Ownership and Control in Outsourcing to China

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Abstract. In this paper, we examine the organization of export processing operations in China. During the 1990s, export processing accounted for over 50% of China's total exports. We observe China's processing exports broken down by who owns the plant and by who controls the inputs that the plant processes. To account for how parties organize export processing in China, we apply two influential theories of the firm, the Holmstrom-Milgrom model and the Grossman-Hart-Moore model. In the Holmstrom-Milgrom framework, we show that it is optimal for a single party to own the processing factory and to control the inputs used in export processing. In the Grossman-Hart-Moore framework, we show that the gains to giving one party factory ownership tend to be greater when that party lacks control over inputs. In the empirical analysis, we find that multinational firms engaged in export processing in China tend to split factory ownership and input control with factory managers in China. Chinese ownership of export processing factories is more common when the foreign buyer (the multinational) controls the inputs than when the processing factory (the factory manager) controls the inputs. This evidence is consistent with Grossman-Hart-Moore but is strongly inconsistent with Holmstrom-Milgrom.

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1. Introduction

Over the last several decades, much of the developing world has adopted trade policies that favor export production. Typically, the early stages of export-led development involve export processing. In this arrangement, firms import parts and components from abroad, process these inputs into finished goods, and then export the final products. In the 1970s, Hong Kong, Singapore, and Taiwan assembled and exported footwear, clothing, and other consumer goods (Findlay and Wellisz, 1993). In the 1980s, China, Mexico, and much of Southeast Asia developed extensive export processing operations (Grunwald and Flam, 1985; Yeats, 2001). And in the 1990s, Central America, Eastern Europe, and South Asia joined the fray.

Multinational enterprises mediate a substantial amount of processing trade involving developing countries (Barba et al., 2002; Borga and Zeile, 2002; Feenstra and Hanson, 2002). These firms design the goods to be produced and distribute final outputs. Where multinationals differ is in how much control they exert over actual processing activities. One source of variation is in terms of who owns the processing factory. While Dell subcontracts the assembly of its personal computers to independent firms in many locations, Intel uses wholly-owned subsidiaries in China, Costa Rica, and elsewhere, to assemble its microchips. Another source of variation is in terms of who controls processing decisions. Dell maintains tight control over who buys what from whom along its PC supply chain. Mattel, in contrast, grants the subcontractors that make its plastic dolls latitude in choosing from whom to purchase raw materials.

In this paper, we examine the organization of export processing operations in China. During the 1990s, processing exports accounted for over 50% of China's total exports. By virtue of the country's trade regulations, we have unusually detailed data on contractual arrangements in Chinese trade. We observe China's processing exports broken down by *who owns the plant* and by *who controls the inputs* that the plant processes. Since the early 1980s, China has permitted foreign ownership of export processing plants. It stipulates that all processing plants (whether Chinese or foreign owned) operate according to one of two regimes: a *pure-assembly* regime, in which a foreign buyer supplies a plant in China with inputs and hires the plant to process them into finished goods, all the while retaining ownership over the inputs; and an *import-and-assembly* regime, in which a plant in China imports inputs of its own accord, processes them, and sells the processed goods to a foreign buyer. We use these data to assess the factors that shape ownership and control decisions in China's export processing sector.

To account for how export processing is organized in China, we turn to two influential theories of the firm. The first is Holmstrom and Milgrom's (1994) model of incentive systems, in which a principal designs a contract to influence an agent's effort supply choice. The contractual instruments the principal may manipulate include the agent's compensation scheme, whether the agent owns the assets used in production, and whether the agent can use these assets to work for other principals. A key feature of the Holmstrom-Milgrom framework is that these instruments are complementary. In export processing, this would mean that the returns to a multinational from having a subcontractor own the processing factory are greater when the subcontractor controls input purchases and when his salary is based on high-powered incentives. We use Holmstrom-Milgrom to develop a simple model of export processing and show that it is optimal for one party (either the principal or the agent, depending on parameter values) to own the factory and to control the inputs used in processing. The direct empirical implication of this result is that factory ownership and input control will tend to go to a single party.

The second theory we apply is that of Grossman and Hart (1986) and Hart and Moore (1990). In their framework, parties use control rights over productive assets to ameliorate hold-up problems created by incomplete contracts. When a multinational transfers ownership of a processing factory to a subcontractor, it gives the subcontractor control rights over the factory. This strengthens the subcontractor's bargaining power with respect to the multinational and so his incentive to invest in projects specific to the multinational. The cost of having the multinational give up these control rights is that its bargaining power and investment incentives are weakened. In export processing, two sets of control rights are at stake, those over the factory and those over the inputs to be processed. We use Grossman-Hart-Moore to develop a second model of export processing and show that the gains to giving one party factory ownership tend to be greater when that party lacks control over inputs. The direct empirical implication is that a multinational will be less likely to own the processing factory when it controls input purchases. This is the opposite of what Holmstrom-Milgrom predicts.

To preview our empirical results, we find that multinational firms engaged in export processing in China tend to split factory ownership and input control with factory managers in China. Chinese ownership of export processing factories is more common when the foreign buyer (the multinational) controls the inputs than when the processing factory (the factory manager) controls the inputs. This evidence is consistent with Grossman-Hart-Moore but is strongly inconsistent with Holmstrom-Milgrom.

Our findings are relevant to several bodies of literature. One is work on the contribution of exports to industrialization (Amsden, 1989; Wade, 1992). In the 1980s, Hong Kong, Singapore, and Taiwan graduated from export processing to original equipment manufacture (OEM) by backward integrating into the production of parts and components (Gereffi and Korzeniewicz, 1994; Orru et al., 1997). In the 1990s, they then graduated to own-brand production by forward integrating into marketing and sales (Chiu, et al., 1997; Hamilton, 1999).

The expansion of East Asian firms up and down the supply chain appears to have helped their economies industrialize. Little is known, however, about the factors that shape these organizational changes. Our work aims to help fill this void by accounting for the ownership and control of production activities in the first stage of export-led development.

A second body of literature to which our work relates is empirical work on modern theories of the firm. Despite intense theoretical interest in Grossman-Hart-Moore and Holmstrom-Milgrom, few papers have tested these models.[1] Even fewer have compared the predictions of one framework against the other. A notable exception is Baker and Hubbard (2000a,b) who examine contractual arrangements in U.S. trucking. They exploit the introduction of on-board computers in trucks, which changed the costs of monitoring truck drivers, to sharpen predictions from theory and to surmount problems associated with not observing key determinants of organizational choice (e.g., the productivity of investment for different parties). They find evidence consistent with both Grossman-Hart-Moore and Holmstrom-Milgrom. Similar in spirit to Baker and Hubbard, we exploit observing ownership decisions in different contractual environments – i.e., China's two processing regimes – to test theory. Our results differ from theirs in that we find little support for Holmstrom-Milgrom in this context.

A third body of literature to which our work relates is theories of ownership decisions in global-production arrangements. Several recent papers build general equilibrium models of trade around specific theories of the firm. Grossman and Helpman (2002a, 2002b) and Antras (2001) use Grossman-Hart-Moore to develop general-equilibrium models of global outsourcing and intra-firm trade. Grossman and Helpman (2002c) apply Holmstrom-Milgrom to model managerial compensation in global production. Marin and Verdier (2001) and Puga and Trefler

[1] For surveys of the theoretical literature, see Hart (1995) and Tirole (1999) and for surveys of the empirical literature, see Baker and Hubbard (2001) and Whinston (2001).

(2002) extend the Aghion and Tirole (1997) theory of delegating authority in organizations to general equilibrium contexts. While we do not examine the general-equilibrium implications of these models, our results are relevant for assessing which underlying framework best describes how parties organize global production.

The remainder of the paper is organized as follows. In section 2, we describe institutional features of export processing in China. In sections 3 and 4, we present models of export processing. In section 5, we give empirical results. And in section 6, we conclude.

2. Export Processing in China

Export processing plays a major role in China's foreign trade. Table 1 shows that over the years 1997-1999, which spans our sample period, processing exports accounted for 53.7% of China's total exports. Export processing in China is broadly similar to that in other countries. It involves a firm in China importing intermediate inputs, processing the inputs, and then exporting the finished goods. The inputs are imported duty-free (as are any investment goods used in export processing) as long as these goods are only used to produce exports. As discussed in the previous section, China has two regulatory regimes for export processing.

The Pure-Assembly Regime.[2] In this arrangement, a foreign firm supplies a factory in China with materials from abroad (Naughton, 1996). The factory in China, whose role is relatively passive, receives orders from and delivers processed goods to the foreign client, who then sells the goods outside China. While the factory takes possession of the imported materials during processing, the foreign firm retains ownership over them. The foreign firm pays the factory in China a fee for its processing services. To obtain clearance from Chinese customs to

[2] The pure-assembly arrangement is translated as either "processing and assembling" or "processing with supplied materials." The import-and-assembly arrangement is translated as "processing with imported materials." We use our own terms for these arrangements in order to define them more clearly.

import materials and to export processed goods, the terms of the transaction between the Chinese factory and the foreign firm must be stipulated in a written contract and presented in advance to Chinese customs officials for approval.[3] Legally, the processing factory may use imported materials for the sole purpose of meeting its obligations to the foreign client.

