The Productivity Effects of Joining Multinational Supply Chains: Evidence from Firm-to-Firm Linkages

Alonso Alfaro-Ureña[1], Isabela Manelici[2] and Jose P. Vasquez*[2]

[1]Banco Central de Costa Rica
[2]UC Berkeley

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Abstract

How integrated are developing countries in the supply chains of multinationals (MNCs) they host? What are the gains to domestic firms from supplying to MNCs? We answer these questions using administrative firm-to-firm transaction data from Costa Rica and two empirical strategies that identify the causal effects of starting to supply an MNC. Proxies of MNC linkages based on Input-Output tables conceal heterogeneities in buyer and seller characteristics relevant to the estimation of both the countrywide integration of MNCs and the effects of matching to an MNC. We provide evidence on substantial linkage heterogeneity and its implications for the estimations above. We then identify the impact of becoming a supplier to an MNC by means of a quasi-experimental government program that matches MNCs with domestic firms. We show that joining MNC supply chains led to strong and persistent gains in firm size and productivity. We add an economy-wide event study that, due to its larger sample size, allows us to explore levers of adjustment to joining MNC supply chains, heterogeneities in treatment effects based on supplier or MNC characteristics, and spillovers of productivity to domestic clients. Our results do not simply reflect firms' response to demand shocks, price effects, or improvements in tax compliance. Instead, they are suggestive of knowledge transfers by MNCs, that affect suppliers' production technology and organization, input choices, and relationships with domestic clients.

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1 Introduction

A long-standing debate has focused on the extent to which attracting foreign capital to developing countries can not only push the productivity frontier of receiving sectors, but also induce productivity catch-up throughout their economies. As multinational corporations (MNCs) lead in the global productivity race and drive most of today's foreign direct investment (FDI),[1] developing countries court MNCs for a short-cut to productivity upgrading. Whether MNCs engage local firms in this upgrading as well hinges, however, on answers to two questions. First, how deep are the local roots of these MNCs? If MNCs operate in enclaves, then there might be little room for ripple effects throughout the economy. Second, if MNCs do establish business linkages with domestic firms, is there convincing causal evidence that these linkages are indeed conduits for productivity growth?

While there is a massive body of research surrounding these questions, three empirical challenges have plagued this literature. These challenges stem from (i) the reliance on Input-Output (I-O) tables to proxy for linkages between domestic firms and MNCs, (ii) the lack of a research design warranting causal claims on the benefits from matches to MNCs, and (iii) the difficulties to measure productivity and pin down the channels through which productivity is improved. Using new data and techniques, we make progress on all three fronts.

To date, the most common practice to capture potential direct linkages between domestic firms and MNCs uses proxies called forward and backward linkages. These proxies have two building blocks: the proportion of a sector's output supplied to another sector (taken from sector-level I-O tables) and the extent of foreign equity participation averaged over all firms in a sector, weighted by each firm's contribution (e.g., to output) in that sector. Each building block rests upon strong assumptions, that we expose with the help of an administrative dataset of all business-to-business (B2B) transactions within Costa Rica.

We show that I-O based proxies of linkage to MNCs conceal substantial two-sided heterogeneity. Domestic firms in the same sector differ in their propensity to sell to sectors with a larger MNC presence and, within a given purchasing sector, in their propensity to actually sell to MNCs. Conditional on their size, sector and location, MNCs differ from domestic firms in the share of inputs in total revenues and in how much of their inputs are actually sourced in Costa Rica. MNCs also differ in the share of the local inputs purchased from domestic firms and in how concentrated domestic purchases are in a handful of firms. Interacted, these heterogeneities produce patterns of linkage to MNCs that differ greatly from what one would predict with I-O based proxies.[2] These findings have implications for the estimation of both the aggregate integration of MNCs in a country and the causal effects of joining MNC supply chains.

[1] Although FDI statistics include some transactions that might not meet the definition of a multinational activity (such as investments in real estate) investments by multinationals dominate FDI flows. See details here.

[2] De Gortari [2017] is another recent paper that pushes back against assumptions behind the use of I-O tables. By emphasizing the importance of specialized inputs, the author brings convincing evidence against the typical I-O based approach in the global value chains literature. In response, he proposes a structural framework to improve on the measure of depth of integration within the NAFTA group. Our approach is more direct, as our data allows us to fully observe the depth of integration of MNCs in the country.

A second challenge in this literature is obtaining an estimate of the causal effects of linking to MNCs. The inability to observe actual matches between domestic firms and MNCs, compounded by the lack of a credible counterfactual for matched domestic firms, have been major threats to causal inference. For instance, MNCs choose suppliers to maximize profits, implying that firms which secure a deal with an MNC are likely to differ greatly from an average firm in their sector. Firms not only vary in their observable characteristics, but also in relevant unobservables, such as whether they have a manager with strong English skills and a vision of firm development through matching with MNCs.

We overcome this challenge by making use of a government program called *Encadenamientos Productivos* (*Productive Linkages*) that generates quasi-experimental variation in opportunities to sell to MNCs. *Productive Linkages* is managed by Procomer, Costa Rica's Trade Promotion Agency. Its objective is to reduce matching frictions between MNCs in Costa Rica and domestic firms in upstream sectors. This is accomplished by identifying the input needs of MNCs and proposing a ranking of the most suitable local suppliers for each need. Rankings are based on thorough evaluations carried out by Procomer staff, who grade each firm's potential to join MNC supply chains. These evaluations focus on features of the firm that are most salient to MNC clients, features usually unobservable in tax returns data.

Hence, we know not only which firm close a deal with an MNC, but also which were its close contenders for that deal. Our empirical strategy shares features with Greenstone, Hornbeck, and Moretti [2010]. The agglomeration spillovers literature also faced difficulties to find valid counterfactuals for incumbents in counties experiencing a large plant opening. These authors addressed that concern by using reported rankings of counties where firms considered opening "million dollar plants" (MDP). Our argument parallels theirs: the suppliers (counties) nearly missing a deal with an MNC (an MDP) offer a valid counterfactual to what would have happened with the winners' performance had they not won the deal.

We implement an event study design to estimate the impact of a first match with an MNC – through the *Productive Linkages* program – on a domestic firm's subsequent performance. Similar to Greenstone, Hornbeck, and Moretti [2010], our event study design can be thought of as a generalized triple-difference design where different firms experience a first match with an MNC in different years. We compare changes in the performance of first-time suppliers to MNCs to both firms that have not yet become suppliers to an MNC and firms that are never observed selling to an MNC within our time frame. The further comparison to contemporaneous outcomes of losing firms for the same deal allows us to derive a more credible estimate of the causal impact of a first match with an MNC. With this last difference we can control for any unobservable heterogeneity that causes selection into the *Productive Linkages* program. Preliminary findings from this design indicate significant and lasting improvements in firm size and productivity.

Next, we employ a second research design that exploits the full dataset of firm-to-firm linkages. Due to its larger sample size, this economy-wide exercise allows us to explore heterogeneous treatment effects (effects varying across different types of suppliers) and dif-

ferent responses to heterogeneous treatments (e.g., matches with different types of MNCs). Also, this design allows us to detect indirect effects of the match spread through the network of the matched firm. This design continues to be an event study, where events refer to all first matches between domestic firms and an MNC occurring between 2010 and 2014. The key difference to the *Productive Linkages* exercise comes from the definitions of the counterfactual path for winning firms. We take advantage of the richness of the data, by implementing increasingly tighter versions of event-study designs - from using the full sample of firms in the economy to using only the sample of firms eventually matched to a foreign firm.

We find that upon joining MNC supply chains, domestic firms experience large and long-term increases in their sales, workforce and total assets. Moreover, these firms also change their sourcing strategy, by switching to a larger share of imports in their inputs.

We then study the impact of starting to sell to an MNC on suppliers' productivity. We start with measures of revenue-based productivity based on production function estimation. We also construct a productivity index for the Cobb-Douglas production function, as proposed in Syverson [2011] and Greenstone, List, and Syverson [2012]. Last, we propose alternative measures of firm performance, which have the advantage of transparency over those based on production function estimation: sales per employee, value added per employee, and profits per employee. Across all of these measures we find the same three patterns: (i) a lack of differential preexisting trends, suggesting that selection into treatment is not a major concern, (ii) a strong and persistent improvement in productivity, and (iii) a levelling off in trends three to four years into joining the MNC supply chain.

Finally, we rule out two alternative hypotheses for the interpretation of our findings. First, we benchmark our results with those from an exercise in which the Government is the source of demand shocks. The lack of (or the weakness and short-term nature of) gains from starting to sell to the Government suggests that there are additional features of matches to MNCs (to their mere demand shock) – plausibly knowledge spillovers – that explain productivity gains. Second, we ask whether our results could be driven by mere improvements in tax compliance and reporting. To the extent that MNCs are under increased scrutiny by tax authorities, one could speculate that a first match to an MNC is a form of "sunshine as disinfectant." We show however that changes in tax behaviors cannot reproduce our results.

The last big hurdle in this literature relates to well-known challenges in measuring firm productivity. As most settings (including ours) lack firm-level data on prices and quantities, it is hard to distinguish between changes in physical efficiency and changes in prices. Prices reflect product differentiation and markups in addition to costs. When unable to rule out price effects directly, the standard approach is to rely on the structural assumptions of a recent literature [Olley and Pakes, 1996, Levinsohn and Petrin, 2003, Ackerberg, Benkard, Berry, and Pakes, 2007, Wooldridge, 2009, De Loecker, 2011, Ackerberg, Caves, and Frazer, 2015]. Preliminary evidence from implementing these methods suggests little sensitivity to the method choice.

To circumvent the dangers of markups that apply to MNCs alone, we use the full po-

tential of the production network and study how new suppliers interact with their (old and new) domestic clients. While indirect, these effects are reliable signals of productivity.

We first inquire whether becoming a supplier to an MNC makes domestic firms shed their domestic business. In the year of their first match to an MNC firms experience a relative dip in revenues from domestic clients. In the following years however, domestic sales slowly increase, relative to the control group and year prior to the event, to the point of reaching sizable growth. First-time suppliers to an MNC do not only increase their total revenues from domestic clients, but also gain more of these clients.

We then investigate whether domestic clients of a first-time supplier to an MNC also see their productivity improve. We require from domestic clients to not be suppliers to an MNC themselves and purchase at least 10 percent of their local inputs from the supplier triggering the event. If a domestic client has several suppliers that start selling to an MNC, its event year is set as the event year of its most important supplier among them. While the statistical significance of point estimates is not robust across specifications, point estimates are positive and have a magnitude gradually rising in time. Productivity spillovers to domestic clients of first-time suppliers to an MNC imply that suppliers to an MNC have acquired new knowledge that is valuable beyond their business with the MNC.

Last, we explore the heterogeneity of productivity gains based on the sector of the buyer. Even conditional on their own sector, domestic firms matched with MNCs in knowledge - intensive sectors experience a stronger productivity boost. We interpret this finding as suggestive of a knowledge transfer channel.

While our empirical evidence comes from Costa Rica, we uncover sourcing patterns for MNCs that are unlikely to be country-specific. Moreover, our economy-wide event study design could be implemented in any country having similar firm-to-firm transaction data. In addition, despite Costa Rica still being a developing country, it has the advantage of strong public institutions, particularly those in charge of dealing with foreign firms.[3] This feature is reflected (i) in a strong and diverse MNC presence in the country, allowing us to explore heterogeneous treatments, and (ii) in the quality of our data, compared across a series of descriptive statistics with similar data sets from developed countries.[4] Lastly, but critically to the strength of our identification, we can exploit the unique features of *Productive Linkages*, a Costa Rican matching program between MNCs and domestic firms, as a source of credible runner-ups to a given match.

Our findings relate to a number of papers that span the trade and development literatures. First, we contribute to a voluminous literature that seeks to measure the productivity gains from FDI. Aitken and Harrison [1999], Javorcik [2004], and Blalock and Gertler [2009] are classical examples in this vast literature. Evidence from this literature is mixed, in part due to aforementioned identification concerns. A common insight of these papers is that

[3]CINDE, the organization responsible for the attraction of foreign investment to the country, was awarded in 2017 for the third consecutive year as the "Best Investment Promotion Agency" of Latin America and the Caribbean in a ranking compiled by the *Site Selection* magazine.

[4]See Appendix D for details.

linkages to local suppliers are likely conduits for productivity spillovers.[5] Most papers do not propose however a formal theory of linkages and their importance. Rodríguez-Clare [1996] is a notable exception. In his model, when MNCs demand specialized inputs from local suppliers, they expand the range of inputs available to domestic producers as well. Through a love of variety for inputs, domestic producers see their productivity raise. Carluccio and Fally [2013] is another more recent exception.

By providing causal evidence on the impact of matching to an MNC on domestic suppliers, we follow this tradition of focusing on backward linkages. We make progress with respect to this literature in directly confronting the selection into matching with foreign firms. We also depart from the FDI literature in focusing only on MNC production. Due to data limitations, MNCs' engagement in international production is usually measured by FDI flows and stocks, although FDI may no longer constitute their primary form of internalization [UNCTAD, 2011, Giorgioni, 2017]. By focusing on MNCs with a substantial presence in the country, we avoid concerns related to FDI statistics, such as the rising use of shell companies.[6] Moreover, our ability to observe actual linkages isolates their role in driving performance improvements, which cannot be achieved with I-O proxies.[7] Last, by finding positive spillovers on the domestic clients of suppliers to MNCs, we provide empirical support for the theory proposed by Rodríguez-Clare [1996] and Carluccio and Fally [2013].

Our paper also contributes to the vast literature linking industrial policy to economic development and growth. Since the seminal work of Rosenstein-Rodan [1943], Hirschman [1958] and Baldwin [1969], the merits and perils of industrial policy have been debated at length. This debate has centered on whether the government can address market failures by targeting subsidies or protection to particular firms or sectors. The existence of externalities is usually presented as the main theoretical justification for deviating from policy neutrality [Harrison and Rodríguez-Clare, 2010]. By finding productivity spillovers from the interaction between MNCs and domestic firms, we contribute to recent empirical evidence on this topic [Lane, 2016, Rotemberg, 2017, Liu, 2017, Juhász, 2018]. We also show that the strength of these spillovers depends on the sector and skill-intensity of both buyers and sellers. This suggests that policies favoring certain linkages over others might be justifiable.

We also contribute to recent literature on production networks and their importance.

[5] According to extensive meta-analyses [Havránek and Iršová, 2011, 2012, Iršová and Havránek, 2013] estimated horizontal and forward spillovers are negligible, whereas the average backward spillover is positive and significant. These meta-analyses found that a 10-percentage-point increase in foreign presence is on average associated with a 3.1 percent increase in the productivity of domestic firms in upstream sectors. Note that while we focus on spillovers through linkages, there are other channels of productivity spillovers. For instance, Alfaro and Chen [Forthcoming] study the selection and market reallocation induced by MNC entry, whereby competition from MNCs leads to factor and revenue reallocation within and between domestic firms and exits of the least productive firms.

[6] Shell companies, or "special purpose entities (SPEs) are companies that do not have substantial economic activity in a country but are used by companies as devices to raise capital or to hold assets and liabilities.[...] SPEs can lead to the inflation of FDI statistics and the obscuring of the ultimate source and destination of FDI" [OECD, 2017b].

[7] With I-O proxies, actual market transactions between MNCs and domestic firms are expected, but not guaranteed. Gains in performance could then be indirect, e.g., through the impact of MNCs on their same-sector domestic competitors, who then impact on their suppliers.

The theory on the aggregate implications of the network structure of an economy has quickly grown in recent years [Gabaix, 2011, Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi, 2012, Carvalho, 2014, Magerman, De Bruyne, Dhyne, and Van Hove, 2016, Oberfield, Forthcoming]. On the empirical side, Belgium (several working papers by Emmanuel Dhyne, Glenn Magerman, and co-authors, plus Dhyne, Kikkawa, Mogstad, and Tintelnot [2017]) and Japan (Furusawa, Inui, Ito, and Tang [2017], Bernard, Moxnes, and Saito [Forthcoming] etc.) are the countries providing most, if not all, of the empirical evidence. To our knowledge, we are the first to exploit a quasi-experimental setup in linkage formation to study the importance of (MNC) clients on firms' outcomes. Also, these papers do not make the contrast between MNCs and domestic firms' heterogeneity in linkages, which is important when assessing benefits from joining MNC supply chains.

Finally, our findings relate to work that considers the role of (public) demand shocks on firm dynamics. Papers such as Ferraz, Finan, and Szerman [2016] and Lee [2017] benefit from an institutional setup, in Brazil and South Korea respectively, in which government contracts are assigned through auctions. Both papers show that winning a government contract firms has persistent effects on firm growth. In contrast to these papers, the shock we study is one of winning a contract with a foreign firm, which is likely to not only act as a demand shock but also provide opportunities for productivity improvement through knowledge transfers.

The remainder of this paper proceeds as follows. Section 2 describes the data. Section 3 presents the drawbacks of I-O based proxies of linkage to MNCs. Section 4 brings quasi-experimental evidence on the impact of starting to supply an MNC. Section 5 implements an economy-wide event study design granting enough power to explore heterogeneous treatments and spillovers to domestic clients of suppliers to MNCs. Section 6 concludes.

2 Data

In the Introduction we detail three challenges faced by researchers hoping to uncover the sourcing behavior of MNCs in a given country and measure the impact of matching with MNCs on domestic firms. We overcome these challenges by using an administrative dataset tracking all B2B relationships in Costa Rica between 2008 and 2016. This data is collected by the Ministry of Finance of Costa Rica (*Ministerio de Hacienda*) through the compulsory tax form D-151. Each firm has to report all its suppliers and clients with a yearly cumulative amount of transactions above 2.5 million Costa Rican Colones (roughly $4,400). As D-151 forms also contain the yearly amount sold to or bought from each partner, this further informs us on the intensity of all B2B linkages in Costa Rica.

The Ministry of Finance uses this data to ensure corporate income tax compliance. To deter firms from inflating their costs or deflating their revenues the Ministry of Finance uses the D-151 data to cross-check the consistency of mutual reporting of any two partners.[8] We

[8]See Section 5.5.1 for a discussion on the self-regulating property of third-party reporting.

pursue the same logic to check on the quality of this data set. Reassuringly, over 90 percent of all transactions and over 87 percent of the value of all transactions can be preserved for analysis, as they are either correctly filled in or filled in with minor mistakes that can be resolved (e.g., with misreporting of decimal points). See Appendix D.2 for details.

We add to this dataset three other administrative datasets allowing us to observe firm characteristics and behavior. The first dataset contains the universe of Costa Rican corporate tax returns spanning the 2005 to 2015 period. All registered corporations are required to submit electronically the yearly tax declaration D-101, in which they report their profit, revenue, and costs. We also add data from the Costa Rican Social Security Fund ("Caja Costarricense del Seguro Social") on the yearly firm-level total wage bill, number of employees, and share of high-skill employees.[9] Our third dataset comes from Costa Rican customs and covers the same time frame. For each firm engaged in international trade we observe its exports and imports, disaggregated by country of destination or origin, date of shipment and product (prices and quantities sold of each ten-digit product).

To construct an exhaustive record of the foreign ownership of firms in Costa Rica, we rely on several data sources. We combine information from *Encuesta Trimestral de Balanza de Pagos* (the "Quarterly Balance of Payments Survey"), *Encuesta Anual* (the "Annual Survey") and *Estudio Economico* ("Economic Study"), each containing time series information on the country and percentage of foreign ownership for a sample of firms with at least partial foreign ownership. From CINDE, the organization responsible for the attraction of FDI to Costa Rica, we have information on the year of entry and country of ownership of those MNCs attracted by CINDE. Finally, we contrast these data sources with data from ORBIS,[10] which allows us to improve upon the grouping of foreign firms, based on their shared global ultimate ownership. Appendix D.4 provides additional details.

Most uniquely, we were granted access to the records of Procomer, the Trade Promotion Agency of Costa Rica. Procomer is the agency that has been implementing a matching program between MNCs and domestic firms since 2004. As detailed in Section 4, this program brings the opportunity of a quasi-experimental research design. Procomer has shared with us its evaluations of over 900 firms and the full history of attempted and successful matches between MNCs and domestic firms. We have also gathered rich contextual information on the matching program after interviews with current and former Procomer staff, as well as with MNCs and domestic firms participating in the program. For details on the Procomer program and data, see Section 4 and Appendix D.5.

[9] A worker is defined as high-skilled if he/she earns more than the minimum wage paid to a worker with vocational post-high school training.

[10] The ORBIS database, compiled by the Bureau van Dijk is a commercial dataset, which contains administrative data on over 160 million firms in over 100 developed and emerging countries. The financial and balance-sheet information in ORBIS comes from business registers collected by the local Chambers of Commerce to fulfill legal and administrative requirements [Kalemli-Özcan, Sørensen, Villegas-Sanchez, Volosovych, and Yeşiltaş, 2015].

3 The Local Integration of MNCs: I-O vs. B2B Evidence

This section brings new evidence on the within-country (or local) integration of MNCs, while emphasizing the importance of B2B data to correctly measure this integration. Before we begin, a few clarifications on terminology and sample choices are in order.

As customary in the MNC literature – see Antràs and Yeaple [2014] and Caves [2007] – we define a multinational firm (MNC hereafter) as "an enterprise that controls and manages production establishments/plants located in at least two countries." We focus on MNCs with their parent in a foreign country and affiliates in Costa Rica.[11] Henceforth, we refer to these MNC's affiliates in Costa Rica as the MNC.

While we identify 2,408 firm groups (firms, hereafter) with a share of equity owned by foreign investors, more than half of these firms are not part of an MNC. Moreover, even among the 1,045 MNCs, half of them do not have a substantial presence in the country. Given our interest to measure the productivity gains of joining MNC supply chains, we focus on the 516 MNCs whose median number of workers – over all years in which the MNC is active in Costa Rica – is at least 100.

While these restrictions on the MNC status and median number of workers[12] might seem costly for the number of firms kept, these 516 MNCs employ over 85 percent of workers, produce over 80 percent of the revenues, and are responsible for over 91 percent of the exported value out to the respective totals for the full sample of 2,408 firms with foreign ownership. Most firms with foreign ownership that we exclude from our study are small (their median number of workers is 12) and serve local demand,[13] either in service sectors (e.g., hotels) or in sectors with low domestic input requirements (e.g., import/export retail or real estate agencies). For further details, see Appendix D.4.

We now turn to issues in measurement of the degree of local integration of MNCs attracted to Costa Rica. We start with a formal discussion of measures of linkage built off I-O tables. We integrate the information from our B2B dataset in two steps. In doing so, we propose two new more disaggregated measures of linkage to MNCs. We find sufficient conditions under which I-O based measures can collapse to these two new firm-level measures of linkage. We also explore how these alternative measures of linkage relate in a population of firms where sufficient conditions for equivalence do not hold.

The goal of this formal exercise is to spell out the strict conditions under which sector-level measures of linkage to MNCs are informative about a firm's actual linkage. In addi-

[11] As opposed to MNCs whose parent is Costa Rican.

[12] The size restriction on MNCs is not unreasonable. For example, the average annual sales of Million Dollar Plants in Greenstone, Hornbeck, and Moretti [2010] are approximately 9 times larger than the average sales of our 516 MNCs. Abebe, McMillan, and Serafinelli [2017] consider only openings of FDI plants in manufacturing for which the plant's labor force is at least 100 employees or constitutes at least 1 percent of total employment in local manufacturing in $\tau = 0$ or $\tau = 1$. In our case, the MNC needs to employ a median of 100 workers across all years in which it is present in Costa Rica.

[13] MNCs are more productive than exporters who are not MNCs, and exporters who are not MNCs are more productive than firms who serve only the domestic market [Helpman, Melitz, and Yeaple, 2004]. Domestically-oriented foreign-owned firms are not covered by the FTZ regime, which is likely to be due to their lower potential to generate productivity improvements for their suppliers.

tion, this exercise allows us to caution against a direct use of firm-level measures of linkage, as they may capture features of firms that are associated to firms' potential productivity growth. These findings are informative to our future choices of research designs.

We then show empirically that I-O based proxies of linkage to MNCs conceal both heterogeneities in the propensity of domestic firms to supply MNCs and in the sourcing behavior of MNCs compared to domestic firms. Interacted, these heterogeneities generate patterns of linkage between domestic firms and MNCs that are substantially different from what one would expect based on I-O tables.

Finally, we argue that relying on I-O based measures has implications not just for one's ability to capture heterogeneities in exposure to MNCs. Using I-O based measures of linkage also affects the estimation of causal effects of starting to supply to MNCs and the accurate measurement of the aggregate integration of MNCs in a country.

3.1 Existing I-O Proxies and New Measures of Linkage to MNCs

To date, the most common solution to the challenge of unobservable linkages between domestic firms and MNCs has relied on proxies called backward and forward linkages. Formulas for these proxies have two building blocks: (i) the proportion of a sector's output supplied to another sector, based on I-O table coefficients and (ii) the extent of foreign equity participation averaged over all firms in a sector, weighted by each firm's contribution (e.g., to output or employment) in that sector.

To fix ideas, we follow Javorcik [2004] and Blalock and Gertler [2008] and use H_k as a measure of foreign presence in sector k: $H_k = (\sum_{i \in \Omega_k} Y_{ik} \times FS_{ik}) \times (\sum_{i \in \Omega_k} Y_{ik})^{-1}$, where Y_{ik} and FS_{ik} are the total sales and share of foreign ownership of firm i in sector k, respectively, and Ω_k is the set of firms in sector k.[14]

We start, as is common in the literature, with $Backward_j^{s\text{-}s}$ (shortened to $B_j^{s\text{-}s}$) as a proxy for foreign presence in the industries supplied by sector j. Define $B_j^{s\text{-}s} = \sum_k \alpha_{jk} \times H_k$, where $\alpha_{jk} = \frac{Y_{j \to k}}{Y_j}$, Y_j is the production of sector j, and $Y_{j \to k}$ is sector j's production sold to sector k. $B_j^{s\text{-}s}$ intends to "capture the extent of potential contacts between domestic suppliers [in sector j] and MNC customers [in sector k] Javorcik [2004]."[15]

Let us now spell out the assumptions behind the use of $B_{lj}^{s\text{-}s}$ by defining two firm-level measures of backward linkages. We introduce our full production network data in two steps, each adding an extra level of detail on firm-level transactions. First, we use our knowledge on the sectors to which a firm sells to, without yet distinguishing which firms within those sectors a firm actually sells to. Concretely, we replace the sector-level α_{jk} with a firm-level α_{ljk}, where α_{ljk} is defined as the proportion of output of firm l in sector j sold to sector k,

[14] Note that while we have dropped the time t subscript for all variables in the definition of H_k, the time subscript is implied in both this formula and in all the upcoming ones.

