Hybrid Vertical FDI

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Abstract

An exploration of Korean MNCs' foreign affiliate-level data reveals that a significant portion of manufacturing foreign affiliates sell both to related and unrelated firms at the same time. We refer to this as hybrid vertical FDI. We rationalize the presence of hybrid vertical FDI by modifying the otherwise standard property-rights model of global sourcing with the subsidiary-level option of supplying inputs to unrelated customers in addition to related firms. Given the positive production externality from serving additional customers (that is proportional to the MNC's productivity) and the costs of getting such benefit (that are increasing in relationship-specificity of the outsourced inputs), the model generates testable hypotheses that are robustly confirmed by our subsequent empirical analysis.

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1 Introduction

Over the last three decades, the world has witnessed rapid growth in international trade and foreign direct investment (FDI), giving rise to the term, an era of hyper-globalization (Subramanian and Kessler, 2013). Behind it lies an significant role of multinational corporations (MNCs) that accounts for as much as 90% of total exports and imports (Bernard et al., 2009) and, by definition, 100% of total FDI flows.

Theoretical development in the trade literature on multinational firms has kept up with their growing importance in the global economy, particularly fueled by advances in the heterogeneous firms trade model framework *a la* Melitz (2003). A traditional theory model of horizontal FDI based on the proximity-concentration trade-off successfully transformed into the productivity sorting model of export and horizontal FDI (Helpman et al., 2004). Likewise, a factor proportion model of offshoring with contractual frictions evolved into the property-rights model of multinational firm boundaries regarding outsourcing and vertical FDI (Antras, 2003 and Antras and Helpman, 2004).[1]

On the empirical front, however, despite thriving firm-level evidence on the pattern of MNCs' behavior, our understanding on the activity of foreign affiliates is rather limited to the case of the U.S., one of few countries that provide a detailed breakdown of subsidiary-level sales and sourcing activity information.[2] Given that very few U.S. foreign affiliates are engaged in intra-firm trade (hence vertical FDI) as shown in Ramondo et al. (2016), most of empirical evidence has been thus skewed toward findings in support of a theory of horizontal FDI (e.g., Brainard,

[1]Conceptual frameworks to understand the motive for other types of FDI activity such as export platform FDI (Ekholm et al., 2007; Tintelnot, 2017) and export-supporting FDI (Krautheim, 2013) have been also developed. Spearot (2012) and Díez and Spearot (2014) consider a separate aspect of greenfield vs. mergers and acquisition in a heterogeneous firms framework. Bilir et al. (2019) consider the role of host-country financial conditions on MNCs' location decisions for horizontal, vertical and platform FDI. See Antras (2015) for a comprehensive review of the recent literature on global production.

[2]To our knowledge, there are three countries that record such detailed subsidiary-level information: Japan, Korea, and the U.S. German Micro database Direct Investment (MiDi) employed in Krautheim (2013) and Tintelnot (2017) only records *total* sales of foreign affiliates.

1997, Yeaple, 2009 and Keller and Yeaple, 2013 among others; Chen and Moore, 2010 for French MNCs.), leaving a theory of vertical FDI largely unexplored by firm-level empirics.[3]

Given the background, this paper explores Korean MNCs' foreign affiliate-level data and contributes to the literature in three ways. First, we document a couple of interesting observations: (i) Korean MNCs conduct vertical FDI fairly actively, particularly pronounced for foreign affiliates located in emerging market countries[4]; (ii) a substantial portion of Korean foreign affiliates—accounting for around 30% (in terms of number) to 60% (in terms of revenue) of total manufacturing subsidiaries—sell (and buy) non-negligible amounts of products both to (from) related and unrelated firms at the same time.[5] Since such affiliates do not fit well to the existing categories of horizontal and vertical FDI, we classify them as *hybrid vertical FDI*.[6] While the former finding implies that the predominant prevalence of horizontal FDI among U.S. MNCs reported in Ramondo et al. (2016) may not fully extend to other countries, the latter calls for alternative or extended models of FDI that can explain such a more complex sales (and buying) pattern of foreign affiliates.[7]

As such, we offer a simple theoretical model that rationalizes the hybrid ver-

[3]Few exceptions include Corcos et al. (2013) and Kohler and Smolka (2014) that test the main predictions of the vertical FDI model by exploring the French and Spanish parent firm-level sourcing decision data, respectively. See Antràs and Yeaple (2014) and references reviewed therein for more discussion.

[4]This is consistent with the main finding in Alfaro and Charlton (2009) that suggests high frequency of vertical FDI at global level based on the information on industry classification of worldwide parent and subsidiary firms.

[5]It is in line with Hyun and Hur (2013) and Baldwin and Okubo (2014) that note a large share of Korean and Japanese foreign affiliates cannot be simply categorized as pure horizontal or vertical FDI. Feinberg and Keane (2006) and Hanson et al. (2001) also noted that U.S. MNC parents and their Canadian and Mexican affiliates show a similar pattern.

[6]Horizontal FDI is to capture a foreign affiliate that serves the foreign market by producing the same products that the headquarter firm produces at home, replacing the headquarter's potential exports to the foreign market. Thus, it is conceptually awkward to classify those subsidiaries who sell a part of their products to related firms as *hybrid horizontal FDI*. In addition, the stylized facts discussed below are more consistent with a classification of hybrid vertical FDI than that of hybrid horizontal FDI.

[7]As a concrete example of hybrid vertical FDI, one may consider the global sourcing structure

tical FDI type of activities, which cannot be easily explained by existing models of FDI. Specifically, we modify the otherwise standard property-rights model of global sourcing by introducing the subsidiary-level option of supplying inputs to third party customers on top of its related-party customers. On the one hand, a foreign subsidiary could benefit from serving additional unrelated customers via productivity spillovers or economies of scale, which would eventually be for the benefit of headquarter firms that make a final decision on whether the subsidiary should become a purely vertical (serving related firms only) or hybrid vertical firm. On the other hand, benefiting from such externality is costly due to the relation-specificity of input production, which may vary across industries. The headquarter firm makes her extensive and intensive margin decisions on hybrid vertical FDI, comparing the costs and benefits.

To the extent that a net gain from switching to hybrid vertical FDI from pure vertical FDI is increasing in subsidiary-level total sales and hence, its productivity, the model predicts that more productive subsidiaries are more likely to become hybrid vertical FDI firms. Moreover, since the cost of (benefiting from) hybrid vertical FDI increases with relationship-specificity, the productivity sorting pattern would be weaker in more complex industries. Conditional on conducting hybrid vertical FDI, the model generates further predictions toward the intensive margin decision of hybrid vertical FDI. As long as the positive externality from hybrid vertical FDI is sufficiently large, the ratio of inter-firm sales to intra-firm sales would be decreasing in productivity. Such a negative relationship would be again less pronounced in more complex industries due to higher costs associated with serving multiple customers and benefiting from it.

Lastly, we provide empirical evidence that supports these predictions of our hybrid vertical FDI model. Regarding the model's prediction on the productivity sorting pattern of the hybrid vertical FDI decision, we employ a linear probability model with the indicator dependent variable that turns on for hybrid vertical

of OLED (Organic Light-Emitting Diode) panels. LG Display, a Korean multinational company, has a production site in Guangzhou, China, that supplies OLED TV panels to many multinational corporations, such as Bang & Olufsen, Sony, Vizio and etc, in addition to its mother company.

FDI firms and off for vertical FDI firms. Controlling for country-sector as well as year fixed effects, our subsidiary-level specification that essentially exploits cross-sectional variation across subsidiaries within a given country-sector yields a positive and statistically significant correlation between the subsidiary-level productivity and the likelihood of conducting hybrid vertical FDI. Including an additional interaction term between the productivity and the sector-level complexity measure confirms the sector-level heterogeneity in the degree of sorting pattern: a negative and statistically significant coefficient estimate on the interaction term.

Replacing the dependent variable with the ratio of inter-firm to intra-firm sales, the sample conditional on conducting hybrid vertical FDI yields a negative and statistically significant coefficient estimate on the productivity variable but a positive and significant coefficient estimation on its interaction term with the sector-level complexity measure, basically confirming the second prediction of the model on intensive margin implications. All of our results are shown to be robust to alternative definitions of hybrid vertical FDI as well as several different measures on the sector-level complexity including the input sector's contract intensity *a la* Nunn (2007), output sector's contract intensity from Rauch (2001), or the one inferred from the pattern of input sourcing in the data.

Our work is closely related to, but substantially different from, previous theoretical studies that discussed variants of classical FDI models. Yeaple (2003) considers an MNE's complex integration strategy to set up horizontal FDI in some countries and vertical FDI in other countries. Grossman et al. (2006) posit a few different possible combinations of the location decision for input production and final assembly abroad. Keller and Yeaple (2013) discuss the gravity implication on the pattern of affiliates' sales when horizontal FDI subsidiaries abroad make an input sourcing decision in the face of knowledge transfer cost from their parent firms. Du et al. (2009) introduce a model of bi-sourcing in which a firm sources the same intermediate inputs from both external and internal suppliers, and Schwarz and Suedekum (2014) develop a model of hybrid sourcing whereby differentiated inputs are supplied both internally and externally. None of these models, however, allow foreign subsidiaries to sell both to related and unrelated firms at the

same time.

Our work is also different from previous empirical studies that find the non-dichotomous pattern of FDI. Hyun and Hur (2013) and Baldwin and Okubo (2014) rely exclusively on a geographical breakdown of foreign affiliates' sales from Korean and Japanese data, respectively, without distinguishing inter-firm and intra-firm sales. Feinberg and Keane (2006) rather focus on two-way bilateral intra-firm trade flows between the U.S. parent firms and their foreign affiliates, and their model allows for foreign affiliates' sales to both related and unrelated firms by assumption. Hanson et al. (2001) instead highlight the prevalence of export-platform FDI and export-supporting FDI among the U.S. MNCs.

