= \beta^\beta(1-\beta)^{1-\beta}\left(\frac{1}{\psi_0}\right)^{1-\beta}\left(1+\beta-\beta\Phi_{FB}^{-\rho}\sum_j\psi_j\phi_{j,FB}^2\right)\Phi_{FB}^{\beta(2-\rho)}\gamma^2 q.\end{aligned} \tag{A.4}$$

Applying the definition of $\Phi_{FB}$ in (3.8),

$$\Phi_{FB}^{-\rho}\sum_j \psi_j \phi_{j,FB}^2 = \frac{\sum_j \psi_j \phi_{j,FB}^2}{\sum_j \eta_j \phi_{j,FB}^{\rho}} = \frac{\sum_j \psi_j \left(\eta_j/\psi_j\right)^{\frac{2}{2-\rho}}}{\sum_j \eta_j \left(\eta_j/\psi_j\right)^{\frac{\rho}{2-\rho}}} = 1,$$

so that (A.4) simplifies to $\beta^{\beta}\left(1-\beta\right)^{1-\beta}\left(\frac{1}{\psi_0}\right)^{1-\beta}\Phi_{FB}^{\beta(2-\rho)}\gamma^2 q$, which, in turn delivers the expression in (3.14) once we define

$$\Theta_{q,FB} \equiv \frac{1}{2}\beta^{\beta}\left(1-\beta\right)^{1-\beta}\left(\frac{1}{\psi_0}\right)^{1-\beta}\Phi_{FB}^{\beta(2-\rho)}. \tag{A.5}$$

## A.2 Connection with Antoniades (2015)

Antoniades (2015) ignores quality changes during transit, so that quality is fixed at the factory level ($\beta \to 0$). In this scenario,

$$\Theta_{z0,FB} \to \frac{1}{\psi_0} \equiv \Theta_{z0,\text{Antoniades}}, \qquad \Theta_{q,\text{Antoniades}} \equiv \frac{1}{2\psi_0} \tag{A.6}$$

Then

$$q = \frac{L}{2\gamma}\frac{2\psi_0\left(A-cw\right)}{2\psi_0-\gamma L}, \tag{A.7}$$

where $A$ is the marginal cost threshold between the firms that produce and those that exit. Antoniades (2015) assumes $2\psi_0 > \gamma L$ to ensure positive qualities and quantities, which is equivalent to the assumption $L\gamma\Theta_{q,FB} < 1$ in the main text.

## A.3 Comparing aggregate productivity across ownership structures

Recall that transferring control to a party raises that party's effective productivity. Aggregate productivity is thus greater under $X$-control if the resulting (weighted) gains in exporter productivity exceed the loss in importer productivity.

$$\Phi_{\mathcal{X}} > \Phi_{\mathcal{M}} \iff \eta\phi_{X,FB}\left(\mu_{X,\mathcal{X}}^{\frac{\rho}{2-\rho}} - \mu_{X,\mathcal{M}}^{\frac{\rho}{2-\rho}}\right) > \left(1-\eta\right)\phi_{M,FB}\left(\mu_{M,\mathcal{M}}^{\frac{\rho}{2-\rho}} - \mu_{M,\mathcal{X}}^{\frac{\rho}{2-\rho}}\right).$$

If exporter and importer marginal costs differ ($\psi_X \neq \psi_M$), the above condition delivers a quadratic equation in $\eta$, whose solution

$$\eta_{\Phi}^{*}\left(\psi_X/\psi_M,\rho\right) \equiv \frac{\sqrt{\left(\psi_X/\psi_M\right)^{\rho}} - \left(\psi_X/\psi_M\right)^{\rho}}{1-\left(\psi_X/\psi_M\right)^{\rho}}, \qquad \psi_X/\psi_M \neq 1,$$

is increasing in $\psi_X/\psi_M$ and increasing in $\rho$. If $\psi_X = \psi_M$, then define $\eta^*_\Phi(1,\rho) \equiv 1/2$, so that aggregate productivity is higher under $X$-control if and only if $X$ effort is more important.