[15] Given our interest in the effect of starting to supply MNCs on a firm's performance, we focus hereafter on $B_{lj}^{s\text{-}s}$. The discussion for the measure of forward linkages, $F_{lj}^{s\text{-}s}$, is analogous to the one for $B_{lj}^{s\text{-}s}$.

$$B_{lj}^{f\text{-}s} = \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \sum_k \alpha_{ljk} \times H_k, \tag{1}$$

where Y_{lj} are the sales of firm l in sector j, $Y_{lj\to k}$ are the sales of firm l in sector j to sector k, and α_{ljk} is the proportion of the sales of firm l in sector j directed to sector k. We use the superscript *f-s* to indicate that our level of disaggregation is "firm-to-sector."

Next, we add the last layer of information allowed by our B2B transactions dataset, i.e., the information on the actual identity of the clients of firm l in each sector k. While the backward linkage measure $B_{lj}^{f\text{-}s}$ was already customized to each firm's sectoral composition of sales, the new measure we define, $B_{lj}^{f\text{-}f}$, makes the customization complete, by acknowledging differences across firms in their actual clients:

$$B_{lj}^{f\text{-}f} = \sum_{i=1}^{N} \frac{Y_{lj\to i}}{\sum_{i=1}^{N} Y_{lj\to i}} \times FS_i = \sum_{i=1}^{N} \frac{Y_{lj\to i}}{Y_{lj}} \times FS_i, \tag{2}$$

where $Y_{lj\to i}$ is the total amount that firm l in sector j sells to a firm i. As mentioned above, it is implied that we refer to time t variables. N is the total number of firms in the economy.

Comparing the three measures of backward linkages $\left(B_{lj}^{s\text{-}s}, B_{lj}^{f\text{-}s}, B_{lj}^{f\text{-}f}\right)$ among each other, we arrive to three straightforward results described in Appendix A.1.1. Result 1 requires firm l in sector j to have the same sectoral decomposition of its sales as its sector j's aggregate decomposition. Result 2 demands that the contribution of firm i to its sector k's output ($\frac{Y_{ik}}{Y_k}$) is enough to know the share of output of firm l in sector j sold to firm i of all the output sold by firm l to sector k ($\frac{Y_{lj\to ik}}{Y_{lj\to k}} = \frac{Y_{ik}}{Y_k}$). Result 3 needs that each firm i in sector k to have the same foreign ownership share as the weighted-average H_k for its sector. Having either of these three results hold implies that at least one layer of disaggregation is redundant. Combining Result 1 with either Result 2 or 3 implies that both layers of disaggregation are redundant.

Given that these sufficient conditions are unlikely to hold in the data – which we show in Section 3.2 – how do these three measures of linkage relate to each other? Moreover, what are their differences informative of? We propose three results, detailed in Appendix A.1.2. First, we derive a relationship between the sector-level $B_{lj}^{s\text{-}s}$, assigned to any firm l in sector j, and its firm-specific $B_{lj}^{f\text{-}s}$, which uses the sectoral split of its sales. We use properties of the variance of a product of random variables[16] to show that $B_{lj}^{s\text{-}s} = B_{lj}^{f\text{-}s} + \kappa \times Cov(\alpha_{jk} - \alpha_{ljk}, H_k)$, (Result 4). Whenever a firm l in sector j has the tendency to underperform in its sales to more foreign sectors k, with respect to the sector-level I-O based share of sales to these sectors (i.e., has the tendency to have $\alpha_{ljk} < \alpha_{jk}$ for sectors k with a higher weighted-average foreign presence, H_k), then $B_{lj}^{s\text{-}s}$ overestimates $B_{lj}^{f\text{-}s}$.[17]

[16] $Cov(X,Y) = \mathbb{E}(XY) - \mathbb{E}(X)\,\mathbb{E}(Y)$ or $\mathbb{E}(XY) = \mathbb{E}(X)\,\mathbb{E}(Y) + Cov(X,Y)$. We use this property repeatedly in this section.

[17] Note that when the sufficient conditions in Result 1 hold, the covariance term becomes zero and we recover the equality between $B_{lj}^{s\text{-}s}$ and $B_{lj}^{f\text{-}s}$.

Second, we can rewrite the definition of $B_{lj}^{s\text{-}s}$ by breaking down the sales of sector j to sector k ($Y_{j\to k}$) into the sales of given firms l in sector j to sector k ($Y_{lj\to k}$), arriving to $B_{lj}^{s\text{-}s} = \sum_{l\in j} s_{lj} \times B_{lj}^{f\text{-}s}$ (Result 5). Hence, the sector-level $B_{lj}^{s\text{-}s}$ is a weighted-average of $B_{lj}^{f\text{-}s}$ across all firms l in sector j, with weights given by the share of output of each firm l in its sector j.

Finally, interested how the average of $B_{lj}^{f\text{-}s}$ $\left(\overline{B_{lj}^{f\text{-}s}}\right)$ relates to $B_{lj}^{s\text{-}s}$, we use again properties of the covariance of two random variables (here B_{lj}^{f-s} and s_{lj}), Result 5, and the fact that $\sum_{l\in j} s_{lj} = 1$. We find that $B_{lj}^{s\text{-}s} = \overline{B_{lj}^{f\text{-}s}} + N_j \times Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right)$ (Result 6). To the extent that B_{lj}^{f-s} and s_{lj} are uncorrelated in a sector j, $B_{lj}^{s\text{-}s}$ is equal to the (unweighted) average of $B_{lj}^{f\text{-}s}$. If B_{lj}^{f-s} and s_{lj} are positively (negatively) correlated, then $B_{lj}^{s\text{-}s}$ is larger (smaller) than the (unweighted) average of $B_{lj}^{f\text{-}s}$. Small (large) firms in sector j would be assigned an upwardly biased $B_{lj}^{s\text{-}s}$, compared to their $B_{lj}^{f\text{-}s}$.

We now turn to describing the relationship between the most disaggregated measure of backward linkages $B_{lj}^{f\text{-}f}$ and the other two measures of linkage: $B_{lj}^{s\text{-}s}$ and $B_{lj}^{f\text{-}s}$. We use again properties of the expected value and previous conclusions to get to our last set of results (which are detailed in Appendix A.1.3). The first result here (Result 7) implies that whenever firm l in sector j has a tendency to undersell to foreign firms i in sector k, relative to their size in their sector k, then B_{lj}^{f-s} is an overestimation of the true B_{lj}^{f-f}.[18] Moreover, even conditional on the same $B_{lj}^{f\text{-}s}$, i.e., even after sharing the same level of aggregate foreign presence across one's known purchasing sectors, suppliers can still differ in their likelihood to actually sell to the foreign buyers in those sectors.[19]

Lastly, we pursue formulas relating directly the measure of linkage commonly used in the literature ($B_{lj}^{s\text{-}s}$) to the one that we can construct using the full information set on firm's l in sector j sourcing behavior, $B_{lj}^{f\text{-}f}$. Result 8 shows that the firm-specific $B_{lj}^{f\text{-}f}$ of firm l in sector j has three components: (i) the prediction from I-O tables of the backward linkage of firm l based on its sector's j aggregate linkage behavior, (ii) firm l's overperformance (relative to its sector) in terms of selling a higher share of its output to more foreign sectors k, and (iii) firm's l overperformance in terms of directing its sector k sales disproportionately towards foreign firms (relative to the size of these buyers i in their sector k).[20]

Thus, Result 8 is an argument against a regression that starts from those now common in the literature and that replaces $B_{lj}^{s\text{-}s}$ with $B_{lj}^{f\text{-}f}$. $B_{lj}^{f\text{-}f}$'s second and last components are likely to capture unobservable features of the firm that may explain both the overperformance in selling to MNCs and the improvement in firm performance.

To the best of our knowledge, this is the first time these $f-s$ and $f-f$ linkage variables

[18] This tendency with respect to sector k is weighted by the importance of sector k in the sales of firm l in sector j.

[19] Note that the sufficient condition in Result 2 is apparent in this result as well. If for firm l in sector j, $\frac{Y_{ik}}{Y_k} = \frac{Y_{lj\to ik}}{Y_{lj\to k}}$ for $\forall i$ and $\forall k$, then $B_{lj}^{f-s} = B_{lj}^{f-f}$.

[20] Note that whenever the sufficient conditions in Results 1 and 2 hold, the covariance terms become zero and $B_{lj}^{f\text{-}f}$ becomes equal to $B_{lj}^{s\text{-}s}$.

are defined and compared to the standard $s - s$ linkage variables. These are useful to spell out (i) the strong assumptions behind the use of sector-level linkage variables to proxy for actual firm-to-firm linkages, with implications, for instance, on the aggregate measure of integration of MNCs and (ii) the selection biases that would affect panel-type regressions directly using the firm-to-firm linkage variables as an explanatory variable. These biases later inform our choices of research designs.

3.2 Evidence on the Heterogeneity in Linkages to MNCs

We now bring the findings in the previous section to our B2B data. We first show in Appendix A.2 that the sufficient conditions under which the three measures of linkage – $B_{lj}^{s\text{-}s}$, $B_{lj}^{f\text{-}s}$, $B_{lj}^{f\text{-}f}$ – are equivalent to each other do not hold in the data. Despite these conditions not holding, the three measures of linkage might still differ too little to make the further disaggregation worthwhile. We start by exploring this possibility graphically.

Figure 1 plots the density in backward linkages at the three levels of aggregation.[21] We find that not only the mean linkage varies depending on the level of aggregation used, but that also the dispersion changes. The most disaggregated measure of connectivity shows substantial heterogeneity among firms. The majority of domestic firms have little interaction with MNCs. For a minority of firms, their output is mainly purchased by MNCs. Hence, the "sector-to-sector" measure dramatically smooths out the true density of backward linkages.

For further insights on the drivers of linkage heterogeneity, we first compare the distribution of $B_{lj}^{s\text{-}s}$ to that of $B_{lj}^{f\text{-}s}$. Even conditional on their sector j, local firms differ in how their sales are distributed across sectors k of different sectoral levels of foreign presence (H_k). This finding reflects local firms' selection into or away from selling to more foreign sectors, foreign firms' selection of specific supplying sectors (or vendors in a given sector), or both.

We plot the distribution of firm-level difference between the "sector-to-sector" and "firm-to-sector" backward measures $\left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}s}\right)$ in Figure A4. We learn that most of the distribution lies on the positive side, meaning that $B_{lj}^{s\text{-}s}$ tends to overestimate $B_{lj}^{f\text{-}s}$. Guided by Result 4, we interpret this fact as one suggesting that domestic firms tend to underperform in their sales to more foreign sectors, with respect to what the I-O matrix would predict.

We then compare the distributions of $B_{lj}^{f\text{-}s}$ and $B_{lj}^{f\text{-}f}$. Even conditional on the same shares sold to same sectors, local firms can differ in their actual customers within each sector. Or symmetrically, even when comparing local firms in the same sector j with the same share of their sales to a sector k, these firms might not be equally preferred by an MNC i in sector k.

[21] To ensure internal consistency, we construct I-O coefficients based on our B2B dataset. Concretely, we aggregate firm-to-firm transactions across firms in the supplying and buying sectors. Our procedure leads to different coefficients from those directly available in the official I-O table of the Central Bank of Costa Rica (BCCR). The I-O table of BCCR is based on surveys to a sample of large firms and reflects a series of corrections applied for harmonization with international I-O tables.

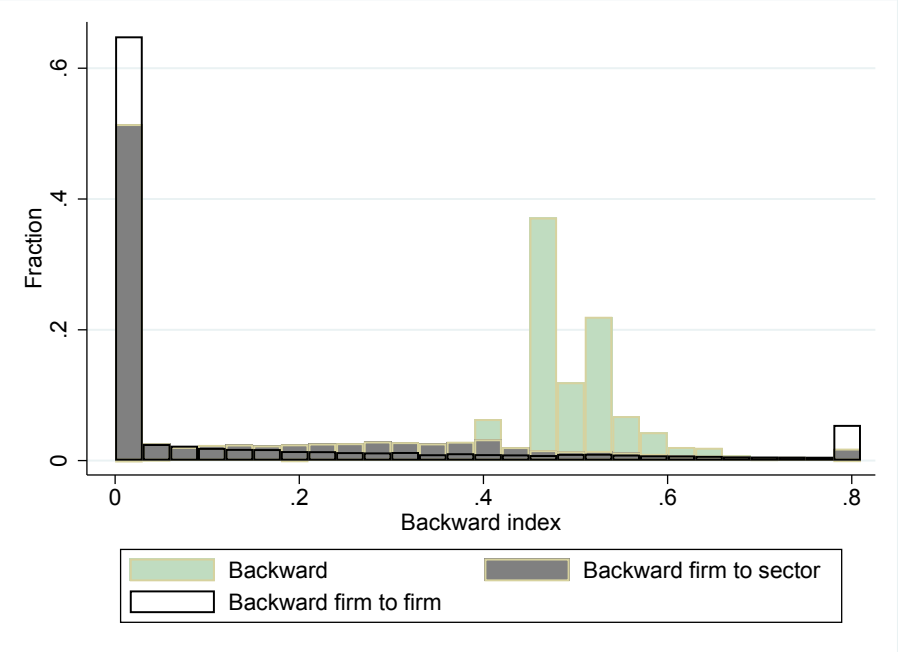


Figure 1: Histograms of firm-level backward linkages

Notes: We construct three firm-level measures of backward forward linkages based on three levels of increasing knowledge on the transactions of a firm. The least data-intensive measure (called "Backward") uses proxies for the extent to which a firm sells to a given sector from I-O tables and for the degree of foreign ownership in those sectors. Constructing "Backward firm-to-sector" requires to know to which sectors a firm sells to, with the foreign ownership of one's clients still being approximated by the sector-level weighted-average ownership. "Backward firm-to-firm" uses the actual B2B transactions data, requiring no further assumptions on the sectors one sells to and the foreign ownership of one's clients.

We define $\left(B_{lj}^{f\text{-}s} - B_{lj}^{f\text{-}f}\right)$ as the firm-level difference between the "firm-to-sector" and "firm-to-firm" backward measures. We plot the density of these differences in Figure A5. Despite finding some dispersion in the distribution and a slightly positive mean, a large mass of the differences is concentrated close to zero. Hence $B_{lj}^{f\text{-}s}$ tends to overestimate $B_{lj}^{f\text{-}f}$, but not by a large margin. In light of Result 7, this finding suggests that on average, the more foreign a firm is, the more likely it is that a the domestic firm would undersell to this foreign firm (relative to its importance in its sector).

We next aim for a quantitative measure of how costly each level of aggregation is. We separate the variation in $\left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}f}\right)$ into its two components: $\left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}s}\right)$ versus $\left(B_{lj}^{f\text{-}s} - B_{lj}^{f\text{-}f}\right)$. We decompose the total sum of squared differences between the I-O matrix prediction $B_{lj}^{s\text{-}s}$ and the actual value $B_{lj}^{f\text{-}f}$ as:

$$\sum_j \sum_{l \in j} \left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}f}\right)^2 = \sum_j \sum_{l \in j} \left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}s}\right)^2 + \sum_j \sum_{l \in j} \left(B_{lj}^{f\text{-}s} - B_{lj}^{f\text{-}f}\right)^2 - 2 \sum_j \sum_{l \in j} \left(B_{lj}^{s\text{-}s} - B_{lj}^{f\text{-}s}\right) \times \left(B_{lj}^{f\text{-}s} - B_{lj}^{f\text{-}f}\right) \quad (3)$$

where the first element of the right hand side of Equation 3 is a measure of the cost of assuming that all firms sell in the same shares to the same sectors, whereas the second element

is a measure of the cost of assuming that firms have the same propensity to sell to foreign clients within a sector. The third element is a covariance term between the two. We find that 83 percent of the variation in the original difference comes from the first element and only 13 percent comes from the second one, with the covariance accounting for 4 percent of the total. This implies that knowing to which economic sectors a given firm sells goes a long way in predicting the level of integration with foreign firms through backward linkages.

With these findings in mind, one comment bears noting. Differences between I-O based proxies of linkage and actual firm-to-firm linkages reflect an equilibrium outcome. Domestic firms differ in their ability and willingness to supply MNCs. As MNCs are likely to have different boundaries of the firm, information sets on the global set of potential suppliers, and production technologies, compared to domestic firms, their sourcing behaviors are also likely to be dissimilar. Hence, discrepancies between I-O based proxies of linkage and firm-to-firm linkages reflect patterns of two-sided heterogeneity.

In what follows, we expose the ways in which MNCs source differently from domestic firms. As we want to avoid attributing to the MNC status what is in fact attributable to one's size, sector or location, throughout this analysis we control for these three firm characteristics. The discussion is based on the results presented in Tables A1 for all sectors in the economy and Table A2 with special focus on manufacturing firms.[22] The tables show results from regressing several firm-level outcomes on a set of year-by-4-digit sector and province fixed effects, a second degree polynomial of log sales, and a foreign owned dummy, which is our explanatory variable of interest. These outcome variables capture what we consider to be the most likely drivers of differentiation in sourcing between MNCs and domestic firms.

Conditional on sector, size, and province, do MNCs have a different share of value added of their total sales than domestic firms? Column 1 of Table A1 shows that once conditioning on a very fine set of fixed effects, foreign firms produce, on average, a robust 6 percent more of value added *in-house*. This difference could reflect both productivity differences between MNCs and domestic firms and a focus of MNCs on processes with a higher in-house value-added.

Conditional on sector, size, and province, do MNCs source a different percentage of their inputs locally, as opposed to importing? Column 2 of Table A1 reports on the share of inputs sourced in Costa Rica (purchased both from domestic and foreign firms) in total inputs. On average, MNCs tend to purchase 7 percent less inputs locally (15 less, in manufacturing). This difference is highly significant. The mean for the local content in inputs is 86 and 83 percent for the full sample and manufacturing firms, respectively.

Conditional on sector, size, and province, do MNCs source a different percentage of their local inputs from domestic (as opposed to foreign-owned) firms? Column 3 of Table A1 reports on the share of inputs purchased from MNCs established in Costa Rica over total inputs purchased in Costa Rica. MNCs tend to purchase a significantly higher percentage of their local inputs from other MNCs. The difference for manufacturing firms is more than twice compared to

[22] Results for both tables are qualitatively very similar but the magnitudes are larger when we focus on manufacturing firms.

that from the sample that uses all sectors (8.6 vs 3.4 percent).

Conditional on sector, size, and province, does the sectoral split of MNCs' purchases differ from the sectoral split of domestic firms' purchases? Column 4 of Table A1 shows differences between domestic and foreign firms in the number of 4-digit sectors from which they source their inputs locally. Foreign firms source on average from 6 percent more sectors. This difference is significant at the 1 percent level, but economically small given that firms source from around six 4-digit sectors on average. We thus find that foreign firms source less of their inputs domestically, but at the same time they source from more economic sectors. While at first sight this might seem counter-intuitive, this finding is consistent with the fact presented in Column 1. Foreign firms tend to outsource locally more of their low-value added tasks and focus on parts of the production process that are more value-added intensive.

Conditional on sector, size, and province, are purchases from a given sector differently concentrated for MNCs than for domestic firms? Column 5 of Table A1 presents positive evidence on this claim. Foreign firms on average source from fewer suppliers within each sector they source from. The difference of 7 percent in the predicted average number of suppliers per 4-digit sector is again statistically significant at the 1 percent confidence level. MNCs concentrate their local purchases within economic sectors relatively more than domestic firms.

3.3 Do I-O Based Assumptions Affect the Estimation of Interest?

While the previous section has shown that more disaggregated data on firm-to-firm transactions reveal strong heterogeneities in linkages to MNCs, this finding does not necessarily imply that these heterogeneities affect the estimation of our object of interest. We now explore the implications of I-O based proxies of linkage on two commonly pursued estimations: (i) the estimation of causal effects of linking to MNCs and (ii) the estimation of descriptive statistics on the aggregate integration of MNCs.

3.3.1 Assumptions Harm the Estimation of Causal Effects of Linking to MNCs

[Work in progress.]

This section presents the dimensions along which firm-to-firm transaction data improve upon previous challenges in the estimation of causal effects using I-O tables alone. As a preview, advantages include: (i) a precise definition of treatment, with an explicit role for firm-to-firm linkages (i.e., with I-O based proxies of linkage one cannot separate between direct treatment effects on actual suppliers to MNCs and indirect treatment effects on competitors to actual suppliers), (ii) the ability to identify a credible control group within the same sector (i.e., with I-O based proxies of linkage, all firms in an upstream sector are considered as equally "treated" by an expansion in foreign presence in a given downstream sector, thus one cannot construct a credible control group within the same sector), and (iii) the identification of the exact moment of a first match, allowing to test for differential pre-existing trends and thus for selection into treatment. Next, this Section explains how the

research designs we propose in Sections 4 and 5 incorporate these improvements. Last, we offer a formal discussion of the conditions under which the aggregation of the causal effects estimated under our two research designs leads to a similar value as that resulting from the aggregation of productivity gains as usually estimated in the literature. Results 6 and 9 are useful at this stage.

3.3.2 Assumptions Harm the Accuracy of Measures of Local MNC Integration

[Work in progress.]

Relying on I-O proxies of linkage can also have large implications on the estimation of descriptive statistics. The accuracy of these descriptive statistics is particularly important when used for policy. For concreteness, we estimate the number of indirect jobs attributable to MNC business in a given country. This statistic is a main pillar in the assessment of benefits from MNC entry by governments, including by the Costa Rican government.[23]

We first estimate, based on I-O table coefficients, the number of indirect jobs credited to MNCs in each sector. We compute the employment in supplying sector j generated by degree-1 linkages with sector k as the total number of workers in sector j, multiplied by the I-O table coefficient of the share of sector j's sales going to sector k. To attribute a part of this indirect employment to foreign firms, we multiply the previous number by the share of sales in sector k generated by foreign firms. For indirect employment of degree-2 or more, we follow a similar logic, weighting the total employment of a sector by the product of the direct and indirect shares of sales.

With the B2B dataset, we compute the indirect number of jobs credited to a given MNC as the sum of the number of workers of all its local suppliers, each number weighted by the share of the sales of that supplier sold to the MNC in question. The assumption embedded in this measure is that workers in a firm are split among tasks serving different customers proportionally to the value of each customer's purchase. This procedure stops at 10 levels of upstreamness.[24]

Table A3 shows striking differences in the two measures of indirect employment. The indirect employment predicted by the I-O table is an over-estimation – by as much as 50 percent – of the indirect employment measured by the B2B dataset. This pattern of over-estimation remains stable across all years in our sample. We also uncover large cross-sector differences in the extent to which the I-O based estimation of the number of indirect jobs differs from the B2B estimation. Table A4 shows that, while I-O proxies for technologically-advanced sectors (e.g., electronic components, medical devices, IT&C) overestimate indirect employment by a factor of 3 to 5, I-O proxies for more traditional sectors (e.g., banana, meat production, retail) underestimate indirect employment by at least a factor of 2.

[23] Find the "Assessment of the Free Trade Zone Regime: Net Benefits for Costa Rica (2011-2015)" (*Balance de las Zonas Francas: Beneficio Neto del Régimen para Costa Rica (2011-2015)*) carried out by Procomer here. One of the main contributions to the estimated benefits is a multiplication of the number of indirect jobs credited to MNCs by the average wage in the economy. The number of indirect jobs is estimated based on the 2011 I-O table of the Central Bank of Costa Rica.

[24] This decision is inconsequential for the estimates and improves computational time.

4 Benefits of Supplying to MNCs: *Productive Linkages* Event Study

As described in Section 3.3.1, the ability to estimate the causal effects of joining MNC supply chains has been constrained by a lack of appropriate data and research designs. The quasi-experimental variation in opportunities to supply MNCs offered by *Productive Linkages* (*Encadenamientos Productivos*) allows us to directly address these challenges.

Productive Linkages is a public program managed by Procomer,[25] Costa Rica's Trade Promotion Agency, which aims to increase the domestic value added for MNCs operating in Costa Rica and help domestic firms start to supply MNCs locally (i.e., export indirectly). This serves as a springboard for later direct access to foreign markets. The program is seen as a catalyst of more local engagement of MNCs and a complementary tool to fiscal policy in improving the investment climate of Costa Rica.[26] The merits of this program and, more broadly, Procomer have also been acknowledged internationally.[27]

Concretely, *Productive Linkages* reduces matching frictions between MNCs in Costa Rica and domestic firms in upstream sectors, by identifying the input needs of MNCs and proposing to the MNC the most suitable local suppliers for each need. These suggested suppliers have been pre-screened by Procomer staff, who carry out thorough evaluations of their potential to join MNC supply chains, resulting in a firm score. The type of information collected by Procomer during this evaluation is not available in administrative datasets (see an example in Figure B7). Hence, Procomer scores provide a more credible resemblance among candidates for a match with an MNC.

The lack of a credible counterfactual has been the main threat to causal inference in this literature. As MNCs choose suppliers to maximize profits, firms securing a deal with an MNC are likely to differ greatly from an average firm in their sector. Firms do not only vary in their observable characteristics, but also in relevant unobservables such as whether they have a manager with good English skills and a vision of firm development through matching with MNCs. The *Productive Linkages* program, by its rankings of suppliers based on their score, already incorporates the most salient of these unobservables.[28]

To our knowledge, this *Encadenamientos Productivos* program provides the first quasi-experimental variation in opportunities to join MNC supply chains across sets of comparable domestic competitors. Greenstone, Hornbeck, and Moretti [2010] addressed a simi-

[25] At its origins in 1999, the program was supported by the Inter-American Development Bank and was known as the *"Supplier Development Project for High-Technology MNCs."* The program has since undergone a number of changes in its organizational structure and name (of which *Costa Rica Provee* or *"Costa Rica Supplies"* was its longest-lasting name). For more details, see Monge-González and Rodríguez-Álvarez [2013].

[26] CINDE, the Costa Rican agency in charge of attracting FDI, added the collaboration with Procomer to foster *Productive Linkages* as a new priority for 2015 to 2018 [CINDE, 2015].

[27] In 2016 the International Trade Centre granted Procomer with the title of "Best Trade Promotion Organization from a Developing Country." For details see this link.