The Import-and-Assembly Regime. In this arrangement, the processing factory in China plays a more active role. Table 1 shows that this regime is the more common form of export processing, accounting for 68.5% of processing exports over the 1997-1999 period. The factory imports materials of its own accord and takes ownership of these materials during processing. It may broker deals to process goods for multiple foreign firms (World Bank, 1994). Thus, the factory in China controls both the import of inputs and the export of processed goods (though usually not the marketing and sale of the good to end users). Legally, Chinese customs treats processing plants under this regime as bonded warehouses – facilities that are permitted to import inputs duty free under the proviso that they export all output. Bonded goods cannot be transferred to another party without the approval of Chinese customs. To become a bonded warehouse, a plant must apply to the Chinese government and have warehouse facilities and accounting personnel that meet government standards.[4] Under either regime, exporters are required to submit monthly reports on the status of their contracts and to verify that the contract has been completed within a month of having exported the finished goods.

There are several important distinctions between the two processing regimes. One relates to controls rights over imported materials. Under pure-assembly, the foreign buyer of the

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[3] The contract must specify the materials (and any equipment) to be imported, the processing activities to be performed, the fees to be paid, and the ports of entry and exit, among other items. See "Regulations Concerning Customs Supervision and Control over the Inward Processing and Assembling Operation (Amended)," Customs General Administration, October 5, 1990, http://www.moftec.gov.cn.

[4] See "Measures on the Administration of the Customs of the People's Republic of China for Bonded Warehouse Factory Engaged in Processing Trade," Customs General Administration, April 6, 1988, http://www.moftec.gov.cn.

processed goods owns the materials used in processing. Without the consent of this buyer, the factory in China cannot legally use the imported materials to process goods for another client. Under import-and-assembly, in contrast, the processing factory owns the imported materials. It may use them to produce for the foreign buyer of its choice, so long as the goods are exported. A second important distinction between the two regimes is that they are subject to different approval processes and regulations. In particular, import-and-assembly factories are required to make greater investments in inventory storage and management. This suggests that a processing plant cannot costlessly or quickly change from one regime to another.

While the Chinese government requires parties to specify the terms of processing trade in detail, the costs of writing or enforcing contracts may be high. One source of contracting costs is variability in product quality. The effort that factory managers devote to meeting quality standards may be difficult to observe or to verify to third parties. If quality is not contractible, then any processing contract is likely to be incomplete. Another source of contracting costs is enforcement. It may be difficult for foreign parties to use Chinese courts to resolve contractual disputes. In response, they may choose not to contract over issues that are unenforceable. Whatever the source of contractual incompleteness, its presence creates distortions that agents may seek to address through how they organize production.

Processing factories may be owned by either Chinese or foreign interests. Foreign-invested enterprises (FIEs) play a major role in China's trade. Table 1 shows that FIEs accounted for 56.5% of China's processing exports over the years 1997-1999. The Chinese government recognizes two categories of FIEs, wholly foreign-owned enterprises and equity joint ventures in which a foreign interest has at least a 25% ownership stake.[5] One issue is

[5] The government also recognizes cooperative joint ventures as a mode of inward foreign investment (Sung, 1998). These are primarily non-equity arrangements between a foreign firm and a domestic partner that account for a very

whether a 25% ownership share gives a foreign party effective control over a processing factory. Standard definitions of whether an enterprise is foreign controlled set a lower ownership threshold. The U.S. government, for instance, defines as foreign-controlled any enterprise in which the ownership stake of a foreign interest is at least 10%. Following this precedent, we treat as foreign controlled both wholly owned factories and equity joint ventures.

Export processing began to take off in China in the late 1980s. Among the pioneers in the sector were Hong Kong trading companies that set up processing plants across the border in Guangdong Province and used Hong Kong as a base from which to manage their operations (Sung, 1991). Hong Kong continues to mediate a large fraction of China's processing trade. Table 1 shows that from 1997 to 1999, 54.7% of China's processing exports were re-exported through Hong Kong. Hong Kong traders provide a range of intermediation services, including finding foreign buyers, sorting and grading goods according to quality, labeling and packaging, and coordinating processing in China with processing in other countries (Naughton, 1997; Feenstra and Hanson, 2002). We shall examine whether processing exports re-exported through Hong Kong differ systematically from those shipped directly to destination markets.

3. The Model

We begin with a general formulation of the problem faced by a firm outsourcing the production of a good to China, describing the approaches of Holmstrom-Milgrom (denoted by HM) and Grossman-Hart-Moore (denoted by GHM). In either framework, the parties involved must choose who should own the factory used in production and who should control the inputs processed by this factory. In the next section we shall adopt specific functional forms in order to obtain solutions to the model under each approach, and compare these.

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small fraction of exports. Since these arrangements typically do not involve foreign investment, we exclude them from our definition of foreign-owned plants. Including them in the analysis does not affect the results.

Consider a principal denoted by h (for headquarters) outsourcing to an agent denoted by f (for factory manager) located in China. The production process has three stages. In the first, either the principal or the agent supplies some inputs at the price $P(e_1)$, where e_1 is the effort devoted by the principal or agent and $P'(e_1) < 0$. Thus, more effort at this stage results in a lower price for the inputs. Second, the agent uses a factory to process these inputs at the cost of $F(e_2)$, where e_2 is the effort devoted by the agent and $F'(e_2) < 0$. This activity results in a given quantity (say, one unit) of the final product, which is then marketed and yields the revenue of $G(e_2,e_3)$, with $G_2 \geq 0$ and $G_3 > 0$. The effort e_3 devoted by the principal to marketing and sales raises revenue; the effort e_2 devoted by the agent to reducing costs may also raise revenue. Combined profits from these various activities are,

$$\pi = G(e_2,e_3) - F(e_2) - P(e_1). \tag{1}$$

The effort levels e_i, i=1,2,3 impose a cost on the parties involved. Use the variable $\delta_1 \in \{0,1\}$ to indicate whether the principle h (for $\delta_1 = 0$) or the agent f (for $\delta_1 = 1$) expends effort e_1. We shall refer to this indicator variable as "control" over purchasing the inputs. Also denote the private costs imposed on the principal by $C_h[(1-\delta_1)e_1, e_3]$ and the costs imposed on the agent by $C_f(\delta_1 e_1, e_2)$, with both functions increasing in their arguments. Total surplus from production is,

$$W = \pi - C_h[(1-\delta_1)e_1, e_3] - C_f(\delta_1 e_1, e_2). \tag{2}$$

In addition to the control of the inputs δ_1, we also introduce the "ownership" variable

$\delta_2 \in \{0,1\}$ to indicate whether the principle h (for $\delta_2 = 0$) or whether the agent f (for $\delta_2 = 1$) owns the factory used to process the inputs. While this indicator variable does not appear in the profits (1) or surplus (2), ownership of the factory will certainly affect the effort levels of the principal and agent, as will be made clear below.[6] With the effort levels depending on δ_1 and δ_2, it follows that the surplus in (2) also depends on these, which we write as $W(\delta_1, \delta_2)$. The goal of our analysis is to see how W (or its certainly equivalent) varies with δ_1 and δ_2. In particular, if $W(0,0) + W(1,1) > W(0,1) + W(1,0)$ then W is strictly *supermodular,* so the highest values for W are obtained when δ_1 and δ_2 take on the *same* values. Then it is optimal for the same party to control the inputs and to own the factory. This is the case on which HM focus. Conversely, when $W(0,0) + W(1,1) < W(0,1) + W(1,0)$ then W is strictly *submodular*, so it is optimal for δ_1 and δ_2 to take on *different* values, meaning that one party controls the inputs and the other owns the factory. We will argue that in our application the GHM model leads to this outcome. Thus, the modularity of W, which we shall assess empirically, provides a test of these two theories.

3.1 Holmstrom-Milgrom Model

In the HM model the effort of agent f is imperfectly observed by the principal h, who compensates the agent based on this noisy signal of effort. Thus, the compensation mechanism and effort levels are solved as a principal-agent problem subject to moral hazard.[7]

In the case where the agent controls the input and chooses effort e_1, then the principal

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[6] We could further introduce a variable $\delta_3 \in \{0,1\}$ to indicate whether the principle h or agent f markets the final good; the latter case would occur when the agent is establishing his own brand-name, rather than acting as an OEM producer for the principal. However, in this paper we will suppose that the principal always markets the final good, and therefore only include the two indicator variables δ_1 and δ_2.