The remainder of this paper is organized as follows. Section 2 introduces the dataset used in the paper and documents key stylized facts from the data. Section 3 develops a theoretical framework that yields testable predictions on hybrid vertical FDI. Section 4 presents empirical evidence, and Section 5 concludes.

2 Data and Stylized Facts

2.1 Data

We employ Korean MNCs' foreign affiliates-level data compiled by the Export and Import Bank of Korea (Korea Eximbank; KEXIM) covering the period of four years from 2004 to 2007.[8] Specifically, KEXIM conducts annual survey of Korean multinational affiliates abroad, targeted at Korean foreign subsidiaries with their accumulated investments over one million US dollars (Cho, 2018).[9] This is a widely-used but relatively not-fully-explored dataset with detailed information on activities of Korean subsidiary firms abroad.[10] For robustness checks later, we also

[8]Since the dataset allows a short panel structure for only a limited set of firms, we focus on cross-sectional analysis in this study.

[9]The sample coverage has increased over time starting with about 100 parents and their 200 foreign affiliates in 2000 (Debaere et al., 2013).

[10]A few studies that used the Korean MNCs' foreign affiliate-level data include Cho (2018),

exploit information on parent firms' names and codes, thereby linking the dataset to the parent-level balance sheet information from the KISVALUE database.

The main strength of this foreign affiliates-level dataset is that its coverage is comparable to the U.S. BEA data. In addition to usual balance sheet items such as employment, asset, and liability information, it provides unique information on each subsidiary's sales and sourcing activities further broken down into geographical and customer-type dimensions: inter-firm or intra-firm local sales (purchases); inter-firm or intra-firm exports to (imports from) Korea; inter-firm or intra-firm exports to (imports from) third countries. Exploring such detailed information, we document several stylized facts on the activity of Korean subsidiaries abroad in the following subsection.

2.2 Stylized facts

Table 1 provides summary statistics on respective sales share of median and average subsidiaries in 2007 by the type of buyer firms and operating regions: unrelated arm's length buyers and related buyers in the host country, Korea, or third countries. Likewise, Table 2 summarizes respective input share of median and average subsidiaries in 2007 by the type of supplier firms and operating regions: unrelated arm's length suppliers and related suppliers in the host country, Korea, or third countries. In both tables, Panel A reports summary statistics for all the subsidiaries in the sample, further broken down into subsidiaries located in advanced countries (Panel B) and subsidiaries located in emerging market countries (Panel C). First two columns in each panel are from all the subsidiaries across all sectors, while the third and fourth columns are from subsidiaries operating in the manufacturing sector.[11]

First of all, Tables 1 reveals the distinct nature of manufacturing subsidiaries

Chung (2014), Debaere et al. (2010), Debaere et al. (2013), Hyun and Hur (2013), etc.

[11] The number of observations in Table 2 is smaller than that in Table 1 due to a greater number of missing information on input purchases.

from subsidiaries in other sectors with regard to their sales to unrelated firms.[12] Panel A in Table 1 shows that the median firm's sales share to unrelated parties in the whole sample is 94%, while that in the manufacturing sector is 77%. Such a relatively lower sales share to unrelated firms in the manufacturing sector is more pronounced in emerging market countries where vertical FDI is likely to be more prevalent.

Taking a closer look at manufacturing sector subsidiaries, which are main focus of the current paper, Table 1 suggests that sales to related firms are much more prevalent among affiliates in emerging market countries than in advanced countries: the share of median manufacturing subsidiaries' sales to related firms is 31% in emerging market countries, while that is 0% in advanced countries. Similarly, Table 2 shows that input purchases from related firms are a little more prevalent among affiliates in emerging market countries than in advanced countries: the share of median manufacturing subsidiaries' inputs purchased from related firms is 31% in emerging market countries, while that is 20% in advanced countries. To the extent that a higher share of intra-firm trade by manufacturing subsidiaries reflects a vertical FDI type of activity, while the opposite is true for a horizontal FDI type of activity, these would imply that vertical FDI activities are more active in emerging market countries, whereas horizontal FDI activities are dominant in advanced countries.

Table 3 supports this way of identifying vertical and horizontal FDI. Focusing on manufacturing sector subsidiaries, first two columns report respective input shares—by the type of supplier firms and operating regions—of median and

[12] Comparing with maufacturing subsidiaries created by vertical, horizontal, or export platform FDI, subsidiaries in other sectors such as the wholesale and retail are likely to have a higher sales ratio to unrelated parties reflecting the export-supporting FDI motive—keeping production at home while shifting distribution tasks to foreign affiliates in the local market, thereby saving the variable distribution cost in return for an additional fixed cost to set up subsidiaries abroad (Krautheim, 2013). In fact, the median firm's sales share to unrelated parties in the whole sale and retail sector in this data is 100%.

average subsidiaries whose intra-firm sales share is 0%, while third and fourth columns are for subsidiaries who sell all of their goods to related firms and the last two columns are for the rest of subsidiaries who sell both to unrelated and related firms. Apparently, supposedly horizontal FDI firms selling none to related firms tend to purchase inputs mostly from unrelated suppliers, whereas likely vertical FDI firms with an intra-firm sales share of 100% tend to purchase inputs mainly from related suppliers.[13] By contrast, those subsidiaries that belong to neither of pure horizontal nor pure vertical FDI appear to purchase relatively evenly from both unrelated and related suppliers, with a median firm sourcing about 31% of total inputs from related parties. Panels B and C confirm that a similar pattern holds in both advanced and emerging market countries.

We further note that manufacturing subsidiaries operating in advanced countries are mostly horizontal FDI types (99 out of 170) and vertical FDI type of subsidiaries are relatively more prevalent in emerging market countries (314 out of 1,275) than in advanced countries (28 out of 170). This is consistent with the existing theoretical literature that a key determinant of horizontal FDI is the market size of host countries while that of vertical FDI is the production cost of host countries (e.g., Antràs and Yeaple, 2014).

Fact 1. *A majority of Korean manufacturing FDI into advanced countries can be classified as pure horizontal FDI, whereas a significant portion of Korean FDI into emerging market countries can be classified as vertical FDI.*

Taking a closer look into an overall distribution of manufacturing subsidiaries' activities beyond simple mean and median statistics offers a few more interesting patterns. Figure 1 illustrates cumulative fraction of the number of manufacturing subsidiaries (left panel) as well as that of sales by manufacturing subsidiaries

[13] Although we may further distinguish horizontal FDI firms from export-platform FDI firms using the detailed geographical information of unrelated arm's length buyers, we simply grouped them together here because there are not many export-platform FDI firms as indicated in Table 1 by median firms' low share of sales to unaffiliated parties in third countries.

(right panel) across the share of total sales to related parties for all manufacturing subsidiaries in the sample (1a and 1b in upper panel), manufacturing subsidiaries located in advanced countries (1c and 1d in middle panel), and manufacturing subsidiaries operating in emerging market countries (1e and 1f in lower panel), respectively.

Figure 1a tells that around 40% of Korean manufacturing subsidiaries abroad in the sample can be classified as pure horizontal FDI firms selling none of their total sales to related parties, while around 30% of them can be classified as pure vertical FDI firms selling 100% of total sales related parties. Most interestingly, the remaining 30% of Korean subsidiaries abroad in the sample belongs to neither group, selling to both unrelated and related parties at the same time.

In terms of respective sales share in total sales by Korean subsidiaries abroad, Figure 1b shows that pure horizontal FDI firms and pure vertical FDI firms account for a little over 20% and a little under 20% of total sales by all Korean subsidiaries in the sample, respectively. This suggests that a majority of total sales—remaining 60%—can be attributed to those subsidiaries selling to both unrelated and related firms.

A quick look at subsidiaries in advanced countries not only confirms Fact 1 that Korean manufacturing FDI into advanced countries are mainly pure horizontal FDI but also suggests that most of them can be classified as either pure horizontal FDI or pure vertical FDI. According to Figure 1c, there are relatively few firms (around 20%) that cannot be classified as pure horizontal (around 60%) or pure vertical (around 20%) FDI firms. Figure 1d further reveals that firms engaging in fairly horizontal FDI—selling only up to 20% of their sales to related parties—account for over 70% of total sales by subsidiaries in advanced countries.

By contrast, Figures 1e and 1f on manufacturing subsidiaries operating in emerging market countries resemble the overall patterns described in Figures 1a and 1b quite closely, reflecting the fact that a large share of manufacturing FDI subsidiaries are concentrated in emerging market economies (1,438 out of 1,627 in 2007 as shown in Table 1). They further show that those subsidiaries selling to both unrelated and related parties—thus cannot be simply classified as either

pure horizontal or pure vertical FDI—account for around 40% of total subsidiaries and over 60% of total sales by subsidiaries in emerging market countries. The pattern of input sourcing is similarly described in Figure 2, delivering a qualitatively identical message.

Fact 2. *A substantial portion of Korean manufacturing FDI cannot be simply classified as pure horizontal or vertical FDI, selling to (and buying from) both unrelated and related firms at the same time. This is particularly less pronounced in advanced countries where horizontal FDI is more prevalent.*

Since the previous literature does not offer any serious theoretical explanation or empirical evidence on FDI firms that sell both to unrelated and related firms at the same time, it begs an answer for why they would do so in the first place. [14] We thus move on to providing a theoretical model that can rationalize the presence of *hybrid vertical* FDI—a substantial portion of Korean manufacturing subsidiaries' operations abroad.[15]

3 A Model of Hybrid Vertical FDI

In this section, we develop a simple model of hybrid vertical FDI by extending a standard property-rights model of vertical FDI with heterogeneous firms developed by Antras and Helpman (2004). A headquarter firm (F) in a northern country (N) with a productivity level φ faces a typical global sourcing problem

[14] Our dataset does not allow us to identify whether foreign subsidiaries are multi-product firms, thereby selling different products to related firms from those sold to unrelated customers. That said, our model introduced in the subsequent section can be viewed as a general case in that a product supplied to related firms is not necessarily the same as the one supplied to unrelated firms.