[28] Unobservables relevant to their appeal to MNCs – such as whether the firm has an English speaking employee, whether it has an enterprise resource planning software in place or whether it has the practice of carrying out financial feasibility studies for its projects – are reflected in their Procomer score. The intent to be matched with an MNC is declared by the very participation in the *Productive Linkages* program.

lar problem in the agglomeration spillovers literature by using reported rankings of counties where firms considered opening "million dollar plants" (MDP). Our argument parallels theirs: the suppliers (counties) nearly missing a deal with an MNC (an MDP) offer a valid counterfactual to what would have happened with the winners' performance had they not won the deal.

In contrast to the MDP setup, we also observe the firm scores behind the ranking shared with MNCs. We use these scores to examine whether differences in the scores of winning and losing firms are statistically significant. This test is additional to that contrasting firm characteristics – both in trends and levels – from tax data. We conjecture that a firm's score is the likely input for MNCs on a firm's overall ability to supply an MNC, as MNCs do not have access to complete (and historical) administrative data as researchers do. Tight scores within a ranking would thus be a reassuring finding.

We implement an event study design to estimate the impact of a first match with an MNC through the *Productive Linkages* program on a domestic firm's subsequent performance. Similar to Greenstone, Hornbeck, and Moretti [2010], our event study design can be thought of as a generalized triple-difference design where different firms experience a first match with an MNC in different years.

We compare changes in the performance of first-time suppliers to MNCs both to firms that have not yet become suppliers to an MNC and firms that are never observed to be selling to an MNC within our time frame. The further comparison to contemporaneous outcomes of losing firms for the same deal allows us to derive a more credible estimate of the causal impact of a first match with an MNC. With this last difference we can control for any unobservable heterogeneity that causes selection into the *Productive Linkages* program.

4.1 Data

[Work in progress.]

Procomer has successfully mediated 1,966 deals between 2001 and 2016. For all deals, we observe who the buyer and winning supplier were, the year the deal was made, its amount, and a description of the good or service traded. Commonly purchased goods include machinery, plastic accessories, and chemical products. Among services, metalworking, software development, and plant and equipment maintenance are most frequently procured.

These 1,966 deals correspond to 514 unique suppliers (of which 80 percent are domestically-owned) and 336 unique buyers (of which 73 percent are foreign-owned). In the empirical analysis, we only keep deals involving domestic sellers and foreign buyers. 239 of the 514 unique suppliers have more than one deal mediated by Procomer. For these suppliers, we retain only the deals occurring in their first year of successful matchmaking.

We add 1,149 evaluations undertaken by Procomer between 2004 and 2015. Each evaluation involves a firm visit from a Procomer assessor and a detailed survey. Recent surveys are organized around five modules: productive capacity, market capacity, cooperation, R&D

capacity, and quality.[29] For example, the quality module asks whether the firm has both general quality management certificates (e.g., ISO-9001) and sector-specific certificates (e.g., ISO-13485, quality management requirements for organizations producing medical devices and related services). The cooperation module asks whether the firm has employees able to negotiate in the language relevant to the market it targets.

Each evaluation is concluded with an absolute score, a letter grade category based on the range of the absolute score, and recommendations on which Procomer program the firm is fit to benefit from. The program we study here (*Productive Linkages* or "Linkage," as abbreviated by Procomer) is one option of follow-up. Figure B7 provides an anonymized example of the summary of an actual evaluation for a firm specialized in the manufacturing of plastic bags.

These 1,149 evaluations refer to 921 distinct firms. A firm can therefore be evaluated more than once, with firms more engaged[30] with Procomer being more likely to be re-evaluated for an updated score. To compare winning and losing candidates for a deal, we keep the absolute score of their most recent evaluation carried out prior to that deal.

Centralizing the Procomer data and merging it with the full-universe administrative datasets involved two tasks: (i) summarizing and digitizing those parts of the data shared as PDFs or archived emails and (ii) carefully assigning tax IDs to firms.[31] Fortunately, most firms in Procomer's records are found in administrative datasets as well.[32]

Merging Procomer datasets to administrative datasets allows us to study the matched firms and check the accuracy of Procomer's records (e.g., check the occurrence and amount of a certain match). Moreover, it allows us to compare matches through Procomer with those occurring in the wider economy. As the digitized corporate tax returns and B2B transactions micro-data start in 2005 and 2008 respectively, and as we need at least two years' worth of data after the match, we study first-matches brokered by Procomer between 2007 and 2014.

4.2 Supportive Evidence. *Work in progress.*

4.3 Econometric Model. *Work in progress.*

4.4 Results. *Work in progress.*

4.5 External Validity

A critique that can be raised about any impact evaluation is the extent to which its results may generalize. As Procomer carries out full mappings of the main supplying sectors to MNCs, the program studied here has a comprehensive national reach. The program has

[29] While the structure of the survey evolved across time, there is considerable continuity in the themes covered.
[30] Through several successful matches or through failed matches, which we also observe.
[31] Most data sources referred to firms by a version of their name (e.g., legal name, commercial name, abbreviation).
[32] Firms not found in a tax dataset appear to have closed before the starting year of the digitized version of the tax dataset.

also run for sixteen years, allowing us to estimate dynamic causal effects of joining MNC supply chains.

Moreover, the type of matchmaking service offered by Procomer since 2001 is far from unique across both developed and developing countries (e.g., the American Supplier Initiative in the US or the Local Content Unit in Rwanda [Steenbergen and Sutton, 2017]). A key advantage of our setup is the practice of evaluating suppliers prior to matches and the sharing of the rankings with the MNC, which gives us a plausible control group. In addition, we can directly investigate the external validity of our findings from Procomer matches, as we can compare them – thanks to the B2B transactions dataset – with those from all other matches to MNCs occurring outside this public program. We are not aware of such circumstances in other countries with similar programs.

5 Benefits of Supplying to MNCs: Economy-wide Event Study

One caveat to the *Productive Linkages* exercise is its relatively small sample size, which provides insufficient power to explore heterogeneous treatment effects (effects varying across different types of suppliers) and different responses to heterogeneous treatments (e.g., matches with different types of MNCs). Also, its sample size undermines our ability to detect indirect effects of the match spread through the network of the matched firm. The external validity of this exercise is another possible critique.

We address these concerns with a second research design that exploits the full dataset of firm-to-firm linkages. This design continues to be an event study, where events refer to first matches between domestic firms and an MNC occurring between 2010 and 2014.[33] The key difference to the *Productive Linkages* exercise comes from the definitions of the counterfactual path for winning firms, as will become apparent below.

To fix ideas, suppose that domestic firms have a Cobb-Douglas production technology:

$$log(Y_{it}) = log(A_{it}) + \beta_l log(L_{it}) + \beta_k log(K_{it}) + \beta_m log(M_{it}), \tag{4}$$

where Y_{it} stands for total revenues, L_{it} for the total number of workers, K_{it} for the value of total assets, and M_{it} for the total input costs (excluding the wage bill) of firm i in calendar year t. A_{it}, the total factor productivity of firm i in calendar year t, is our object of interest. We allow $log(A_{it})$ to have a component that depends upon a firm's interaction with MNCs

[33]This restriction is justified by our intention to measure precisely the first year in which a domestic firms sells to an MNC. 2008 was the first year when the D-151 tax form (the base for the B2B dataset) could be filed electronically. However, as 2008 was the year of transition to a digitized filing, firms were still allowed to file the form on paper. Hence, we suspect the 2008 dataset is incomplete. As we look for the first year a domestic firm sells to an MNC, we cannot infer that a firm first observed as selling to an MNC in 2009 was not also selling to an MNC in 2008 but had filed the form on paper in 2008. To avoid mismeasurement of the event year, we only consider matches to MNCs from 2010 onward for domestic firms not found to have sold to an MNC both in 2009 (the first year electronic filings were mandatory) and 2008. See Appendix D for details.

$\left(A_{it}(MNC)\right)$, in addition to a firm fixed effect $\left(\alpha_i\right)$, an interactive fixed effect for the calendar year by province of firm i by 4-digit sector code of i by cohort of i $\left(\lambda_{t\times p(i)\times s(i)\times c(i)}\right)$ and firm-specific shocks in calendar year t $\left(\varepsilon_{it}\right)$,

$$log(A_{it}) = \alpha_i + \lambda_{t\times p(i)\times s(i)\times c(i)} + A_{it}(MNC) + \varepsilon_{it}. \tag{5}$$

We propose two event study specifications for $A_{it}(MNC)$. First, we estimate a more parsimonious specification that simply tests for a productivity shift assumed to occur immediately after the first match with an MNC and to remain constant in subsequent years. In practice, this shift in productivity estimates the average productivity in years post-event with respect to the average productivity in years pre-event, hence the notation $\overline{\theta}_{post}$. We then study yearly effects to learn about the dynamic path of productivity before and after a first match with an MNC.

Mean productivity shift specification for $A_{it}(MNC)$:

$$A_{it}(MNC) = \overline{\theta}_{post}\mathbb{1}\left\{t \geq \tau_i\right\}$$

Yearly effects specification for $A_{it}(MNC)$:

$$A_{it}(MNC) = \sum_{k=\underline{C}}^{\overline{C}} \theta_k D_{it}^k \tag{6}$$

where τ_i is the first year a domestic firm sells to an MNC and $\tau_i \in [2010, 2014]$. To define D_{it}^k, $\underline{C}$ and $\overline{C}$, some context is needed. As customary in an event study, calendar years t are first mapped to their event time equivalent.[34] Even if we had started with a balanced panel of firms of T time periods, as long as we have heterogeneous event dates, the sample is not balanced in event time.[35] Before we define D_{it}^k, we thus need to decide how to handle data outside of the event time window, given by $\underline{C}$ and $\overline{C}$. We follow the approach of "binning up" the endpoints[36] and define $D_{it}^k := \mathbb{1}[t = \tau_i + k]\ \forall k$ such that $\underline{C} < k < \overline{C}$, $D_{it}^{\overline{C}} = \mathbb{1}[t \geq \tau_i + \overline{C}]$, and $D_{it}^{\underline{C}} = \mathbb{1}[t \leq \tau_i + \underline{C}]$, where $\mathbb{1}[.]$ is an indicator function for the expression in brackets being true.

Next, we replace $A_{it}(MNC)$ with the two specifications from equation 6 first in equation 5, then in equation 4, to obtain the two main models for estimation.

[34] For firm i becoming a first-time supplier to an MNC in 2010, τ_i=*2010*, event-year *+1* is *2011* and *-1* is *2009*.

[35] Units experiencing the event earlier have fewer pre-event observations and units experiencing the event later have fewer post-event observations.

[36] For another example of binning endpoints in an event study, see McCrary [2007]. An alternative to "binning up" endpoints is to fully saturate the model, include all event time dummies but only report the event dates with a balanced sample. While we do not report these results for brevity, they are almost identical to those using the "binning up" approach.

Mean productivity shift model:

$$\begin{aligned} log(Y_{it}) =& \alpha_i + \lambda_{t \times p(i) \times s(i) \times c(i)} + \beta_l log(L_{it}) + \beta_k log(K_{it}) + \beta_m log(M_{it}) \\ &+ \theta_1 \mathbb{1}\{t \geq \tau_i\} + \varepsilon_{it} \end{aligned}$$

Yearly effects model:

$$\begin{aligned} log(Y_{it}) =& \alpha_i + \lambda_{t \times p(i) \times s(i) \times c(i)} + \beta_l log(L_{it}) + \beta_k log(K_{it}) + \beta_m log(M_{it}) \\ &+ \sum_{k=\underline{C}}^{\overline{C}} \theta_k D_{it}^k + \varepsilon_{it}. \end{aligned} \tag{7}$$

The sequence of θ_k is our object of interest. In the yearly effects model, because not all parameters are identified as written, we normalize θ_{-1} to zero to simplify the test for an effect on impact. The precise interpretation of the sequence θ_k depends on what we assume for the counterfactual path for winning firms. We implement this event study using two samples, with each sample implicitly defining another counterfactual path.

We start with a sample containing domestic firms that become suppliers to an MNC after 2010 (included) and domestic firms that are never observed as supplying to an MNC in our B2B transactions dataset.[37] These domestic firms are required to satisfy minimal size restrictions of a median number of workers of at least 3 and median total yearly revenues of at least \$25,000 (PPI-deflated to 2013 US\$) across all years appearing in the tax datasets.[38] Last, we exclude firms that are state-owned, registered as households (as opposed to private businesses), NGOs, and those in the financial, construction, and education sectors. See Appendix D.1 for more details.

The resulting large sample size allows us to include narrowly defined fixed effects, i.e., [calendar year $\times$ province $\times$ 4-digit sector code $\times$ cohort] and firm fixed effects. We thus compare outcomes for treated firms in event year k to outcomes in event year *-1* for firms that are of the same age group, in the same narrowly defined sector and province (including oneself). Moreover, the inclusion of never matched firms benchmarks trends in outcomes between the calendar years corresponding to event years k and *-1* to outcomes between the same calendar years for never matched firms. Firm fixed effects already control away firm-specific time-invariant unobservables.

Next, it is important to test whether the two sets of controls – firms not yet matched to an MNC and firms never matched to an MNC – are, in fact, exchangeable. A reasonable concern with using firms never matched to an MNC as control is that MNCs may not randomly choose among firms in a given province, narrowly defined sector, and cohort.

[37] Hence we exclude firms that are observed as supplying an MNC either in 2008 or 2009. For such firms, we cannot identify the first year they become suppliers to an MNC. Results from mean-shift estimations including these firms as well (yearly coefficients cannot be estimated on firms with an unknown event year) are strikingly similar to those from the sample described here and are available upon request.

[38] These firms must also report workers and revenues in all years when they are active for tax purposes.

To address this concern, we reestimate the model without the firms never matched to an MNC and check how the point estimates of θ_k change. While excluding these firms makes us lose power, we can at least examine whether most of our treatment effects are driven by the contrast with these firms never supplying an MNC or by the differential timing of a first match among those eventually becoming suppliers to an MNC. Similarity between estimates for θ_k would suggest that selection into supplying to an MNC is not a major concern. Beyond the restrictions imposed on the larger sample, we require the sample of eventually-matched firms to be balanced in event time between *-2* to *+2*. This avoids results being driven by changes in composition in the neighborhood of events.

When our sample is restricted to domestic firms first matched to an MNC between 2010 and 2014, we use [calendar year $\times$ province $\times$ 4-digit sector code] and firm fixed effects. As we continue to normalize the θ_{-1} coefficient to zero, θ_k, then measures the mean outcomes of matched firms in event year k with respect to the mean outcomes of firms in the same province and narrowly defined sector (including oneself) in the year prior to their first match (in excess of time trends and firm fixed effects).

Some further estimation details bear noting. First, the models in equation 7 are adapted in their outcome variable (here total revenues, Y_{it}), and time-varying controls (here number of workers, total assets, and total input costs excluding the wage bill, i.e., L_{it}, K_{it}, and M_{it} respectively) depending on the exercise. The definition of recurrent variables and general methodology are not altered throughout this section.

Second, whenever we use the sample including firms never matched to an MNC we cluster standard errors at the *2-digit sector* $\times$ *province* level. Whenever we focus on the sample of firms eventually matched to an MNC alone we cluster standard errors at the *event year* $\times$ *province* level. The first clustering choice accounts for possible correlations in outcomes among firms in a certain 2-digit sector and province. Adding *event year* clustering is impossible as event years cannot be assigned to never matched firms. *Event year* clustering is recommended whenever event dates are concentrated on a few values (in our case, 2010 to 2014). While adding sectoral clustering to *event year* $\times$ *province* clustering is too exacting for our smaller sample of eventually matched firms, results from such clustering are qualitatively similar and available upon request.

Last, all yearly effects specifications define $\underline{C} = -4$ and $\overline{C} = +4$. Given the starting and ending years of our tax data panels (see Section 2 for details), from event year *-4* to *+4* we have a nearly balanced sample. Moreover, by construction, the sample containing only firms that become suppliers to an MNC is balanced from event year *-2* to *+2*. We report coefficients beyond the window of full balancing of this sample for transparency.

5.1 Firms Grow in Size after Starting to Supply to an MNC

Table C5 shows the results of running specification 7 adapted to dependent variables capturing firm size: log total sales (including exports) and log total number of workers. Columns 1 and 2 report the event study estimates for the sample including both domestic

firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Columns 5 and 6 focus only on the sample of domestic firms becoming first-time suppliers to an MNC.[39]

Reassuringly, first-time suppliers to MNCs do not exhibit preexisting differential trends with respect to either of the control groups implied by each sample. As all our specifications lack firm-specific trends – including only firm fixed effects – new suppliers to an MNC do not appear to be selected based on their past firm growth.

After their first match to an MNC, firms display robust and long-lasting increases in size. Firms expand from the same year of their first contract with an MNC, increasing their sales by 12 to 15 percent (columns 1 and 5) and workforce by 6 to 7 percent (columns 6 and 2). Their sales improve further in the next three years, when sales reach a plateau at a 20 to 29 percent (columns 2 and 6) higher value than that of the control group in event year *-1*. The number of workers presents a similar levelling off after year three, at a 9 to 20 percent higher value (columns 5 and 2), though this growth seems less robust in the restricted sample.

When comparing only among firms ultimately matched to an MNC we find stronger increases in sales than those from the extended sample. This suggests a slight trend in sales growth also among firms never supplying to an MNC. This phenomenon is reversed for workers: weaker results for the sample of only first-time suppliers suggest that these firms were more efficient in their labor use, particularly relative to their stronger increase in sales.

While first-time suppliers to an MNC experience sizable expansions, one might be concerned that this expansion is a mere mechanical effect of adding a new client to one's portfolio. We now examine whether firms also experience a gain in productivity once becoming a supplier to an MNC.

5.2 Firms Experience Productivity Gains after Starting to Sell to an MNC

In the words of De Loecker and Goldberg [2014], "the voluminous empirical literature on the effects of trade on firm productivity" has mostly "been loose in its use of the term productivity." Most frequently-used measures of productivity lump together physical efficiency and prices (beyond costs, prices also reflect product differentiation and markups). This critique equally applies to the literature on the effects of FDI on firm productivity. Moreover, the FDI literature has mostly been generous in its use of the term "spillovers." A common definition for vertical spillovers would require them to be "positive externalities stemming from the relationships of foreign enterprises with domestic suppliers or customers" [Harrison and Rodríguez-Clare, 2010].

When a backward linkage refers to a supplying contract by a domestic firm to an MNC, one would need to observe the terms of this contract, prices in particular, to be able to show explicitly whether an improvement in physical efficiency has actually occurred or whether

[39]The extended sample in Table C5 is larger than that in Table C7, as the latter requires all firms to report K, L, and M, while the former only requires reporting K and L for 2-factor Cobb-Douglas and translog production functions. Columns 3, 4, 7, and 8 in Table C5 show findings on productivity also apply to this less restrictive sample.

such improvement has already been rewarded through lower prices to the efficiency - enhancing MNC. Lacking contract-specific (or even firm-specific) prices between MNCs and their domestic suppliers, we proceed in steps.

First, we use measures of productivity resulting from production function estimation. We start by assuming a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers, and input costs as input measures for K, L, and M respectively. Given its flexibility, we also use the translog functional form, which is a second-order approximation to general production functions. For both Cobb-Douglas and translog, we estimate the coefficients on factors of production over the entire sample of domestic firms, controlling for narrowly defined fixed effects.

We also construct a productivity index for the Cobb-Douglas production function, as proposed in Syverson [2011] and Greenstone, List, and Syverson [2012]. Instead of regressing sales on input usage and estimating the input coefficients, this method "residualizes" sales by subtracting firm-level inputs used, weighted by the respective 2-digit-level cost shares. Concretely, the Cobb-Douglas productivity index dependent variable is $Y_{ist} - \alpha_{k,s2D} \times K_{ist} - \alpha_{l,s2D} \times WB_{ist} - \alpha_{m,s2D} \times M_{ist}$, where $\alpha_{l,s2D}$=(2-digit sectoral wage bill)/(2-digit sectoral revenues), $\alpha_{m,s2D}$=(2-digit sectoral input costs)/(2-digit sectoral revenues), and $\alpha_{k,s2D} = 1 - \alpha_{l,s2D} - \alpha_{m,s2D}$ (avoiding the need to measure capital costs).

Tables C6 reports mean shift event study results for the extended sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Columns 1 to 3 use fixed effects defined at the [calendar year $\times$ province $\times$ 4-digit sector code] level, whereas Columns 4 to 6 impose even more narrowly-defined fixed effects at the [calendar year $\times$ province $\times$ 4-digit sector code $\times$ cohort] level. All columns include firm fixed effects. Across measures of productivity and combinations of fixed effects, becoming a first-time supplier to an MNC is estimated to bring a boost in productivity of 5 to 8 percent.

Table C7 displays similar patterns to those observed for firm expansion. Firms ultimately matched to an MNC do not display differential pretrends in any of these measures of productivity. Both when compared to firms never matched to an MNC or among themselves, first-time suppliers do not appear to be selected into supplying to an MNC based on a history of productivity growth. First-time suppliers are found to experience an improvement in productivity from the same year of their first match, an improvement which is amplified in the next three years to the point of reaching a plateau from 8 (column 1) to 17 percent (column 6) higher than the one in event year *-1*.[40]

Columns 4 to 6 offer estimates of the post-event coefficients that are consistently larger than those in columns 1 to 3. This points to the existence of weaker, yet positive trends of productivity for domestic firms never matched to an MNC that are of the same age and in the same 4-digit sector and province as first-time suppliers. This finding could be explained by agglomeration externalities *à la* Marshall [1890].

[40]Table C8 focuses on the extended sample and shows that results are not driven by our choice of the event window.

Measures of productivity employed so far are to varying extents vulnerable to simultaneity and selection biases, as illustrated by De Loecker and Goldberg [2014]. Given that these measures cannot yet cleanly identify productivity, we are currently implementing state-of-art techniques that make additional assumptions to allow identification, as in Ackerberg, Caves, and Frazer [2015].

Table C9 proposes additional measures of firm performance, which have the advantage of transparency over those based on production function estimation. All columns present event study estimates over the sample of firms both never and eventually supplying to an MNC. Column 1 uses as dependent variable log sales per employee, column 2 uses log value added per employee, while column 3 uses log profits per employee. All three measures exhibit a strong boost after the first match to an MNC and a leveling off three years into being a supplier to an MNC. While these measures do not distinguish between physical efficiency and price/markup treatment effects either, they confirm strong and persistent gains in the combination of the two effects.

Next, we exploit our ability to not only observe relationships between domestic firms and their MNC clients, but also all other business relationships of these domestic firms. Columns 4 and 5 in Table C9 explore how the value of sales to domestic clients and the number of domestic clients evolve after a domestic firm becomes a supplier to an MNC.[41]

Interestingly, in the year of their first match to an MNC, firms experience a relative dip in domestic sales of 8 percent. In the following years domestic sales slowly increase relative to the control group and event year *-1*, to the point of reaching an 11 percent relative growth. The number of domestic clients also rises gradually, arriving to 20 percent more domestic clients or 2 more clients relative to the average number of domestic clients of 10.

Table C10 investigates whether domestic clients of a first-time supplier to an MNC also see their productivity improve after the event of this supplier. We measure productivity as in Table C7. To enter this estimation, domestic clients need to have never sold to an MNC themselves and need to be purchasing at least 10 percent of their local inputs (in value) from the supplier triggering the event. If a domestic client has several suppliers that start selling to an MNC, its event year is set as the event year of its most important supplier among them.

While the statistical significance of point estimates is not robust across specifications, point estimates are positive and have a magnitude gradually rising in time. Columns 4 to 6 focus only on the set of domestic clients of firms that eventually become suppliers to an MNC. For these domestic clients, we show that — four years after one of their significant suppliers has started selling to an MNC as well – their productivity is 12 to 13 percent higher.

These findings provide empirical support for the theory of Rodríguez-Clare [1996] and Carluccio and Fally [2013]. Rodríguez-Clare [1996] proposes a formal concept of linkages between MNCs and domestic firms and a formal theory of their importance. A combination of the love of variety for inputs in the production of final goods and increasing returns to scale in the production of inputs (those demanded by MNCs, most importantly, but not

[41] Domestic clients include both domestically-owned firms and state-owned entities.

only) leads to a productivity boost for domestic final-good producers.

More recently, Carluccio and Fally [2013] develop a model that assumes that foreign firms - with an advanced technology – require different inputs than those of firms with the domestic technology. These authors provide a formal framework for pecuniary externalities, in which the love of variety in inputs and the cost advantage of inputs demanded by foreign firms benefit the more productive domestic firms.[42]

The slow increase in (revenue-based) productivity for domestic clients could thus reflect an adjustment period to the new products and services offered by the supplier to an MNC or, as in Carluccio and Fally [2013], the costly adoption of the foreign technology. Symmetrically, the dip then slow increase in domestic sales of first-time suppliers to an MNC could also indicate a process of transition of domestic clients to the new varieties offered by the first-time supplier. The lack of firm-level prices for inputs and output limits our ability to discriminate between the pecuniary and non-pecuniary parts of these externalities.[43]

Nonetheless, Tables C9 and C10 suggest that benefits from supplying to an MNC are not limited to higher mark-ups tolerated by the MNC – first-time suppliers end up expanding their domestic business as well and trigger performance gains to domestic clients.[44]

5.3 Firms Change Behavior after Starting to Supply to an MNC

In Table C11, we continue to exploit our ability to observe exactly which firm becomes a supplier to an MNC and when. This table uses the extended set of firms consisting of both first-time domestic suppliers to an MNC and domestic firms never observed selling to an MNC. Rich firm-level data allows us to study how firms react to their joining MNC supply chains. Overall, Table C11 reveals that first-time suppliers made technological and organizational changes – e.g., in factors of production and sourcing strategy – that are incompatible with MNCs inducing price effects alone.

Column 1 shows that firms increase their total assets by up to 16 percent 4 years into supplying to an MNC. Firms also increase their input costs by up to 17 percent over the same period, with importing firms experiencing a dramatic boost in the value of their imports of up to 43 percent. Among importing firms, not only do they import substantially more but imports replace 3 to 5 percent of inputs previously locally-sourced.

Firms starting to supply to an MNC are also found to adjust their workforce. Column

[42] Only the most productive domestic firms are able to switch to the foreign technology.

[43] Kee [2015] collects survey data from the garment sector in Bangladesh that allows her to observe which domestic firms share suppliers with MNCs. In addition, she collects firm-level input and output prices, which she then uses to deflate material costs and sales. Consequently, the shared-supplier spillovers on domestic firms measured by Kee [2015] are more credibly non-pecuniary in nature.