[7] In GHM, by contrast, the parties' efforts are not verifiable, but they are observable.

observes the signal $x_1 = e_1 + \varepsilon_1$, with $\varepsilon_1 \sim N(0, \sigma_1^2)$. Likewise, the agent chooses effort e_2 and the principal observes the signal $x_2 = e_2 + \varepsilon_2$, with $\varepsilon_2 \sim N(0, \sigma_2^2)$. Then the *wage compensation* paid by the principal to the agent is $\delta_1\alpha_1 x_1 + \alpha_2 x_2$, where the parameters α_1 and α_2 of this compensation scheme will be optimally chosen as described below.[8]

In addition to wage compensation, it is possible that the agent receives a portion of profits due to ownership of the factory. When $\delta_2 = 1$, so the agent owns the factory, we will suppose that he receives the transfer price of $T + \varepsilon_3$ for the final good that is sent to the principal, with $\varepsilon_3 \sim N(0, \sigma_3^2)$. Thus, we are treating the transfer price as subject to some uncertainty. With this transfer, the profits earned by the agent at the second-stage of production are:

$$\text{Agent f receives:} \qquad \pi_2 = T - F(e_2) - P(e_1) + \varepsilon_3 \,. \tag{3}$$

It follows that the profits obtained by the principal at the third-stage of production are:

$$\text{Principal h receives:} \qquad \pi_3 = G(e_2,e_3) - T - \varepsilon_3 \ , \tag{4}$$

where $\pi_2 + \pi_3$ equals total profits π in (1).

Noting that (3)-(4) apply when the agent f owns the factory, δ_2=1, it follows that the surplus earned by the agent f in general is,

$$W_f = \delta_2\pi_2 + (\delta_1\alpha_1 x_1 + \alpha_2 x_2) - C_f(\delta_1 e_1, e_2). \tag{5}$$

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[8] In addition, there could be a fixed salary of β paid to the agent, so that total compensation is $\delta_1\alpha_1 x_1 + \alpha_2 x_2 + \beta$. Since the salary has no impact on effort levels or ownership choices, we normalize it to zero.

The first term on the right of (5) is the return from owning the factory, the second terms in parentheses are the compensation paid by the principal, and the final term is the agent's cost of supplying effort. In comparison, the surplus obtained by the principal is,

$$W_h = \pi_3 + (1 - \delta_2)\pi_2 - (\delta_1\alpha_1 x_1 + \alpha_2 x_2) - C_h[(1-\delta_1)e_1, e_3]. \qquad (6)$$

We shall assume that the principal is risk neutral, whereas the agent is risk averse. Notice that both profits π_2 and the compensation $(\delta_1\alpha_1 x_1 + \alpha_2 x_2)$ obtained by the agent in (5) are random. Following Holmstrom and Milgrom (1994), we shall adopt the utility function $U(W_f) = -\exp(-rW_f)$ for the agent, with constant absolute risk aversion $r > 0$. Then it follows that the certainty equivalent of the agent's expected utility is,

$$\begin{aligned} WCE_f &= \delta_2[T - F(e_2) - P(e_1)] + (\delta_1\alpha_1 e_1 + \alpha_2 e_2) - C_f(\delta_1 e_1, e_2) \\ &\quad - \frac{r}{2}\left(\delta_1\alpha_1^2\sigma_1^2 + \alpha_2^2\sigma_2^2 + \delta_2\sigma_3^2\right), \qquad (7) \end{aligned}$$

where the final term appearing in (7) is the variance of the agent's random surplus in (5).

The optimization problem solved by the agent is to choose effort level e_1 (when δ_1=1) and e_2 to maximize (7), given the values of the ownership/control parameters δ_i and the compensation parameters α_i, i=1,2. Because the choice of effort levels does not affect the variance term appearing in (7), the agent's problem can be written as:

$$\text{Agent f solves: } \max_{\delta_1 e_1, e_2} \delta_2[T - F(e_2) - P(e_1)] + (\delta_1\alpha_1 e_1 + \alpha_2 e_2) - C_f(\delta_1 e_1, e_2). \qquad (8)$$

The principal realizes that the agent will be making effort choices according to (8), and takes this into account when maximizing total surplus. Expected surplus for the principal is obtained by replacing the random signals x_i in (6) by e_i, i=1,2, and ignoring the stochastic part of the transfer price in π_2 and π_3. Expected surplus for the principal can be summed with the certainty equivalent for the agent in (7) to obtain the *certainly equivalent of total surplus,* WCE. The optimization problem for the principal is to maximize this certainty equivalent:

$$\text{Principal h solves: } \max_{(1-\delta_1)e_1, e_3, \alpha_1, \alpha_2} \text{WCE} = \pi - C_h[(1-\delta_1)e_1, e_3] - C_f(\delta_1 e_1, e_2) - \frac{r}{2}\left(\delta_1\alpha_1^2\sigma_1^2 + \alpha_2^2\sigma_2^2 + \delta_2\sigma_3^2\right), \qquad (9)$$

subject to the effort levels for the agent being chosen according to (8).

The control variables in (9) are the effort level e_1 supplied by the principal when δ_1=0, the effort level e_3, and the compensation parameters α_i, i=1,2. Notice that the agent's effort levels e_2, and e_1 when δ_1=1, obtained as the solution to (8) are functions of the compensation parameters, which is taken into account when solving (9). On the other hand, the control and ownership variable δ_i, i=1,2, are taken as parameters when solving (9), so that we obtain a solution WCE(δ_1, δ_2) from the HM model.

3.2 Grossman-Hart-Moore Model

In the GHM model, we think of the efforts e_i, i=1,2,3, as committed before any production occurs. These effort levels are observable to both parties but unverifiable to any third party. This makes contracts incomplete: prior to the parties making effort investments it is not possible to write a contract that specifies how gains from trade will be divided. Instead, the two parties divide the ex-post profits π in (1), using Nash bargaining. Let π_h and π_f denote threat-point payoffs available to party h, the headquarters firm , and party f, the factory manager processing inputs, if Nash bargaining breaks down. (We no longer refer to h and f as the principal and agent, since this distinction has little meaning in GHM.) Under Nash bargaining, the ex-post profits π will be allocated between the two parties according to,

$$\text{Party h receives:} \qquad \pi_h + (\pi - \pi_h - \pi_f)/2 = (\pi + \pi_h - \pi_f)/2 \,, \tag{10}$$

$$\text{Party f receives:} \qquad \pi_f + (\pi - \pi_h - \pi_f)/2 = (\pi + \pi_f - \pi_h)/2 \,. \tag{11}$$

It follows that each party will choose effort levels to maximize the difference between these payoffs and the costs of supplying effort:

$$\text{Party h solves:} \qquad \max_{[1-\delta_1]e_1, e_3} \; (\pi + \pi_h - \pi_f)/2 - C_h([1\text{-}\delta_1]e_1, e_3) \,, \tag{12}$$

$$\text{Party f solves:} \qquad \max_{\delta_1 e_1, e_2} \; (\pi + \pi_f - \pi_h)/2 - C_f(\delta_1 e_1, e_2) \,. \tag{13}$$

The specification of the choice variables above indicates that headquarters h chooses e_1 when δ_1=0, while the factory manager f chooses e_1 when δ_1=1. Note that the threat points themselves may depend on the effort levels, which will be taken into account when solving (12)-(13). In addition, the threat point will depend on the control of the inputs and ownership of the factory, δ_1 and δ_2, as will be made clear when we solve (12)-(13) in the next section. The effort levels solving these can be substituted back into (2) to compute the total surplus conditional on the control of inputs and ownership of the factory, $W(\delta_1, \delta_2)$. Then the optimal ownership and control structure is obtained by choosing (δ_1, δ_2) to maximize W. This will be compared to the solution for WCE(δ_1, δ_2) in (9) in the HM model.

The GHM formulation is rather different from the principal's optimization problem in (9), though the exact way in which these problems differ will depend on the specification of threat-point payoffs π_h and π_f. In the next section we will be more explicit about these payoffs in the GHM model, and also adopt a linear-quadratic form for all functions. These assumptions will allow us to obtain explicit solution for total surplus in the two models, and then choose the control and ownership structure to maximize the total surplus.

4. Solution in the Linear-Quadratic Case

Suppose that the cost P of purchasing the inputs, the cost F of processing them, and the revenue G received from the final product are all linear functions of effort:

$$P(e_1)=P_0(1-e_1), \quad F(e_2) = A(1-e_2), \quad G(e_2, e_3) = B(1+\lambda e_2+e_3)\,, \tag{14}$$

so that,

$$\pi = B(1+\lambda e_2+e_3) - A(1-e_2) - P_0(1-e_1) \tag{15}$$

where P_0, A, B > 0, and the parameter $\lambda \geq 0$ indicates the extent to which effort by agent f in the second stage of production (processing inputs) contributes to increased sales in the third stage.