### A.3.1 Continuum of ownership arrangements

This section abstracts from the all-or-nothing ownership structure in the main text, instead allowing a continuum of possible ownership arrangements, indexed by the exporter's share of the renegotiation surplus, $\tau \in [0,1]$. Let

$$\mu_{j,\tau} \equiv \begin{cases} \tau\delta + \frac{1}{2}(1-\delta) & j = X \\ (1-\tau)\,\delta + \frac{1}{2}(1-\delta) & j = M \end{cases}$$

be $j$'s effective share under arrangement $\tau$, and let

$$\Phi_\tau \equiv \left(\eta\,\phi^\rho_{X,\tau} + (1-\eta)\,\phi^\rho_{M,\tau}\right)^{\frac{1}{\rho}}, \qquad \phi_{j,\tau} \equiv \left(\mu_{j,\tau}\frac{\eta_j}{\psi_j}\right)^{\frac{1}{2-\rho}}$$

be aggregate and individual ownership-adjusted efficiencies. A simple threshold rule determines whether increasing the exporter's share increases control-adjusted efficiency.

**Lemma 5.** *$\Phi_\tau$ is increasing in $\tau$ for $\tau < \tau^*$, and decreasing in $\tau$ for $\tau \geq \tau^*$, where the unique threshold exporter share, $\tau^* = \tau^*(\psi_X/\psi_M, \eta)$, is*

1. *increasing in exporter relevance, $\eta$, and*
2. *decreasing in exporter's relative marginal cost of effort, $\psi_X/\psi_M$.*

*Proof.* Ownership-adjusted productivity, $\Phi_\tau$, is differentiable in $\tau$, so that

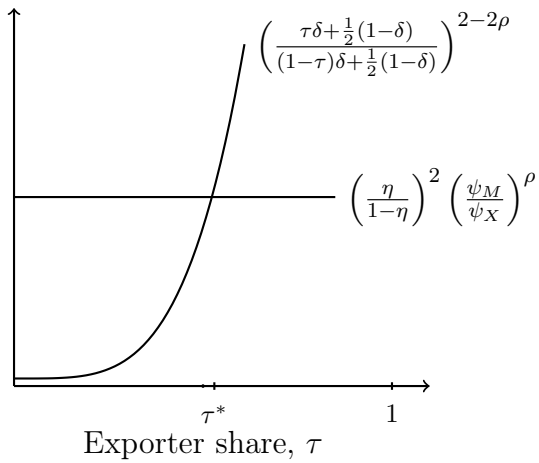
$$\frac{\partial \Phi_\tau}{\partial \tau} = \frac{\delta}{2-\rho}\Phi_\tau^{1-\rho}\left[\eta\frac{\phi^\rho_{X,\tau}}{\mu_{X,\tau}} - (1-\eta)\frac{\phi^\rho_{M,\tau}}{\mu_{M,\tau}}\right],$$

which is positive if and only if

$$\left(\frac{\eta}{1-\eta}\right)^2\left(\frac{\psi_M}{\psi_X}\right)^\rho > \left(\frac{\tau\delta + \frac{1}{2}(1-\delta)}{(1-\tau)\,\delta + \frac{1}{2}(1-\delta)}\right)^{2-2\rho}.$$

Figure 8 plots these terms as functions of $\tau$. With the exception of $\rho$ (effort substitutability), which appears on both sides of the inequality, this expression compares (i) on the left-hand side, the effects of shipping technology (exporter relevance, $\eta$, and individual marginal costs $\psi_j$); and (ii) on the right-hand side, the effects of contractual incompleteness (relationship specificity, $1-\delta$, and the exporter's share of renegotiation surplus, $\tau$).