[44] Anecdotal evidence collected by the authors during interviews with suppliers to MNCs suggests that the contrary occurs in practice: suppliers to MNC have to lower their mark-ups to compete, for instance, with imports exempted from custom duties through the Free Trade Zone regime (28 percent of the sales of MNCs triggering the first matches studied here are made by firms part of the FTZ regime). Interviews conducted by Javorcik, Keller, and Tybout [2008] with suppliers to Wal-Mart in Mexico reveal the "take-or-leave-it" bargaining style of Wal-Mart and thus the very low profit margins suppliers must agree to when selling to Wal-Mart. In the Czech Republic, surveys find that 37.5 percent of suppliers were required by their MNC customers to lower their prices by 1 to 30 percent [Javorcik, 2008].

5 reports event study estimates on firms' average wage bill. While the MNC treatment led to a 2 percent increase in average wages 3 to 4 years after the event, this result might confound the hiring of better-paid employees with an increase in the pay of pre-existing employees. Ideally, one would like to distinguish between these two levers of adjustment.

While we do not observe the identity of workers before and after the match to an MNC, we know how many workers in a given year are labeled as high-skill (i.e., he/she earns more than the minimum wage paid to a worker with vocational post-high school training). This measure has the caveat that a too wide range of skills is reduced to a single category of skill, not permitting us to analyze more subtle changes in the within-firm skill distribution. That said, Column 6 shows that the number of high-skill employees of a firm increases by up to 12 percent 4 years after the first match to an MNC. However, the increase in the proportion of high-skill employees in the firm is not statistically significantly different from zero (Column 7). Given the caveat just mentioned, the skill-composition may have still changed after the first match to an MNC – however in ways not captured by the threshold defined above.

5.4 Productivity Gains are Heterogeneous across Firms' Characteristics

We first inquire on the degree of heterogeneity in treatment effects based on characteristics of domestic suppliers. Then we document whether heterogeneous treatments, i.e., matches occurring with MNCs of different characteristics, generate different responses. Evidence of heterogeneity in productivity gains would be of interest for public policy, especially for programs or incentives that discriminate across the supplier or MNC characteristics driving such heterogeneity. In addition, patterns of heterogeneity in productivity gains based on supplier or MNC features can be suggestive of the channels behind these gains.

Table C12 focuses on suppliers in the three most populated sectoral groups: manufacturing, retail, and services. Columns 1 to 3 are based on the extended sample, and columns 4 to 6 on the sample containing only firms that become eventually matched to an MNC. Each column is the result of a different regression preserving only the firms in the titled sector.

Four patterns stand out in Table C12. First, suppliers from retail - the most frequent sector both in the broader and restricted sample - either experience no gain or a weaker gain in productivity (Columns 5 and 2) upon getting matched to their first MNC. Second, firms operating in manufacturing and services experience comparable productivity boosts within each sample, boosts which are significantly stronger than in retail. Third, the improvement in performance for firms in manufacturing appears as more sluggish (Columns 1 and 4) than that in services (Columns 3 and 6).[45] Last, for both manufacturing and services, the stronger results obtained from the restricted sample imply productivity spillovers to firms in the same 4-digit sector and province.

Next, we use our knowledge of the number of high-skilled workers among all workers employed by a firm each year. We assign to each firm its mean share of high-skilled workers

[45] To the extent that firms in manufacturing have higher costs of adjustment to new technologies or processes, this result becomes intuitive.

across all years when the firm is active. These firm-level mean shares form an economy-wide distribution that we split in three equally-sized bins: the bottom 33 percentiles, the central 34 to 67 percentiles and the top percentiles between 68 and 99. In Table C13, we then investigate whether productivity gains are distinct across bins of firm-level mean shares of high-skill. Columns 1 to 3 run separate event studies for each bin, whereas Column 4 reports results from a pooled regression testing a difference in event study coefficients for the central bin compared to the bottom and top bins combined.

Domestic suppliers in the central bin of firm-level high-skill composition seem to experience smaller and weaker productivity gains than those in the bottom and top bins. While this difference fails to attain statistical significance at conventional levels, it is suggestive of a mild U-shaped relationship between a firm's share of skilled workers and its ability to benefit from supplying to an MNC.

In Table C14 we turn to the sector of MNCs triggering our events. Joining the supply chain of an MNC in the retail sector is found to not improve suppliers' performance, whereas joining the supply chain of an MNC either in manufacturing or services leads to robust boosts in productivity. This finding contrasts with evidence from Romania, where a 10 percent increase in the number of foreign retail chains' outlets is found to be associated with a 2.4 to 2.6 percent boost in TFP for food suppliers [Javorcik and Li, 2013].

Table C15 proposes a different split of event-triggering MNCs between those part of the Free Trade Zone (FTZ) regime and those outside of this regime. To be granted access to an FTZ, MNCs need to be export-oriented, conduct scientific research, *or* be part of a "strategic sector" (e.g., advanced manufacturing and life sciences). Most MNCs in an FTZ meet all three criteria. We find evidence that domestic firms who join the supply chain of an MNC in an FTZ see their productivity rise by up to 9 percent more than for those joining the supply chain of an MNC outside of FTZs (Column 3). This finding is consistent with several explanations, e.g., a different sectoral composition for MNCs inside and outside FTZs or the starker quality-upgrading imposed by export-oriented MNCs (mostly under the FTZ regime). The limited number of first matches after 2010 to an MNC in an FTZ provides insufficient power to discriminate among these explanations with confidence.

Alternatively, in C16 we classify MNCs into three equally-sized bins based on their mean share of skilled workers by the same method introduced above. Again, Columns 1 to 3 run separate event studies for each bin of skill for the purchasing MNC, whereas Column 4 reports results from a pooled regression testing a difference in event study coefficients for the central bin compared to the bottom and top bins combined. We learn that gains in productivity for suppliers are not increasing in the skill-intensity of MNCs, but rather follow and inverted U-shape.

Productivity improvements for domestic firms that start supplying to intermediately-skilled MNCs are up to 7 percent higher than for those that start supplying MNCs in the extremes of the skill distribution of MNCs. Given the narrowly defined fixed effects used in the regression in Column 4, this result is not simply driven, for instance, by a differential

selection of sectors into supplying MNCs of different skill-intensities. Note that the range of high-skill shares for MNCs in the bottom bin – [0.15, 0.55) – corresponds to ranges in the center and top bins – [0.05-0.34) and [0.34-1) – of high-skill shares for domestic suppliers. Thus, medium-ranged MNCs are comparable in high-skill shares to top-ranged domestic suppliers. Meanwhile top-ranged MNCs, placed between [0,80-1), are more clustered at the right-tail of high-skill shares than top-ranged suppliers, located between [0.34-1].

Taken together, the evidence from Tables C13 and C16 supports the conjecture that more skill-intensive MNCs are likely to provide stronger opportunities for productivity growth – plausibly through larger knowledge transfers. However, with a too wide gap in the skill-intensity of suppliers and MNCs, the latter might lack the capacity to absorb the knowledge transferable by the most skill-intensive MNCs.

5.5 Ruling Out Alternative Hypotheses

In this final step, we rule out alternative explanations that could explain the patterns in the data. There are two main competing hypotheses.

5.5.1 Firms do not Improve Their Third Party Reporting after Starting to Sell to an MNC

One alternative hypothesis is that domestic firms starting to supply to an MNC improve their tax compliance in such a way that it could generate gains in firm productivity of the type we estimated in previous sections. To the extent that MNCs are under increased scrutiny by tax authorities, one could speculate that a first match to an MNC is a form of "sunshine as disinfectant."

Firms in Costa Rica have to report in the D-151 form all their transactions with corporate suppliers and clients of a yearly total amount above $4,400. In theory, the incentive structure of D-151 is one that predicts few inconsistencies between reports of the buyer and supplier of a transaction. But when tax authorities lack resources to pursue all anomalies in reporting, odds of being audited are not equally distributed across transactions and firms. The self-regulating benefit of third-party reporting is weakened for transactions or firms under lower scrutiny. Pomeranz [2015] finds that randomly-assigned audit announcements lead to an increase in value added tax payments by suppliers of treated firms. By a similar logic, if first-time suppliers to MNCs perceive MNCs as more prone to audits than domestic clients, these suppliers may improve the quality of their D-151 reporting.

Table C17 uses as dependent variables three measures of quality in reporting. As D-151 allows for cross-checks of consistency in the buyer's and seller's records of each transaction, these measures are built based on D-151. We use here the raw version of D-151, as opposed to the version used for analysis in all other sections (see Appendix D.2 for details). As firms can improve their reporting in two ways (reducing gaps in reported values for mutually-declared transactions and reducing the frequency of transactions that are not mutually declared), dependent variables capture both levers. Columns 1 to 3 focus on the extended

sample including firms never matched to an MNC, Columns 4 to 6 on the restricted sample containing only firms becoming suppliers to an MNC.

The first measure – called "Seller-diff" – is a weighted average of the percentage difference in values reported, across all transactions in a year for which a firm is the seller. The percentage difference is computed as the (maximum value reported-minimum value reported)/(minimum value reported). "Seller-diff" uses as weights the importance of the transaction in that year for the seller. If buyers are persistently those reporting larger amounts than sellers, as tax evasion incentives would suggest, then "Seller-diff" captures the amount of under-reporting of one's sales compared to what is reported by one's buyers. "Buyer-diff" is analogously constructed, this time keeping only transactions for which a firm is the buyer. If incentives act as just described, then "Buyer-diff" reflects the amount of over-reporting of one's purchases, compared to what is reported by one's sellers.[46] Columns 1, 2, 4, and 5 find no changes in either behavior.

The third measure of reporting quality focuses on unreciprocated reports of a transaction (i.e., transactions that can be found only in the D-151 forms of one party), as opposed to discrepancies in amounts declared between two-sided reports. "Mis-Seller" is defined as (the total number of buyers that reported a given firm as a seller, buyers that are not reported back by the seller)/(the total number of buyers of the said selling firm). Columns 3 and 6 in Table C17 display no clear pattern of increased reporting of one's buyers.

These findings from D-151 records confirm that domestic firms that join MNC supply chains do not improve their compliance in third party reporting. Furthermore, in previous sections we have found marked increases in a wide array of firms' size and performance measures. Given that most of these measures either do not have a direct link to a firm's tax liability or imply an opposite behavior of what would be predicted by a mere reduction in tax-evasive behaviors, it is unlikely that tax compliance effects could reproduce them all.[47]

[46] We claim this measure captures, to first order, the over-reporting behavior of the treated buyer – as opposed to under-reporting behavior of the supplier to the treated buyer. The intuition is that treatment is plausibly more efficient in improving reporting for the treated firm itself than for sellers to the treated firm. This intuition is confirmed in Pomeranz [2015], whose estimated increase in value added payments is significantly higher for treated firms than for their suppliers. An analogous argument applies for "Seller-diff".

[47] Costa Rica imposes increasing average tax rates on profits as a function of a firm's revenue. The resulting tax schedule exhibits two notches at the US$150,000 and US$300,000 (2015, PPP) revenue thresholds where the average tax rate applied to profits jumps first from 10 to 20 percent, then from 20 to 30 percent. [Bachas and Soto, 2016] find two behavioral responses: (i) some firms reduce their revenue below these thresholds, as to lower the tax rate they face on their entire profit base and (ii) firms remaining above these revenue thresholds respond to the higher tax rate by reducing their reported profits. These authors show that costs are relatively easier to manipulate, compared to revenues. In our study, had costs been artificially high prior to a first deal with an MNC, a higher scrutiny on firms dealing with MNCs would imply a lowering of potentially inflated prior costs. The marked boost in input costs reported in Column 2 of Table C11 suggests a legitimate expansion in operations. Moreover, in light of Costa Rica's tax system, persistent boosts in measures of performance per worker (e.g., Sales/Worker, Value Added/Worker, Profits/Worker, or Wage Bill/Worker) and of productivity (based on production function estimation and a productivity index) are implausible behavioral responses to what may be a heightened scrutiny on one's tax compliance.

5.5.2 Not Just a Demand Story: Event Study of Becoming a Government Contractor

MNC clients may differ from domestic clients in more than their potential for knowledge spillovers, but also in features of their contracts that are themselves attractive to domestic suppliers. Reliable payment,[48] the potential for future scaling of the collaboration, transparent and efficient decision-making are attractive features of selling to an MNC client. A natural question then arises: How important is it that the demand shock comes from an MNC affiliate? Could other types of demand shocks – sharing relevant features with a demand shock from an MNC – replicate our findings?

To address these questions, we study the effects of public procurement on domestic firms. Government public procurement accounted for approximately 15 percent of the 2014 Costa Rican GDP (excluding oil revenues) [OECD, 2015]. Typically, over 90 percent of Government purchases are carried out by five autonomous institutions: the Costa Rican Electricity Institute (*Instituto Costarricense de Electricidad*), the National Road Council, the Costa Rican Department of Social Security (*Caja Costarricense de Seguro Social*), the Costa Rican Oil Refinery (*Refinadora Costarricense de Petróleo*) and the National Bank of Costa Rica [OECD, 2015]. Hence, Government purchases share with MNC purchases features of reliability and scale. Moreover, once a firm is already pre-registered and pre–qualified, future contracts with the Government are more likely to occur.[49]

In terms of process, Government entities generally acquire their goods and services through public tenders, which are advertised in the official legal bulletin, *La Gaceta*, and other major newspapers. In 2010, the Government of Costa Rica created an electronic platform for public procurement called Mer-Link.[50] Mer-Link allows for a transparent search of both open and closed public tenders, with a detailed description of the product or service procured. All firms are evaluated in their ability to fulfill a given contract, with the details of the evaluation available for public consultation. This evaluation process has similar learning benefits to the evaluations carried out by Procomer through its *Productive Linkages* programs and to audits carried out independently by MNCs prior to contracting a new supplier.[51]

Therefore, we study a new treatment, defined as a first sale to the Government. As before, data constraints require such a sale to occur between 2010 and 2014. To avoid overlapping treatments, we only preserve domestic firms that have never supplied to an MNC. We continue to use the event study methodology described at the beginning of Section 5, altered only in the event of interest. We repeat for the set of first-time suppliers to the Government

[48] The same argument is made in Ferraz et al. [2016]: the Government is a more reliable payer than most private parties. This reliability gives vendors security that the terms of the contract will be respected, which encourages them to make the investments necessary to fulfill the contract.

[49] Similar to contracting with MNCs, contracting with the Government presents a learning curve about the demand for one's products. Ferraz, Finan, and Szerman [2016] show that in Brazil, winning a Government contract leads to firm growth, not only because firms are more likely to win more contracts in the future, but also because they enter more valuable auctions and access more product markets.

[50] To access the Mer-Link website, see here. Mer-Link coexists with another purchasing system, called CompraRed, but Mer-Link has grown into the dominating platform.

[51] Javorcik [2008] argue that audits by MNCs can be invaluable to local suppliers, as they shed light on operational deficiencies previously unknown to suppliers.

all regression exercises conducted for first-time suppliers to an MNC. Those exercises employing the extended sample of first-time suppliers and firms never supplying to an MNC are replicated with an extended sample of first-time suppliers to the Government and firms never supplying to the Government.

Table C18 is the analog of Table C5, with the event and samples adapted to the current exercise. We find that in the extended sample firms increase more modestly in size than after a first match with an MNC, whereas in the sample preserving only first-time suppliers to the Government the gains in size are no longer statistically different from zero. Switching to measures of productivity, Tables C19, C20, and C21 are the counterparts of prior Tables C6, C7, and C8. The new tables exhibit significantly smaller and shorter-lived improvements in productivity, which are not robust across samples and definitions of the dependent variable. The same pattern emerges from the comparison of Table C22 to Table C9: alternative measures of firm performance are either found unchanged by the event of starting to supply to the Government or found as only modestly improved in the year of the event alone.

The most striking finding in Table C22 is the one in Column 4. Public purchases are found to substitute purchases from domestic private firms, which is consistent with a lack of improvement in firm size and performance. This effect contrasts with that displayed in Column 4 of Table C9. For first-time suppliers to an MNC, at the beginning, sales to the MNC crowd out sales to domestic firms, but from event year *+3* onward, domestic sales experience a boost as well. Findings for first-time suppliers to MNCs are also consistent with those firms' estimated increases in firm size and performance.

We conclude that our estimated productivity gains from joining MNC supply chains cannot simply capture demand effects. The lack of (or the weakness and short-term nature of) gains from starting to sell to the Government suggests that there are additional features of matches to MNCs, plausibly knowledge spillovers, that explain productivity gains.

6 Conclusion

Work in progress.

Attracting MNCs has been long perceived as a short-cut for developing countries to boost their aggregate productivity. Whether MNCs actually integrate in the rest of the economy and bring productivity gains for those domestic firms with whom they do business is of great interest for policy. The debate on these questions has not yet been conclusive due the lack of appropriate data – i.e., one that allows to observe matches between MNCs and domestic firms – and the lack of research designs able to warrant a causal interpretation of estimated productivity gains.

We address these questions by using a confidential administrative dataset that tracks all firm-to-firm transactions in Costa Rica and two empirical strategies that identify the causal effects of becoming a supplier to an MNC. Proxies of MNC linkages based on Input-Output tables conceal heterogeneities in buyer and supplier characteristics relevant to the

estimation of both the countrywide integration of MNCs and causal effects of matching to an MNC. We provide evidence on striking patterns of linkage heterogeneity and their implications for the estimations just mentioned.

We then causally identify the impact of becoming a supplier to an MNC by means of a unique government program, *Productive Linkages*, that matches MNCs with domestic firms. We show that joining MNC supply chains led to strong and persistent gains in firm size and productivity. We add to the *Productive Linkages* exercise an economy-wide event study that, due to its larger sample size, allows us to investigate levers of adjustment to joining MNC supply chains, heterogeneities in treatment effects based on supplier or MNC characteristics, and spillovers of productivity to domestic clients.

Our findings do not simply reflect firms' response to demand shocks, price effects, or improvements in tax compliance. Instead, they are suggestive of knowledge transfers by MNCs that influence suppliers' production technology and organization, input choices and relationships with domestic clients. Overall, our results imply that while MNCs are not deeply integrated in Costa Rica, firms joining their supply chains are greatly benefited. In a different project, we aim to quantify the general equilibrium implications of these results.

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A Local Depth of MNC Supply Chains: B2B vs. I-O

A.1 Derivation of Results Comparing New and Existing Measures of Backward Linkages to MNCs

A.1.1 Results 1, 2, and 3

In this Appendix subsection we expand our derivation of the Results 1, 2, and 3, presented in Subsection 3.1.

Result 1. *For firm l in sector j, $\alpha_{ljk} = \alpha_{jk}$ for $\forall k$ is a sufficient condition for $B^{f\text{-}s}_{lj} = B^{s\text{-}s}_{lj}$. To the extent that a firm l in sector j has the same sectoral decomposition for its output sales as its sector j aggregate decomposition, $B^{f\text{-}s}_{lj}$ does not improve upon $B^{s\text{-}s}_{lj}$.* □

Result 2. *For firm l in sector j, $\frac{Y_{lj\to k}}{Y_{lj\to ik}} \times \frac{Y_{ik}}{Y_k} = 1$ (or $\frac{Y_{lj\to ik}}{Y_{lj\to k}} = \frac{Y_{ik}}{Y_k}$) for $\forall i$ foreign and $\forall k$ is a sufficient condition for $B^{f\text{-}f}_{lj} = B^{f\text{-}s}_{lj}$. To the extent that knowing the contribution of firm i to sector k's output ($\frac{Y_{ik}}{Y_k}$) is enough to capture the share of output of firm l in sector j sold to firm i of all the output sold by firm l to sector k ($\frac{Y_{lj\to ik}}{Y_{lj\to k}}$), then $B^{f\text{-}f}_{lj}$ does not improve upon $B^{f\text{-}s}_{lj}$.* □

Result 3. *If for $\forall i$ and $\forall k$, $FS_{ik} = H_k$, then $B^{f\text{-}f}_{lj} = B^{f\text{-}s}_{lj}$ for $\forall l$ in $\forall j$. To the extent that any buying firm i in sector k has the same foreign ownership share as the weighted-average H_k for its sector, then $B^{f\text{-}f}_{lj}$ does not improve upon $B^{f\text{-}s}_{lj}$.* □

Proofs: Let us first start by writing the three different measures of backward linkages: "sector-to-sector" $B^{s\text{-}s}_{lj}$, "firm-to-sector" $B^{f\text{-}s}_{lj}$ and "firm-to-firm" $B^{f\text{-}f}_{lj}$. These definitions are the same ones presented in Subsection 3.1:

$$B^{s\text{-}s}_{j} = \sum_k \frac{Y_{j\to k}}{Y_j} \times H_k = \sum_k \alpha_{jk} \times H_k, \tag{A1}$$

$$B^{f\text{-}s}_{lj} = \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \sum_k \alpha_{ljk} \times H_k, \tag{A2}$$

$$B^{f\text{-}f}_{lj} = \sum_{i=1}^{N} \frac{Y_{lj\to i}}{\sum_{i=1}^{N} Y_{lj\to i}} \times FS_i = \sum_{i=1}^{N} \frac{Y_{lj\to i}}{Y_{lj}} \times FS_i. \tag{A3}$$

Result 1 is evident replacing α_{jk} in Equation A1 for α_{ljk} in Equation A2. Equation A3 adds the last layer of information allowed by our B2B transactions dataset (i.e., information on the actual identity of the clients of firm l in each sector k). While the backward linkage measure $B^{f\text{-}s}_{lj}$ was already customized to each firm's sectoral composition of sales, the new measure we define ($B^{f\text{-}f}_{lj}$) makes the customization complete, by acknowledging differences across firms in their actual clients.

Let us now reorganize the N firms in the economy across their main sector k and take

out the common factor of $1/Y_{lj}$:

$$B_{lj}^{f\text{-}f} = \sum_{i=1}^{N} \frac{Y_{lj\to i}}{Y_{lj}} \times FS_i = \sum_k \sum_{i\in k} \frac{Y_{lj\to ik}}{Y_{lj}} \times FS_{ik} = \frac{1}{Y_{lj}} \sum_k \sum_{i\in k} Y_{lj\to ik} \times FS_{ik}. \tag{A4}$$

To identify a sufficient condition under which $B_{lj}^{f\text{-}f} = B_{lj}^{f\text{-}s}$, we rewrite $B_{lj}^{f\text{-}s}$ by making the formula of H_k explicit, factorizing out $1/Y_{lj}$ and introducing $Y_{lj\to k}$ into the summation over all firms i in sector k:

$$B_{lj}^{f\text{-}s} = \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \frac{1}{Y_{lj}} \sum_k Y_{lj\to k} \times \frac{\sum_{i\in k} Y_{ik} \times FS_{ik}}{\sum_{i\in k} Y_{ik}} = \frac{1}{Y_{lj}} \sum_k \sum_{i\in k} Y_{lj\to k} \times \frac{Y_{ik}}{Y_k} \times FS_{ik}. \tag{A5}$$

We can further explore equation A5 by multiplying and dividing by $Y_{lj\to ik}$ inside the second summation of the last step:

$$B_{lj}^{f\text{-}s} = \frac{1}{Y_{lj}} \sum_k \sum_{i\in k} Y_{lj\to ik} \times FS_{ik} \times \frac{Y_{lj\to k}}{Y_{lj\to ik}} \times \frac{Y_{ik}}{Y_k}. \tag{A6}$$

Comparing the last expressions in equations A2 and A3, we obtain Result 2.

Lastly, Result 3 becomes apparent when instead of making the formula of H_k explicit in $B_{lj}^{f\text{-}s}$, we write $Y_{lj\to k}$ as a summation of $Y_{lj\to ik}$ acros all firms i in sector k. Thus, Result 3 comes from the comparison of equations A4 and A7:

$$B_{lj}^{f\text{-}s} = \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \frac{1}{Y_{lj}} \sum_k Y_{lj\to k} \times H_k = \frac{1}{Y_{lj}} \sum_k \sum_{i\in k} Y_{lj\to ik} \times H_k. \tag{A7}$$

□

A.1.2 Results 4, 5, and 6

In this Appendix subsection we expand our derivation of Results 4, 5, and 6, presented in Subsection 3.1.

Result 4. $B_{lj}^{s\text{-}s} = B_{lj}^{f\text{-}s} + \kappa \times Cov(\alpha_{jk} - \alpha_{ljk}, H_k)$. *Whenever a firm l in sector j has the tendency to underperform in its sales to more foreign sectors k with respect to the sector-level I-O based share of sales to these sectors (i.e., has the tendency to have $\alpha_{ljk} < \alpha_{jk}$ for sectors k with a higher weighted-average foreign presence, H_k), then $B_{lj}^{s\text{-}s}$ overestimates $B_{lj}^{f\text{-}s}$. Note that when the sufficient conditions in Result 1 hold, the covariance term becomes zero and we recover the equality between $B_{lj}^{s\text{-}s}$ and $B_{lj}^{f\text{-}s}$.* □

Result 5. $B_{lj}^{s\text{-}s} = \sum_{l\in j} s_{lj} \times B_{lj}^{f\text{-}s}$. *The sector-level $B_{lj}^{s\text{-}s}$ is a weighted-average of $B_{lj}^{f\text{-}s}$ across all firms l in sector j, with the weights given by the share of output of each firm l in its sector j.* □

Result 6. *$B_{lj}^{s\text{-}s} = \overline{B_{lj}^{f\text{-}s}} + N_j \times Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right)$. To the extent that B_{lj}^{f-s} and s_{lj} are uncorrelated in a sector j, $B_{lj}^{s\text{-}s}$ is equal to the (unweighted) average of $B_{lj}^{f\text{-}s}$. If B_{lj}^{f-s} and s_{lj} are positively (negatively) correlated, then $B_{lj}^{s\text{-}s}$ is larger (smaller) than the (unweighted) average of $B_{lj}^{f\text{-}s}$. Small (large) firms in sector j would be assigned an upwardly biased $B_{lj}^{s\text{-}s}$ compared to their $B_{lj}^{f\text{-}s}$.* □

Proofs: We use properties of the variance of a product of random variables and the following equalities (holding by definition): $\sum_k \frac{Y_{j\to k}}{Y_j} = \sum_k \alpha_{jk} = 1$ and $\sum_k \frac{Y_{lj\to k}}{Y_{lj}} = \sum_k \alpha_{ljk} = 1$, to show that:

$$\begin{aligned} B_{lj}^{s\text{-}s} &= \sum_k \alpha_{jk} \times H_k = \kappa \times \left(\frac{1}{\kappa}\sum_k \alpha_{jk} \times H_k\right) = \kappa \times \mathbb{E}(\alpha_{jk} \times H_k) \\ &= \kappa \times \left[\mathbb{E}(\alpha_{jk}) \times \mathbb{E}(H_k) + Cov(\alpha_{jk}, H_k)\right] = \kappa \times \left[\mathbb{E}(\alpha_{jk}) \times \overline{H_k} + Cov(\alpha_{jk}, H_k)\right] \\ &= \kappa \times \left[\frac{1}{\kappa} \times \sum_k \alpha_{jk} \times \overline{H_k} + Cov(\alpha_{jk}, H_k)\right] = \overline{H_k} + \kappa \times Cov(\alpha_{jk}, H_k) \end{aligned} \tag{A8}$$

By a similar calculation (only replacing α_{jk} with α_{ljk}) we obtain the formula for $B_{lj}^{f\text{-}s}$, $B_{lj}^{f\text{-}s} = \overline{H_k} + \kappa \times Cov(\alpha_{ljk}, H_k)$, where κ is the total number of sectors k. Combining the formulas we obtain:

$$\begin{aligned} B_{lj}^{s\text{-}s} &= B_{lj}^{f\text{-}s} - \kappa \times Cov(\alpha_{ljk}, H_k) + \kappa \times Cov(\alpha_{jk}, H_k), \\ &= B_{lj}^{f\text{-}s} + \kappa \times Cov(\alpha_{jk} - \alpha_{ljk}, H_k). \end{aligned} \tag{A9}$$

Which is our Result 4.