In addition, suppose that the costs of supplying effort take on the quadratic form:

$$C_h((1-\delta_1)e_1, e_3) = \frac{\gamma_h}{2}[(1-\delta_1)e_1^2 + e_3^2], \quad C_f(\delta_1 e_1, e_2) = \frac{\gamma_f}{2}(\delta_1 e_1^2 + e_2^2)\,, \tag{16}$$

with γ_h, $\gamma_f > 0$. Notice that we are treating the effort levels as additively separable in each of these cost functions, which will mean that they are neither substitutes nor complements in supply. This formulation is reasonable if the efforts are expended at different points in time, with purchasing the inputs occurring before the production or sales stages. HM, in contrast, assume that the efforts expended by the agent are complementary, but we will be able to obtain results analogous to theirs even without this assumption.

4.1 Holmstrom-Milgrom Model

Using the functional forms in (14) and (15), it is relatively easy to solve the optimization problems (12) and (13), with the optimal effort levels and compensation parameters shown in Table 2. These are solved for each pair of the ownership/control variables δ_i, i=1,2. We will discuss the solution for one such pair, and then just report the solutions in the other cases.

Consider the case where the principal h controls the input and owns the factory, so that $\delta_1=0$ and $\delta_2=0$. We refer to this case as (h,h), where the first variable refers to control of the inputs, and the second to ownership of the factory. Then the agent receives the compensation $\alpha_2 e_2$, and problem (8) is restated as,

$$\max_{e_2} \; \alpha_2 e_2 - \frac{\gamma_f}{2}(e_2^2)\,. \tag{8'}$$

This gives the simple solution $e_2 = \alpha_2/\gamma_f$ for the agent's supply of effort. Substituting this into (9), the principal's problem becomes:

$$\max_{e_1,e_3,\alpha_2} B[1+\lambda(\alpha_2/\gamma_f)+e_3]-A[1-(\alpha_2/\gamma_f)]-P_0(1-e_1)-\frac{\gamma_h}{2}(e_1^2+e_3^2)-\frac{\alpha_2^2}{2\gamma_f}-\frac{r}{2}\left(\alpha_2^2\sigma_2^2\right)\,. \tag{9'}$$

The solutions for e_1 and e_3 are $e_1 = P_0/\gamma_h$ and $e_3 = B/\gamma_h$, as reported in the upper-left cell of Table 2. Since there is no incentive problem for the principal's supply of effort, these are the first-best solutions. In addition, the solution for α_2 is $\alpha_2 = (A+\lambda B)/(1+\gamma_f r\sigma_2^2)$. The first-best value for the compensation α_2 would be $(A+\lambda B)$, reflecting the marginal productivity of effort e_2. The principal chooses a compensation parameter *less than* this due to the noisy signal received on e_2. In comparison, for the case (h,f), or $(\delta_1, \delta_2) = (0,1)$ in the upper-right cell of Table 2, the principal retains control over the input decision, but gives ownership of the factory to the agent. This offsets the incentive problem in compensating the agent through wages, so the agent's effort e_2 rises as compared to the previous case. Since the agent receives more of his compensation through profits rather than wages, the variance term appearing in (7) and (9) is reduced. The only drawback to giving the agent ownership is that there is a new source of uncertainly introduced via the transfer price, which is the term $\delta_2\sigma_3^2$ in (7) and (9).

It is useful to compare the certainly equivalent of total surplus, WCE, in these two cases where δ_1 (control over the input) is fixed while δ_2 (ownership of the factory) varies. Substituting the linear and quadratic forms (14), (15) into (9), and taking the difference between the case of h ownership ($\delta_2 = 0$) and f ownership ($\delta_2 = 1$), we can derive:

$$\begin{aligned} WCE(\delta_1,0) - WCE(\delta_1,1) = &\left(\frac{P_0}{\delta_1\gamma_f + (1-\delta_1)\gamma_h} - \bar{e}_1\right)[\delta_1\gamma_f + (1-\delta_1)\gamma_h]\Delta e_1 \\ &+ \left(\frac{\lambda B + A}{\gamma_f} - \bar{e}_2\right)\gamma_f \Delta e_2 - \frac{r}{2}(\delta_1\Delta\alpha_1^2\sigma_1^2 + \Delta\alpha_2^2\sigma_2^2) + \frac{r}{2}\sigma_3^2, \end{aligned} \tag{17}$$

where, for a given input control structure, $\Delta e_i \equiv [e_i(\delta_1,0) - e_i(\delta_1,1)]$ is the change in the optimal level of e_i induced by changing δ_2 from 1 to 0 (giving h factory ownership) and $\bar{e}_i$ is the average of the optimal e_i's for δ_2=0 and δ_2=1. Likewise, $\Delta\alpha_i \equiv [\alpha_i(\delta_1,0) - \alpha_i(\delta_1,1)]$ is the change in a wage compensation parameter. Note that any term that involves e_3 is differenced out of (17), since from Table 2 the optimal e_3 is constant across all ownership/control structures.

The expression on the right-hand-side of (17) has an intuitive interpretation. The term inside the first set of large brackets is the first-best level of e_1 relative to the average level of e_1 under either f or h factory ownership. Similarly, the term inside the second set of large brackets is the first-best level of e_2 relative to the average level of e_2 under f or h factory ownership. These terms measure the distance of each party's investment from the first best and so capture the average distortion to each party's investment due to the incentive problems with wage compensation. The Δe_i terms capture the increase/decrease in a party's investment in going from f to h ownership of the factory. In the case we have been discussing (the top row of Table 2), the principal's effort level $e_1 = P_0/\gamma_h$ is unchanged by ownership, so $\Delta e_1 = 0$, but the agent's effort level is reduced when the principal has ownership, so $\Delta e_2 < 0$.

The final terms on the right of (17) reflect the change in the variance of the agent's income due to changing ownership from the agent to the principal. In general we have $\Delta\alpha_2 > 0$, since giving the principal ownership implies more wage compensation to the agent. When $\delta_1 = 1$ (so the agent has control over the input), then we also have $\Delta\alpha_1 > 0$. For both reasons, the variance of agent's *wage* income rises when the principal has factor ownership. Offsetting this, when the principal has ownership then the agent avoids the uncertainly in profits (σ_3^2) due to the transfer price.

It can be noticed that there is a high degree of symmetry in the effort levels and compensation parameters reported in Table 2. Indeed, nearly all reported values for these occur *both* on the diagonal and the off-diagonal. The only exception is the disincentive to the *agent's* effort level e_1 devoted to reducing the cost of the input when the *principal* owns the firm. This off-diagonal cell (f,h), in the lower-left of Table 2, is the only case where e_1 is less than its first-best value. Since this is the only difference between the diagonal and off-diagonal elements, if we sum the values of WCE computed along the diagonal, and subtract its values along the off-diagonal, we obtain the loss attributed to the reduction in e_1 in the (f,h) regime:

$$\text{WCE}(0,0) + \text{WCE}(1,1) - \text{WCE}(0,1) - \text{WCE}(1,0) = \frac{P_0^2}{2}\left(\frac{r\sigma_1^2}{1+\gamma_f r\sigma_1^2}\right) > 0. \qquad (18)$$

It follows from (18) that the objective function WCE is strictly *supermodular*, so that higher values tend to be obtained when δ_1 and δ_2 take on the *same* values.[9]

The supermodularity of the objective function has direct empirical implications. Suppose that for any parameters A, B, P_0, γ_h, $\gamma_f > 0$, $\lambda \geq 0$, and $\sigma_i^2 > 0$, i=1,2,3, ownership and control is chosen to maximize WCE(δ_1, δ_2). Now treat the parameters as random variables, and compute the probabilities that each control/ownership pair (δ_1, δ_2) is chosen. To sharpen this comparison, let us consider optimal ownership structure *conditional on* the control of inputs. Then the conditional probabilities that it is optimal for the principal to own the firm are,

[9] This is the same result obtained by Holmstrom and Milgrom (1994) in a more general model, though some of our assumptions are weaker than theirs As noted above, we have allowed the effort levels to be additively separable in the agent's private costs, whereas HM assume that these are complements.

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 0) = \text{Prob}[\text{WCE}(0, 0) - \text{WCE}(0, 1) > 0] , \tag{19}$$

and,

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 1) = \text{Prob}[\text{WCE}(1, 0) - \text{WCE}(1, 1) > 0] . \tag{20}$$

By using the supermodularity of WCE in (18), we see that [WCE(0, 0) – WCE(0, 1)] > [WCE(1, 0) – WCE(1, 1)]. It follows that (19) exceeds (20): the probability that the principal will own the factory conditional on controlling the inputs *exceeds* the probability that the principal will own the factory when the agent control the inputs. The reason for this is that the incentive problem is ameliorated when the *same party* has ownership and control. When the agent controls the inputs, it makes sense to also give him ownership, so as to avoid incentive problems in wage compensation. When the principal controls the inputs, however, then that portion of wage compensation is no longer given to the agent, so that factory ownership would introduce unnecessary randomness in the agent's return. We summarize these results with:

Proposition 1

In the Holmstrom-Milgrom model, allowing the parameters A, B, P_0, γ_h, γ_f, λ and σ_i^2, i=1,2,3, to be random and computing the optimal ownership structure, we find that:

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 0) > \text{Prob}(\delta_2 = 0 \mid \delta_1 = 1).$$

Thus, ownership tends to be given to the same party that controls the inputs.