**Figure 8:** Ownership-adjusted productivity




*Notes:*

Since $LHS$ is increasing in the exporter's relative importance, and the importer's relative *in*efficiency, it is possible that $LHS < RHS$ for sufficiently low $\eta$ or large $\psi_X/\psi_M$. Intuitively, the gains from transfer additional control to $X$ decrease as his effort becomes inconsequential, or if the importer is more efficient at the margin. In either of these cases, define $\tau^* = 0$. □

## A.4 Optimal initial quality

### A.4.1 Solving for optimal factory quality

The marginal cost of initial quality is $\psi_0 z_0$, while the marginal benefit is

$$\frac{(1-\beta)\,\gamma q}{z_0^{\beta}}\left(\Omega_{\mathcal{O}}\,E_{\mathcal{O}}\left(q,z_0\right)^{\beta}+\omega_{SOLO}\,E_{SOLO}\left(q,z_0\right)^{\beta}\right), \tag{A.8}$$

where $E_{\mathcal{O}}\left(q,z_0\right)$ and $E_{SOLO}\left(q,z_0\right)$, the aggregate maintenance efforts under a joint transit phase and $X$'s solo venture, are given in (3.31) and (3.23), and $\Omega_{\mathcal{O}} \equiv \sum_j \omega_{j,\mathcal{O}}$.

The factors

$$\omega_{SOLO} \equiv \frac{1}{2}\delta^{1-\beta}, \qquad \omega_{j,\mathcal{O}} \equiv \lambda_j \mu_{j,\mathcal{O}}\left(1+\frac{\beta}{2-\beta}\eta_{-j}\left(\frac{\phi_{-j,\mathcal{O}}}{\Phi_{\mathcal{O}}}\right)^{\rho}\right).$$

summarize the effects of the immediate outside option and future cooperation. Substituting

$E_{\mathcal{O}}(q, z_0)$ and $E_{SOLO}(q, z_0)$,

$$\psi_0 z_0 = (1-\beta)\left((\beta)^{\beta}(\gamma q)^2 z_0^{-\beta}\right)^{\frac{1}{2-\beta}}\left(\omega_{SOLO}\Phi_{SOLO}^{\frac{\beta(2-\rho)}{2-\beta}} + \Omega_{\mathcal{O}}\Phi_{\mathcal{O}}^{\frac{\beta(2-\rho)}{2-\beta}}\right),$$

and then solving for $z_0$ yields (3.38) in the main text.

### A.4.2 Proof of Proposition 3 (comparing initial quality across ownership structures)

Conditional on shipment volume, $q$, the first-best, and $\mathcal{O}-$controlled factory qualities are

$$z_{0,FB}(q) = \Theta_{z0,FB}\,\gamma q, \qquad z_{0,\mathcal{O}}(q) = \Theta_{z0,\mathcal{O}}\,\gamma q, \quad \mathcal{O} \in \mathcal{X}, \mathcal{M}.$$

Comparing interior solutions,

$$z_{0,FB} > z_{0,\mathcal{O}} \iff \omega_{SOLO}\left(\frac{\Phi_{SOLO}}{\Phi_{FB}}\right)^{\frac{\beta(2-\rho)}{2-\beta}} + \Omega_{\mathcal{O}}\left(\frac{\Phi_{\mathcal{O}}}{\Phi_{FB}}\right)^{\frac{\beta(2-\rho)}{2-\beta}} < 1,$$

and

$$z_{0,\mathcal{X}} > z_{0,\mathcal{M}} \iff \left(\frac{\Phi_{\mathcal{X}}}{\Phi_{\mathcal{M}}}\right)^{\frac{\beta(2-\rho)}{2-\beta}} > \frac{\Omega_{\mathcal{M}}}{\Omega_{\mathcal{X}}}.$$