[15] As discussed in footnote 6, it is conceptually reasonable to classify those subsidiaries who sell a part of their products to related firms as *hybrid vertical* FDI as opposed to *hybrid horizontal* FDI.

characterized as in Antras (2015). With respect to having a southern firm (I) in a southern country (S) supply intermediate inputs for her, the headquarter firm solves the following maximization problem:

$$\begin{array}{cc} \underset{h(\varphi),m(\varphi),s(\varphi)}{max} & \beta_i p\left(q\left(\varphi\right)\right) q\left(\varphi\right) - w_N h\left(\varphi\right) - w_N f_i - s\left(\varphi\right) \\ s.t. & s\left(\varphi\right) + \left(1-\beta_i\right) p\left(q\left(\varphi\right)\right) q\left(\varphi\right) - \tau w_S m\left(\varphi\right) \geq 0 \\ & h\left(\varphi\right) = argmax_h \left\{\beta_i p\left(q\left(\varphi\right)\right) q\left(\varphi\right) - w_N h\left(\varphi\right)\right\} \\ & m\left(\varphi\right) = argmax_m \left\{\left(1-\beta_i\right) p\left(q\left(\varphi\right)\right) q\left(\varphi\right) - \tau w_S m\left(\varphi\right)\right\} \end{array} \tag{1}$$

in which

$$\begin{aligned} q\left(\varphi\right) &= \varphi \left(\frac{h}{\eta}\right)^{\eta} \left(\frac{m}{1-\eta}\right)^{1-\eta}, \\ p\left(q\left(\varphi\right)\right) &= B^{1/\sigma} \sigma \left(\sigma-1\right)^{-(\sigma-1)/\sigma} q\left(\varphi\right)^{-1/\sigma}, \\ B &= \frac{1}{\sigma} \left(\frac{\sigma}{(\sigma-1)P}\right)^{1-\sigma} \alpha \left(w_N L_N + w_S L_S\right), \end{aligned}$$

with the inverse demand function $p\left(q\left(\varphi\right)\right)$ for q amount of the headquarter firm's differentiated final good being derived from a typical CES utility function:

$$u = \left(1-\alpha\right) \log z + \alpha \log \left(\int_{\omega \in \Omega} q\left(\omega\right)^{(\sigma-1)/\sigma} d\omega\right)^{\sigma/(\sigma-1)}.$$

In (1), h and η respectively represent the headquarter service and its intensity in the production of a final good, m denotes I's manufacturing production, s is the fee received by I in exchange for a contract of supplying m to F, w_j represents the wage of country j, $\tau\left(\geq 1\right)$ denotes variable costs of offshoring, $\beta_i \in (0,1)$ and f_i denote the headquarter's bargaining power parameter and her fixed cost associated with global sourcing, respectively, with $i = O$ for outsourcing or V for vertical integration.[16]

[16] As we do not analyze the general equilibrium consequence of adding hybrid vertical FDI to the list of possible organizational forms from which headquarter firms may choose, B, w_N, and w_S are treated as fixed variables in the following analysis.

With regard to the headquarter's integration decision, we extend the standard global sourcing model in (1) by considering the possibility of having a vertically integrated southern firm (I_v) provide inputs for an unrelated northern firm (F_o) through an outsourcing agreement, in addition to supplying inputs for the headquarter (F_v). In particular, I_v's production of inputs for F_v and F_o, respectively denoted by m_v and m_o, affect the final outputs of F_v (whose productivity being φ_v) and F_o (whose productivity being φ_o), respectively denoted by q_v and q_o, as follows:

$$\begin{aligned} q_v\left(\varphi_v; x_o\right) &= \varphi_v \left(\tfrac{h_v}{\eta}\right)^{\eta} \left(\tfrac{e(x_o) m_v}{1-\eta}\right)^{1-\eta}, \text{ with} \\ e\left(x_o\right) &= 1 \text{ for } x_o = 1, \text{ and} \\ \tfrac{\partial e(x_o)}{\partial x_o} > 0, \tfrac{\partial^2 e(x_o)}{\partial x_0^2} &< 0 \text{ for } x_o \geq 1, \end{aligned} \tag{2}$$

and

$$q_o\left(\varphi_o\right) = \varphi_o \left(\tfrac{h_o}{\eta}\right)^{\eta} \left(\tfrac{m_o}{1-\eta}\right)^{1-\eta},$$

where $x_o - 1\ (\geq 0)$ denotes the number of F_o that I_v serves. While x_o is supposed to be a positive natural number, we treat it as if it is a continuous variable in our analysis for analytical convenience.

Note that a positive external effect associated with I_v's production of outsourced inputs, denoted by $e\left(x_o\right)$, exists toward I_v's production for its headquarter, but not vice versa. This asymmetry in external effects associated with I_v's input production is designed to reflect that I_v's outsourcing relationship with F_o is assumed to be a standard one described in (1): All of I_v's potential surplus from supplying m_o is transferred to F_o through s. Thus, F_v has no incentive to utilize any extra production knowledge that her subsidiary acquires from its production of m_v for improving its input production for F_o.[17]

In contrast to this, the headquarter who allows her subsidiary to supply inter-

[17]Because I_v obtains no profit from its sales to F_o, it seems easier to assume that outsourcing

mediate inputs for other firms through an outsourcing agreement does have an incentive to utilize the extra production knowledge that I_v acquires from supplying such inputs (i.e., m_o) for improving input production for the headquarter (i.e., $e(x_o)\, m_v$). As the intermediate inputs typically have some relationship-specific features, utilization of such knowledge requires a fixed investment, f_{VO}, in addition to a standard fixed cost for a subsidiary firm, $f_V\ (> f_O)$.

Thus, the profit function of a headquarter who allows her integrated subsidiary to supply inputs *to* $x_o - 1$ number of other final-good producers, $\pi_v(\varphi_v; x_o)$, is defined by

$$p(q_v(\varphi_v;\cdot))\, q_v(\varphi_v;\cdot) - w_N h_v(\varphi_v;\cdot) - \tau w_S m_v(\varphi_v;\cdot) - w_N f_V - w_N(x_o^{\kappa} - 1) f_{VO} \tag{3}$$

where we abbreviate "x_o" by "$\cdot$" for notational simplicity. Note that $\kappa\ (> 0)$ denotes the degree of hardship in transforming the production knowledge of outsourced inputs for unrelated firms into the one applicable for intermediate inputs for the headquarter. As shown in this following analysis, this parameter κ plays an important role both for the headquarter's extensive margin decision on hybrid vertical FDI (versus pure vertical FDI) and for her intensive margin decision that determines the ratio of a subsidiary's sales to unrelated to that of related firms.

Prior to analyzing the headquarter's extensive and intensive margin decisions, we can derive the equilibrium values for the key choice variables relevant to hy-

sales are sold at the marginal cost and generate no profit, a typical assumption for the production of standardized inputs. We may justify our explitic modeling of production relationship between I_v and F_o as follows. The degree of relation-specificity in manufacturing outsourced inputs would affect the degree of hardship in tranforming the production knowledge of outsourced inputs into the one applicable for input production for the headquarter. We capture such a hardship by a parameter κ by making the cost of benefiting from producing outsourced inputs increase in the number of unrelated firms that I_v serves, powered by κ, as shown in (3). This parameter plays a crucial role in our model's theoretical predictions, for which our empirical analysis provides supporting evidences.

brid vertical FDI as follows:

$$\begin{aligned} m_o(\varphi_o) &= (1-\eta)\,\gamma_m^o \varphi_o^{(\sigma-1)}, \\ h_o(\varphi_o) &= \eta\gamma_h^o \varphi_o^{(\sigma-1)}, \text{ with} \\ \gamma_m^o &= \frac{(1-\beta_o)^{-(\sigma-1)\eta+\sigma}\beta_o^{(\sigma-1)\eta}B(\sigma-1)}{(w_N)^{(\sigma-1)\eta}(\tau w_S)^{\sigma(1-\eta)+\eta}}, \\ \gamma_h^o &= \frac{\beta_o^{1+(\sigma-1)\eta}(1-\beta_o)^{(\sigma-1)(1-\eta)}B(\sigma-1)}{(w_N)^{1+(\sigma-1)\eta}(\tau w_S)^{(\sigma-1)(1-\eta)}} \end{aligned} \tag{4}$$

and

$$\begin{aligned} m_v(\varphi_v; x_o) &= (1-\eta)\,\gamma_m^v \varphi_v^{(\sigma-1)} \left[e(x_o)\right]^{(\sigma-1)(1-\eta)}, \\ h_v(\varphi_v; x_o) &= \eta\gamma_h^v \varphi_v^{(\sigma-1)} \left[e(x_o)\right]^{(\sigma-1)(1-\eta)}, \text{ with} \\ \gamma_m^v &= \frac{(1-\beta_v)^{-(\sigma-1)\eta+\sigma}\beta_v^{(\sigma-1)\eta}B(\sigma-1)}{(w_N)^{(\sigma-1)\eta}(\tau w_S)^{\sigma(1-\eta)+\eta}}, \\ \gamma_h^v &= \frac{\beta_v^{1+(\sigma-1)\eta}(1-\beta_v)^{(\sigma-1)(1-\eta)}B(\sigma-1)}{(w_N)^{1+(\sigma-1)\eta}(\tau w_S)^{(\sigma-1)(1-\eta)}} \end{aligned} \tag{5}$$

where $\beta_v = \beta_o + (1-\beta_o)\,\delta > \beta_o$, having $\delta \in (0,1)$ represent the fraction of the revenue generated by combining m_v and h_v, after firing the manager of I_v.