We turn next to the Grossman-Hart-Moore model, where it turns out that we will find the opposite prediction.

4.2 Grossman-Hart-Moore Model

To review the timing of actions in the GHM model, parties first choose effort levels (headquarters h chooses e_1, if δ_1 equals 0, and e_3; factory manager f chooses e_1, if δ_1 equals 1, and e_2), then production occurs, and then ex-post profits are divided. Prior to these actions, the parties choose a structure for input control (δ_1) and factory ownership (δ_2). This structure determines each party's threat-point payoff and so his bargaining power and incentive to invest in effort. Naturally, the parties choose the structure that maximizes the total surplus W in (2).

To determine the optimal control and ownership structure, we must specify the threat-point payoffs, π_f and π_h, and then solve for optimal effort levels under the four possible regimes. These are shown in Table 3. First, consider the case where headquarters h controls the input and owns the factory, so that $\delta_1=0$ and $\delta_2=0$, which we refer to as (h,h) and which occupies the upper-left quadrant of Table 3. In the disagreement point, h's threat is to fire the manager, hire a new manager on the spot market, and continue with production. In so doing, h would end up with a manager who has not made the appropriate effort investments. Thus, threat-point revenues from production (Be_3) are a function of h's effort only and production costs, $\hat{F} \geq A$, are higher than under joint production. (We use the caret to denote threat-point values.)

The threat point for f is to quit working for h and find a job with another employer. We assume that this employer would not value f's effort investments for the project with h, so that f would receive a flat wage, $\hat{y}$.[10] Using these specifications of π_f and π_h and of ex-post profits under joint production in (15), we solve (12)-(13) for case (h,h) to obtain the optimal effort levels shown in Table 3.

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[10] This assumption can be relaxed to make the wage a function of e_2 without changing the main results.

Moving across the first row of Table 3, compare case (h,h) to (h,f), in which h still controls the inputs but f now owns the factory. Giving f ownership of the factory changes threat-point payoffs and so the bargaining power of each party. At the disagreement point, h would have to turn to the spot market to rent a factory (at some cost $\hat{z}$) and to hire a manager (yielding input cost $\hat{F}$). We assume h's investments in marketing would be less productive with a rented factory, and so only generate revenue $\hat{B}e_3$, where $\hat{B} < B$. The threat point for f is to buy inputs on the spot market at price $\hat{P}_0 \geq P_0$ and sell the processed inputs on the spot market (rather than through h) generating revenues $\hat{G}$. Comparing optimal effort levels in (h,h) and (h,f), we see that giving f ownership of the factory raises f's effort investment (since his bargaining power has increased) and lowers h's effort investment (since his bargaining power has decreased).

Next, consider the outcome under the two ownership structures in which f controls the inputs, which are shown in the second row of Table 3. In case (f,h), in which h owns the factory, h's threat point is to hire a manager on the spot market (yielding input costs $\hat{F}$) and to buy inputs on the spot market (at price $\hat{P}_0$). Again, at the disagreement point the revenue that h generates is a function of his effort only. Even though f does not own the factory, controlling the inputs gives him outside options that he did not have in case (h,h). We assume his threat point is now to rent a factory on the spot market (at cost $\hat{z}$) and sell the processed inputs on the spot market (for revenues $\hat{G}$). With a rented factory, f's investments would be less productive than under joint production, yielding input costs $\hat{A}(1-e_2) \geq A(1-e_2)$. Based on these payoffs, Table 3 shows optimal effort levels for case (f,h) in the lower-left quadrant.

Going from (f,h) to (f,f), in which f controls the inputs and owns the factory, we see that h's outside options deteriorate, since h must now rent a factory on the spot market in which his investments would be less productive, and that f's outside options improve, since f gains ownership of the factory. Thus, f's effort investment rises and h's falls.

Under either f or h control of the inputs, giving h ownership of the factory yields a similar change in h's investment incentives: gaining the factory improves h's bargaining power. Giving f ownership of the factory raises his incentive to invest, but the kick is larger when h controls the inputs than when f controls the inputs. The reason for this is that when f neither owns the factory nor controls the inputs he has poor outside options and minimal bargaining power. In this case, giving f ownership of the factory yields a large boost to f's bargaining power and investment incentive. In contrast, when f controls the inputs he has some bargaining power. In this case, giving him ownership of the factory doesn't do as much to raise his bargaining power as when he lacks input control and has bleak outside options.

Having solved for optimal effort levels, we calculate the total surplus W in (2) under the different factory-ownership and input-control regimes. As before, we examine $W(\delta_1,0)$-$W(\delta_1,1)$, the change in total surplus in going from the factory manager f owning the factory (δ_2=1) to the multinational headquarters h owning the factory (δ_2=0), under the two input-control structures. Combining (2), (15), and (16), $W(\delta_1,0)$-$W(\delta_1,1)$, can be written in general form as,

$$\begin{aligned} W(\delta_1,0) - W(\delta_1,1) &= B(\lambda\Delta e_2 + \Delta e_3) + A\Delta e_2 - \gamma_f \bar{e}_2 \Delta e_2 - \gamma_h \bar{e}_3 \Delta e_3 \\ &= \left(\frac{B}{\gamma_h} - \bar{e}_3\right)\gamma_h \Delta e_3 + \left(\frac{\lambda B + A}{\gamma_f} - \bar{e}_2\right)\gamma_f \Delta e_2 \end{aligned} \tag{21}$$

where, for a given input control structure, Δe_i is the change in the optimal level of e_i induced by changing δ_2 from 1 to 0 (giving h factory ownership) and $\bar{e}_i$ is the average of the optimal e_i's for δ_2=0 and δ_2=1. Note that any term that involves e_1 is differenced out of (21), since from Table 3 the optimal e_1 is constant across factory-ownership structures for a given input-control structure.

We can interpret the various terms of (21) in much the same way as in the HM model. The expressions in large brackets are the first-best level of e_2 or e_3 relative to their average levels under either f or h factory ownership. The Δe_i terms capture the increase/decrease in a party's investment in going from f to h ownership of the factory. For the GNM model, $\Delta e_2<0$ and $\Delta e_3>0$, since giving factory ownership to h raises his investment and lowers f's. Thus, (21) says that for a given input control structure it will be optimal to give h (f) ownership of the factory when doing so raises his investment incentive by a large amount *and* when his investments are highly distorted by incomplete contracts.

We now compare predictions for which factory-ownership regime will obtain under the two input-control structures. For random values of the parameters A, B, P_0, γ_h, $\gamma_f > 0$ and $\lambda \geq 0$, denote the conditional probabilities that party h should own the firm:

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 0) = \text{Prob}[W(0, 0) - W(0, 1) > 0], \tag{19'}$$

and

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 1) = \text{Prob}[W(1, 0) - W(1, 1) > 0]\,. \tag{20'}$$

Then solving for these using (21) and Table 3,

$$\begin{aligned} W(0,0) - W(0,1) &= \frac{1}{8\gamma_h}(B - \hat{B})^2 - \frac{1}{8\gamma_f}(2\lambda B + A)A \\ W(1,0) - W(1,1) &= \frac{1}{8\gamma_h}(B - \hat{B})^2 - \frac{1}{8\gamma_f}(2\lambda B + A - \hat{A})(A - \hat{A}). \end{aligned} \tag{22}$$

In general, we cannot sign either term in (22). These signs will depend on the parameter values (in a sensible way). It is clear, however, that the expression in the first row of (22) is smaller than the expression in the second row, or that there is a bigger gain in total surplus to giving h ownership of the factory when f controls the input than when h controls the input. Thus, (22) implies $W(1,0) + W(0,1) > W(0,0) + W(1,1)$ such that $W(\delta_1,\delta_2)$ is submodular. This yields the testable prediction that *h ownership of the factory will be more likely when f has input control than when h has input control*. We summarize this as follows.

<u>Proposition 2</u>

In the Grossman-Hart-Moore model, allowing the parameters A, B, P_0, γ_h, γ_f, λ to be random and computing the optimal ownership structure, we find that:

$$\text{Prob}(\delta_2 = 0 \mid \delta_1 = 0) < \text{Prob}(\delta_2 = 0 \mid \delta_1 = 1).$$

Thus, ownership tends to be given to the party that *does not* control the inputs.

In the first empirical test, we will be computing the probabilities of factory-ownership, conditional on input-control, to see whether the predictions of Proposition 1 or 2 are supported by the data. In this application we can be completely general in the stochastic specification, allowing all the parameters A, B, P_0, γ_h, γ_f, and σ_i^2, i=1,2,3, to vary randomly. In a second test, however, we will want to model some of these parameters as deterministic functions of observed variables in a regression framework. In that case, we restrict the application of Propositions 1 and 2 to only include *additive* errors in $WCE(\delta_1,0)$-$WCE(\delta_1,1)$ or $W(\delta_1,0)$-$W(\delta_1,1)$.