Next, we show that the sector-level $B_{lj}^{s\text{-}s}$ is a weighted-average of firm-level $B_{lj}^{f\text{-}s}$. To this end, we rewrite the definition of $B_{lj}^{s\text{-}s}$ by breaking down the sales of sector j to sector k ($Y_{j\to k}$) into the sales of given firms l in sector j to sector k ($Y_{lj\to k}$):

$$\begin{aligned} B_{lj}^{s\text{-}s} &= \sum_k \frac{Y_{j\to k}}{Y_j} \times H_k = \sum_k \frac{\sum_{l\in j} Y_{lj\to k}}{Y_j} \times H_k = \sum_{l\in j}\sum_k \frac{Y_{lj\to k}}{Y_j} \times H_k, \\ &= \sum_{l\in j} \frac{Y_{lj}}{Y_j} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \sum_{l\in j} s_{lj} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \sum_{l\in j} s_{lj} \times B_{lj}^{f\text{-}s}. \end{aligned} \tag{A10}$$

Which is our Result 5.

Finally, honing in on how the average of $B_{lj}^{f\text{-}s}$ $\left(\overline{B_{lj}^{f\text{-}s}}\right)$ relates to $B_{lj}^{s\text{-}s}$, we use again properties of the covariance of two random variables (here B_{lj}^{f-s} and s_{lj}), Result 5 and the fact that

$\sum_{l \in j} s_{lj} = 1$ to get:

$$\begin{aligned}
\mathbb{E}\left(s_{lj} \times B_{lj}^{f\text{-}s}\right) &= \mathbb{E}\left(s_{lj}\right) \times \mathbb{E}\left(B_{lj}^{f\text{-}s}\right) + Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right), \\
\Rightarrow \frac{1}{N_j}\sum_{l \in j} s_{lj} \times B_{lj}^{f\text{-}s} &= \left(\frac{1}{N_j}\sum_{l \in j} s_{lj}\right) \times \left(\frac{1}{N_j}\sum_{l \in j} B_{lj}^{f-s}\right) + Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right), \\
\Rightarrow \frac{1}{N_j}\sum_{l \in j} s_{lj} \times B_{lj}^{f\text{-}s} &= \left(\frac{1}{N_j} \times 1\right) \times \overline{B_{lj}^{f\text{-}s}} + Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right), \\
\Rightarrow B_{lj}^{s\text{-}s} &= \overline{B_{lj}^{f\text{-}s}} + N_j \times Cov\left(s_{lj}, B_{lj}^{f\text{-}s}\right).
\end{aligned} \tag{A11}$$

Which is our Result 6. □

A.1.3 Results 7, 8, and 9

In this Appendix subsection we expand our derivation of Results 7, 8, and 9, presented in Subsection 3.1.

Result 7. $B_{lj}^{f\text{-}s} = B_{lj}^{f\text{-}f} + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right)$. *Whenever firm l in sector j has a tendency to undersell to foreign firms i in sector k relative to their size in their sector k, then B_{lj}^{f-s} is an overestimation of the true B_{lj}^{f-f}. This tendency with respect to sector k is weighted by the importance of sector k in the sales of firm l in sector j.*
Rearranging this expression, we get $B_{lj}^{f\text{-}f} = B_{lj}^{f\text{-}s} + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{lj\to ik}}{Y_{lj\to k}} - \frac{Y_{ik}}{Y_k}, FS_{ik}\right)$. Even conditional on the same $B_{lj}^{f\text{-}s}$, i.e., even after sharing the same level of aggregate foreign presence across one's known purchasing sectors, suppliers can still differ in their likelihood to actually sell to the foreign buyers in those sectors. Note that the sufficient condition in Result 2 is apparent in this result as well. If for firm l in sector j, $\frac{Y_{ik}}{Y_k} = \frac{Y_{lj\to ik}}{Y_{lj\to k}}$ for $\forall i$ and $\forall k$, then $B_{lj}^{f-s} = B_{lj}^{f-f}$. □

Result 8. $B_{lj}^{f\text{-}f} = B_{lj}^{s\text{-}s} + \kappa \times Cov(\frac{Y_{lj\to k}}{Y_{lj}} - \frac{Y_{j\to k}}{Y_j}, H_k) + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{lj\to ik}}{Y_{lj\to k}} - \frac{Y_{ik}}{Y_k}, FS_{ik}\right)$. *The firm-specific $B_{lj}^{f\text{-}f}$ of firm l in sector j has three components: (i) the prediction from I-O tables of the backward linkage of firm l based on its sector's j aggregate linkage behavior, (ii) firm l's overperformance (relative to its sector) in terms of selling a higher share of its output to more foreign sectors k, and (iii) firm's l overperformance in terms of directing its sector k sales disproportionately towards foreign firms (relative to the size of these buyers i in their sector k). Note that whenever the sufficient conditions in Results 1 and 2 hold, the covariance terms become zero and $B_{lj}^{f\text{-}f}$ becomes equal to $B_{lj}^{s\text{-}s}$. Result 8 is an argument against a regression that starts from those now common in the literature and that replaces $B_{lj}^{s\text{-}s}$ with $B_{lj}^{f\text{-}f}$. $B_{lj}^{f\text{-}f}$'s second and last components are likely to capture unobservable features of the firm that may explain both the overperformance in selling to MNCs and the improvement in firm performance.* □

Result 9. $B_{lj}^{s\text{-}s} = \sum_{l\in j} s_{lj} \times B_{lj}^{f\text{-}f} + \sum_{l\in j} s_{lj} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right)$
$= \overline{B_{lj}^{f\text{-}f}} + N_j \times Cov\left(s_{lj}, B_{lj}^{f\text{-}f}\right) + \sum_{l\in j} s_{lj} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right)$

Note that whenever the sufficient conditions of Result 2 are satisfied, $B_{lj}^{f\text{-}f} = B_{lj}^{f\text{-}s}$ *for* $\forall$ *firm* l *in* $\forall$ *sector* j *and Result 9 collapses to Result 6.* □

Proofs: From our definition of $B_{lj}^{f\text{-}f}$ we have:

$$\begin{aligned} B_{lj}^{f\text{-}f} &= \sum_k \sum_{i\in k} \frac{Y_{lj\to ik}}{Y_{lj}} \times FS_{ik} = \sum_k N_k \,\mathbb{E}\left(\frac{Y_{lj\to ik}}{Y_{lj}} \times FS_{ik}\right), \\ &= \sum_k N_k \left[\mathbb{E}\left(\frac{Y_{lj\to ik}}{Y_{lj}}\right)\mathbb{E}\left(FS_{ik}\right) + Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}}, FS_{ik}\right)\right], \\ &= \sum_k N_k \times \frac{1}{N_k} \times \frac{Y_{lj\to k}}{Y_{lj}} \times \overline{FS_k} + \sum_k N_k Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}}, FS_{ik}\right), \\ &= \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times \overline{FS_k} + \sum_k N_k Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}}, FS_{ik}\right). \end{aligned} \tag{A12}$$

Note that in Equation A1, H_k can be replaced by $\sum_{i\in k} \frac{Y_{ik}}{Y_k} \times FS_{ik} = \overline{FS_k} + N_k \times Cov(\frac{Y_{ik}}{Y_k}, FS_{ik})$. We rely on this expression and properties of covariances to arrive to our Result 7:

$$\begin{aligned} B_{lj}^{f\text{-}s} &= \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times H_k = \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times \overline{FS_k} + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov(\frac{Y_{ik}}{Y_k}, FS_{ik}), \\ &= B_{lj}^{f\text{-}f} - \sum_k N_k \times Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}}, FS_{ik}\right) + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov(\frac{Y_{ik}}{Y_k}, FS_{ik}), \\ &= B_{lj}^{f\text{-}f} + \sum_k N_k \times \left[\frac{Y_{lj\to k}}{Y_{lj}} \times Cov\left(\frac{Y_{ik}}{Y_k}, FS_{ik}\right) - Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}}, FS_{ik}\right)\right], \\ &= B_{lj}^{f\text{-}f} + \sum_k N_k \times \frac{Y_{lj\to k}}{Y_{lj}} \times \left[Cov\left(\frac{Y_{ik}}{Y_k}, FS_{ik}\right) - Cov\left(\frac{Y_{lj\to ik}}{Y_{lj}} \times \frac{Y_{lj}}{Y_{lj\to k}}, FS_{ik}\right)\right], \\ &= B_{lj}^{f\text{-}f} + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right). \end{aligned} \tag{A13}$$

Next, we aim for formulas relating directly the measure of linkage commonly used in the literature ($B_{lj}^{s\text{-}s}$) to the one that we can construct using the full information set on firm's l in sector j sourcing behavior, $B_{lj}^{f\text{-}f}$. Plugging Result 7 into Result 4, we show how a firm-level

$B_{lj}^{f\text{-}f}$ differs from its sector-level proxy, $B_{lj}^{s\text{-}s}$:

$$\begin{aligned}
B_{lj}^{s\text{-}s} =& B_{lj}^{f\text{-}s} + \kappa \times Cov(\alpha_{jk} - \alpha_{ljk}, H_k), \\
=& B_{lj}^{f\text{-}f} + \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right) + \kappa \times Cov(\alpha_{jk} - \alpha_{ljk}, H_k), \\
\Rightarrow B_{lj}^{f\text{-}f} =& B_{lj}^{s\text{-}s} + \kappa \times Cov\left(\frac{Y_{lj\to k}}{Y_{lj}} - \frac{Y_{j\to k}}{Y_j}, H_k\right) \\
&+ \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{lj\to ik}}{Y_{lj\to k}} - \frac{Y_{ik}}{Y_k}, FS_{ik}\right).
\end{aligned} \tag{A14}$$

Which is our Result 8.

Particularly interested in how the average of $B_{lj}^{f\text{-}f}$ $\left(\overline{B_{lj}^{f\text{-}f}}\right)$ relates to $B_{lj}^{s\text{-}s}$, we combine Results 5 and 7 to uncover our Result 9:

$$\begin{aligned}
B_{lj}^{s\text{-}s} &= \sum_{l\in j} \frac{Y_{lj}}{Y_j} \times B_{lj}^{f\text{-}s} = \sum_{l\in j} \frac{Y_{lj}}{Y_j} \times B_{lj}^{f\text{-}f} + \sum_{l\in j} \frac{Y_{lj}}{Y_j} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right), \\
&= N_j \times \left(\frac{1}{N_j} \sum_{l\in j} \frac{Y_{lj}}{Y_j}\right) \times \left(\frac{1}{N_j} \sum_{l\in j} B_{lj}^{f\text{-}f}\right) + N_j \times Cov\left(\frac{Y_{lj}}{Y_j}, B_{lj}^{f\text{-}f}\right) + \\
&+ \sum_{l\in j} \frac{Y_{lj}}{Y_j} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right), \\
&= \overline{B_{lj}^{f\text{-}f}} + N_j \times Cov\left(\frac{Y_{lj}}{Y_j}, B_{lj}^{f\text{-}f}\right) + \sum_{l\in j} \frac{Y_{lj}}{Y_j} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right), \\
&= \overline{B_{lj}^{f\text{-}f}} + N_j \times Cov\left(s_{lj}, B_{lj}^{f\text{-}f}\right) + \sum_{l\in j} s_{lj} \sum_k \frac{Y_{lj\to k}}{Y_{lj}} \times N_k \times Cov\left(\frac{Y_{ik}}{Y_k} - \frac{Y_{lj\to ik}}{Y_{lj\to k}}, FS_{ik}\right).
\end{aligned} \tag{A15}$$

□

A.2 Evidence Against Sufficient Conditions for Equality Among Linkage Proxies

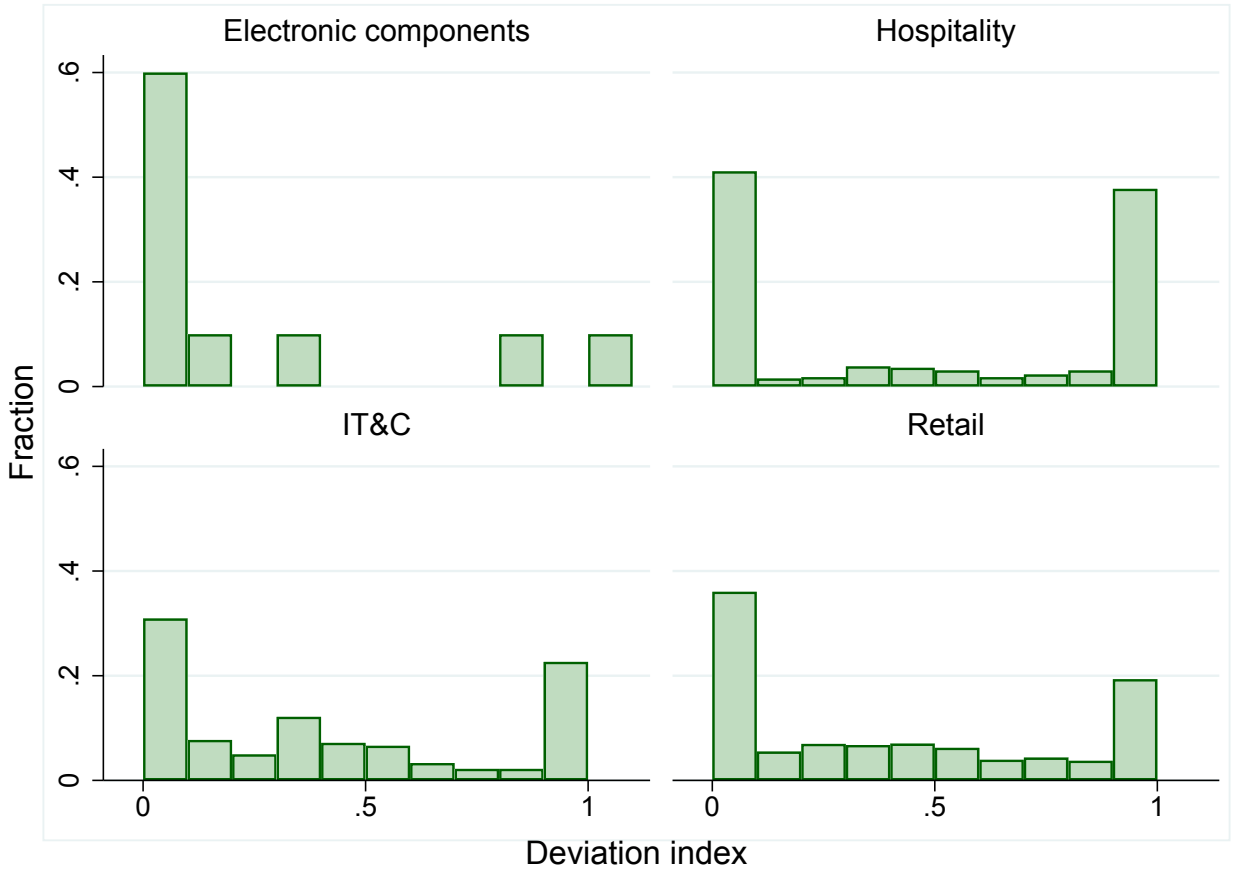


Figure A1: Sectoral heterogeneity in the extent to which $\alpha_{ljk} = \alpha_{jk}$ holds true

Notes: Result 1 states that for firm l in sector j, $\alpha_{ljk} = \alpha_{jk}$, $\forall k$, is a sufficient condition for $B_{lj}^{f\text{-}s}$ to equal $B_{lj}^{s\text{-}s}$. To evaluate this claim, we consider sectors j one-by-one and construct a firm-level measure that captures the firm's overall deviation from I-O predicted sectoral shares. Concretely, for each firm l in sector j we compute $\sum_k \left(\alpha_{ljk} - \alpha_{jk}\right)^2$. If the claim in Result 1 were true, then this firm-level measure would equal zero. We find evidence suggesting that firm-level sectoral divisions of sales differ greatly from I-O predicted divisions. To exemplify our finding, we present in Figure A1 the histograms corresponding to four sectors: electronic components, hospitality, IT&C, and retail. We find sectoral differences in the frequency with which this condition is not met: while in the electronic components sector this condition is more likely to be met, all other sectors have a majority of firms diverging from I-O based sectoral divisions of sales.

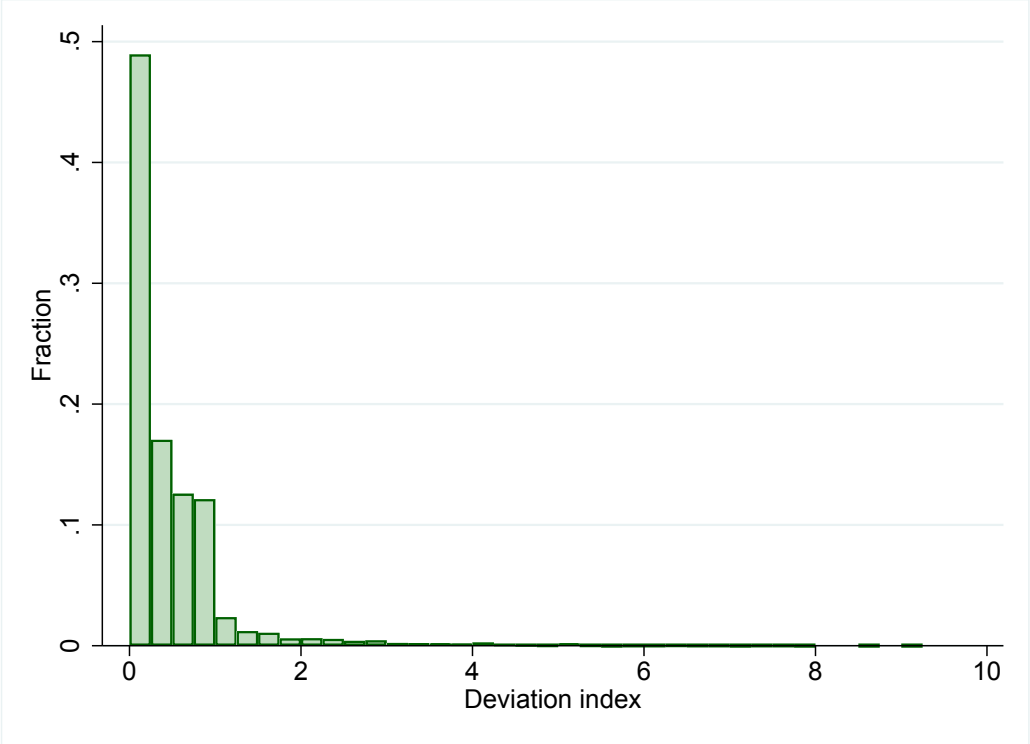


Figure A2: Even for domestic firms selling to foreign firms, $\frac{Y_{lj\to ik}}{Y_{lj\to k}} = \frac{Y_{ik}}{Y_k}$ does not hold

Notes: Result 2 states that for firm l in sector j $\frac{Y_{lj\to ik}}{Y_{lj\to k}} = \frac{Y_{ik}}{Y_k}$, $\forall i$ foreign and $\forall k$, is a sufficient condition for $B_{lj}^{f\text{-}f}$ to equal $B_{lj}^{f\text{-}s}$. We find that this sufficient condition does not hold either. Focusing on 2013, our sample contains 5,112 domestic firms selling to at least one of 2,140 firms with foreign capital. Conditional on being a supplier to at least one foreign firm (i.e., being one of these 5,112 domestic firms), there is a total of close to 11 million potential transactions with any of these 2,140 foreign buyers. 99.8 percent of these potential transactions do not occur. Therefore, mechanically, for all of these combinations $\frac{Y_{lj\to ik}}{Y_{lj\to k}} < \frac{Y_{ik}}{Y_k}$. Out of the 5,110 transactions that do materialize, Figure A2 shows the histogram of $\sum_k \left(\frac{Y_{lj\to ik}}{Y_{lj\to k}} - \frac{Y_{ik}}{Y_k}\right)^2$ computed for each firm l in sector j. We observe that less than half of these cases are close to the target value of zero. Overall, this implies that the sufficiency requirement for Result 2 does not hold for the vast majority of combinations.

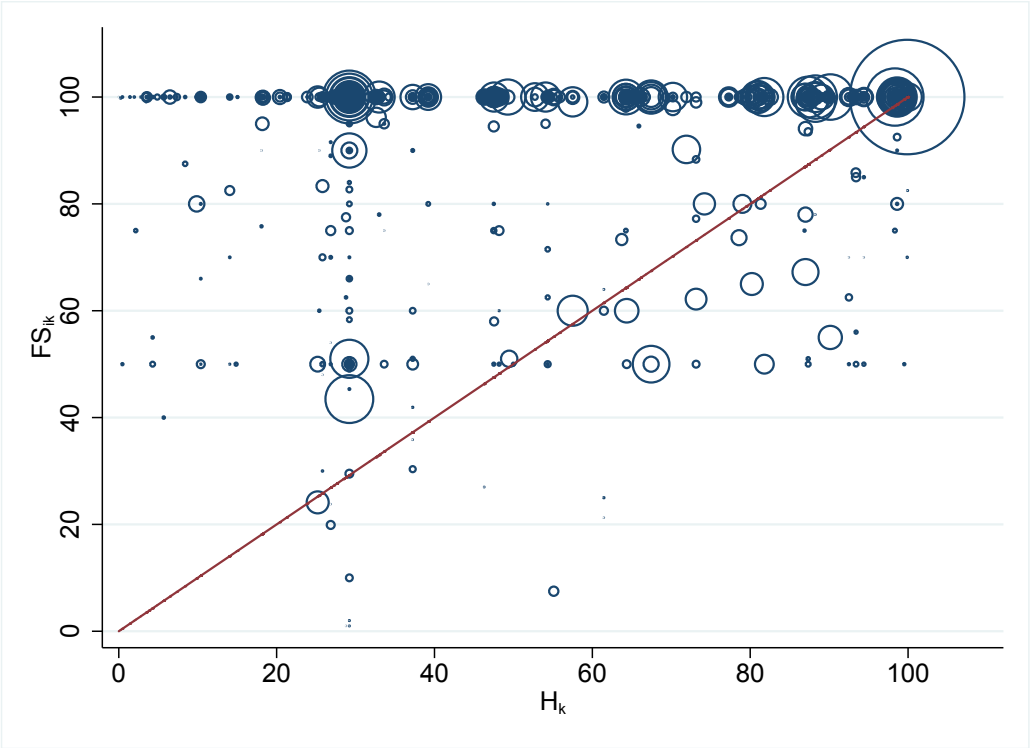


Figure A3: Heterogeneity in foreign ownership shares, $FS_{ik} = H_k$ does not hold.

Notes: Result 3 shows that if for $\forall i$ and $\forall k$, $FS_{ik} = H_k$, then $B_{lj}^{f\text{-}f}$ equals $B_{lj}^{f\text{-}s}$, $\forall l$ in $\forall j$. Figure A3 focuses on foreign firms alone and shows that there is considerable heterogeneity in foreign ownership shares. The horizontal axis corresponds to H_k. If the condition above had held for firms i foreign, then all markers on the graph would have been been located along the 45 degree line. Instead, the graph shows no clear pattern, with most foreign firms having a foreign equity share close to 100 percent, irrespective of the value H_k of their sector. For firms i domestic in a sector k containing at least one foreign firm, again this condition does not hold.

A.3 Further Disaggregation of the Data Shows Strong Heterogeneities in Proxies of Linkage to MNCs

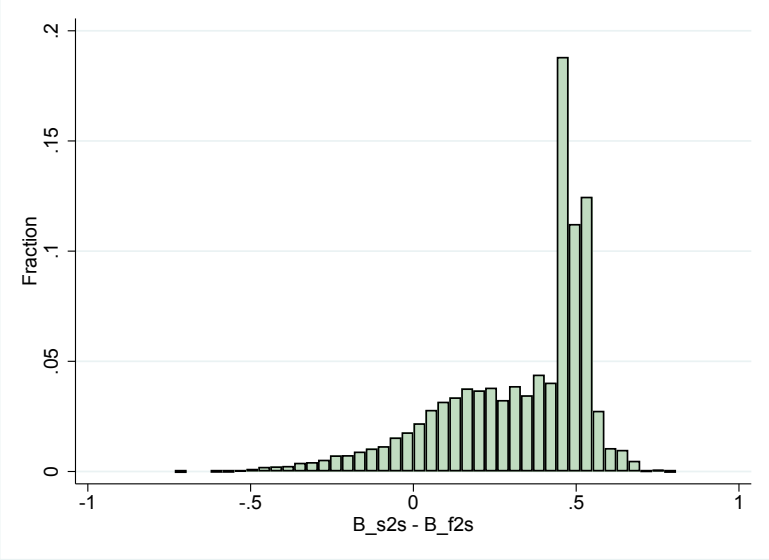


Figure A4: "sector-to-sector" vs "firm-to-sector" backward linkages

Notes: The figure plots a histogram of the firm level differences between the "sector-to-sector" and the "firm-to-sector" measure of backward linkages. "Backward sector-to-sector" uses proxies for the extent to which a firm sells to a given sector from I-O tables and for the degree of foreign ownership in those sectors. To construct "Backward firm-to-sector" requires to know to which sectors a firm sells to, with the foreign ownership of one's clients still being approximated by the sector-level weighted-average ownership.