Conditional on shipment volume, differences in factory quality are independent of the marginal cost of initial quality, $\psi_0$, and the solo venture effect (which is independent of ownership during delivery). Therefore,

$$\begin{aligned}\operatorname{sign}\{z_{0,\mathcal{X}}(q) - z_{0,\mathcal{M}}(q)\} &= \operatorname{sign}\left\{\Phi_{\mathcal{X}}^{\frac{\beta(2-\rho)}{2-\beta}}\Omega_{\mathcal{X}} - \Phi_{\mathcal{M}}^{\frac{\beta(2-\rho)}{2-\beta}}\Omega_{\mathcal{M}}\right\} \\ &= \operatorname{sign}\left\{\Omega_{\mathcal{M}}\left(\Phi_{\mathcal{X}}^{\frac{\beta(2-\rho)}{2-\beta}} - \Phi_{\mathcal{M}}^{\frac{\beta(2-\rho)}{2-\beta}}\right) + \Phi_{\mathcal{X}}^{\frac{\beta(2-\rho)}{2-\beta}}(\Omega_{\mathcal{X}} - \Omega_{\mathcal{M}})\right\}.\end{aligned}$$

The first term is positive whenever the exporter's share of aggregate effort exceeds some threshold $\eta_{\Phi}^{*}(\psi_X/\psi_M, \rho)$, and increasing in $\eta$, as demonstrated in Section A.3, while the second term is always positive. Figure 7 depicts the threshold rule in $(\beta, \eta)$–space.

**Lemma 6.** *Conditional on shipping volume, $q$, the exporter thus creates higher quality goods when in charge of shipping if aggregate productivity is higher under his control (i.e., if $\eta > \eta_{\Phi}^{*}(\psi_X/\psi_M, \rho)$).*

This is a sufficient, but not necessary condition for higher quality goods under exporter-control. Suppose $\eta < \eta_{\Phi}^{*}(\psi_X/\psi_M, \rho)$, so that $\Phi_{\mathcal{X}}^{\beta(2-\rho)/(2-\beta)} - \Phi_{\mathcal{M}}^{\beta(2-\rho)/(2-\beta)} < 1$. Then there

exists $\eta_z^* \equiv \eta_z^*(\psi_X/\psi_M, \rho, \beta, \delta) < \eta_\Phi^*(\psi_X/\psi_M, \rho)$ such that

$$\eta \in [\eta_z^*, \eta_\Phi^*] \quad \Longrightarrow \quad \Omega_{\mathcal{M}} \left( \Phi_{\mathcal{M}}^{\frac{\beta(2-\rho)}{2-\beta}} - \Phi_{\mathcal{X}}^{\frac{\beta(2-\rho)}{2-\beta}} \right) \leq \Phi_{\mathcal{X}}^{\frac{\beta(2-\rho)}{2-\beta}} \left( \Omega_{\mathcal{X}} - \Omega_{\mathcal{M}} \right),$$

with equality at $\eta = \eta_z^*$.

## A.5 Optimal shipment volume

Assuming an interior solution, $q_{\mathcal{O}}$ solves

$$p\left(q, z_{1,\mathcal{O}}(q)\right) + q \frac{\partial p\left(q, z_{1,\mathcal{O}}(q)\right)}{\partial q} = \frac{\partial}{\partial q} \left[ cwq + \frac{1}{2}\psi_0 z_{0,\mathcal{O}}(q)^2 + \sum \frac{1}{2}\psi_j e_{j,\mathcal{O}}(q)^2 \right], \tag{A.9}$$

where

$$\begin{aligned}
&(1) & z_{1,\mathcal{O}}(q) &= \left( (\beta)^\beta \Theta_{z0,\mathcal{O}}^{2(1-\beta)} \Phi_{\mathcal{O}}^{\beta(2-\rho)} \right)^{\frac{1}{2-\beta}} \gamma q \\
&(2) & p\left(q, z_{1,\mathcal{O}}(q)\right) &\equiv A + \gamma z_{1,\mathcal{O}}(q) - \frac{\gamma}{L} q \\
&(3) & \sum \frac{1}{2}\psi_j e_{j,\mathcal{O}}(q)^2 &= \frac{\Psi_{\mathcal{O}}}{2} \left( \frac{E_{\mathcal{O}}(q)}{\Phi_{\mathcal{O}}} \right)^2 = \frac{\Psi_{\mathcal{O}}}{2} \left( \frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}} \right)^2 (\gamma q)^2 \\
&(4) & \Psi_{\mathcal{O}} &\equiv \sum_j \psi_j \phi_{j,\mathcal{O}}^2.
\end{aligned}$$

The left-hand side of (A.9) is marginal revenue, evaluated at the optimal final quality $z_{1,\mathcal{O}}$. The right hand-side is the marginal cost of shipping volume, which, in addition to the direct effect on factory costs, $cwq$, also incorporates the effects on downstream efforts.