3.1 Extensive margin decision on Hybrid Vertical FDI

For analytical simplicity, we now introduce a specific functional form for the production externality as follows:

$$e(x_o) = x_o^{\epsilon} \text{ for } x_0 \geq 1,$$

with $\epsilon \in (0,1)$.

Then, the headquarter's extensive-margin-decision problem is

$$\underset{x_o \geq 1}{Max} \left[\Lambda_v \varphi_v^{(\sigma-1)} x_o^{\epsilon(\sigma-1)(1-\eta)} - w_N \left(x_o^{\kappa} - 1 \right) f_{VO} - w_N f_V \right], \text{ with}$$
$$\Lambda_v = \frac{B \beta_v^{\eta(\sigma-1)} (1-\beta_v)^{(1-\eta)(\sigma-1)} [\sigma - (\sigma-1)\beta_v \eta - (\sigma-1)(1-\beta_v)(1-\eta)]}{(w_N)^{\eta(\sigma-1)} (\tau w_S)^{(1-\eta)(\sigma-1)}} \tag{6}$$

While the equilibrium value for x_o (≥ 1), denoting it by x_o^E, needs to be a positive natural number ($x_o^E - 1$ representing the number of F_o that F_v allows I_v to provide its outsourced inputs), we can still treat x_o as a continuous variable in solving the maximization problem of (6) to characterize x_o^E qualitatively. Then, (6) yields:

$$x_o^E = \left(\frac{\epsilon (1-\eta) (\sigma-1) \Lambda_v \varphi_v^{(\sigma-1)}}{\kappa w_N f_{VO}} \right)^{\frac{1}{\kappa - \epsilon(1-\eta)(\sigma-1)}}. \tag{7}$$

Without loss of generality, we can focus on the case in which $x_o \in [1, \infty)$ as a solution to (6). Focusing on this case, we assume that $\kappa > \epsilon (1-\eta) (\sigma-1)$ and $\epsilon (1-\eta) (\sigma-1) \Lambda_v \varphi_v^{(\sigma-1)} \geq \kappa w_N f_{VO}$.[18] Then, x_o^E in (7) shows the following relationships between the extensive margin decision on hybrid FDI and two key

[18] $\kappa > \epsilon (1-\eta) (\sigma-1)$ is a stability condition that insures a bounded solution for the extensive-margin-decision problem in (6). While $\epsilon (1-\eta) (\sigma-1) \Lambda_v \varphi_v^{(\sigma-1)} < \kappa w_N f_{VO}$ will hold for a headquarter firm with a sufficiently small productivity level, there is no loss of generality in assuming the other inequality (i.e., $\epsilon (1-\eta) (\sigma-1) \Lambda_v \varphi_v^{(\sigma-1)} \geq \kappa w_N f_{VO}$) as it would still allow the headquarter firm to choose pure vertical FDI over hybrid vertical FDI.

parameters of our model, φ_v and κ:

$$\begin{aligned} \frac{d \ln x_o^E}{d \ln \varphi_v} &= \frac{(\sigma-1)}{\kappa-\epsilon(1-\eta)(\sigma-1)} > 0, \\ \frac{d}{d\kappa}\left(\frac{d \ln x_o^E}{d \ln \varphi_v}\right) &= \frac{-(\sigma-1)}{[\kappa-\epsilon(1-\eta)(\sigma-1)]^2} < 0, \end{aligned} \tag{8}$$

which in turn implies the following claim:

Claim 1. The higher the productivity of a headquarter firm (a higher φ_v) is, the more likely the headquarter firm will choose hybrid vertical FDI (a higher value for x_o^E) over pure vertical FDI (with $x_o^E = 1$). Moreover, such a tendency is weaker as transformation of production knowledge is harder (with a higher κ).

The higher the productivity of a headquarter firm is, the higher the input production of her subsidiary firm (m_v) will be, as shown in (5). This implies that the production externality toward her final output (q_v) will be bigger for such a headquarter firm, as demonstrated in (2), which in turn implies a stronger incentive for her to choose hybrid vertical FDI. A higher fixed cost associated with transforming the production knowledge from the input production for an unrelated firm into the production of inputs for the headquarter will mitigate the incentive to choose hybrid vertical FDI over pure vertical FDI.

3.2 Intensive margin decision of Hybrid Vertical FDI

In this subsection, we analyze the intensive margin decision of a headquarter firm who conducts hybrid vertical FDI. Because one of observable variables in the data is the ratio of sales to unrelated to that of related firms, we focus on the following

ratio:

$$\begin{aligned} r\left(\varphi_v\right) &\equiv \frac{x_o(1-\beta_o)p(q_o(\varphi_o;\varphi_v))q_o(\varphi_o;\varphi_v)}{(1-\beta_v)p(q_v(\varphi_v))q_v(\varphi_v;\varphi_o)} \\ &= \frac{\Delta_o}{\Delta_v}\left(\frac{\varphi_o}{\varphi_v}\right)^{(\sigma-1)} x_o^{1-\epsilon(\sigma-1)(1-\eta)} \end{aligned} \tag{9}$$

where

$$\begin{aligned} \Delta_o &= \frac{\sigma(1-\beta_o)B\beta_o^{\eta(\sigma-1)}(1-\beta_o)^{(1-\eta)(\sigma-1)}}{w_N^{\eta(\sigma-1)}(\tau w_S)^{-(1-\eta)(\sigma-1)}}, \\ \Delta_v &= \frac{\sigma(1-\beta_v)B\beta_v^{\eta(\sigma-1)}(1-\beta_v)^{(1-\eta)(\sigma-1)}}{w_N^{\eta(\sigma-1)}(\tau w_S)^{-(1-\eta)(\sigma-1)}}. \end{aligned}$$

After substituting x_0 with its equilibrium value, x_o^E in (7), we can conduct the following comparative statics analysis on $r\left(\varphi_v\right)$:

$$\begin{aligned} \frac{d\ln r(\varphi_v)}{d\ln\varphi_v} &= \frac{-(\sigma-1)[\kappa-1]}{\kappa-\epsilon(1-\eta)(\sigma-1)} \\ \frac{d}{d\kappa}\left(\frac{d\ln r(\varphi_v)}{d\ln\varphi_v}\right) &= \frac{-(\sigma-1)[1-\epsilon(1-\eta)(\sigma-1)]}{[\kappa-\epsilon(1-\eta)(\sigma-1)]^2} \end{aligned} \tag{10}$$

Recalling that $\kappa > \epsilon\left(1-\eta\right)\left(\sigma-1\right)$ by assumption, if $\epsilon\left(1-\eta\right)\left(\sigma-1\right) > 1$, then $\kappa > 1$, which in turn implies $\frac{d\ln r(\varphi_v)}{d\ln\varphi_v} < 0$ and $\frac{d}{d\kappa}\left(\frac{d\ln r(\varphi_v)}{d\ln\varphi_v}\right) > 0$. This observation yields the following claim:

Claim 2. If $\epsilon\left(1-\eta\right)\left(\sigma-1\right) > 1$, the sales ratio of unrelated firms to related firms, $r\left(\varphi_v\right)$, is decreasing in φ_v. Moreover, such a tendency is weaker as transformation of production knowledge is harder (with a higher κ).

To understand the role that the inequality condition, $\epsilon\left(1-\eta\right)\left(\sigma-1\right) > 1$, plays in the above claim, note that the revenue of a headquarter firm that engages in hybrid vertical FDI shown in (6) depends on the number of unrelated firms to which her subsidiary firm provides inputs (this number plus one, to be more

precise), i.e., x_0, that is powered by $\epsilon(1-\eta)(\sigma-1)$. Thus, $\epsilon(1-\eta)(\sigma-1)$ measures the degree of externality that the production of inputs for unrelated firms generates towards the headquarter firm's revenue, thus, towards the subsidiary firm's input sales to his headquarter. Because the subsidiary firm's input sales to unrelated firms increase proportionally in the number of such firms, the ratio of sales to unrelated to that of related firms decreases if $\epsilon(1-\eta)(\sigma-1) > 1$: This inequality condition implies that the subsidiary firm's input sales to his headquarter increases more than proportionally in x_0.

While it is theoretically possible to have $\epsilon(1-\eta)(\sigma-1) < 1$, which in turn leads to a wider range of possibilities with regard to the derivatives in (10), we will focus on the case with $\epsilon(1-\eta)(\sigma-1) > 1$ in the following analysis. As shown later, the empirical analysis generates results that are consistent with Claim 2. This is not very surprising given the fact that Claim 2 is about the intensive margin decision of hybrid vertical FDI (as opposed to pure vertical FDI), into which a headquarter firm's selection would have been stronger with a higher degree of production externality of outsourced inputs toward her revenue (i.e., a higher value for $\epsilon(1-\eta)(\sigma-1)$).

4 Empirical Evidence

4.1 Econometric specification

This section undertakes an empirical investigation into main predictions of the model derived in the previous section. Specifically, we pay particular attention to relationship between productivity level and the pattern of hybrid vertical FDI activities implied by the model from both intensive and extensive margin perspectives.

To begin with the extensive margin implication, we note that the sorting pattern of the model predicts that more productive subsidiaries will decide to provide inputs to third-party customers in addition to parent firms (Claim 1). As such, a

necessary condition for the model to be valid is to find supportive evidence on a positive correlation between productivity and the hybrid vertical FDI mode.

Accordingly, we consider a following linear probability model as the baseline specification for the extensive margin analysis:

$$Hybrid_{icst} = \beta Productivity_{icst} + \gamma X_{icst} + FE + \kappa_{icst}, \tag{11}$$

for a subsidiary i located in a country c producing s sector goods in year t. The dependent variable, $Hybrid_{icst}$, is an indicator variable that turns on for subsidiaries conducting hybrid vertical FDI and turns off for subsidiaries focusing on pure vertical FDI. $Productivity_{icst}$ denotes firm-level productivity, while X_{icst} includes a set of various relevant firm-level control variables. FE encompasses country-sector fixed effects (FE_{cs}) as well as year fixed effects (FE_t), thereby exploring *cross-sectional* variation across subsidiaries within a given sector in a country.