In this second application, it is straightforward to obtain results on the sensitivity of the ownership choice to the model parameters under the two input-control structures. GHM suggests that raising a party's investment productivity will make it more likely that that party has ownership over productive assets. Consistent with the logic of Proposition 2, we show that this effect is strongest when a party *does not* have control over the inputs.

<u>Proposition 3</u>

Define $\Delta W(\delta_1) \equiv W(\delta_1,0) - W(\delta_1,1)$. Then from (22),

$$\text{(i)}\ \left.\frac{\partial \Delta W}{\partial B}\right|_{\delta_1=0} < \left.\frac{\partial \Delta W}{\partial B}\right|_{\delta_1=1}, \quad \text{(ii)}\ \left.\frac{\partial \Delta W}{\partial A}\right|_{\delta_1=0} < \left.\frac{\partial \Delta W}{\partial A}\right|_{\delta_1=1}, \quad \text{(iii)}\ \left.\frac{\partial \Delta W}{\partial \gamma_f}\right|_{\delta_1=0} > \left.\frac{\partial \Delta W}{\partial \gamma_f}\right|_{\delta_1=1} \qquad (23)$$

In words, (i) says that raising h's investment productivity (B) does more to raise the likelihood that h owns the factory under f input control than under h input control, (ii) says that raising f's investment productivity (A) does more to lower the likelihood that h owns the factory under h input control than under f input control, and (iii) says that raising f's investment costs (γ_f) does more to raise the likelihood that h owns the factory under h input control than under f input control. These are additional testable predictions of GHM.

5. Empirical Results

In this section we test the empirical predictions of the Grossman-Hart-Moore and Holmstrom-Milgrom models. The data are from the Customs General Administration of the People's Republic of China and show processing exports by year (1997-1999), destination country, four-digit SITC product, origin province in China, customs regime (pure-assembly or import-and-assembly), firm type (foreign-owned or Chinese-owned), and export status (direct export or re-export through Hong Kong). We have about 60,000 observations per year.

5.1 Grossman-Hart-Moore versus Holmstrom-Milgrom

Both the GHM and HM frameworks make explicit predictions about the relative likelihood of foreign ownership of an export processing factory under different input-control structures. For the HM model, Proposition 1 states that the foreign buyer of the processed inputs is *more* likely to own the processing factory when it controls the inputs used in processing. For the GHM model, Proposition 2 states the opposite. The foreign buyer is *less* likely to own the processing factory when it controls the inputs used in processing.

Before testing these predictions, we develop some notation. As in the models, δ_1 defines the input-control structure and δ_2 defines the factory-ownership structure. The pure-assembly processing regime, in which the foreign buyer controls the inputs used in processing, is equivalent to party h, the headquarters firm, owning the inputs, or δ_1=0. The import-and-assembly regime, in which the Chinese factory controls the inputs used in processing, is equivalent to party f, the factory manager, owning the inputs, or δ_1=1. Foreign ownership of the processing factory is equivalent to party h owning the factory, or δ_2=0. Chinese ownership of the processing factory is equivalent to party f owning the factory, or δ_2=1.

In the first test of these propositions, we compute the conditional probabilities of ownership. A problem we encounter, however, is that we do not have firm-level data on ownership, but rather, have Chinese trade data *on export by ownership*. To make the connection between these data and our theoretical statements in Proposition 1 and 2, let ω denote the vector of variables A, B, P_0, γ_h, γ_f, λ (along with σ_i^2, i=1,2,3, in the HM model) that vary randomly. Suppose that ω is distributed across factories in China according to the density function f(ω). Also, let x(ω) denote the export of each factory, so that total exports are $X = \int x(\omega) f(\omega) d\omega$. Finally, define the indicator variable $D(\delta_1,\delta_2,\omega)$ as unity if (δ_1,δ_2) is the control/ownership structure that governs processing trade for factory ω. Thus, D(i,j,ω) takes a value of unity if factory ω is subject to input control by party i ($\delta_1 = i$) and ownership by party j ($\delta_2 = j$), and zero otherwise.

With this notation, the frequency of each control/ownership structure in our data would be:

$$P(\delta_1, \delta_2) = \int D(\delta_1, \delta_2, \omega) f(\omega) d\omega, \text{ for } \delta_1, \delta_2 \in \{0, 1\}, \tag{24}$$

and to test whether the predictions of the GHM or HM models hold, we would examine the sign of $[P(0,0) - P(0,1)] - [P(1,0) - P(1,1)]$, as in Propositions 1 and 2. We cannot measure this magnitude, however, but instead observe:

$$S(\delta_1, \delta_2) = \int [x(\omega)/X] \, D(\delta_1, \delta_2, \omega) f(\omega) d\omega, \text{ for } \delta_1, \delta_2 \in \{0, 1\}. \tag{25}$$

That is, we observe the *market share* of exports accounted for by each control/ownership structure, which depends on the relative exports $[x(\omega)/X]$ from each plant. Then we will construct the magnitude $[S(0,0) - S(0,1)] - [S(1,0) - S(1,1)]$ to test the GHM and HM models. Using (25) to substitute for (24) in this hypothesis test relies on the assumption that *exports from each factory are uncorrelated with the control/ownership structure.* We have no way to test the validity of this assumption, but maintain it throughout our analysis.

We refer to the quantity $RFO \equiv [S(0,0) - S(0,1)] - [S(1,0) - S(1,1)]$ as *relative foreign ownership.* This "double difference" compares the likelihood of foreign ownership under different input-control structures, so it differences out any year-industry-destination country-province specific effects that influence the choice of ownership structure but that are common across input-control structures. These effects include the relative costs of incorporating a domestic versus a foreign enterprise in China and the relative tax advantages of domestic versus foreign ownership. Equivalently, we can view RFO as comparing the relative likelihood of foreign input control under different ownership structures. Such a comparison differences out any cell-specific effects that influence the choice of input-control structure but that are common across ownership structures. These effects include the cost of setting up a pure-assembly factory or an import-and-assembly factory.

To test the predictions the sign of RFO, Table 4 shows the share of processing exports by factory-ownership and by input-control structure, averaged across the year-industry-destination market-province cells in our data. Reading across the first row, foreign-buyer control of the inputs (the pure-assembly regime) combined with foreign ownership of the factory accounts for an average of 7.9% of processing exports, while foreign control of the inputs combined with Chinese ownership of the factory accounts for 23.2% of processing exports. The mean difference in these two shares, shown in the third column of Table 4, is highly statistically significant. This implies that, conditioning on the foreign buyer controlling the inputs, Chinese ownership of the processing factory is more likely than foreign ownership of the factory. Reading across the second row of Table 4, factory control of the inputs (the import-and-assembly regime) combined with foreign ownership of the factory accounts for 50.1% of processing exports and factory control of the inputs combined with Chinese ownership of the factory accounts for 18.8% of processing exports. Again, the mean difference in these two shares is highly statistically significant. Conditioning on the Chinese factory controlling the inputs, foreign ownership of the factory is more likely than Chinese ownership of the factory.

At first glance, the results suggest that parties in processing trade tend to split factory ownership and input control. This would be consistent with Grossman-Hart-Moore but inconsistent with Holmstrom-Milgrom. To show this more formally, the third row of Table 4 shows relative foreign ownership, which GHM predicts will be negative and HM predicts will be positive. In Table 4, we see that relative foreign ownership is negative and highly statistically significant. Foreign ownership of the processing factory is less likely when the foreign buyer controls the inputs than when the Chinese factory controls the inputs. In the full sample, the data show support for GHM but strongly reject HM.

We proceed to examine whether the results are stable over time and whether the results depend on who intermediates the shipment of exports to destination markets. In Table 5, the first row shows relative foreign ownership by year for the full sample. Relative foreign ownership is negative and highly statistically significant in all years. There is a slight upward trend in the absolute value of this measure, suggesting that over time parties are moving even further away from giving factory ownership and input control to a single party.

The second two rows of Table 5 show that relative foreign ownership is negative and statistically significant both in the case of processing exports that are shipped directly to destination markets and in the case of processing exports that are re-exported through Hong Kong. We also see that relative foreign ownership is much more negative in the latter case than in the former. This means that, compared to processing exports shipped directly, processing exports shipped through Hong Kong are much more likely to be produced under an arrangement in which parties split factory ownership and input control.

To explain this result, consider the logic of the GHM model in the event that there are differences between foreign buyers located in Hong Kong and foreign buyers located elsewhere. As a major entrepôt, Hong Kong may offer abundant trading opportunities to local firms. Parties in Hong Kong that engage in processing trade with China tend to be commercial traders that also intermediate processing trade with many other countries (Sung, 1991). Given a disagreement with the manager of a processing factory, these traders may have outside options that are better than those of foreign buyers not located in an entrepôt. In the regime where the foreign buyer controls the inputs, transferring factory ownership from a buyer in Hong Kong to the factory manager in China may diminish the Hong Kong buyer's outside options only slightly, leading to only a modest weakening in his investment incentives. This would create a strong incentive to split factory ownership and input control. It would also suggest that the rationale for giving factory ownership to the factory manager when the foreign buyer controls the inputs may be greater for processing trade intermediated by Hong Kong than for direct processing trade.