To facilitate comparison with the first-best outcome, gather terms so that we can perform the standard marginal benefit vs (direct) marginal cost

$$A - \frac{2\gamma}{L}\left(1 - L\gamma\Theta_{q,\mathcal{O}}\right) q = cw, \tag{A.10}$$

where

$$\Theta_{q,\mathcal{O}} \equiv \Theta_{z0,\mathcal{O}}^{1-\beta} \Theta_{E,\mathcal{O}}^{\beta} - \frac{1}{2}\left( \psi_0 \Theta_{z0,\mathcal{O}}^2 + \Psi_{\mathcal{O}} \times \left( \frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}} \right)^2 \right). \tag{A.11}$$

Solving for for $q$,

$$q_{\mathcal{O}} = \frac{L}{2\gamma} \frac{A - cw}{1 - L\gamma\Theta_{q,\mathcal{O}}}.$$

## A.6 Optimal ownership

This section expresses joint welfare solely as a function of ownership, $\mathcal{O}$, by first expressing welfare as a function of the volume shipped. From (3.41)

$$z_{1,\mathcal{O}}(q) = \Theta_{z1,\mathcal{O}}\,\gamma q, \qquad \Theta_{z1,\mathcal{O}} \equiv \Theta_{z0,\mathcal{O}}^{1-\beta}\Theta_{E,\mathcal{O}}^{\beta} = \left(\beta^{\beta}\Theta_{z0,\mathcal{O}}^{2(1-\beta)}\Phi_{\mathcal{O}}^{\beta(2-\rho)}\right)^{\frac{1}{2-\beta}}.$$

Final sales revenue is

$$r_{\mathcal{O}} \equiv r\left(q_{\mathcal{O}}, z_1\left(E_{\mathcal{O}}(q_{\mathcal{O}})\middle| z_{0,\mathcal{O}}(q_{\mathcal{O}})\right)\right) = \left(A + \gamma\Theta_{z1,\mathcal{O}}\,\gamma q_{\mathcal{O}} - \frac{\gamma}{L}q_{\mathcal{O}}\right)q_{\mathcal{O}}$$

so that joint welfare is given by

$$\begin{aligned}
W_{\mathcal{O}} &\equiv r_{\mathcal{O}} - \left(cwq_{\mathcal{O}} + \frac{1}{2}\psi_0\left[z_{0,\mathcal{O}}(q_{\mathcal{O}})\right]^2 + \sum\frac{1}{2}\psi_j\left[e_{j,\mathcal{O}}(q_{\mathcal{O}})\right]^2\right)\\
&= \left(A + \gamma\Theta_{z1,\mathcal{O}}\,\gamma q_{\mathcal{O}} - \frac{\gamma}{L}q_{\mathcal{O}}\right)q_{\mathcal{O}}\\
&\quad - \left(cwq_{\mathcal{O}} + \frac{1}{2}\left(\psi_0\left(\Theta_{z0,\mathcal{O}}\,\gamma q_{\mathcal{O}}\right)^2 + \Psi_{\mathcal{O}} \times \left(\frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}}\gamma q_{\mathcal{O}}\right)^2\right)\right)\\
&= \left[A - cw - \frac{\gamma}{L}\left(1 - L\gamma\Theta_{q,\mathcal{O}}\right)q_{\mathcal{O}}\right]q_{\mathcal{O}},
\end{aligned}$$

where

$$\Theta_{q,\mathcal{O}} \equiv \Theta_{z1,\mathcal{O}} - \frac{1}{2}\left(\psi_0\Theta_{z0,\mathcal{O}}^2 + \Psi_{\mathcal{O}} \times \left(\frac{\Theta_{E,\mathcal{O}}}{\Phi_{\mathcal{O}}}\right)^2\right).$$