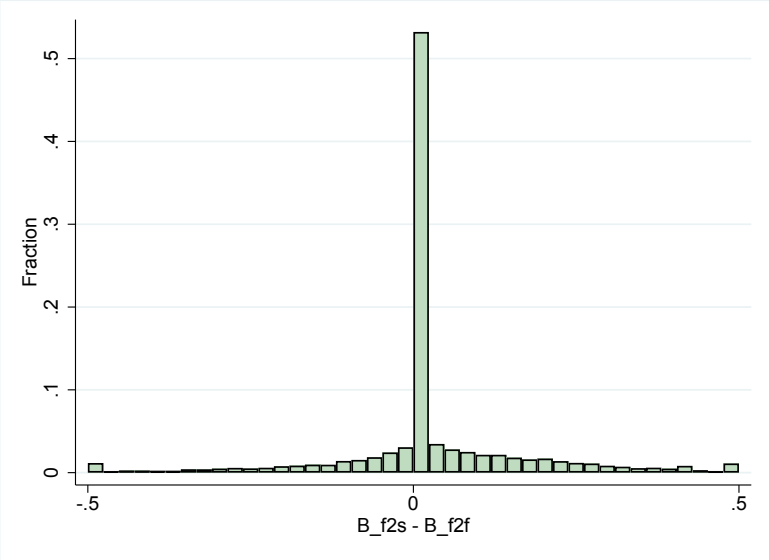


Figure A5: "firm-to-sector" vs "firm-to-firm" backward linkages

Notes: The figure plots a histogram of the firm level differences between the "firm-to-sector" and the "firm-to-firm" measure of backward linkages. "Backward firm-to-sector" requires to know to which sectors a firm sells to, with the foreign ownership of one's clients still being approximated by the sector-level weighted-average ownership. "Backward firm-to-firm" uses the actual B2B transactions data, requiring no further assumptions on the sectors one sells to and the foreign ownership of one's clients.

A.4 MNCs Source Differently from Domestic Firms: Key Differences

Table A1: Foreign vs Domestic Buyer's Behavior: All Sectors

	VA Share (1)	Local (2)	Foreign Local (3)	Sectors (4)	Sup per Sector (5)
Foreign Dummy	0.060***	-0.071***	0.034***	0.069***	-0.076***
	(0.014)	(0.002)	(0.003)	(0.007)	(0.003)
Year-4DSect FE	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Sales Polynomial	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. (level)	0.50	0.86	0.27	6.33	1.43
SD Dep. Var. (level)	1.33	0.27	0.29	8.96	0.71
Adjusted R^2	0.048	0.42	0.17	0.64	0.37
# Observations	101099	101099	101099	101099	101099
# Fixed Effects	2161	2161	2161	2161	2161
# Firms	19049	19049	19049	19049	19049

Notes: Each column in Table A1 shows the result of a different regression where each column header represents the dependent variable. The regressions use data from 2008-2015 because this is the period where transactions data is available. The main explanatory variable of interests is a dummy variable which is equal to one for firms with some foreign ownership. All regressions include the interaction of year by 4-digit fixed effects, province fixed effect and a second order polynomial in log total sales as control variables. VA Share in column 1 is defined as the share of value added over a firm's total sales. The variable Local in column 2 is defined as the share of inputs purchased in Costa Rican territory over firm's total inputs (purchased locally plus imported). The variable Foreign Local in column 3 is defined as the share of inputs purchased from foreign firms in Costa Rican territory over total inputs purchased in Costa Rican territory. The variable Sectors in column 4 is the log of the number of 4-digit sectors from which the firm source inputs. Finally, the variable Sup per Sector in column 5 is defined as the log of the average number of suppliers per sector from which the firm source inputs.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table A2: Foreign vs Domestic Buyer's Behavior: Manufacturing

	VA Share (1)	Local (2)	Foreign Local (3)	Sectors (4)	Sup per Sector (5)
Foreign Dummy	0.073***	-0.153***	0.086***	0.109***	-0.063***
	(0.010)	(0.005)	(0.007)	(0.015)	(0.006)
Year-4DSect FE	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Sales Polynomial	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. (level)	0.44	0.83	0.30	8.91	1.38
SD Dep. Var. (level)	0.39	0.29	0.28	13.4	0.53
Adjusted R^2	0.090	0.52	0.15	0.75	0.41
# Observations	16436	16436	16436	16436	16436
# Fixed Effects	697	697	697	697	697
# Firms	2710	2710	2710	2710	2710

Notes: Each column in Table A2 shows the result of a different regression where each column header represents the dependent variable. The regressions use data of manufacturing firms from 2008-2015 because this is the period where transactions data is available. The main explanatory variable of interests is a dummy variable which is equal to one for firms with some foreign ownership. All regressions include the interaction of year by 4-digit fixed effects, province fixed effect and a second order polynomial in log total sales as control variables. VA Share in column 1 is defined as the share of value added over a firm's total sales. The variable Local in column 2 is defined as the share of inputs purchased in Costa Rican territory over firm's total inputs (purchased locally plus imported). The variable Foreign Local in column 3 is defined as the share of inputs purchased from foreign firms in Costa Rican territory over total inputs purchased in Costa Rican territory. The variable Sectors in column 4 is the log of the number of 4-digit sectors from which the firm source inputs. Finally, the variable Sup per Sector in column 5 is defined as the log of the average number of suppliers per sector from which the firm source inputs.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

A.5 Assumptions Harm the Accuracy of Measures of MNC Integration

Table A3: Sectoral differences in indirect employment of foreign firms (thousands)

	Direct	Indirect				
		I-O Matrix		B2B trans.		
Year	Jobs	Jobs	Ind/Dir	Jobs	Ind/Dir	I-O/B2B
2008	280	150	0.54	99	0.35	1.51
2009	268	149	0.55	104	0.39	1.43
2010	279	151	0.54	100	0.36	1.50
2011	290	154	0.53	102	0.35	1.52
2012	301	159	0.53	110	0.37	1.45
2013	306	168	0.55	110	0.36	1.52
2014	306	168	0.55	113	0.37	1.48
2015	314	174	0.55	117	0.37	1.48

Notes: To compute how much indirect employment of degree 1 is generated by foreign firms we weigh the number of workers of supplying firms/sectors by the share of sales that those firms/sectors sale to foreign firms. For indirect employment of degree 2 or more we follow a similar logic, weighting the total employment of a firm/sector by the product of the direct and indirect shares of sales. The total indirect employment is the sum of indirect employment of degrees up to degree 10.

Table A4: Sectoral differences in indirect employment of foreign firms (thousands)

		Indirect		
	Direct	I-O matrix	B2B trans	I-O/B2B
Banana	34.9	2.6	7.8	0.34
Meat	15.7	5.3	12.2	0.44
Retail	31.7	12.0	24.6	0.49
Pinneaple	5.9	1.5	1.4	1.07
Hospitality	10.1	5.5	2.0	2.80
Administrative	27.2	4.2	1.5	2.84
Electronic components	6.6	1.9	0.6	3.11
Medical devices	14.0	5.3	1.5	3.42
Construction	6.0	12.0	3.5	3.42
IT&C	6.0	2.0	0.4	4.94

Notes: To compute how much indirect employment of degree 1 is generated by foreign firms in a given sector we weigh the number of workers of supplying firms/sectors by the share of sales that those firms/sectors sale to foreign firms. For indirect employment of degree 2 or more we follow a similar logic, weighting the total employment of a firm/sector by the product of the direct and indirect shares of sales. The total indirect employment is the sum of indirect employment of degrees up to degree 10.

B Benefits of supplying to MNCs: *Productive Linkages* event study

[Work in progress.]



Figure B6: Screenshot of the *Costa Rica Provee* (Costa Rica Supplies) program

Notes: As the screenshot describing the program states, its aim is to detect "the needs of transnational companies, identify business opportunities and recommend registered suppliers who meet the production, technical, and quality specifications and characteristics required by the business at hand." For more details, use this link.

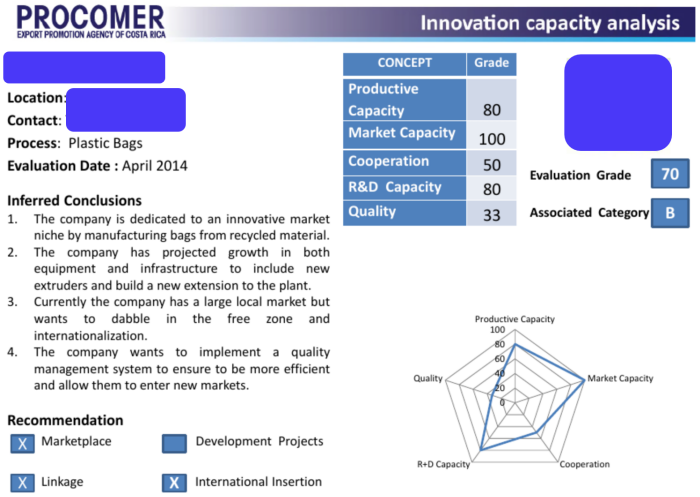


Figure B7: An actual summary of an (anonymized) evaluation of a Costa Rican firm

Notes: Behind this summary sheet of a Procomer evaluation is a survey asking detailed questions on each of the five modules appraised by Procomer: productive capacity, market capacity, cooperation, R&D capacity and quality. For example, the quality module asks whether the firm has both general quality management certificates (e.g., ISO-9001) and sector-specific certificates (e.g., ISO-13485, quality management requirements for organizations producing medical devices and related services). The cooperation module asks whether the firm has employees able to negotiate in the language relevant to the market it targets. Each evaluation is concluded with an absolute score, a letter grade category based on the range of the absolute score and recommendations on which Procomer program the firm is fit to benefit from. The program we study here (*Productive Linkages* or "Linkage" in short) is one option of follow-up. The firm appraised in this example is involved in the manufacturing of plastic firms and is interested in starting to supply to MNCs in Free Trade Zones. Due to shortcomings in its quality management system, the firm is – as of April 2014 – only part of the middle category of suppliers (B).

C Benefits of supplying to MNCs: Economy-Wide Event Study

C.1 Firms grow in size after starting to supply to an MNC

Table C5: Event Study. Firm Expansion

	Total Sales (1)	Number of Workers (2)	CD *K, L* (3)	TL *K, L* (4)	Total Sales (5)	Number of Workers (6)	CD *K, L* (7)	TL *K, L* (8)
$t \leq -4$	-0.005	-0.018	-0.022	-0.018	-0.015	0.028	-0.030	-0.035
	(0.022)	(0.018)	(0.018)	(0.019)	(0.048)	(0.030)	(0.033)	(0.034)
$t = -3$	0.012	0.009	-0.013	-0.013	0.017	0.002	0.008	0.005
	(0.019)	(0.017)	(0.017)	(0.018)	(0.033)	(0.021)	(0.018)	(0.019)
$t = -2$	0.016	0.010	0.006	0.005	0.008	-0.010	0.009	0.005
	(0.017)	(0.012)	(0.016)	(0.018)	(0.020)	(0.014)	(0.021)	(0.021)
$t = 0$	0.116***	0.075***	0.071***	0.067***	0.154***	0.057***	0.105***	0.106***
	(0.019)	(0.016)	(0.012)	(0.011)	(0.022)	(0.017)	(0.022)	(0.022)
$t = 1$	0.172***	0.122***	0.092***	0.080***	0.188***	0.082**	0.126***	0.127***
	(0.024)	(0.021)	(0.015)	(0.014)	(0.039)	(0.032)	(0.025)	(0.025)
$t = 2$	0.205***	0.156***	0.094***	0.080***	0.225***	0.089*	0.127***	0.132***
	(0.031)	(0.023)	(0.020)	(0.019)	(0.058)	(0.049)	(0.034)	(0.034)
$t = 3$	0.253***	0.200***	0.103***	0.089***	0.288***	0.099	0.169***	0.174***
	(0.032)	(0.025)	(0.024)	(0.023)	(0.082)	(0.068)	(0.047)	(0.047)
$t \geq 4$	0.255***	0.210***	0.102***	0.085**	0.279**	0.082	0.163**	0.169**
	(0.048)	(0.039)	(0.038)	(0.034)	(0.107)	(0.090)	(0.067)	(0.067)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	No	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	No	No	No	No
Never_Matched	Yes	Yes	Yes	Yes	No	No	No	No
Mean Dep. Var. (level)	0.65	12.9	0.65	0.65	1.59	21.0	1.59	1.59
SD Dep. Var. (level)	2.04	33.0	2.04	2.04	3.91	46.3	3.91	3.91
Adjusted R^2	0.84	0.79	0.91	0.91	0.89	0.86	0.94	0.94
# Observations	89024	89024	89024	89024	7211	7211	7211	7211
# Fixed Effects	23638	23638	23638	23638	2582	2582	2582	2582
# Firms	12764	12764	12764	12764	771	771	771	771

Notes: Table C5 shows the results of running specification 7 adapted to two dependent variables capturing firm size: log total sales (including exports) and log total number of workers. The event is defined as a first time sale to an MNC. Columns 1 to 4 report event study estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Clustering of standard errors is at the 2-digits sector by province level. Columns 5 to 8 focus only on the sample of domestic firms becoming first-time suppliers to an MNC after 2010 and use standard error clustering at event by province level. As the extended sample in this table is a supraset of that in Table C7 – because it does not require that all firms report input costs (M) – Columns 3, 4 and 7, 8 repeat the exercise in Columns 2, 3 and 5, 6 from Table C7 with one modification only - assuming a 2-factor (instead of a 3-factor) production function. Means (in levels) of dependent variables are reported in US$ millions (PPI-deflated to 2013 US$) for sales and in number of workers. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

C.2 Firms experience productivity gains after starting to sell to an MNC

Table C6: Event Study Mean Shift: Firm Level Productivity

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
Mean Prod. Shift	0.052***	0.081***	0.064***	0.053***	0.071***	0.054***
	(0.015)	(0.013)	(0.010)	(0.015)	(0.010)	(0.008)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	Yes	Yes	Yes	No	No	No
Year-4DSect-Prov-Age FE	No	No	No	Yes	Yes	Yes
Adjusted R^2	0.64	0.95	0.96	0.63	0.95	0.96
# Observations	47818	47818	47818	43368	43368	43368
# Firms	7411	7411	7411	6531	6531	6531

Notes: Table C6 shows the results of running the mean-shift version of specification 7 adapted to three measures of productivity. The event is defined as a first time sale to an MNC. All columns report event study mean shift estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 1-3 differ from columns 4-6 in the fixed effects used. Columns 1 and 4 use as a dependent variable a productivity index constructed under the assumption a Cobb-Douglas production function. This method "residualizes" sales by subtracting firm-level inputs used, weighted by the respective 2-digit-level cost shares. Concretely, the Cobb-Douglas productivity index dependent variable is $Y_{ist} - \alpha_{k,s2D} \times K_{ist} - \alpha_{l,s2D} \times WB_{ist} - \alpha_{m,s2D} \times M_{ist}$, where $\alpha_{l,s2D}$=(2-digit sectoral wage bill)/(2-digit sectoral revenues), $\alpha_{m,s2D}$=(2-digit sectoral input costs)/(2-digit sectoral revenues) and $\alpha_{k,s2D} = 1 - \alpha_{l,s2D} - \alpha_{m,s2D}$. Columns 2 and 5 use a measure of productivity resulting from production function estimation. These columns assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for *K*, *L*, and *M* respectively. Columns 3 and 6 differ from Columns 2 and 5 in their assumption of a translog functional form. For both Cobb-Douglas and translog, we estimate the coefficients on factors of production over the entire sample of domestic firms, controlling for narrowly defined fixed effects. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C7: Event Study: Firm Level Productivity

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
$t \leq -4$	0.009	-0.003	0.002	0.014	0.014	-0.004
	(0.017)	(0.015)	(0.012)	(0.059)	(0.040)	(0.038)
$t = -3$	-0.006	-0.001	0.000	-0.011	0.017	0.001
	(0.017)	(0.013)	(0.011)	(0.041)	(0.029)	(0.030)
$t = -2$	0.004	0.011	0.014	0.001	0.018	0.008
	(0.013)	(0.010)	(0.009)	(0.023)	(0.021)	(0.021)
$t = 0$	0.033**	0.048***	0.037***	0.054**	0.065***	0.056***
	(0.016)	(0.011)	(0.009)	(0.021)	(0.015)	(0.016)
$t = 1$	0.058***	0.066***	0.052***	0.053	0.067**	0.061***
	(0.019)	(0.013)	(0.010)	(0.032)	(0.026)	(0.021)
$t = 2$	0.074***	0.089***	0.073***	0.115***	0.118***	0.113***
	(0.022)	(0.017)	(0.015)	(0.040)	(0.039)	(0.031)
$t = 3$	0.076***	0.093***	0.077***	0.142**	0.151**	0.150***
	(0.020)	(0.021)	(0.017)	(0.055)	(0.060)	(0.045)
$t \geq 4$	0.074**	0.113***	0.088***	0.145*	0.157*	0.169***
	(0.030)	(0.023)	(0.020)	(0.071)	(0.080)	(0.059)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	No	No	No
Never_Matched	Yes	Yes	Yes	No	No	No
Mean Dep. Var. (level)	0.29	0.87	0.87	0.29	2.30	2.30
SD Dep. Var. (level)	0.53	2.43	2.43	0.47	4.86	4.86
Adjusted R^2	0.63	0.95	0.96	0.69	0.97	0.98
# Observations	43368	43368	43368	3999	3999	3999
# Fixed Effects	12222	12222	12222	1574	1574	1574
# Firms	6531	6531	6531	480	480	480

Notes: Table C7 shows the results of running specification 7 adapted to the same three measures of productivity defined for Table C6. The event is defined as a first time sale to an MNC. Columns 1 to 4 report event study estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 5 to 8 focus only on the sample of domestic firms becoming first-time suppliers to an MNC after 2010 and use standard error clustering at event by province level. Means (in levels) of sales (residualized in Columns 1 and 4) are reported in US$ millions (PPI-deflated to 2013 US$). Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C8: Event Study: Firm Level Productivity, Robustness of Event Window

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
$t \leq -4$				0.009	-0.003	0.002
				(0.017)	(0.015)	(0.012)
$t \leq -3$ / $t = -3$	0.005	-0.002	0.002	-0.006	-0.001	0.000
	(0.016)	(0.013)	(0.011)	(0.017)	(0.013)	(0.011)
$t = -2$	0.004	0.011	0.014	0.004	0.011	0.014
	(0.013)	(0.010)	(0.009)	(0.013)	(0.010)	(0.009)
$t = 0$	0.033**	0.048***	0.037***	0.033**	0.048***	0.037***
	(0.016)	(0.011)	(0.009)	(0.016)	(0.011)	(0.009)
$t = 1$	0.058***	0.066***	0.052***	0.058***	0.066***	0.052***
	(0.019)	(0.013)	(0.010)	(0.019)	(0.013)	(0.010)
$t = 2$	0.074***	0.089***	0.073***	0.074***	0.089***	0.073***
	(0.022)	(0.017)	(0.015)	(0.022)	(0.017)	(0.015)
$t \geq 3$ / $t = 3$	0.075***	0.102***	0.082***	0.076***	0.093***	0.077***
	(0.023)	(0.020)	(0.017)	(0.020)	(0.021)	(0.017)
$t \geq 4$				0.074**	0.113***	0.088***
				(0.030)	(0.023)	(0.020)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.63	0.95	0.96	0.63	0.95	0.96
# Observations	43368	43368	43368	43368	43368	43368
# Firms	6531	6531	6531	6531	6531	6531

Notes: Table C8 shows the results of running specification 7 adapted to the same three measures of productivity defined for Table C6. The event is defined as a first time sale to an MNC. All columns report event study estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Columns 1 to 3 differ from Columns 4 to 6 in the definition of $\underline{C}$ and $\overline{C}$, i.e., $\underline{C}$=*-3* and $\overline{C}$=*+3* for Columns 1 to 3 and $\underline{C}$=*-4* and $\overline{C}$=*+4* for Columns 4 to 6. Clustering of standard errors is at the 2-digit sector by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C9: Event Study: Other Proxies of Productivity

	Sales/ Worker (1)	VA/ Worker (2)	Profits/ Worker (3)	Sales to Dom. clients (4)	Number of Dom. clients (5)
$t \leq -4$	0.014	0.015	0.014	-0.021	-0.030
	(0.017)	(0.035)	(0.028)	(0.038)	(0.030)
$t = -3$	0.003	0.017	0.000	-0.017	-0.020
	(0.024)	(0.023)	(0.019)	(0.029)	(0.028)
$t = -2$	0.006	0.023	0.006	-0.019	-0.004
	(0.021)	(0.024)	(0.020)	(0.023)	(0.021)
$t = 0$	0.041***	0.047**	0.036*	-0.082**	0.038*
	(0.015)	(0.023)	(0.019)	(0.040)	(0.021)
$t = 1$	0.050***	0.062**	0.042**	-0.003	0.127***
	(0.015)	(0.024)	(0.018)	(0.044)	(0.022)
$t = 2$	0.048**	0.089***	0.049***	0.044	0.148***
	(0.022)	(0.021)	(0.016)	(0.057)	(0.031)
$t = 3$	0.053**	0.130***	0.098***	0.114**	0.186***
	(0.024)	(0.031)	(0.023)	(0.045)	(0.031)
$t \geq 4$	0.045	0.111***	0.072***	0.113*	0.205***
	(0.036)	(0.031)	(0.024)	(0.066)	(0.036)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	Yes
Never_Matched	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. (level)	0.059	0.026	0.032	0.69	10.4
SD Dep. Var. (level)	0.12	0.058	0.058	2.19	30.8
Adjusted R^2	0.79	0.61	0.63	0.84	0.85
# Observations	89024	89024	89024	64680	64680
# Fixed Effects	23638	23638	23638	20081	20081
# Firms	12764	12764	12764	11258	11258

Notes: All columns report event study estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Column 1 uses as dependent variable log sales per employee, column 2 uses log value added per employee, while column 3 uses log profits per employee. Columns 4 and 5 explore how the value of sales to domestic clients (includes both domestically-owned firms and state-owned entities) and the number of domestic clients evolve after a domestic firm becomes a supplier to an MNC. Clustering of standard errors is at the 2-digit sector by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C10: Event Study: Productivity Gains to Domestic Buyers of New Suppliers to MNCs

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
$t \leq -4$	0.035	0.001	0.003	0.001	0.016	0.002
	(0.021)	(0.017)	(0.015)	(0.054)	(0.043)	(0.040)
$t = -3$	0.017	-0.010	-0.005	0.005	-0.014	-0.015
	(0.020)	(0.015)	(0.013)	(0.038)	(0.031)	(0.028)
$t = -2$	0.030	0.013	0.008	-0.007	-0.013	-0.011
	(0.023)	(0.018)	(0.015)	(0.026)	(0.021)	(0.020)
$t = 0$	0.024*	0.004	0.003	0.040	0.015	0.015
	(0.014)	(0.013)	(0.013)	(0.026)	(0.021)	(0.019)
$t = 1$	0.006	0.009	0.012	0.050	0.040	0.041
	(0.018)	(0.018)	(0.017)	(0.035)	(0.028)	(0.026)
$t = 2$	0.019	0.016	0.023	0.078	0.042	0.040
	(0.018)	(0.023)	(0.022)	(0.054)	(0.042)	(0.038)
$t = 3$	0.049**	0.020	0.030	0.144**	0.094*	0.086*
	(0.023)	(0.023)	(0.023)	(0.067)	(0.052)	(0.047)
$t \geq 4$	0.016	0.031	0.034	0.134*	0.129**	0.120**
	(0.035)	(0.025)	(0.023)	(0.079)	(0.065)	(0.060)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-3DSect-Prov FE	No	No	No	Yes	Yes	Yes
Year-3DSect-Prov-Age FE	Yes	Yes	Yes	No	No	No
Never_Matched	Yes	Yes	Yes	No	No	No
Mean Dep. Var. (level)	0.30	0.65	0.65	0.28	0.59	0.59
SD Dep. Var. (level)	0.53	1.28	1.28	0.37	0.68	0.68
Adjusted R^2	0.62	0.95	0.96	0.73	0.97	0.98
# Observations	36963	36963	36963	1919	1919	1919
# Fixed Effects	9793	9793	9793	694	694	694
# Firms	5617	5617	5617	231	231	231

Notes: Table C10 checks whether domestic clients of a first-time supplier to an MNC also see their productivity improve after the event of this supplier. Outcome variables are defined as in Table C6. To enter this estimation, domestic clients need to have never sold to an MNC themselves and need to be purchasing at least 10 percent of their local inputs (in value) from the supplier triggering the event. If a domestic client has several suppliers that start selling to an MNC, its event year is set as the event year of its most important supplier among them. Columns 1 to 3 report event study estimates for the sample including both domestic clients of firms that never supply to an MNC and domestic clients of firms that eventually become suppliers to an MNC. Clustering of standard errors is at the 2-digit sector by province level. Columns 4 to 6 focus only on the set of domestic clients of firms that eventually become suppliers to an MNC and use standard error clustering at event by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

C.3 Firms Change Behavior after Starting to Supply to an MNC

Table C11: Event Study: Firm Level Levers of Adjustment

	K	M	Imports	Import Share	Wage-Bill/ Worker	HS Workers	HS Share
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$t \leq -4$	-0.034	-0.041	-0.142	-0.006	-0.003	-0.023	-0.001
	(0.025)	(0.027)	(0.096)	(0.017)	(0.008)	(0.024)	(0.007)
$t = -3$	-0.011	-0.004	0.105	-0.007	0.003	-0.008	-0.002
	(0.027)	(0.025)	(0.100)	(0.015)	(0.006)	(0.015)	(0.005)
$t = -2$	-0.015	0.015	-0.030	-0.001	0.001	-0.011	-0.003
	(0.023)	(0.022)	(0.066)	(0.013)	(0.006)	(0.018)	(0.005)
$t = 0$	0.034	0.090***	0.237***	0.013	0.011	0.054***	0.010
	(0.038)	(0.024)	(0.069)	(0.013)	(0.007)	(0.016)	(0.006)
$t = 1$	0.067*	0.107***	0.254***	0.015	0.012	0.074***	0.005
	(0.040)	(0.031)	(0.073)	(0.010)	(0.008)	(0.023)	(0.006)
$t = 2$	0.115**	0.091	0.360***	0.028***	0.019**	0.091***	0.001
	(0.047)	(0.057)	(0.074)	(0.010)	(0.009)	(0.024)	(0.007)
$t = 3$	0.156***	0.121**	0.480***	0.052***	0.024**	0.112***	0.003
	(0.048)	(0.060)	(0.114)	(0.011)	(0.011)	(0.029)	(0.009)
$t \geq 4$	0.162**	0.171*	0.433***	0.033**	0.020	0.124***	0.002
	(0.072)	(0.096)	(0.151)	(0.014)	(0.015)	(0.028)	(0.009)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Never_Matched	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. (level)	0.57	0.61	0.33	0.47	0.0055	5.05	0.22
SD Dep. Var. (level)	19.7	2.03	1.07	0.35	0.0039	16.6	0.30
Adjusted R^2	0.82	0.86	0.79	0.76	0.84	0.82	0.74
# Observations	68706	45287	11352	7866	89024	89024	89024
# Fixed Effects	18969	12599	4125	3190	23638	23638	23638
# Firms	10050	6741	2034	1631	12764	12764	12764