Regarding the dependent variable, we define hybrid vertical FDI subsidiaries as those whose intra-firm sales share in total sales is smaller than 90% while sales to local unrelated firms do not exceed 50% of total sales. Other subsidiaries whose share of intra-firm sales in total sales is greater than or equal to 90% are defined as pure vertical FDI firms. The rest of subsidiaries with the share of local inter-firm sales exceeding 50% are considered as horizontal FDI firms and thus are excluded from the sample. This way of classification is summarized as below, and we will also verify the robustness by considering alternative threshold values in defining the hybrid vertical FDI mode.

Definition 1. $Hybrid_{icst} = 1$ if (i) $\frac{\text{intra-firm sales}}{\text{total sales}} < 0.9$ and (ii) $\frac{\text{local inter-firm sales}}{\text{total sales}} < 0.5$; $Hybrid_{icst} = 0$ if $\frac{\text{intra-firm sales}}{\text{total sales}} \geq 0.9$. $Hybrid_{icst}$ is undefined for horizontal FDI firms with $\frac{\text{local inter-firm sales}}{\text{total sales}} \geq 0.5$.

Although the baseline firm-level productivity measure is the subsidiary-level labor productivity (in log) calculated from subsidiary-level data on total revenue

and number of employees,[19] we also check the robustness of the results by employing parent-level total factor productivity measures. As for other relevant control variables, we add a subsidiary's age (in log) to control for a simple localization strategy—a subsidiary initially set up as a vertical FDI firm providing inputs to related firms may gradually consider expanding its customer base in local markets, possibly to hedge against market-specific final goods demand shocks. We also include a subsidiary's total assets variable (in log) to control for a possible scale effect to the extent that serving multiple customers necessarily requires an expansion of production facilities that may affect the measured productivity.

On top of the baseline specification that checks a positive correlation, we also investigate the empirical validity of a more subtle prediction of the model regarding the effect of potential sector-level heterogeneity on the degree of, if any, positive correlation. Noting that Claim 1 suggests that positive correlation would be weaker as the sector-level complexity (κ) increases, we add an interaction term between productivity and the sector-level complexity ($Complex_s$):

$$Hybrid_{icst} = \beta_1 Productivity_{icst} + \beta_2 Productivity_{icst} \times Complex_s + \gamma X_{icst} + FE + \kappa_{icst}, \tag{12}$$

As for the sector-level complexity ($Complex_s$), we consider three different proxy variables. First, we measure a given sector's *input* complexity using a weighted average of input sectors' contract intensity *a la* Nunn (2007). In examining the hypothesis whether countries with better contract enforcement export relatively more in industries for which contract intensity is stronger, Nunn (2007) constructed a variable that measures, for each good, the proportion of its intermediate inputs that require relationship-specific investments.

In a nutshell, inputs requiring relationship-specific investments are identified from Rauch (2001)'s classification, which, in turn, is matched to each final good

[19] We acknowledge that subsidiary-level total factor productivity estimation was not feasible due to a limited panel structure and insufficient information from the dataset.

using input coefficients from the Input-Output table as a weight. The rationale behind the measure is that parts of investments made by an input supplier to customize an input for the needs of a final good producer are relationship-specific because the value of the investments in customization are higher within the buyer-seller relationship than outside the relationship. In our context, the degree of relationship specificity is reflected in κ that captures the degree of hardship in transforming the production knowledge of inputs for other final-good producers into the one applicable for inputs for the headquarter.

However, one may argue that what matters is not what a given subsidiary uses as an input but what she produces and sells to serve unrelated and related customers. As such, we also employ a given sector's own degree of differentiation *a la* Rauch (2001) as a measure of *output* complexity.

Lastly, we infer the degree of sector-level complexity from the firm-level input sourcing pattern from the data. As documented in Table 3, pure vertical FDI firms tend to purchase most of their inputs from related firms, while hybrid vertical FDI firms purchase inputs from both unrelated and related firms. In our model, the degree of hardship in transforming production knowledge (κ) implies higher adjustment cost of establishing unrelated input suppliers as a firm becomes a hybrid vertical FDI subsidiary from a pure vertical FDI subsidiary. To the extent that firms would rely more heavily on inputs from related parties as κ is higher, average firm's share of inputs sourced from related parties in each sector can serve as a degree of sector-level complexity.

Beyond investigating the extensive margin implication, we further examine the intensive margin implication by checking the validity of Claim 2: Conditional on conducting hybrid vertical FDI, the sales ratio of unrelated firms to related firms is negatively correlated with firm-level productivity, the tendency of which is less pronounced as the sector-level complexity increases. The formal specification is expressed as below:

$$SalesRatio_{icst} = \beta_1 Productivity_{icst} + \beta_2 Productivity_{icst} \times Complex_s + \gamma X_{icst} + FE + \kappa_{icst},$$

(13)

where the dependent variable is now replaced with firm-level sales ratio of unrelated to related firms (in log) and the sample is restricted to subsidiaries conducting hybrid vertical FDI.

4.2 Empirical results

Column (1) in Table 4 reports baseline regression result specified in equation (11) whereby the dependent variable $Hybrid_{icst}$ is defined in accordance with Definition 1. As the model predicts, there is a statistically significant positive correlation between subsidiary-level productivity and the likelihood of conducting hybrid vertical FDI. It also suggests that, other things being equal, older subsidiaries are more likely to conduct hybrid vertical FDI. There is also a strong correlation between the subsidiary's asset size and the mode of hybrid vertical FDI, possibly reflecting additional production facilities required for sales to unrelated firms that might be differentiated from products sold to related firms.

Columns (2)-(4) summarize regression results specified in equation (12), checking the effect of sector-level heterogeneity pattern on the degree of correlation between subsidiary-level productivity and the likelihood of conducting hybrid vertical FDI. They confirm that positive correlation is stronger as a given sector's complexity is lower, no matter whether the sector-level complexity is measured in terms of input sector contract intensity (column (2)) or output sector contract intensity (column (3)). When it is measured as a given sector's sourcing pattern inferred from the current dataset, a qualitatively identical pattern is obtained (column (4)).

To check the robustness of the results to the way hybrid vertical FDI is defined, we consider an alternative threshold level of 80% for the definition of hybrid vertical and pure vertical FDI—subsidiaries with the intra-firm sales share in total sales greater than 80% are defined as pure vertical FDI ($Hybrid_{icst} = 0$),

while those with the share of intra-firm sales in total sales below 80% as well as local inter-firm sales share below 50% are defined as hybrid vertical FDI firms ($Hybrid_{icst} = 1$). Table 5 repeats regression results reported in Table 4 with the alternative dependent variable and shows qualitatively and quantitatively robust patterns, albeit the statistical significance level for the interaction term is somewhat weaker than the baseline result.

As additional robustness check, Table 6 repeats baseline regression results with yet another definition of hybrid vertical FDI whereby the sample exclusion threshold is set as 40% of local inter-firm sales share for horizontal FDI firms—that is, subsidiaries with the intra-firm sales share in total sales greater than 90% are defined as pure vertical FDI ($Hybrid_{icst} = 0$), while those with the share of intra-firm sales in total sales below 90% as well as local inter-firm sales share below 40% are defined as hybrid vertical FDI firms ($Hybrid_{icst} = 1$). Overall, we confirm that results are robust both quantitatively and qualitatively to alternative definitions of hybrid vertical FDI.

Next, we move on to the intensive margin analysis results. Table 7 reports baseline intensive margin regression results specified in equation (13) whereby the dependent variable $SalesRatio_{icst}$ is firm-level sales ratio of unrelated to related firms (in log). The sample is restricted to hybrid vertical FDI as defined in Definition 1. As the model predicts, there is on average negative but statistically insignificant correlation between subsidiary-level productivity and the sales ratio of unrelated to related firms (column (1)). Columns (2)-(4) summarize regression results, checking the pattern of sector-level heterogeneity in the degree of correlation between subsidiary-level productivity and the sales ratio variable. They show that the coefficient estimate on firm-level productivity is negative and statistically significant, while its interaction term with the sector-level complexity is positive and statistically significant, irrespective of the sector-level complexity measures considered—input sector contract intensity (column (2)), output sector contract intensity (column (3)) or input sourcing pattern (column (4)).

Tables 8 and 9 check the robustness of the baseline intensive margin analysis reported in Table 7 by restricting the sample based on alternative definitions of

hybrid vertical FDI. Specifically, the sample in Table 8 is based on an alternative threshold level of 80% for the definition of hybrid vertical and pure vertical FDI, while the sample in Table 9 is based on the sample using an exclusion threshold of 40% of local inter-firm sales share for horizontal FDI firms. Both results confirm quantitatively and qualitatively robust findings to alternative definitions of hybrid vertical FDI to restrict the sample.

Lastly, we check the robustness of the baseline results to an alternative productivity measure based on parent firm's total factor productivity. Exploiting information on parent firms' names and codes, we match the subsidiary-level dataset to the parent-level balance sheet data from which parent-level total factor productivity measure is obtained. We note that the matching process is far from complete due to the limited coverage of the parent-level balance sheet database to large firms, reducing the estimation sample significantly by around one-third. Despite such a challenge, the estimation results reported in Table 10 is reassuring: for both extensive margin (columns (1) and (2)) and intensive margin analysis (columns (3) and (4)), overall results with parent-level total factor productivity measures are qualitatively identical to the baseline results with subsidiary-level labor productivity measures.