Assuming interior solutions under both ownership structures ($q_{\mathcal{X}}, q_{\mathcal{M}} > 0$), and substituting the optimal shipping volume into the term in brackets,

$$\begin{aligned}
W_{\mathcal{O}} &\equiv \left[A - cw - \frac{\gamma}{L}\left(1 - L\gamma\Theta_{q,\mathcal{O}}\right) \times \frac{L}{2\gamma}\frac{A - cw}{1 - L\gamma\Theta_{q,\mathcal{O}}}\right]q_{\mathcal{O}}\\
&= \frac{1}{2}\left(A - cw\right)q_{\mathcal{O}}\\
&= \frac{1}{2}\left(A - cw\right)\frac{L}{2\gamma}\frac{A - cw}{1 - L\gamma\Theta_{q,\mathcal{O}}}\\
&= \frac{L}{4\gamma}\frac{\left(A - cw\right)^2}{1 - L\gamma\Theta_{q,\mathcal{O}}}.
\end{aligned}$$

To compare welfare across ownership structures, factor $L\left(A - cw\right)^2/4\gamma \geq 0$, so that

$$W_{\mathcal{X}} > W_{\mathcal{M}} \iff \Theta_{q,\mathcal{X}} > \Theta_{q,\mathcal{M}},$$

that is, the parties are jointly better off under exporter control if shipping volumes are greater under exporter control.

**Limiting behaviour as $\beta \to 1$** If quality at the destination is wholly determined during transit ($\beta \to 1$), exporter control is then optimal if

$$\Phi_{\mathcal{X}}^{\rho} - \Phi_{\mathcal{M}}^{\rho} \geq \frac{1}{2}\left(\Psi_{\mathcal{X}} - \Psi_{\mathcal{M}}\right).$$

Substituting for $\Phi_{\mathcal{O}}$ and $\Psi_{\mathcal{O}}$, this condition is equivalent to

$$\sum_j \eta_j \left(\frac{\eta_j}{\psi_j}\right)^{\frac{\rho}{2-\rho}} \left(\mu_{j,\mathcal{X}}^{\frac{\rho}{2-\rho}} - \mu_{j,\mathcal{M}}^{\frac{\rho}{2-\rho}}\right) > \sum_j \frac{\psi_j}{2} \left(\frac{\eta_j}{\psi_j}\right)^{\frac{2}{2-\rho}} \left(\mu_{j,\mathcal{X}}^{\frac{2}{2-\rho}} - \mu_{j,\mathcal{M}}^{\frac{2}{2-\rho}}\right).$$

All else equal, this is more likely when exporter effort is important ($\eta$ large).

### A.6.1 Contract-specific fixed costs

According to the optimal-$\mathcal{O}$ rule "$W_{\mathcal{X}} > W_{\mathcal{M}} \iff \Theta_{q,\mathcal{X}} > \Theta_{q,\mathcal{M}}$", the degree of product differentiation, $\gamma$, and destination market conditions, $(L, A)$, do not affect the choice of ownership, conditional on all other model parameters.

Consider instead

$$W_{\mathcal{O}} = \frac{L}{4\gamma} \frac{(A - cw)^2}{1 - L\gamma\Theta_{q,\mathcal{O}}} - f_{\mathcal{O}},$$

where $f_{\mathcal{O}} > 0$ is an ownership-specific fixed cost that may vary across buyer-seller pairs. Then

$$W_X > W_M \iff \frac{\Theta_{q,\mathcal{X}} - \Theta_{q,\mathcal{M}}}{\left(1 - L\gamma\Theta_{q,\mathcal{X}}\right)\left(1 - L\gamma\Theta_{q,\mathcal{M}}\right)} > \frac{4\left(f_{\mathcal{X}} - f_{\mathcal{M}}\right)}{\left[L\left(A - cw\right)\right]^2}.$$

Setting $f_{\mathcal{X}} = f_{\mathcal{M}}$ delivers the previous result.