Notes: Table C11 shows the results of running specification 7 adapted to a series of potential levers of adjustment to joining MNC supply chains. The outcome variables used are (in order of the columns): total assets, input costs, value of imports, proportion of imports of total input costs, wage bill divided by the contemporaneous number of workers, number of high-skill employees and the proportion of high-skill employees in the firm. All columns include never treated firms and cluster standard errors at the level of the 2-digit sector by province. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

C.4 Productivity Gains are Heterogeneous across Firms' Characteristics

Table C12: Event Study: Productivity Gains by Supplier Sector

	Manuf (1)	Retail (2)	Serv (3)	Manuf (4)	Retail (5)	Serv (6)
$t \leq -4$	-0.01	-0.00	0.01	-0.12	0.02	-0.10
	(0.04)	(0.01)	(0.03)	(0.13)	(0.04)	(0.12)
$t = -3$	0.05	-0.00	-0.02	-0.05	0.02	-0.09
	(0.04)	(0.01)	(0.03)	(0.08)	(0.03)	(0.08)
$t = -2$	0.03	0.02*	-0.02	-0.05	0.02	-0.04
	(0.03)	(0.01)	(0.03)	(0.05)	(0.02)	(0.06)
$t = 0$	0.03	0.04***	0.07***	0.07	0.03	0.17***
	(0.03)	(0.01)	(0.02)	(0.05)	(0.02)	(0.06)
$t = 1$	0.08**	0.05***	0.08***	0.13	0.02	0.22***
	(0.03)	(0.01)	(0.03)	(0.09)	(0.03)	(0.08)
$t = 2$	0.12***	0.05***	0.11***	0.26**	0.03	0.33***
	(0.04)	(0.01)	(0.03)	(0.13)	(0.04)	(0.11)
$t = 3$	0.11**	0.08***	0.08*	0.31*	0.07	0.38***
	(0.04)	(0.02)	(0.05)	(0.16)	(0.05)	(0.14)
$t \geq 4$	0.11**	0.07***	0.11**	0.33	0.05	0.46**
	(0.04)	(0.02)	(0.05)	(0.22)	(0.06)	(0.18)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	No	No	No
Mean Dep. Var. (level)	0.59	1.14	0.57	0.98	2.95	1.34
SD Dep. Var. (level)	1.22	2.89	1.93	1.32	5.64	3.31
Adjusted R^2	0.94	0.97	0.93	0.97	0.98	0.95
# Observations	6096	22715	14557	505	2515	979
# Fixed Effects	1881	5803	4538	253	868	453
# Firms	830	3168	2533	63	267	150

Notes: The dependent variable in all columns is a measure of productivity resulting from production function estimation. We assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for K, L and M respectively. Each column reports event study point estimates from a separate regression in which firms preserved for estimation are those operating in the sectoral group listed in the row heading. We keep the three most populated sectoral groups: manufacturing, retail and services. Specifications 1 to 3 include never treated firms and cluster standard errors at the level of the 2-digit sector by province. Specifications 4 to 6 focus only on eventually treated firms and implement the clustering at the event-by-province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C13: Event Study: Productivity Gains by Supplier Skill Level

	Bottom Third (1)	Center Third (2)	Top Third (3)	Pooled Diff Center vs Rest (4)
$t \leq -4$	-0.03	-0.01	0.01	-0.03
	(0.03)	(0.02)	(0.02)	(0.02)
$t = -3$	-0.02	-0.03	0.01	-0.03
	(0.04)	(0.03)	(0.02)	(0.03)
$t = -2$	0.01	0.03	-0.00	0.01
	(0.04)	(0.02)	(0.02)	(0.03)
$t = 0$	0.07*	0.01	0.05***	-0.02
	(0.04)	(0.03)	(0.02)	(0.03)
$t = 1$	0.05	0.03	0.06***	-0.02
	(0.04)	(0.03)	(0.02)	(0.03)
$t = 2$	0.09**	0.06**	0.05**	-0.02
	(0.04)	(0.03)	(0.02)	(0.03)
$t = 3$	0.09**	0.04	0.09***	-0.04
	(0.04)	(0.03)	(0.02)	(0.03)
$t \geq 4$	0.10**	0.07**	0.11***	-0.05
	(0.05)	(0.03)	(0.03)	(0.03)
Year-4DSect-Prov_FE	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes
HS Share	[0-0.05)	[0.05-0.34)	[0.34-1)	[0-1]
Adjusted R^2	0.93	0.95	0.96	0.95
# Observations	12189	13122	12534	43174
# Firms	1904	1907	1799	6472

Notes: The dependent variable in all columns is a measure of productivity resulting from production function estimation. We assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for *K*, *L* and *M* respectively. Each supplying firm is assigned its mean share of high-skilled workers across all years when the firm is active. These firm-level mean shares form an economy-wide distribution that we split in three equally-sized bins: the bottom 33 percentiles, the central 34 to 67 percentiles and the top percentiles between 68 and 99. Columns 1 to 3 run separate event studies for each bin, whereas Column 4 reports results from a pooled regression testing a difference in event study coefficients for the central bin compared to the bottom and top bins combined. Specifications include never treated firms and cluster standard errors at the level of the 2-digit sector by province. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C14: Event Study: Productivity Gains by MNC Sector

	Manuf (1)	Retail (2)	Serv (3)
$t \leq -4$	0.02	0.12	-0.05
	(0.08)	(0.09)	(0.11)
$t = -3$	-0.01	0.12*	-0.07
	(0.05)	(0.07)	(0.07)
$t = -2$	0.06	0.10**	-0.05
	(0.04)	(0.05)	(0.05)
$t = 0$	0.10**	0.02	0.13***
	(0.04)	(0.05)	(0.05)
$t = 1$	0.08	0.06	0.20***
	(0.06)	(0.06)	(0.07)
$t = 2$	0.16**	0.06	0.25***
	(0.08)	(0.08)	(0.09)
$t = 3$	0.20**	0.10	0.30**
	(0.09)	(0.09)	(0.12)
$t \geq 4$	0.27**	-0.03	0.43***
	(0.12)	(0.12)	(0.16)
Firm FE	Yes	Yes	Yes
Year-4DSect-Prov FE	Yes	Yes	Yes
Mean Dep. Var. (level)	2.81	2.15	1.73
SD Dep. Var. (level)	5.73	4.71	3.45
Adjusted R^2	0.98	0.98	0.97
# Observations	1445	576	929
# Fixed Effects	691	276	455
# Firms	174	69	113

Notes: The dependent variable in all columns is a measure of productivity resulting from production function estimation. We assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for K, L and M respectively. Each column reports event study point estimates from a separate regression in which firms preserved for estimation are those whose first MNC client operates in the sectoral group listed in the row heading. We keep the three most populated sectoral groups: manufacturing, retail and services. As for this exercise one needs to know which MNC triggered the event of a first match, by construction, all specifications in this table focus only on eventually treated firms and implement the clustering at the event-by-province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C15: Event Study: Productivity Gains by MNC FTZ Status

	Not in FTZ (1)	In FTZ (2)	Pooled Diff (3)
$t \leq -4$	0.05	-0.02	0.02
	(0.03)	(0.06)	(0.04)
$t = -3$	0.02	0.01	0.01
	(0.02)	(0.05)	(0.04)
$t = -2$	0.02	0.02	0.03
	(0.02)	(0.06)	(0.04)
$t = 0$	0.04**	0.17**	0.05
	(0.02)	(0.07)	(0.05)
$t = 1$	0.08***	0.26***	0.05
	(0.02)	(0.07)	(0.05)
$t = 2$	0.08***	0.20**	0.04
	(0.03)	(0.09)	(0.05)
$t = 3$	0.07*	0.28**	0.09*
	(0.04)	(0.11)	(0.05)
$t \geq 4$	0.04	0.31***	0.09**
	(0.05)	(0.11)	(0.05)
Year-4DSect-Prov_FE	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes
Adjusted R^2	0.97	0.97	0.96
# Observations	5802	566	7642
# Firms	906	103	1180

Notes: The dependent variable in all columns is a measure of productivity resulting from production function estimation. We assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for *K*, *L* and *M* respectively. Columns 1 and 2 report event study point estimates from separate regressions in which firms preserved for estimation are those whose first MNC client is either not part or part of a Free Trade Zone (FTZ). Column 3 is a pooled regression over the two previous samples. As for this exercise one needs to know which MNC triggered the event of a first match, by construction, all specifications in this table focus only on eventually treated firms and implement the clustering at the event-by-province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C16: Event Study: Productivity Gains by MNC Skill Level

	Bottom Third (1)	Center Third (2)	Top Third (3)	Pooled Diff Center vs Rest (4)
$t \leq -4$	-0.02	0.02	-0.03	0.05
	(0.05)	(0.08)	(0.05)	(0.03)
$t = -3$	0.01	-0.04	-0.02	0.00
	(0.04)	(0.06)	(0.04)	(0.04)
$t = -2$	-0.01	0.03	-0.03	0.05
	(0.03)	(0.05)	(0.03)	(0.04)
$t = 0$	0.05*	0.09**	0.03	0.01
	(0.03)	(0.04)	(0.04)	(0.03)
$t = 1$	0.08**	0.17***	0.08*	0.03
	(0.04)	(0.06)	(0.04)	(0.03)
$t = 2$	0.05	0.22***	0.09*	0.07*
	(0.05)	(0.08)	(0.05)	(0.03)
$t = 3$	0.10	0.29***	0.07	0.06
	(0.06)	(0.10)	(0.06)	(0.04)
$t \geq 4$	0.08	0.28**	0.05	0.07*
	(0.08)	(0.12)	(0.08)	(0.04)
Year-4DSect-Prov_FE	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes
HS Share	[0.15-0.55)	[0.55-0.80)	[0.80-1)	[0.15-1]
Adjusted R^2	0.98	0.95	0.97	0.97
# Observations	1274	1854	2044	6844
# Firms	191	310	340	1073

Notes: The dependent variable in all columns is a measure of productivity resulting from production function estimation. We assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for *K*, *L* and *M* respectively. Each first MNC client is assigned its mean share of high-skilled workers across all years when the MNC is active. These mean shares across all first MNC clients form a distribution that we split in three equally-sized bins: the bottom 33 percentiles, the central 34 to 67 percentiles and the top percentiles between 68 and 99. Columns 1 to 3 run separate event studies for each bin, whereas Column 4 reports results from a pooled regression testing a difference in event study coefficients for the central bin compared to the bottom and top bins combined. As for this exercise one needs to know which MNC triggered the event of a first match, by construction, all specifications in this table focus only on eventually treated firms and implement the clustering at the event-by-province level. Robust standard errors in parentheses. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

C.5 Ruling Out Alternative Hypotheses

C.5.1 Firms do not Improve Their Third Party Reporting after Starting to Sell to an MNC

Table C17: Event Study: Similar Compliance in Third Party Reporting Before and After Supplying to an MNC

	Seller-Diff (1)	Buyer-Diff (2)	Mis-Seller (3)	Seller-Diff (4)	Buyer-Diff (5)	Mis-Seller (6)
$t \leq -4$	-0.005	0.001	-0.001	-0.004	-0.003	0.008
	(0.003)	(0.003)	(0.001)	(0.015)	(0.012)	(0.008)
$t = -3$	-0.001	0.003	0.000	0.001	-0.001	0.007
	(0.002)	(0.003)	(0.001)	(0.007)	(0.007)	(0.005)
$t = -2$	-0.000	0.002	-0.002*	0.000	0.001	-0.000
	(0.002)	(0.002)	(0.001)	(0.005)	(0.004)	(0.003)
$t = 0$	0.002	0.004*	0.000	-0.001	0.001	-0.002
	(0.002)	(0.002)	(0.001)	(0.004)	(0.004)	(0.003)
$t = 1$	0.004	0.003	0.002	-0.001	0.006	-0.003
	(0.002)	(0.003)	(0.001)	(0.006)	(0.007)	(0.006)
$t = 2$	0.000	0.001	0.003**	-0.003	0.004	-0.006
	(0.002)	(0.003)	(0.001)	(0.010)	(0.010)	(0.007)
$t = 3$	-0.001	0.002	0.003	-0.004	0.003	-0.009
	(0.003)	(0.003)	(0.002)	(0.013)	(0.013)	(0.009)
$t \geq 4$	-0.002	0.000	0.003*	-0.004	0.004	-0.013
	(0.003)	(0.003)	(0.002)	(0.016)	(0.018)	(0.013)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	No	No	No
Never_Matched	Yes	Yes	Yes	No	No	No
Mean Dep. Var. (level)	0.0094	0.018	0.0047	0.020	0.022	0.010
SD Dep. Var. (level)	0.035	0.048	0.023	0.049	0.051	0.030
Adjusted R^2	0.15	0.11	0.13	0.15	0.072	0.11
# Observations	53275	53275	53275	4864	4864	4864
# Fixed Effects	17727	17727	17727	2028	2028	2028
# Firms	10098	10098	10098	762	762	762

Notes: Table C17 shows the results of running specification 7 adapted to three measures of quality in third-party reporting. "Seller-diff" is a weighted average of the percentage difference in values reported, across all transactions in a year for which a firm is the seller. The percentage difference is computed as the (maximum value reported-minimum value reported)/(minimum value reported). "Seller-diff" uses as weights the importance of the transaction in that year for the seller. "Buyer-diff" is analogously constructed, this time keeping only transactions for which a firm is the buyer. "Mis-Seller" is defined as (the total number of buyers that reported a given firm as a seller, buyers that are not reported back by the seller)/(the total number of buyers of the said selling firm). The event is defined as a first time sale to an MNC. Columns 1 to 4 report event study estimates for the sample including both domestic firms that become first-time suppliers to an MNC after 2010 and domestic firms never observed as supplying to an MNC during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 5 to 8 focus only on the sample of domestic firms becoming first-time suppliers to an MNC after 2010 and use standard error clustering at event by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

C.5.2 Not Just a Demand Story: Event Study of Becoming a Government Contractor

Table C18: Event Study: No or Short-term Growth after Becoming a Government Contractor

	Total Sales (1)	Number of Workers (2)	CD *K, L* (3)	TL *K, L* (4)	Total Sales (5)	Number of Workers (6)	CD *K, L* (7)	TL *K, L* (8)
$t \leq -4$	-0.011	-0.011	-0.006	0.003	0.078	0.012	0.080*	0.081*
	(0.017)	(0.014)	(0.014)	(0.013)	(0.046)	(0.040)	(0.045)	(0.047)
$t = -3$	0.000	-0.006	0.008	0.011	0.014	-0.007	0.039	0.041
	(0.015)	(0.014)	(0.009)	(0.009)	(0.036)	(0.033)	(0.028)	(0.031)
$t = -2$	0.005	-0.007	0.007	0.008	-0.022	-0.024	0.001	0.001
	(0.011)	(0.011)	(0.011)	(0.010)	(0.026)	(0.018)	(0.024)	(0.025)
$t = 0$	0.044***	0.010	0.040***	0.040***	0.039*	0.021	0.008	0.009
	(0.009)	(0.017)	(0.009)	(0.010)	(0.022)	(0.019)	(0.021)	(0.021)
$t = 1$	0.057***	0.040***	0.045***	0.046***	-0.005	0.002	-0.019	-0.016
	(0.014)	(0.012)	(0.014)	(0.014)	(0.036)	(0.041)	(0.035)	(0.034)
$t = 2$	0.069***	0.047***	0.046***	0.046***	-0.030	-0.017	-0.037	-0.034
	(0.015)	(0.016)	(0.013)	(0.013)	(0.044)	(0.065)	(0.045)	(0.044)
$t = 3$	0.040	0.034	0.028	0.026	-0.106	-0.027	-0.108	-0.104
	(0.027)	(0.025)	(0.024)	(0.022)	(0.065)	(0.100)	(0.075)	(0.071)
$t \geq 4$	0.023	0.050	0.001	-0.002	-0.121	-0.052	-0.110	-0.104
	(0.036)	(0.037)	(0.023)	(0.023)	(0.092)	(0.126)	(0.096)	(0.087)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	No	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	No	No	No	No
Never_Matched	Yes	Yes	Yes	Yes	No	No	No	No
Mean Dep. Var. (level)	1.02	17.7	1.02	1.02	3.96	38.1	3.96	3.96
SD Dep. Var. (level)	4.88	55.6	4.88	4.88	17.4	143.4	17.4	17.4
Adjusted R^2	0.87	0.83	0.92	0.93	0.94	0.92	0.96	0.96
# Observations	116198	116198	116198	116198	5069	5069	5069	5069
# Fixed Effects	27901	27901	27901	27901	1784	1784	1784	1784
# Firms	15518	15518	15518	15518	495	495	495	495

Notes: Table C18 shows the results of running specification 7 adapted to two dependent variables capturing firm size: log total sales (including exports) and log total number of workers. The event is defined as the first time a domestic firm sells to the Government. Columns 1 to 4 report the event study estimates for the sample including both domestic firms that become first-time contractors for the Government after 2010 and domestic firms never observed as selling to the Government during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 5 to 8 focus only on the sample of domestic firms that become first-time contractors for the Government after 2010 and use standard error clustering at event by province level. As the extended sample in this table is a supraset of that in Table C20 – because it does not require that all firms report input costs (M) – Columns 3, 4 and 7, 8 repeat the exercise in Columns 2, 3 and 5, 6 from Table C20 with one modification only - assuming a 2-factor (instead of a 3-factor) production function. Means (in levels) of dependent variables are reported in US$ millions (PPI-deflated to 2013 US$) for sales and in number of workers. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C19: Event Study Mean Shift: No or Small Improvement in Firm Productivity after Becoming a Government Contractor

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
Mean Prod. Shift	-0.006	0.018*	0.004	0.005	0.027**	0.009
	(0.012)	(0.010)	(0.009)	(0.014)	(0.011)	(0.008)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	Yes	Yes	Yes	No	No	No
Year-4DSect-Prov-Age FE	No	No	No	Yes	Yes	Yes
Adjusted R^2	0.63	0.96	0.97	0.62	0.96	0.97
# Observations	65750	65750	65750	60682	60682	60682
# Firms	9522	9522	9522	8552	8552	8552

Notes: Table C19 shows the results of running the mean-shift version of specification 7 adapted to three measures of productivity. The event is defined as a first time sale to the Government. All columns report event study mean shift estimates for the sample including both domestic firms that become first-time suppliers to the Government after 2010 and domestic firms never observed as supplying to the Government during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 1-3 differ from columns 4-6 in the fixed effects used. Columns 1 and 4 use as a dependent variable a productivity index constructed under the assumption a Cobb-Douglas production function. This method "residualizes" sales by subtracting firm-level inputs used, weighted by the respective 2-digit-level cost shares. Concretely, the Cobb-Douglas productivity index dependent variable is $Y_{ist} - \alpha_{k,s2D} \times K_{ist} - \alpha_{l,s2D} \times WB_{ist} - \alpha_{m,s2D} \times M_{ist}$, where $\alpha_{l,s2D}$=(2-digit sectoral wage bill)/(2-digit sectoral revenues), $\alpha_{m,s2D}$=(2-digit sectoral input costs)/(2-digit sectoral revenues) and $\alpha_{k,s2D} = 1 - \alpha_{l,s2D} - \alpha_{m,s2D}$. Columns 2 and 5 use a measure of productivity resulting from production function estimation. These columns assume a Cobb-Douglas technology, with revenues (PPI-deflated to 2013 US$) as the output measure and total net assets, number of workers and input costs as input measures for *K*, *L* and *M* respectively. Columns 3 and 6 differ from Columns 2 and 5 in their assumption of a translog functional form. For both Cobb-Douglas and translog, we estimate the coefficients on factors of production over the entire sample of domestic firms, controlling for narrowly defined fixed effects. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C20: Event Study: No or Short-term Productivity Gains from Becoming a Government Contractor

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
$t \leq -4$	0.020	-0.011	-0.003	0.043	0.026	0.062
	(0.012)	(0.010)	(0.009)	(0.066)	(0.061)	(0.046)
$t = -3$	0.010	-0.000	0.001	0.022	0.002	0.031
	(0.012)	(0.008)	(0.007)	(0.045)	(0.042)	(0.031)
$t = -2$	0.010	0.003	0.004	0.023	0.007	0.013
	(0.011)	(0.009)	(0.008)	(0.018)	(0.018)	(0.015)
$t = 0$	0.022*	0.026***	0.014*	0.000	0.010	-0.008
	(0.012)	(0.010)	(0.008)	(0.017)	(0.021)	(0.015)
$t = 1$	0.026*	0.031**	0.016*	-0.006	-0.002	-0.024
	(0.015)	(0.012)	(0.009)	(0.034)	(0.038)	(0.028)
$t = 2$	0.008	0.023	0.006	-0.001	-0.000	-0.040
	(0.019)	(0.015)	(0.012)	(0.039)	(0.051)	(0.035)
$t = 3$	0.000	0.002	-0.011	-0.019	-0.037	-0.087*
	(0.018)	(0.016)	(0.012)	(0.043)	(0.069)	(0.045)
$t \geq 4$	0.014	0.012	0.002	0.004	-0.012	-0.082
	(0.021)	(0.018)	(0.015)	(0.047)	(0.088)	(0.057)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov FE	No	No	No	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	No	No	No
Never_Matched	Yes	Yes	Yes	No	No	No
Mean Dep. Var. (level)	0.30	1.42	1.42	0.34	4.98	4.98
SD Dep. Var. (level)	0.54	6.10	6.10	0.37	20.4	20.4
Adjusted R^2	0.62	0.96	0.97	0.64	0.98	0.99
# Observations	60682	60682	60682	3602	3602	3602
# Fixed Effects	15511	15511	15511	1243	1243	1243
# Firms	8552	8552	8552	376	376	376

Notes: Table C20 shows the results of running specification 7 adapted to the same three measures of productivity defined for Table C19. The event is defined as a first time sale to the Government. Columns 1 to 4 report event study estimates for the sample including both domestic firms that become first-time suppliers to the Government after 2010 and domestic firms never observed as supplying to the Government during our entire B2B transactions data. Clustering of standard errors is at the 2-digit sector by province level. Columns 5 to 8 focus only on the sample of domestic firms becoming first-time suppliers to an MNC after 2010 and use standard error clustering at event by province level. Means (in levels) of sales (residualized in Columns 1 and 4) are reported in US$ millions (PPI-deflated to 2013 US$). Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C21: Event Study: Firm Level Productivity, Robustness of Event Window

	CD Index (1)	CD *K,L,M* (2)	TL *K,L,M* (3)	CD Index (4)	CD *K,L,M* (5)	TL *K,L,M* (6)
$t \leq -4$				0.020	-0.011	-0.003
				(0.012)	(0.010)	(0.009)
$t \leq -3$, $t = -3$	0.017	-0.008	-0.002	0.010	-0.000	0.001
	(0.011)	(0.009)	(0.008)	(0.012)	(0.008)	(0.007)
$t = -2$	0.010	0.002	0.003	0.010	0.003	0.004
	(0.011)	(0.009)	(0.008)	(0.011)	(0.009)	(0.008)
$t = 0$	0.023*	0.026***	0.014*	0.022*	0.026***	0.014*
	(0.012)	(0.010)	(0.008)	(0.012)	(0.010)	(0.008)
$t = 1$	0.026*	0.031**	0.016*	0.026*	0.031**	0.016*
	(0.015)	(0.012)	(0.009)	(0.015)	(0.012)	(0.009)
$t = 2$	0.008	0.023	0.006	0.008	0.023	0.006
	(0.019)	(0.014)	(0.012)	(0.019)	(0.015)	(0.012)
$t \geq 3$, $t = 3$	0.007	0.007	-0.005	0.000	0.002	-0.011
	(0.018)	(0.015)	(0.012)	(0.018)	(0.016)	(0.012)
$t \geq 4$				0.014	0.012	0.002
				(0.021)	(0.018)	(0.015)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.62	0.96	0.97	0.62	0.96	0.97
# Observations	60682	60682	60682	60682	60682	60682
# Firms	8552	8552	8552	8552	8552	8552

Notes: Table C21 shows the results of running specification 7 adapted to the same three measures of productivity defined for Table C19. The event is defined as a first time sale to the Government. All columns report event study estimates for the sample including both domestic firms that become first-time suppliers to the Government after 2010 and domestic firms never observed as supplying to the Government during our entire B2B transactions data. Columns 1 to 3 differ from Columns 4 to 6 in the definition of $\underline{C}$ and $\overline{C}$, i.e., $\underline{C}$=*-3* and $\overline{C}$=*+3* for Columns 1 to 3 and $\underline{C}$=*-4* and $\overline{C}$=*+4* for Columns 4 to 6. Clustering of standard errors is at the 2-digit sector by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C22: Event Study: Other Proxies of Productivity

	Sales/ Worker (1)	VA/ Worker (2)	Profits/ Worker (3)	Sales to Dom. clients (4)	Number of Dom. clients (5)
$t \leq -4$	0.001	0.023	0.023	0.009	-0.011
	(0.014)	(0.029)	(0.023)	(0.019)	(0.020)
$t = -3$	0.007	-0.016	-0.008	-0.000	-0.015
	(0.012)	(0.025)	(0.019)	(0.017)	(0.014)
$t = -2$	0.012	0.037	0.037**	-0.002	-0.006
	(0.011)	(0.023)	(0.016)	(0.010)	(0.011)
$t = 0$	0.033**	0.055*	0.046*	-0.155***	-0.011
	(0.014)	(0.028)	(0.024)	(0.046)	(0.013)
$t = 1$	0.018	0.035	0.034*	-0.090***	0.014
	(0.012)	(0.024)	(0.020)	(0.029)	(0.018)
$t = 2$	0.022	0.009	0.011	-0.104**	0.032
	(0.017)	(0.033)	(0.029)	(0.049)	(0.020)
$t = 3$	0.007	0.013	0.006	-0.128**	0.001
	(0.025)	(0.033)	(0.025)	(0.052)	(0.025)
$t \geq 4$	-0.027	-0.017	-0.007	-0.119**	0.005
	(0.023)	(0.037)	(0.032)	(0.057)	(0.030)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year-4DSect-Prov-Age FE	Yes	Yes	Yes	Yes	Yes
Never_Matched	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. (level)	0.066	0.027	0.032	1.09	17.2
SD Dep. Var. (level)	0.16	0.069	0.069	5.43	54.9
Adjusted R^2	0.80	0.60	0.62	0.89	0.90
# Observations	116198	116198	116198	83895	83895
# Fixed Effects	27901	27901	27901	23975	23975
# Firms	15518	15518	15518	13956	13956

Notes: All columns report event study estimates for the sample including both domestic firms that become first-time suppliers to the Government after 2010 and domestic firms never observed as supplying to the Government during our entire B2B transactions data. Column 1 uses as dependent variable log sales per employee, column 2 uses log value added per employee, while column 3 uses log profits per employee. Columns 4 and 5 explore how the value of sales to domestic clients (excludes the Government) and the number of domestic clients evolve after a domestic firm becomes a supplier to the Government. Clustering of standard errors is at the 2-digit sector by province level. Robust standard errors in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

D Data

D.1 Corporate Tax Returns and Social Security Micro-data

Our first administrative dataset contains the universe of corporate tax returns of active firms over the 2005 to 2015 period. Firms are defined in our dataset as a corporation or individual[52] conducting business in Costa Rica, and every firm must file a yearly tax declaration called D-101 (*"Declaracion Jurada del Impuesto Sobre la Renta"* or the "Affidavit of Income Tax") to the Ministry of Finance of Costa Rica (*Ministerio de Hacienda*). This form contains information on profit, revenue, cost, assets, among others. Costs are reported into a few line items, which include, administrative cost (including wages), material inputs, capital depreciation, interest payments and other costs. Currently not filing the D-101 results in payments of fines up to $385, plus 11%-12% annual interest on one's income tax liability.