5.2 Additional Results on the Grossman-Hart-Moore Model

The results in Tables 4 and 5 show support for the Grossman-Hart-Moore model but not for the Holmstrom-Milgrom model. We now examine other testable implications of GHM. We use as dependent variables $[S(0,0) - S(0,1)]$, which is the share of processing exports by foreign-owned factories relative to the share of processing exports by Chinese-owned factories in the pure-assembly regime (foreign control of inputs), and $[S(1,0) - S(1,1)]$, which is the share of processing exports by foreign-owned factories relative to the share of processing exports by Chinese-owned factories in the import-and-assembly regime (Chinese control of inputs). As in the last section, we use these shares to measure the average probability of foreign ownership by year-industry-destination country-province cell in the two input-control regimes.

Equation (22) gives a structural equation for foreign ownership as a function of the investment productivities of the foreign buyer and the factory manager. Since we do not observe the variables on the right of (22), we adopt the following reduced-form specifications:

$$\begin{aligned} S_i(0,0) - S_i(0,1) &= \beta^0 + \theta^0 X_i + \gamma^0 Y_i + \eta_i + \mu_i^0 \\ S_i(1,0) - S_i(1,1) &= \beta^1 + \theta^1 X_i + \gamma^1 Y_i + \eta_i + \mu_i^1 \end{aligned} \tag{26}$$

where i is the year-industry-destination country-province cell, X_i is a vector of proxy variables for the foreign buyer's investment productivity (B); Y_i is a vector of proxy variables for the factory manager's investment productivity (A); β^j, θ^j, and γ^j are parameters related to input-control regime j; η_i is an unobserved component specific to cell i; and μ_i^j is an error term. From (22), any factor that raises the foreign buyer's investment productivity makes foreign factory ownership more likely, which suggests $\theta^j>0$, and any factor that raises the factory manager's investment productivity makes foreign ownership less likely, which suggests $\gamma^j<0$.

Complicating estimation of (26) is the presence of year-industry-destination country-province specific fixed effects, η_i. Unobserved factors that affect the ownership decision include the cost of incorporating a foreign enterprise in China or the tax treatment of foreign enterprises in China (which vary by year, industry, and Chinese province), the tax treatment of earnings in China by a multinational firm's host country (which vary by year and destination country), and the perceived risk of investing in China (which varies by year, industry, destination country, and Chinese province). These unobserved determinants of the ownership decision may be correlated with the investment intensity of the parties involved in processing trade (e.g., foreign buyers or factory managers may be less willing to invest in a project if their earnings will be taxed at a high rate), which would tend to make OLS estimation of (25) inconsistent. To control for cell-specific fixed effects, we difference the first and second equations in (26) to obtain,

$$[S_i(0,0)-S_i(0,1)]-[S_i(1,0)-S_i(1,1)]=(\beta^0-\beta^1)+(\theta^0-\theta^1)X_i+(\gamma^0-\gamma^1)Y_i+\mu_i^0-\mu_i^1, \quad (27)$$

where the dependent variable becomes relative foreign ownership as shown in Tables 4 and 5. Equation (27) is the specification we use for estimation.

Proposition 3 gives predictions for the sensitivity of relative foreign ownership to the parties' investment productivities. The sensitivity of foreign ownership to the foreign buyer's investment productivity is smaller (*less positive*) under foreign input control that under Chinese input control, which suggests that $(\theta^0 - \theta^1) < 0$. Similarly, the sensitivity of foreign ownership to the factory manager's investment productivity is greater (*more negative*) under foreign input control that under Chinese input control, which suggests that $(\gamma^0 - \gamma^1) < 0$.

To test these predictions, we regress relative foreign ownership on factors that influence the ownership decision. The investments of a foreign buyer in marketing and sales are likely to do more to raise the value of the project the higher is the quality of the good being processed. One measure of product quality is the variability in export prices across destination markets (within a given industry). Greater price variability within an industry signals variation in product attributes, which are in part determined by firm investments in product quality. A second measure of product quality is the prevalence of differentiated products within an industry. Many differentiated goods are branded, which involve specific investments by a firm in copyrights, trademarks, patents, and marketing. We measure product differentiation using Rauch's (1999) classification of SITC products.[11] A third measure of product quality is the per capita income of the destination country. To the extent that quality is income elastic, countries with higher average incomes are likely to demand higher quality products.

The investments by the factory manager in processing activities are likely to be more important in environments where the supply of skilled labor is relatively scarce. We take the

[11] Rauch constructs this classification based on how the majority of five-digit products inside a three or four-digit SITC industry are sold. Homogeneous goods are those sold on organized exchanges, such as commodities markets; reference-priced goods are those whose prices are listed in published international trade journals; and differentiated goods are all other goods. The sale of homogeneous and reference-priced goods tends to occur through exchanges in which the identity of buyers and sellers is either well-known or unimportant. Differentiated goods are presumably those ill-suited to the impersonal exchange of standardized markets.

Chinese province as the relevant labor market for a processing factory. One measure of the supply of skilled labor is the provincial wage in manufacturing, which is a skill-intensive sector, relative to the provincial wage in agriculture and other industries, which in China are less skill-intensive sectors. The higher is the relative manufacturing wage, the lower is the supply of skilled labor, the stronger is the factory manager's investment intensity, and the less likely is foreign ownership. A second measure of the supply of skilled labor is the share of provincial employment in manufacturing. The higher is the manufacturing employment share, the higher is the supply of skilled labor, and the more likely is foreign ownership.

We also control for additional factors that might influence foreign ownership in export processing. One set includes the GDP of the destination country and the GDP of the province in China were processing occurs. Multinational firms may be more prevalent in larger destination countries and in larger host regions (CITE), though it is not clear that these effects will vary across input-control regimes. A second factor we control for is the corporate income tax rate in the destination country. By owning the processing factory in China, a multinational firm engaging in processing trade may be better able to transfer price. Higher taxes should then make foreign ownership of processing factories in China more attractive. These gains will presumably be higher when the multinational also controls input purchases and so can dictate the input prices paid by the processing factory. This suggests that relative foreign ownership will be positively correlated with corporate income taxes. A third factor we control for is whether a product is subject to Multi-fiber Arrangement (MFA) quotas in the destination country to which it is shipped. For a multinational firm importing MFA goods into a destination country from China, there may be gains to having these goods produced by arms-length manufacturers. Doing so may make it easier to ship the goods to the destination market through a third country, thereby possibly avoiding MFA quotas on China (which tend to bind in many MFA countries). These gains will presumably be greater when the multinational does not control input purchases (and so can better hide involvement in the transaction).

Table 6 reports the regression results. Using the full sample, column (1) reports the base specification and column (2) reports the base specification plus industry and destination-region dummy variables. Columns (3) and (4) repeat these specifications using only observations on processing exports shipped directly to destination markets and columns (5) and (6) repeat the specifications using only observations on processing exports re-exported through Hong Kong. Since some regressors vary by industry but not by other dimensions, we allow for correlation in the errors across observations that share the same four-digit industry.

Consider first the results on the full sample. In column (1), relative foreign ownership is negatively correlated with the three measures of product quality, which are export price variability, the prevalence of differentiated products, and per capita GDP in the destination country. Coefficients on all three variables are precisely estimated. This is consistent with the prediction of the GHM model that the (positive) sensitivity of foreign ownership to the productivity of investments by the foreign buyer is greater when the foreign buyer lacks control over input purchases. In column (2), which adds industry and region dummy variables, the magnitudes of coefficient estimates fall slightly, but each remains precisely estimated except that on differentiated products. Consistent with the results in Table 5, relative foreign ownership is significantly more negative for processing exports re-exported through Hong Kong.

In columns (1) and (2), we also see that relative foreign ownership is negatively correlated with the Chinese province relative manufacturing wage, where this coefficient is precisely estimated. This is consistent with the GHM prediction that the (negative) sensitivity of foreign ownership to the productivity of investments by the factory manager will be greater when the factory manager does not control input purchases. The coefficients on the other provincial variables, the Chinese province share of employment in manufacturing and the GDP of the Chinese province GDP, are imprecisely estimated.

In terms of additional control variables for the ownership decision, relative foreign ownership is greater in products and destination countries subject to MFA quotas and in destination countries with higher corporate tax rates, both of which are as expected. There appears to be no correlation between relative foreign ownership and destination country GDP and no consistent correlation between relative foreign ownership and the distance from China to the destination market.

In columns (3) and (4), we restrict the sample to cases in which processing exports are shipped directly to destination markets. This tends to increase the magnitude of the coefficient estimates but does not change the qualitative nature of the results. In columns (5) and (6) we restrict the sample to case in which processing exports are re-exported through Hong Kong. The vast majority of these exports come from Guangdong Province, which neighbors Hong Kong. As are result, we lose much of the cross-province variation in the data and so drop the regressors that are specific to the province. For this sample, the magnitude of coefficient estimates is smaller and some variables lose statistically significance.