5 Conclusion

An analysis of firm-level data of foreign subsidiaries of Korean multinational companies establishes new stylized facts of Korean FDI, especially identifying that a sizable portion of subsidiaries selling their products both to related and unrelated firms. To explain this newly identified mode of FDI, namely hybrid vertical FDI, we extend a standard property-right based model of vertical FDI by allowing the possibility of a subsidiary firm's supplying inputs not only for its headquarter but also for unrelated firms. The headquarter firm has an incentive to allow such outsourced activities of her subsidiary as she may benefit from the associated positive production externality toward her subsidiary's input production for herself.

Such a production externality will be stronger for a more productive subsidiary as its input production level that can benefit from the externality is higher. Because of relationship-specific aspects of outsourced production, transforming the production knowledge from outsourced input into the one for input production for the headquarter company is not automatic and it gets harder with a higher level of contractual complexity associated with input production (which reflects the degree of its relationship-specificity).

The theoretical model of hybrid vertical FDI generates testable predictions on the extensive margin decision regarding hybrid vertical FDI (versus pure vertical FDI) as well as on the intensive margin implication (conditional on hybrid vertical FDI) regarding the ratio of a subsidiary's sales to unrelated to related firms. The empirical analysis provides supportive evidence for the predicted positive correlation between choosing hybrid vertical FDI and the subsidiaries' productivities, which is weakened by the contractual complexity of input production. Our empirical analysis also supports the prediction of a negative correlation between the ratio of a subsidiary's sales to unrelated to related firms and the subsidiaries' productivities, which is again weakened by the contractual complexity.

While the empirical analysis provides supportive evidence for the theoretical model of hybrid vertical FDI, it can be worthwhile to relax some of simplifying assumptions of this model, and empirically test the predictions of such a more general model, if there exists a FDI data set that allows such testing. For example, one may try to analyze the matching issue between a northern firm's southern subsidiary and another northern firm that tries to outsource its inputs, which would be directly testable if buyer-supplier matched data were to become available.

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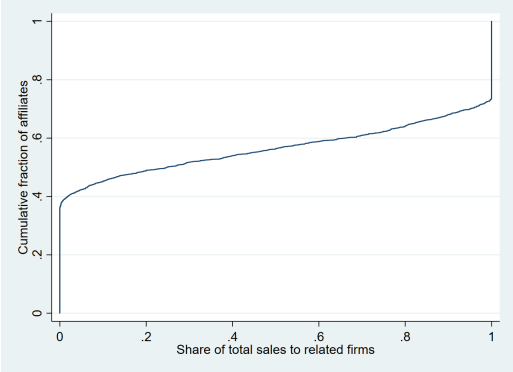
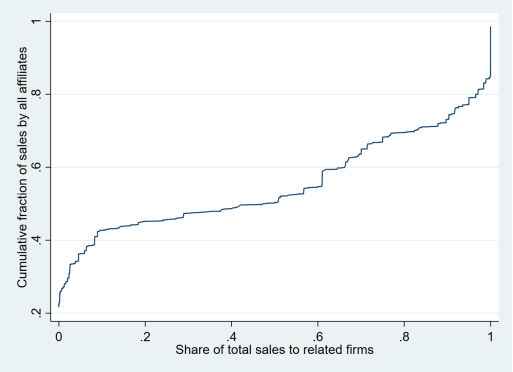
Figure 1: Prevalence of (Un)Related Sales by Korean Manufacturing FDI Abroad

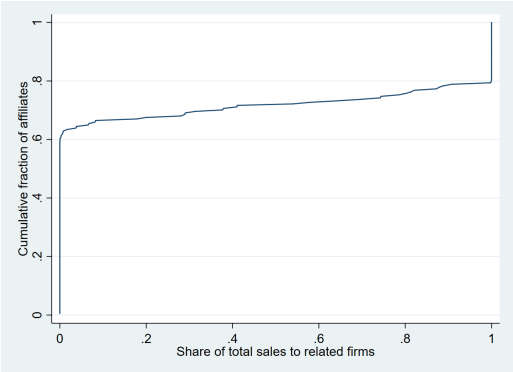
(a) Cumulative Fraction of Number of Affiliates: All



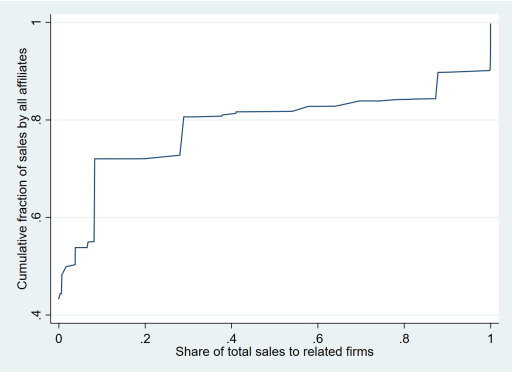
(b) Cumulative Fraction of Sales by Affiliates: All



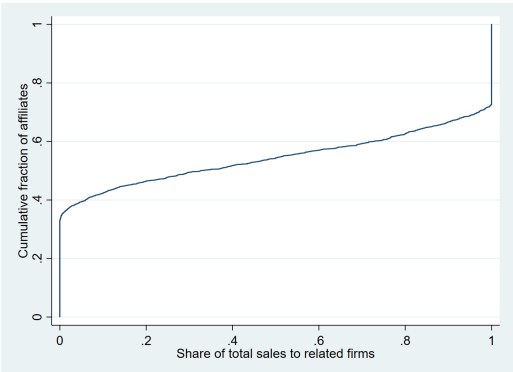
(c) Cumulative Fraction of Number of Affiliates: AEs



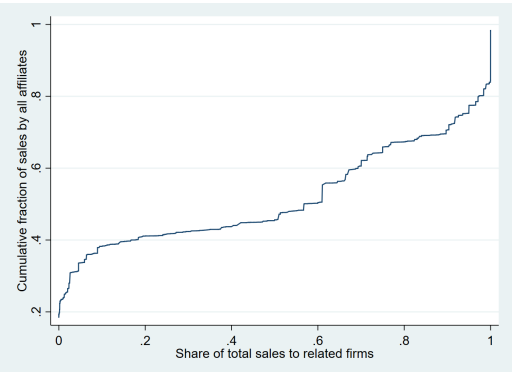
(d) Cumulative Fraction of Sales by Affiliates: AEs



(e) Cumulative Fraction of Number of Affiliates: EMEs



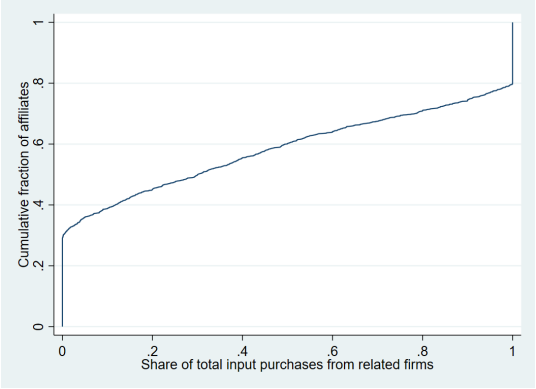
(f) Cumulative Fraction of Sales by Affiliates: EMEs



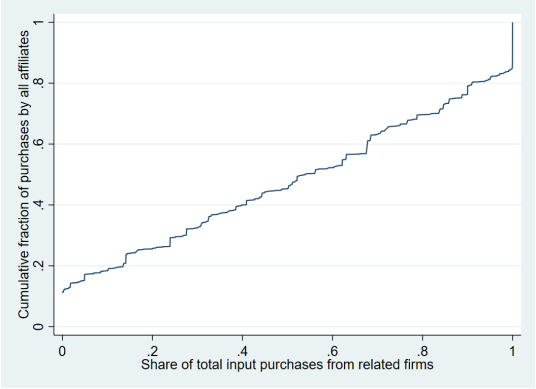
Notes: This figure illustrates cumulative fraction of the number of manufacturing subsidiaries (left panel) as well as that of sales by manufacturing subsidiaries (right panel) across the share of total sales to related parties in 2007. (a) and (b) are for all the manufacturing subsidiaries abroad in the sample; (c) and (d) are for all the manufacturing subsidiaries operating in advanced countries; (e) and (f) are for all the manufacturing subsidiaries operating in emerging market countries.

Figure 2: Prevalence of (Un)Related Sourcing by Korean Manufacturing FDI Abroad

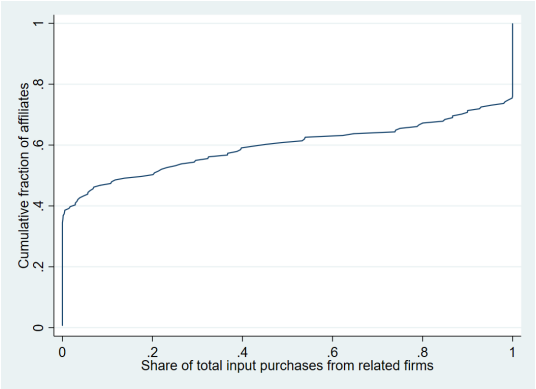
(a) Cumulative Fraction of Number of Affiliates: All



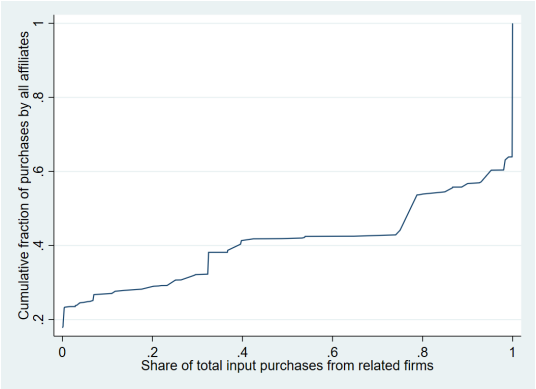
(b) Cumulative Fraction of Purchases by Affiliates: All