In addition, this dataset includes variables that come from data reported to the Costa Rican Social Security Fund ("Caja Costarricense del Seguro Social") which include the number of employees and wage bill for each firm, as well as the share of high-skill employees.[53] We consider firms as active – hence, they appear in our datasets – if they report data to the Social Security at some point during our period of analysis.

The information from those two primary sources is complemented in our dataset with information on ownership and management from the Central Bank and other sources we examine. The Bank identifies groups of firms that have common owners using data from the National Registry of firms, domestic and foreign surveys, and other public and private information. These groups of firms are called *"grupo corporativo"* or "corporate group". A *"grupo empresarial"* or "firm group" is a set of firms that not only share ownership but behave as one firm, meaning that one cannot consider them as separate business ventures.[54]

We add to the definition of firm groups the sets of firms that belong to the same corporate group and belong to the same sector. Additionally, we use information from the Orbis and Amadeus databases from Bureau Van Dijk to augment our knowledge of firms that are related to each other.[55] There are 3947 corporate groups identified, as well as 1881 firm groups. We expand our dataset to include tax returns data from firms even if they lack social security data if it is known that they are part of a corporate group.[56]

For the purposes of our empirical excercise, we collapse the data and treat firm groups as one individual firm. We keep track of business relationships of all firms in the group with other parties, but keeping only one identifier for the group. We keep the characteristics

[52] For instance, any individual renting real estate or providing professional services must comply with this requirement.

[53] For the construction of this variable, a worker is defined as high-skilled if he/she earns more than the minimum wage paid to a worker with vocational post-high school training.

[54] Hypothetical firms A, B, and C owned by the same corporation operate in a way such that, in our data, some assets are owned by firm A, wages are paid by firm B, and firm C pays costs related to the whole operation, and all three firms behave as one for which the objective is to sell product z in Costa Rica.

[55] These are discussed in more detail in Appendix D.4.

[56] The most telling behavior of a firm to identify such case is having income above a threshold –usually $1 million– but with no employees reported.

(identifier, sector, location) of the most relevant firm in terms of sales within the group.

We want to keep the universe of domestic private firms that are part of the non-financial market economy. Therefore, we drop non-governmental organizations (NGOs), public entities (including utilities), and those observations that are registered as households. We drop data from the education sector (private owned schools and universities), and the construction sector,[57] as well as firms related to the financial sector. We do not consider an observation as a firm if there is less than one worker reported in all the period of observation. The aforementioned criteria let us identify 75,123 firms.

We impose minimal size restrictions for our sample in our empirical exercise. Firms have to report both workers and sales with no gaps in the data, and we consider only firms that, over the years, have a median of at least three workers. Finally, we drop firms with median sales of less than $25,000 PPI-deflated to 2013 US$. These restrictions leave us with 22,891 firms. The loss in number of observations, however, is not that significant when we compare with the universe of private firms that are part of the non-financial market economy.

The size restrictions we impose do not seem to hamper the coverage of our variables. Even though we lose more than two thirds of the firms, Table D23 shows that we keep those that employ most of the labor force and represent the largest share of sales, exports, income, costs and assets. In most variables we have coverage of around 80% of the values of the variables.

Table D23: Sample data coverage

	Coverage
Wage bill	84.4%
Exports	84.7%
Imports	88.4%
Total sales	77.7%
Employment	79.9%
Value Added	78.0%
Input costs	81.1%
Total Net Assets	72.5%

Notes: Values in millions of PPI-deflated 2013 US$. For details on the sources and construction of the variables related to foreign trade, see Appendix D.3.

In the following table we present descriptive statistics of the variables in the universe of non-financial market economy dataset in contrast to the sample used in the empirical exercises.

[57] Most of these firms are active for one construction project only, disappearing immediately after being active for one or two years.

Table D24: Descriptive statistics, sample data

	N	Mean	S.D.	Median
Non-financial market economy				
Wage Bill	75,123	45.5	313.3	11.1
Exports	4,093	490.4	3,016.2	24.2
Imports	20,486	206.6	1,456.1	13.0
Total Sales	74,840	446.2	3,498.4	106.1
Employment	75,123	7.2	32.6	2.5
Value Added	74,817	179.0	1,068.5	63.8
Input Costs	62,415	307.5	2,895.0	26.0
Total Net Assets	64,186	406.2	7,367.0	54.1
Sample				
Wage Bill	22,891	121.0	559.0	35.9
Exports	2,472	675.3	3,797.5	30.9
Imports	7,937	449.9	2,292.3	32.4
Total Sales	22,891	1,120.3	6,295.8	294.2
Employment	22,891	17.9	57.1	6.9
Value Added	22,891	410.6	1,895.7	153.2
Input Costs	18,893	800.6	5,183.7	114.5
Total Net Assets	20,142	954.8	12,944.2	148.1

Notes: With the exception of employment, the mean, s.d., and median in thousands of PPI-deflated 2013 US$.

D.2 Firm-to-firm Transactions Micro-data

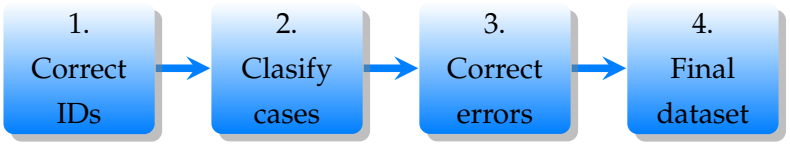
Our most important dataset allows us tracks all business-to-business (B2B) relationships in Costa Rica between 2008 and 2016. This data is collected by the Ministry of Finance through the tax form D-151, the "Declaración anual resumen de clientes, proveedores y gastos específicos" (Declaration of the yearly summary of clients, suppliers and specific expenses). This declaration is compulsory not only to private businesses, but to all actors in the economy (e.g. individuals providing professional services, public entities, NGOs, embassies etc.), irrespective of being subject to the corporate income tax or not. A late filing of this fee is heavily penalized, e.g. in 2016 the late filing fee could go from $7,040 to $70,400.

To help enforce taxes, each firm has to report all of its corporate suppliers and clients with a yearly accumulated amount of transactions above 2.5 million Costa Rican colones (approximately $4,400).[58] Third-party reporting, of the type D-151 ensures, is used by the tax authority to identify firms that have not complied with their filing obligations, e.g. firms that have over-reported their costs or under-reported their revenues to reduce their profit

[58]For the sale of professional services by individuals, the threshold is less than $100.

tax liability. The tax authority uses different communication interventions, namely emails, phone calls, or personal visits, to follow up with non-filers [Brockmeyer, Hernandez, Kettle, and Smith, 2016]. As D-151 forms contain the yearly amount sold to or bought from each partner, this dataset allows us not just to track buyer-supplier relationships in a given year, but also the intensity of those relationships.

A sequence of steps was followed to ensure that several coding or reporting errors were corrected in the raw D-151 database, and that the ID's of firms identified as buyers and sellers are coherent with the rest of our data. The steps can be summarized as follows:



The first step relates to the fact that the Ministry of Finance usually assigns extra characters to the ID's of corporations or individuals, which need to be removed before the data can be linked to the tax returns and social security microdata. The presence of foreign IDs require additional steps to ensure data quality: it is not unusual that early transactions of a foreign firm are recorded using passport or foreigns ID numbers, whereas later on those transactions are recorded using a Costa Rican tax ID. BCCR tracks those changes to ensure that the transactions are imputed to the correct tax ID when building the dataset.

The second step involves identifying different reporting inconsistencies. The ideal case is one in which the transaction between two firms is reported by both firms, given the same description, and having the exact same reported amount in both filings. In such case, the duplication is taken into consideration to keep it as one observation, and there is no need to perform any additional corrections. However, inconsistencies arise when transactions appear only once, the amount shown is different within a pair, submissions that were rejected by the Ministry of Finance cause duplicates of correct lines, or there is a lack of data. Also, whenever individuals buy from firms, they are not required to report that purchase, so around one fifth of the reports by firms have no counterpart but cannot be classified as an error or misreporting.

The corrections that were done to the dataset are summarized herafter:

1. Whenever the transaction was reported by both parts but with amounts appearing to differ because of a simple error in the position of a decimal point, historical data was used to identify the correct data.

2. When a pair of transactions have one of the parts reporting an amount of zero, the amount from the transaction reporting a positive value was assumed to be correct. The same solution was used when one part of the couple fills in incorrectly one of the IDs as the value for the transaction.

3. When the difference in the amount of a pair of transactions is more than 20% or more than 50 millions of colones (close to $100 thousand), and one of the sides of the transac-

tion showed a value of more than 500 millions of colones (close to $1 million)[59] careful manual checks were completed using historical data to identify the correct value.

4. When a transaction appeared more times because of a resubmission (usually for corrections), only the most recent observation was kept.

The following tables summarize the number of transactions and the corresponding value of the transactions that were analyzed. For the empirical exercise we can use two sets of transactions: first, the data showing up in pairs that were either matched perfectly in the raw data or with inconsistencies that were solved by the corrections explained beforehand. The second set of transactions that we can use are the cases where transactions had no partner, either because there was a reason for not having it as explained above, or because there is missing information.

Unsolved cases include those that could eventually be corrected but for which the value of the transaction is below our chosen threshold for manual checks. The second category of data that we cannot use are cases where transactions had no duplicate, but they are classified as rejected by the Ministry of Finance in the revision of the tax declaration submissions. There is a small set of transactions that we were able to identify as duplicates of others that are already considered in the data. Finally, the smallest set of transactions includes those that were excluded due to being mistakenly reported.[60]

Table D25: Number of cases, B2B micro-data

	2008		**2012**		**2015**	
Type of case	Count	%	Count	%	Count	%
Data in pairs	535,863	41.9%	998,355	40.5%	1,383,820	42.2%
No partner	493,769	38.7%	1,256,978	51.0%	1,626,907	49.6%
Subtotal of used data	**1,029,632**	**80.6%**	**2,255,333**	**91.5%**	**3,010,727**	**91.9%**
Unsolved	128,599	10.1%	202,710	8.2%	251,499	7.7%
No partner and rejected	108,969	8.5%	-	0.0%	-	0.0%
Duplicate	4,904	0.4%	5,936	0.2%	14,652	0.4%
Excluded	5,414	0.4%	34	0.0%	32	0.0%
Total	**1,277,518**	**100.0%**	**2,464,013**	**100.0%**	**3,276,910**	**100.0%**

[59] This last criteria was required to prioritize which transactions would be manually checked. Even though only a fourth of the transactions were checked, they represented more than 80% of the value.

[60] For example, the Ministry of Finance is aware that accountant firms sometimes mix up the forms of different client firms when submitting them to the tax authority, which are later rectified.

Table D26: Value of transactions, B2B micro-data

Type of case	2008 Value	2008 %	2012 Value	2012 %	2015 Value	2015 %
Data in pairs	45,812	63.6%	55,489	67.5%	69,450	69.1%
No partner	11,808	16.4%	16,637	20.2%	18,496	18.4%
Subtotal of used data	**57,620**	**80.0%**	**72,126**	**87.7%**	**87,946**	**87.6%**
Unsolved	7,766	10.8%	10,002	12.2%	12,324	12.3%
No partner and rejected	6,145	8.5%	-	0.0%	-	0.0%
Duplicate	170	0.2%	71	0.1%	172	0.2%
Excluded	359	0.5%	1	0.0%	2	0.0%
Total	**72,060**	**100.0%**	**82,200**	**100.0%**	**100,444**	**100.0%**

Notes: Values in millions of PPI-deflated 2013 US$.

We are able to use no less than 80% of the transactions and value of the data from the raw files of the Ministry of Finance. After a few years, this number is above 90%. Moreover, we are not losing data that is either rejected, duplicate or excluded (especially during the first of our sample), these are reporting or dataset errors that cannot be considered real transactions. Additionally, the transactions that are not used because they are categorized as "unsolved" are usually less than 10% of the total. It should be noted that they the value represents a slightly larger percentage because some of the mistakes involve the system ignoring the decimal point, which can overestimate the values of the transaction by one or more orders of magnitude.

Descriptive statistics of our database show that the behavior of the Costa Rican production network is similar to those of other countries. For example, Bernard, Moxnes, and Saito [Forthcoming] document among several stylized factor for the Japanese production network that larger firms have more suppliers, and there is negative degree assortativity among sellers and buyers. Both facts are observed in our data, as shown in Graphs D8 and D9.

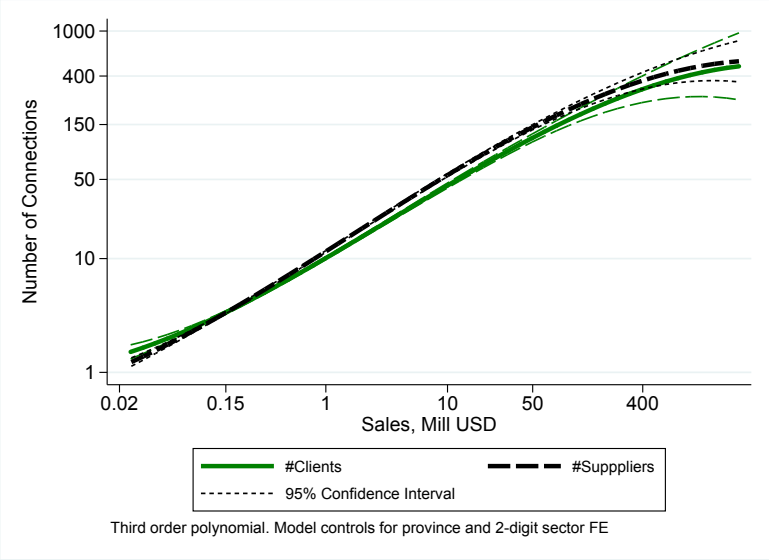


Figure D8: Size, in-degree and out-degree

Notes: The figure shows the third degree polynomial regression of firm-level log number of clients and suppliers (vertical axis) on log sales (horizontal axis) after controlling for year, 4-digit sector and province fixed effects. The two lines represent the number of clients and the number of suppliers as separate regressions, along their respective 95% confidence interval.

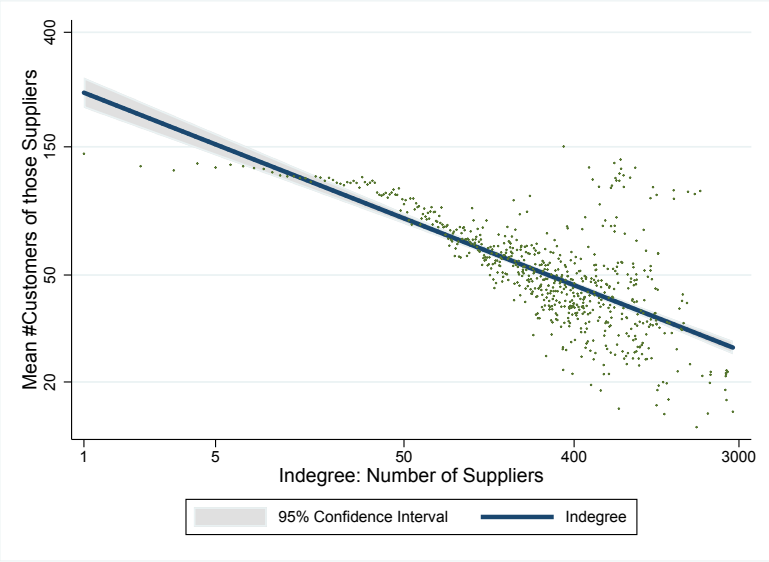


Figure D9: Degree Assortativity for Costa Rican Suppliers

Notes: The x axis shows the number of suppliers for each Costa Rican firm and y axis shows the the average number of clients of those suppliers.

D.3 Customs Micro-data

For the firms that engage in international trade we observe aggregate imports and exports, which are included in the database described in Appendix D.1. The data is reported in customs and collected by the Ministry of Finance with the same identification used for the rest of the data.

We have additional disaggregation for the data on exports and imports. We have access to the individual reports for each foreign trade transaction. This allows us to observe the country of destination or origin, exact date of shipment, description of the product, prices and quantities sold of each 10-digit product). From 2010 onward, the data is further disaggregated identifying the name of the individual foreign partner, in contrast to the older country-level aggregation of daily shipments of a product.

D.4 Foreign Ownership Micro-data

There is no centralized reporting in Costa Rica regarding the country of origin of the capital of firms. Our first source is the reporting that firms active under the Free Trade Zone (FTZ) regime. Costa Rica has followed a strategy of pursuing FDI investment by offering benefits to firms established in FTZ regimes. As summarized in OECD [2017a], the FTZ regime exempts the beneficiary firm from custom duties on imports and exports, the withholding tax (on royalties, fees, dividends), interest income, the sales tax on local purchases of goods and services and the stamp duty.

In addition, the FTZ regime exempts profits from corporate income tax for 8 years and provides a 50% corporate income tax reduction during the following 4 years, but differences exist depending on the types of activities and the location of the FTZ. Profits from sales to the domestic market are taxed under separate tax rules. Companies that may apply for the FTZ regime must be either (i) export service companies (at least 50% of services must be exported), (ii) scientific research firms (companies or organizations), (iii) "strategic companies" or part of "strategic sectors" or (iv) "significant suppliers" (at least 40% of their sales are made to FTZ companies). Because of those benefits, the firms have to comply with full reporting of the sources of capital and accounting data, which is collected by Procomer and is made available to the Central Bank for statistical purposes.

There are, however, limitations regarding the knowledge of foreign ownership outside of the FTZ regime. The Central Bank carries out three additional surveys as sources for complementary information on flows and sources of capital for foreign owned firms.

1. *Encuesta Trimestral de Balanza de Pagos*, or the "Quarterly Balance of Payments Survey": collects information on a sample of large firms (currently 250 to 300 firms) on their country of origin and percentage of foreign ownership.

2. *Encuesta Anual*, or the "Annual Survey": similar to the quarterly survey, but administered on a yearly basis. It contains a sample of 50 to 100 firms.

3. *Estudio Economico*, or the "Economic Study": when Costa Rica updated the system of national accounts, the Central Bank surveyed thousands of firms. Out of those, it identified and started tracking close to 944 firms having received foreign capital. For those firms, there is knowledge about the percentage of foreign ownership.

Our third source of information is Orbis, a commercial product belonging to Bureau

Van Dijk and accessed through UC Berkeley's subscription. We queried Orbis for all MNCs (*Global Ultimate Owners* in Orbis nomenclature) that have a presence (affiliate or branch) in Costa Rica, identifying the names and IDs of firms in Costa Rica and abroad, including intermediate ownership. As mentioned in Appendix D.1, Orbis allowed us to expand our knowledge of firm groups in Costa Rica. Orbis was also used to identify which of the foreign-owned firms in Costa Rica are actually part of an MNC. For foreign-firms for which this information was not readily available in Orbis, we carried out manual searches.

A final source of information is the Costa Rican Investment Promotion Agency (CINDE), which is a a private, non-profit organization that started its operations in 1982. CINDE has mediated the entry of more than 300 high-tech companies in Costa Rica, including Intel, Procter&Gamble, Hewlett Packard, Baxter and St. Jude Medical. CINDE shared with us data regarding the identity and date of entry of MNCs attracted to Costa Rica by CINDE.

After cross-checking across all sources, we have identified 3,809 tax IDs that have partial or full foreign ownership. To obtain a sample comparable to that of our domestic firms, we apply the same criteria used in Appendix D.1. We exclude NGOs, governmental entities (e.g., embassies) and households, so as to focus on private firms. In addition, we drop firms in the education, financial and construction sectors. After adding the information on firms' shared ownership, we arrive to 2,408 groups of firms (firms hereafter) with at least partial foreign ownership.

As motivated in Section 3, not all of these 2,408 are suitable for our analysis. More than half of these 2,408 firms are not part of an MNC. Moreover, even among the 1,045 actual MNC affiliates, half do not have a substantial presence in the country. Given our interest in measuring the productivity gains of joining MNC supply chains, we focus on the 516 of those 1,045 MNCs whose median number of workers, – over all years in which the MNC is active in Costa Rica, – is at least 100.

In Table D27 we present descriptive statistics for the sample of domestic private firms that are part of the non-financial market economy, as well as for firms with foreign ownership. We split firms with foreign ownership in two, making the distinction between (large) MNCs and the rest of foreign-owned firms. Excluded foreign-owned firms are significantly larger than domestic firms, while (large) MNCs are themselves an order of magnitude larger than excluded foreign-owned firms.

While restrictions on the MNC status and median number of workers might seem costly for the number of firms kept – out to the respective totals for the full sample of 2,408 firms with foreign ownership – these 516 MNCs are actually responsible for most of the foreign activity in Costa Rica. Table D28 presents totals adding up values for all firms part of the non-financial market economy, domestic- and foreign-owned alike. Columns (B) and (C) present the percentage of those values that are accounted for by firms with (partial or full) foreign ownership and (large) MNCs, respectively.

The last column shows that for most of the variables, the MNCs that we use for our

empirical exercises account for around 80% to 90% of the totals across all firms with foreign ownership. Hence, the minimal criteria resulting in the sample of 516 MNCs are not restrictive in terms of their coverage of the full sample of foreign-owned firms.

Table D27: Descriptive statistics

	N	Mean	S.D.	Median
Fully domestic firms				
Wage Bill	75,123	45.5	313.3	11.1
Exports	4,093	490.4	3,016.2	24.2
Imports	20,486	206.6	1,456.1	13.0
Total Sales	74,840	446.2	3,498.4	106.1
Employment	75,123	7.2	32.6	2.5
Value Added	74,817	179.0	1,068.5	63.8
Input Costs	62,415	307.5	2,895.0	26.0
Total Net Assets	64,186	406.2	7,367.0	54.1
Firms with Foreign Ownership *Excluding (Large) MNCs*				
Wage Bill	1,892	284.2	453.1	118.0
Exports	654	1,244.8	4,245.7	95.3
Imports	1,271	1,313.6	3,767.5	108.6
Total Sales	1,891	3,292.0	9,675.3	799.7
Employment	1,892	22.1	24.5	12.1
Value Added	1,891	1,238.7	3,316.4	388.2
Input Costs	1,779	2,019.8	8,061.2	184.7
Total Net Assets	1,849	4,228.4	15,171.9	705.7
(Large) MNCs				
Wage Bill	516	5,174.1	9,432.5	2,467.0
Exports	377	22,444.3	106,003.2	3,441.4
Imports	491	16,362.7	91,367.2	2,031.9
Total Sales	516	49,828.4	133,652.9	16,190.2
Employment	516	487.9	999.2	233.1
Value Added	516	19,964.2	73,481.4	7,425.3
Input Costs	499	30,322.8	82,202.9	7,547.5
Total Net Assets	514	41,815.8	84,237.1	13,905.7

Notes: With the exception of employment, the mean, s.d., and median in thousands of PPI-deflated 2013 US$.

Table D28: Sample coverage

	(A) Total	(B) All firms with foreign ownership	(C) (Large) MNCs	(C)/(B) (Large) MNCs/ Firms for. owned
Wage Bill	6,625.0	48.4%	40.3%	83.2%
Exports	11,282.8	82.2%	75.0%	91.2%
Imports	13,936.8	69.6%	57.6%	82.8%
Total Sales	65,332.9	48.9%	39.4%	80.5%
Employment	832.2	35.3%	30.3%	85.7%
Value Added	26,034.3	48.6%	39.6%	81.5%
Input Costs	37,915.7	49.4%	39.9%	80.8%
Total Net Assets	55,382.7	52.9%	38.8%	73.3%

Notes: Employment in thousands. The rest of the variables are in millions of PPI-deflated 2013 US$.

Table D29: Most frequent countries of global ultimate ownership

Country	Frequency	Percent	Cumulative
US	201	41.02	41.02
PA	31	6.33	47.35
ES	23	4.69	52.04
MX	23	4.69	56.73
CO	22	4.49	61.22
GB	18	3.67	64.90
DE	16	3.27	68.16
CH	14	2.86	71.02
FR	13	2.65	73.67
JP	13	2.65	76.33
CA	10	2.04	78.37
GT	10	2.04	80.41
SV	9	1.84	82.24
NI	7	1.43	83.67
NL	7	1.43	85.11
VE	6	1.22	86.33
CL	5	1.02	87.35
ID	5	1.02	88.37
IE	5	1.02	89.39
LU	5	1.02	90.41

Notes: Table D29 reports the countries of global ultimate ownership that correspond to at least 5 of the 516 MNCs in the final sample. 41 percent of MNCs are US-owned.

D.5 Procomer Micro-data

[Work in progress.]