6. Conclusion

[To be written]

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Table 1: Foreign Ownership, Export Processing, and Trade in China

Year	Processing Exports/ Total Exports	FIE Exports/ Total Exports	Share in Total Processing Exports of Import-and-Assembly	Share in Total Processing Exports of Hong Kong Re-Exports	Share in Total Processing Exports of FIE Exports
1997	0.525	0.342	0.696	0.565	0.545
1998	0.545	0.370	0.694	0.562	0.566
1999	0.542	0.385	0.665	0.516	0.584

Notes: Columns (1) and (2) show processing exports and exports by foreign-invested enterprises, respectively, as a share of total China exports; columns (3)-(5) show as a share of total China processing exports, processing exports under the import-and-assembly regime, processing exports re-exported through Hong Kong, and processing exports by foreign-invested enterprises, respectively.

Table 2:

Optimal Effort Levels and Compensation Parameters in the Holmstrom-Milgrom Model

Control of the Inputs		Ownership of the Factory: $\delta_2 = 0$, Principal h owns	Ownership of the Factory: $\delta_2 = 1$, Agent f owns
	$\delta_1 = 0$, Principal h controls	**Case (h,h), WCE(0,0)** $e_1 = P_0/\gamma_h$ $e_2 = \alpha_2/\gamma_f$ $\alpha_2 = (A + \lambda B)/(1 + \gamma_f r\sigma_2^2)$ $e_3 = B/\gamma_h$	**Case (h,f), WCE(0,1)** $e_1 = P_0/\gamma_h$ $e_2 = (A + \alpha_2)/\gamma_f$ $\alpha_2 = \lambda B/(1 + \gamma_f r\sigma_2^2)$ $e_3 = B/\gamma_h$
	$\delta_1 = 1$, Agent f controls	**Case (f,h), WCE(1,0)** $e_1 = \alpha_1/\gamma_h$ $\alpha_1 = P_0/(1 + \gamma_f r\sigma_1^2)$ $e_2 = \alpha_2/\gamma_f$ $\alpha_2 = (A + \lambda B)/(1 + \gamma_f r\sigma_2^2)$ $e_3 = B/\gamma_h$	**Case (f,f), WCE(1,1)** $e_1 = P_0/\gamma_h$ $e_2 = (A + \alpha_2)/\gamma_f$ $\alpha_2 = \lambda B/(1 + \gamma_f r\sigma_2^2)$ $e_3 = B/\gamma_h$

Table 3:

Threat-Point Payoffs and Optimal Effort Levels in the Grossman-Hart-Moore Model

Control of the Inputs		**Ownership of the Factory:** $\delta_2 = 0$, **Party h owns**	**Ownership of the Factory:** $\delta_2 = 1$, **Party f owns**
	$\delta_1 = 0$, **Party h controls**	**Case (h,h)** $\pi_f = \hat{y}$ $\pi_h = Be_3 - \hat{F} - P_0(1-e_1)$ $e_1 = P_0/\gamma_h$ $e_2 = (\lambda B + A)/2\gamma_f$ $e_3 = B/\gamma_h$	**Case (h,f)** $\pi_f = \hat{G} - A(1-e_2) - \hat{P}_0$ $\pi_h = \hat{B}e_3 - \hat{F} - P_0(1-e_1) - \hat{z}$ $e_1 = P_0/\gamma_h$ $e_2 = (\lambda B + 2A)/2\gamma_f$ $e_3 = (B+\hat{B})/2\gamma_h$
	$\delta_1 = 1$, **Party f controls**	**Case (f,h)** $\pi_f = \hat{G} - \hat{A}(1-e_2) - P_0(1-e_1) - \hat{z}$ $\pi_h = Be_3 - \hat{F} - \hat{P}_0$ $e_1 = P_0/\gamma_f$ $e_2 = (\lambda B + A + \hat{A})/2\gamma_f$ $e_3 = B/2\gamma_h$	**Case (f,f)** $\pi_f = \hat{G} - A(1-e_2) - P_0(1-e_1)$ $\pi_h = \hat{B}e_3 - \hat{F} - \hat{P}_0 - \hat{z}$ $e_1 = P_0/\gamma_f$ $e_2 = (\lambda B + 2A)/2\gamma_f$ $e_3 = (B+\hat{B})/2\gamma_h$

Table 4:

Share of Processing Exports by Factory Ownership and Processing Regime

Control over Inputs (processing regime)	Ownership of Factory: Foreign	Ownership of Factory: Chinese	Difference in Shares
	S(0,0)	S(0,1)	S(0,0) - S(0,1)
Foreign Buyer (pure-assembly)	0.079	0.232	-0.152
	(0.003)	(0.006)	(0.008)
	S(1,0)	S(1,1)	S(1,0) - S(1,1)
Chinese Factory (import-and-assembly)	0.501	0.188	0.312
	(0.005)	(0.004)	(0.007)
			[S(0,0) - S(0,1)]- [S(1,0) - S(1,1)]
Relative Likelihood of Foreign Ownership			-0.465
			(0.009)

Notes: This table shows means for shares of processing exports by factory ownership (foreign versus Chinese) and input-control structure (pure-assembly versus import-and-assembly regimes) for 181,789 observations by year, industry, destination country, and origin province. Heteroskedasticity-consistent standard errors are in parentheses.

Table 5: Relative Foreign Ownership by Year and Export

	Relative Likelihood of Foreign Ownership [S(0,0) - S(0,1)] - [S(1,0) - S(1,1)]		
	1997	1998	1999
All	-0.442	-0.464	-0.488
Exports	(0.017)	(0.016)	(0.015)
N	59,105	59,410	63,274
Direct	-0.242	-0.257	-0.309
Exports	(0.020)	(0.019)	(0.018)
N	43,447	44,212	47,954
Re-Exports thru	-0.722	-0.746	-0.788
Hong Kong	(0.012)	(0.011)	(0.011)
N	15,658	15,198	15,320

Notes: This table shows the share of processing exports by foreign-owned factories minus the share of processing exports by Chinese-owned factories under the pure-assembly processing regime minus that under the import-and-assembly processing regime. See Table 4 for more details. Heteroskedasticity-consistent standard errors are in parentheses.

Table 6: Regression Results for the Grossman-Hart-Moore Model

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Hong Kong	-0.313	-0.303				
Re-Export Dummy	(0.036)	(0.036)				
Export Price	-0.034	-0.027	-0.047	-0.030	-0.014	-0.014
Variability	(0.005)	(0.005)	(0.007)	(0.008)	(0.005)	(0.005)
Differentiated	-0.221	-0.127	-0.202	-0.077	-0.315	-0.209
Product	(0.097)	(0.136)	(0.099)	(0.150)	(0.156)	(0.096)
Destin. Country	-0.086	-0.064	-0.125	-0.119	-0.036	0.025
Per Capita GDP	(0.020)	(0.035)	(0.027)	(0.043)	(0.027)	(0.043)
Destin. Country	0.001	-0.011	-0.008	-0.031	-0.002	0.002
GDP	(0.008)	(0.009)	(0.013)	(0.014)	(0.008)	(0.010)
MFA Dummy	0.331	0.320	0.425	0.403	0.167	0.177
	(0.051)	(0.052)	(0.067)	(0.069)	(0.048)	(0.046)
1 - Corp. Tax Rate	-0.063	-0.041	-0.172	-0.073	0.039	-0.002
	(0.054)	(0.036)	(0.081)	(0.057)	(0.050)	(0.048)
Distance to China	-0.059	-0.035	-0.092	0.027	0.018	-0.087
	(0.018)	(0.087)	(0.028)	(0.102)	(0.018)	(0.082)
Province Relative	-1.544	-1.457	-1.342	-1.189		
Manuf. Wage	(0.519)	(0.508)	(0.528)	(0.506)		
Province Manuf.	-0.131	-0.123	-0.116	-0.094		
Employ. Share	(0.111)	(0.108)	(0.114)	(0.109)		
Province GDP	-0.041	-0.042	-0.016	-0.022		
	(0.035)	(0.034)	(0.036)	(0.034)		
N	70,438	70,438	52,596	52,596	17,842	17,842
R Squared	0.246	0.256	0.141	0.164	0.070	0.090

Notes to Table 6: This table shows regression results for equation (27). The dependent variable is relative foreign ownership, a definition and summary statistics for which are given in Tables 4 and 5. All continuous variables are in logs (expect Differentiated Product, which is a level share). Columns (1) and (2) show results for the full sample, columns (3) and (4) show results for processing exports shipped directly to destination markets, and columns (4) and (5) show results for processing exports re-exported through Hong Kong. Columns (2), (4), and (6) include dummy variables for the one-digit SITC industry and for the destination region. Standard errors are in parentheses and are corrected for heteroskedasticity and for correlation in the errors across observations that share the same four-digit industry.