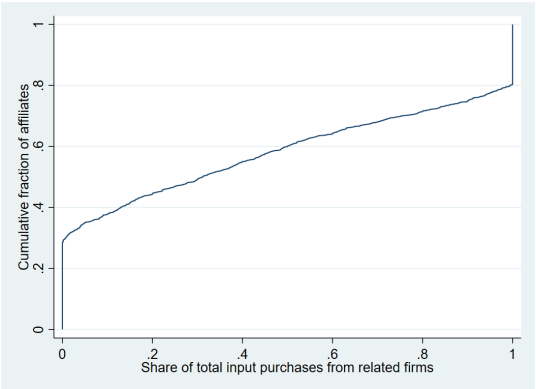
(c) Cumulative Fraction of Number of Affiliates: AEs



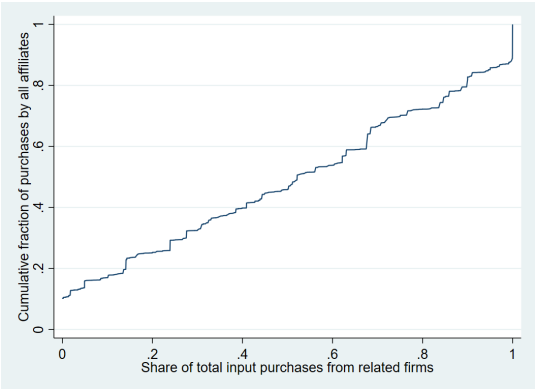
(d) Cumulative Fraction of Purchases by Affiliates: AEs



(e) Cumulative Fraction of Number of Affiliates: EMEs



(f) Cumulative Fraction of Purchases by Affiliates: EMEs



Notes: This figure illustrates cumulative fraction of the number of manufacturing subsidiaries (left panel) as well as that of input purchases by manufacturing subsidiaries (right panel) across the share of total input purchases from related parties in 2007. (a) and (b) are for all the manufacturing subsidiaries abroad in the sample; (c) and (d) are for all the manufacturing subsidiaries operating in advanced countries; (e) and (f) are for all the manufacturing subsidiaries operating in emerging market countries.

Table 1: The Patterns of Sales Activities by Korean MNCs' Foreign Affiliates

Panel A: All Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
To any unaffiliated parties	0.61	0.94	0.57	0.77
To local unaffiliated parties	0.50	0.48	0.45	0.26
To unaffiliated parties in Korea	0.03	0.00	0.03	0.00
To unaffiliated parties in third countries	0.09	0.00	0.09	0.00
To any affiliated parties	0.40	0.07	0.43	0.23
To local affiliated parties	0.16	0.00	0.15	0.00
To affiliated in Korea	0.20	0.00	0.25	0.00
To affiliated in third countries	0.03	0.00	0.04	0.00
Obs	2,404		1,696	

Panel B: Advanced Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
To any unaffiliated parties	0.73	1.00	0.72	1.00
To local unaffiliated parties	0.62	0.99	0.60	0.99
To unaffiliated parties in Korea	0.02	0.00	0.02	0.00
To unaffiliated parties in third countries	0.09	0.00	0.10	0.00
To any affiliated parties	0.27	0.00	0.28	0.00
To local affiliated parties	0.16	0.00	0.18	0.00
To affiliated in Korea	0.08	0.00	0.08	0.00
To affiliated in third countries	0.02	0.00	0.02	0.00
Obs	620		208	

Panel C: Emerging Market Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
To any unaffiliated parties	0.57	0.79	0.55	0.69
To local unaffiliated parties	0.46	0.30	0.42	0.20
To unaffiliated parties in Korea	0.03	0.00	0.03	0.00
To unaffiliated parties in third countries	0.09	0.00	0.09	0.00
To any affiliated parties	0.43	0.21	0.45	0.31
To local affiliated parties	0.15	0.00	0.14	0.00
To affiliated in Korea	0.24	0.00	0.27	0.00
To affiliated in third countries	0.04	0.00	0.04	0.00
Obs	1,784		1,488	

Notes: This table summarizes the patterns of sales activities by Korean MNCs' foreign affiliates in 2007. Panel A reports summary statistics for all the subsidiaries in the sample; Panel B for subsidiaries located in advanced countries; Panel C for subsidiaries located in emerging market countries. First two columns in each panel are from all the subsidiaries across all sectors, while the third and fourth columns are from subsdiaries in the wholesale and retail sector and the last two columns consider manufacturing subsidiaries. In each panel, average and median share of sales to unrelated arm's length customers as well as those to related parties are reported and further decomposed across the location of buyers (local, Korea, or third countries).

Table 2: The Patterns of Sourcing Activities by Korean MNCs' Foreign Affiliates

Panel A: All Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
From any unaffiliated parties	0.56	0.68	0.58	0.70
From local unaffiliated parties	0.46	0.38	0.47	0.45
From unaffiliated parties in Korea	0.04	0.00	0.05	0.00
From unaffiliated parties in third countries	0.06	0.00	0.07	0.00
From any affiliated parties	0.44	0.32	0.42	0.30
From local affiliated parties	0.12	0.00	0.11	0.00
From affiliated in Korea	0.20	0.07	0.28	0.10
From affiliated in third countries	0.03	0.00	0.02	0.00
Obs	1,927		1,452	

Panel B: Advanced Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
From any unaffiliated parties	0.51	0.54	0.60	0.80
From local unaffiliated parties	0.42	0.15	0.49	0.50
From unaffiliated parties in Korea	0.03	0.00	0.02	0.00
From unaffiliated parties in third countries	0.07	0.00	0.08	0.00
From any affiliated parties	0.49	0.46	0.41	0.20
From local affiliated parties	0.09	0.00	0.10	0.00
From affiliated in Korea	0.37	0.06	0.30	0.02
From affiliated in third countries	0.03	0.00	0.01	0.00
Obs	458		171	

Panel C: Emerging Market Countries in 2007	All Sectors		Manufacturing	
	Mean	Median	Mean	Median
From any unaffiliated parties	0.58	0.70	0.58	0.69
From local unaffiliated parties	0.47	0.45	0.47	0.45
From unaffiliated parties in Korea	0.05	0.00	0.05	0.00
From unaffiliated parties in third countries	0.06	0.00	0.07	0.00
From any affiliated parties	0.42	0.30	0.42	0.31
From local affiliated parties	0.13	0.00	0.12	0.00
From affiliated in Korea	0.27	0.07	0.28	0.12
From affiliated in third countries	0.03	0.00	0.02	0.00
Obs	1,469		1,281	

Notes: This table summarizes the patterns of sourcing activities by Korean MNCs' foreign affiliates in 2007. Panel A reports summary statistics for all the subsidiaries in the sample; Panel B for subsidiaries located in advanced countries; Panel C for subsidiaries located in emerging market countries. First two columns in each panel are from all the subsidiaries across all sectors, while the third and fourth columns are from subsdiaries in the wholesale and retail sector and the last two columns consider manufacturing subsidiaries. In each panel, average and median share of purchases from unrelated arm's length customers as well as those from related parties are reported and further decomposed across the location of buyers (local, Korea, or third countries).

Table 3: Sourcing and Sales Activities by Korean MNCs' Foreign Affiliates in Manufacturing

Panel A: All Countries in 2007	Intrafirm Sales Share=0		Intrafirm Sales Share=1		0<Intrafirm Sales Share<1	
	Mean	Median	Mean	Median	Mean	Median
From any unaffiliated parties	0.60	0.73	0.32	0.00	0.61	0.69
From local unaffiliated parties	0.06	0.00	0.26	0.00	0.48	0.48
From unaffiliated parties in Korea	0.07	0.00	0.03	0.00	0.05	0.00
From unaffiliated parties in third countries	0.27	0.00	0.03	0.00	0.08	0.00
From any affiliated parties	0.40	0.00	0.68	1.00	0.39	0.31
From local affiliated parties	0.05	0.00	0.32	0.00	0.06	0.00
From affiliated in Korea	0.21	0.00	0.32	0.06	0.32	0.21
From affiliated in third countries	0.01	0.00	0.04	0.00	0.02	0.00
Obs	507		342		596	

Panel B: Advanced Countries in 2007	Intrafirm Sales Share=0		Intrafirm Sales Share=1		0<Intrafirm Sales Share<1	
	Mean	Median	Mean	Median	Mean	Median
From any unaffiliated parties	0.68	1.00	0.36	0.05	0.53	0.63
From local unaffiliated parties	0.58	0.90	0.35	0.00	0.36	0.21
From unaffiliated parties in Korea	0.02	0.00	0.01	0.00	0.05	0.00
From unaffiliated parties in third countries	0.08	0.00	0.00	0.00	0.12	0.00
From any affiliated parties	0.32	0.00	0.64	0.95	0.47	0.37
From local affiliated parties	0.03	0.00	0.38	0.00	0.08	0.00
From affiliated in Korea	0.28	0.00	0.26	0.00	0.38	0.26
From affiliated in third countries	0.00	0.00	0.00	0.00	0.02	0.00
Obs	99		28		43	

Panel C: Emerging Market Countries in 2007	Intrafirm Sales Share=0		Intrafirm Sales Share=1		0<Intrafirm Sales Share<1	
	Mean	Median	Mean	Median	Mean	Median
From any unaffiliated parties	0.74	1.00	0.32	0.00	0.61	0.69
From local unaffiliated parties	0.60	0.73	0.25	0.00	0.49	0.49
From unaffiliated parties in Korea	0.07	0.00	0.03	0.00	0.04	0.00
From unaffiliated parties in third countries	0.07	0.00	0.04	0.00	0.08	0.00
From any affiliated parties	0.26	0.00	0.68	1.00	0.39	0.31
From local affiliated parties	0.05	0.00	0.31	0.00	0.06	0.00
From affiliated in Korea	0.20	0.00	0.33	0.11	0.31	0.21
From affiliated in third countries	0.01	0.00	0.05	0.00	0.02	0.00
Obs	408		314		553	

Notes: This table summarizes the relationship between sourcing and sales activities by Korean MNCs' manufacturing foreign affiliates in 2007. Panel A reports summary statistics for all the manufacturing subsidiaries in the sample; Panel B for subsidiaries located in advanced countries; Panel C for subsidiaries located in emerging market countries. First two columns in each panel are for pure horizontal FDI subsidiaries (intrafirm sales share=0); the third and fourth columns are for pure vertical FDI subsidiaries (intrafirm sales share=1); the last two columns are for the rest of subsidiaries (0<intrafirm sales share<1). In each panel, average and median share of inputs purchased from unrelated suppliers as well as those from related parties are reported and further decomposed across the location of suppliers (local, Korea, or third countries).

Table 4: Productivity and Modes of FDI: Baseline Estimation

Dependent variable: (Hybrid=1)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	0.018	***	0.037	***	0.100	***	0.083	***
	(0.004)		(0.004)		(0.025)		(0.025)	
(Subsidiary Firm's Productivity)it			-0.036	***	-0.042	***	-0.160	***
X (Contract Intensity)s			(0.005)		(0.014)		(0.055)	
(Age)it	0.114	***	0.113	***	0.114	***	0.113	***
	(0.013)		(0.017)		(0.016)		(0.018)	
(Total Asset)it	0.043	***	0.043	***	0.043	***	0.043	***
	(0.007)		(0.003)		(0.003)		(0.004)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	1,863		1,863		1,863		1,863	
Adj R squared	0.120		0.120		0.120		0.122	

Notes: This table summarizes baseline estimation results, testing the validity of Claim 1. The dependent variable is an indicator variable with 1 for hybrid vertical FDI and 0 for vertical FDI whereby vertical FDI and hybrid vertical is defined as the share of intra-firm sales over and below 90%, respectively. The sample excludes horizontal FDI subsidiaries with the share of local sales to unrelated arm's length firms over 50%. Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 5: Productivity and Modes of FDI: Robustness to Alternative Threshold Levels I

Dependent variable: (Hybrid=1)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	0.018	***	0.033	***	0.075	**	0.062	***
	(0.005)		(0.010)		(0.030)		(0.020)	
(Subsidiary Firm's Productivity)it			-0.027		-0.030	*	-0.110	**
X (Contract Intensity)s			(0.020)		(0.016)		(0.040)	
(Age)it	0.096	***	0.095	***	0.096	***	0.095	***
	(0.010)		(0.011)		(0.015)		(0.013)	
(Total Asset)it	0.039	***	0.040	***	0.038	***	0.039	***
	(0.012)		(0.007)		(0.007)		(0.007)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	1,863		1,863		1,863		1,863	
Adj R squared	0.111		0.111		0.111		0.112	

Notes: This table summarizes robustness of the baseline estimation results—testing the validity of Claim 1—to alternative threshold levels in defining vertical and hybrid vertical FDI. The dependent variable is an indicator variable with 1 for hybrid vertical FDI and 0 for vertical FDI whereby vertical FDI and hybrid vertical is defined as the share of intra-firm sales over and below 80%, respectively. The sample excludes horizontal FDI subsidiaries with the share of local sales to unrelated arm's length firms over 50%. Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 6: Productivity and Modes of FDI: Robustness to Alternative Threshold Levels II

Dependent variable: (Hybrid=1)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	0.015	***	0.033	***	0.097	***	0.063	***
	(0.003)		(0.005)		(0.019)		(0.014)	
(Subsidiary Firm's Productivity)it			-0.033	***	-0.042	***	-0.118	***
X (Contract Intensity)s			(0.007)		(0.011)		(0.033)	
(Age)it	0.117	***	0.117	***	0.117	***	0.117	***
	(0.012)		(0.019)		(0.018)		(0.020)	
(Total Asset)it	0.045	***	0.044	***	0.044	***	0.045	***
	(0.006)		(0.002)		(0.002)		(0.002)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	1,781		1,781		1,781		1,781	
Adj R squared	0.116		0.116		0.116		0.117	

Notes: This table summarizes robustness of the baseline estimation results—testing the validity of Claim 1—to alternative threshold levels in defining horizontal FDI. The dependent variable is an indicator variable with 1 for hybrid vertical FDI and 0 for vertical FDI whereby vertical FDI and hybrid vertical is defined as the share of intra-firm sales over and below 90%, respectively. The sample excludes horizontal FDI subsidiaries with the share of local sales to unrelated arm's length firms over 40%. Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 7: Productivity and Sales Share of Hybrid Vertical FDI: Baseline Estimation

Dependent variable: (Sales Share)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	-0.001		-0.401	***	-1.942	***	-0.374	**
	(0.003)		(0.134)		(0.280)		(0.159)	
(Subsidiary Firm's Productivity)it			0.730	***	1.002	***	0.904	**
X (Contract Intensity)s			(0.220)		(0.129)		(0.393)	
(Age)it	0.080	***	0.090	*	0.086	***	0.083	
	(0.025)		(0.045)		(0.008)		(0.051)	
(Total Asset)it	-0.027		-0.020		-0.011		-0.024	
	(0.070)		(0.073)		(0.074)		(0.069)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	683		683		683		683	
Adj R squared	0.164		0.164		0.163		0.151	

Notes: This table summarizes baseline estimation results, testing the validity of Claim 2. The dependent variable is a ratio of inter-firm sales to intra-firm sales in log, conditional on conducting hybrid vertical FDI (i.e., the share of intra-firm sales below 90% and the share of local sales to unrelated arm's length firms below 50%). Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 8: Productivity and Sales Share of Hybrid Vertical FDI: Robustness to Alternative Threshold Levels I

Dependent variable: (Sales Share)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	-0.005		-0.453	**	-2.165	***	-0.502	***
	(0.057)		(0.175)		(0.203)		(0.150)	
(Subsidiary Firm's Productivity)it			0.829	***	1.116	***	1.229	***
X (Contract Intensity)s			(0.277)		(0.088)		(0.306)	
(Age)it	0.104	***	0.113	**	0.111	**	0.111	***
	(0.028)		(0.045)		(0.048)		(0.014)	
(Total Asset)it	-0.074		-0.068		-0.058		-0.069	
	(0.074)		(0.076)		(0.079)		(0.075)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	554		554		554		554	
Adj R squared	0.157		0.166		0.176		0.164	

Notes: This table summarizes robustness of the baseline estimation results—testing the validity of Claim 2—to alternative threshold levels in defining vertical and hybrid vertical FDI. The dependent variable is a ratio of inter-firm sales to intra-firm sales in log, conditional on conducting hybrid vertical FDI (i.e., the share of intra-firm sales below 80% and the share of local sales to unrelated arm's length firms below 50%). Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 9: Productivity and Sales Share of Hybrid Vertical FDI: Robustness to Alternative Threshold Levels II

Dependent variable: (Sales Share)it	(1)		(2)		(3)		(4)	
Contract intensity measure:			Nunn		Rauch		Sourcing	
(Subsidiary Firm's Productivity)it	-0.026		-0.417	***	-1.918	***	-0.537	***
	(0.052)		(0.110)		(0.248)		(0.164)	
(Subsidiary Firm's Productivity)it			0.717	***	0.977	***	1.262	***
X (Contract Intensity)s			(0.209)		(0.110)		(0.426)	
(Age)it	0.094	***	0.105	**	0.103	***	0.089	***
	(0.026)		(0.038)		(0.007)		(0.013)	
(Total Asset)it	0.008		0.015		0.028		0.008	
	(0.078)		(0.080)		(0.080)		(0.081)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	597		597		597		597	
Adj R squared	0.168		0.174		0.181		0.174	

Notes: This table summarizes robustness of the baseline estimation results—testing the validity of Claim 2—to alternative threshold levels in defining horizontal FDI. The dependent variable is a ratio of inter-firm sales to intra-firm sales in log, conditional on conducting hybrid vertical FDI (i.e., the share of intra-firm sales below 90% and the share of local sales to unrelated arm's length firms below 40%). Sector-level complexity measure is input complexity from Nunn (2007) in column (2); output complexity from Rauch (2001) in column (3); sourcing-based measure from the current dataset in column (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.

Table 10: Robustness to Alternative Productivity Measure

Dependent variable:	(1) (Hybrid=1)it		(2) (Hybrid=1)it		(3) (Sales Share)it		(4) (Sales Share)it	
(Parent Firm's Productivity)it	-0.027		0.277	***	0.097	***	-1.350	***
	(0.025)		(0.045)		(0.108)		(0.367)	
(Parent Firm's Productivity)it			-0.508	***			2.364	***
X (Contract Intensity)s			(0.040)				(0.443)	
(Age)it	0.068	***	0.065	**	0.275	***	0.302	**
	(0.022)		(0.030)		(0.079)		(0.101)	
(Total Asset)it	0.032		0.031	***	-0.124		-0.117	
	(0.013)		(0.007)		(0.100)		(0.101)	
Country-Sector Fixed effects	Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes	
Obs	533		533		196		196	
Adj R squared	0.060		0.062		0.172		0.181	

Notes: This table summarizes robustness of the baseline estimation results—testing the validity of Claim 1 and Claim 2—to alternative productivity measure based on parent firms' TFP. The dependent variable in columns (1) and (2) is an indicator variable with 1 for hybrid vertical FDI and 0 for vertical FDI whereby vertical FDI and hybrid vertical is defined as the share of intra-firm sales over and below 90%, respectively. The sample in columns (1) and (2) excludes horizontal FDI subsidiaries with the share of local sales to unrelated arm's length firms over 50%. The dependent variable in columns (3) and (4) is a ratio of inter-firm sales to intra-firm sales in log, conditional on conducting hybrid vertical FDI (i.e., the share of intra-firm sales below 90% and the share of local sales to unrelated arm's length firms below 50%). Sector-level complexity measure is input complexity from Nunn (2007) in columns (2) and (4). All columns include country-sector fixed effects and year fixed effects. Standard errors are clustered in multi-way at both country and sector levels. *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level.