Home-Country Productivity Spillovers from US Multinational Activity

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Abstract

This paper examines the role of multinationals in home-country productivity growth. A large body of work has examined the impact of multinational enterprises (MNEs) on domestic firms in foreign (host) countries through inward foreign direct investment (FDI). There is much less research on spillover effects from outward FDI on firms in the home countries of MNEs. However, policies promoting and subsidizing outward FDI have gained traction in developing countries as a means to potentially boost productivity growth. I evaluate this in the US context from 1989 to 2016 by estimating the impact of exposure to MNEs through horizontal and vertical linkages. Compared to existing work that relies on industry-level proxies of FDI and MNE exposure, I exploit firm-level variation in exposure to multinationals within the same product space and in buyer-supplier relationships. In addition, I distinguish between the endogenous network effect of exposure to a more productive firm, multinational or not, and the direct impact of being connected to an MNE. I find substantial direct positive effects of US multinationals on the productivity of their customers and competitors, and negative impacts on their suppliers.

1 Introduction

For a long time, scholars and policymakers have sought to understand how the activities of multinational enterprises (MNEs) shape the economic landscapes of the countries in which they operate. Of particular interest has been the prospect of multinationals as drivers of international technology diffusion, the idea that firms could gain productivity-enhancing knowledge through interactions with producers from other countries. In this regard, inward foreign direct investment (FDI) by MNEs has received considerable attention: if multinationals generate positive externalities on domestic firms in foreign (host) countries, then there is a policy rationale for attracting inward FDI.[1]

The effect of outward FDI has been explored to a lesser extent and researchers have focused primarily on the impacts on home-country employment, investment and exporting (Lipsey, 2004;

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[1]See Smeets (2008), Harrison and Rodríguez-Clare (2010), Havranek and Irsova (2011) and Alfaro (2017) for reviews of the literature.

Desai et al., 2009). However, policies promoting and subsidizing outward FDI have recently gained traction in developing countries, particularly in China (Perea and Stephenson, 2017). Proponents of such policies highlight the potential for productivity spillovers from multinational parent companies to domestic firms in the home country.

In this paper, I examine the impact of outward FDI in the US by estimating how much the productivity of US firms varies by their exposure to US multinationals through horizontal and vertical linkages. Using data from 1989 to 2016 on publicly-listed companies in *Compustat*, I document a positive relationship between an MNE's productivity and its activities abroad. To examine spillovers, I construct firm-specific measures of exposure to MNEs through vertical buyer-supplier relationships and horizontal product-market competition. My results show that domestic customers and competitors of MNEs tend to be more productive, while MNE suppliers within the US experience a negative impact on their total factor productivity (TFP).

The rest of this paper proceeds as follows: in the next section, I provide an overview of the existing literature. Section 3 outlines my empirical approach, and section 4 describes the data. Results are presented in section 5. Section 6 concludes.

2 Background and Related Literature

The basis for home-country productivity spillovers from outward FDI relies on the existence of an "own-firm effect", that is, the impact of an MNE's activities abroad on the its own productivity. Navaretti and Castellani (2004) and Borin and Mancini (2016) find that Italian firms become more productive after investing abroad, and Hijzen et al. (2011) find weaker productivity impacts for French MNEs. There are several reasons why one could expect a positive own-firm effect of FDI on productivity. MNEs may be become more productive due to scale economies, affiliate specialization within the firm, or knowledge acquired as result of deliberate technology-sourcing[2] in the host-country, and the parent company subsequently learning from its affiliates.

The knowledge or technology acquisition channel is the more salient source of potential home-country productivity spillovers. If an MNE's performance is improved by knowledge acquired abroad, domestic firms in the home country could benefit from relationships with the parent company in the same way that foreign firms in host countries could benefit from relationships with its affiliates. That is, transmission channels for spillovers from outward FDI are likely to be similar to those discussed in the literature on inward FDI. Within an industry, greater domestic productivity could be driven by competitive pressures, imitation of manufacturing processes or managerial strategies (Wang and Blomström, 1992), and workers moving to domestic firms with knowledge retained from experience in MNEs (Glass and Saggi, 2002). Vertical spillovers across buyer-supplier relationships could also be generated by customers of MNEs gaining access to higher-quality inputs, or suppliers benefiting from being integrated into MNEs' more efficient supply chains (Javorcik, 2004; Alfaro-Urena et al., 2019).

[2] For instance, early work by Kogut and Chang (1991) and Yamawaki (1993) suggests Japanese firms' investments in the US were aimed at tapping into the technological capacity of innovative US industries.

Empirical evidence of home-country productivity spillovers from outward FDI is limited. At the macroeconomic level, Potterie and Lichtenberg (2001) estimates the impact of changes in a country's R&D stock on its trade and investment partners, and finds larger spillovers from investing in R&D-intensive countries than from being invested in by those countries. Castellani and Pieri (2016) study a set of European countries, and finds that home-country labor productivity growth is positively correlated with outward investments in sales and distribution, but negatively correlated with outward investments in manufacturing activities. At the firm level, Braconier et al. (2001) find no relationship between Swedish firms' labor productivity and research and development (R&D) in foreign countries, while Globerman et al. (2000) show that domestic firms are more likely to cite patents from foreign locations in which Swedish multinationals have greater investments. Using data from on Estonian enterprises, Vahter et al. (2007) find a positive own-firm effect of outward FDI but weak evidence of intra-sectoral spillovers. My paper is most closely related to work by Tang and Altshuler (2015), who find a positive relationship between the productivity of domestic publicly-listed companies in the US and multinational activities in downstream industries.

In addition to providing further evidence on the existence of outward FDI spillovers, I improve upon existing work by exploiting firm-level variation in exposure to multinationals within the same product space and in buyer-supplier relationships. There are several advantages of firm-specific linkages over industry-level proxies. Firstly, it enables me to detect spillovers that would otherwise be masked by sector aggregation. This has been shown to be quantitatively meaningful in the inward FDI literature. For instance, Newman et al. (2015) find that domestic Vietnamese firms who purchase inputs from MNE affiliates have higher productivity, whereas industry-level forward spillovers from MNEs is negative. Secondly, by observing the interfirm linkages, I avoid making assumptions about the MNEs' input sourcing behavior which, as Barrios et al. (2011) point out, are implicit in standard industry-level measures.

Furthermore, I am able to explore richer interactions between vertical and horizontal effects. Consider a scenario represented in Figure 1, suppliers A and B in the upstream sector sell to competitor A and the MNE respectively, while customers A and B in the downstream sector buy from the MNE and competitor B, respectively. Supplier B could experience direct backward spillovers (BS_{MB}) due to its trading relationship with the MNE. Supplier A, on the other hand, is only indirectly affected by the MNE, either through the horizontal spillovers from Supplier B or the horizontal impact of the MNE on Competitor A (BS_{MAA}) who purchases from Supplier A. Industry-level measures of MNE exposure would only recover a composite estimate of the direct and indirect vertical spillovers, while my approach is able to distinguish between them and quantify the relative importance of each channel.

An additional contribution of my work is that I distinguish between general productivity spillovers in the US economy and the specific effects of MNE activities. Many of the mechanisms through which home-country spillovers from MNEs may occur are not exclusive to outward FDI; knowledge acquired by any other means could be transmitted in much the same way as technical expertise gained abroad. To the extent that exposure to more productive firms has differential

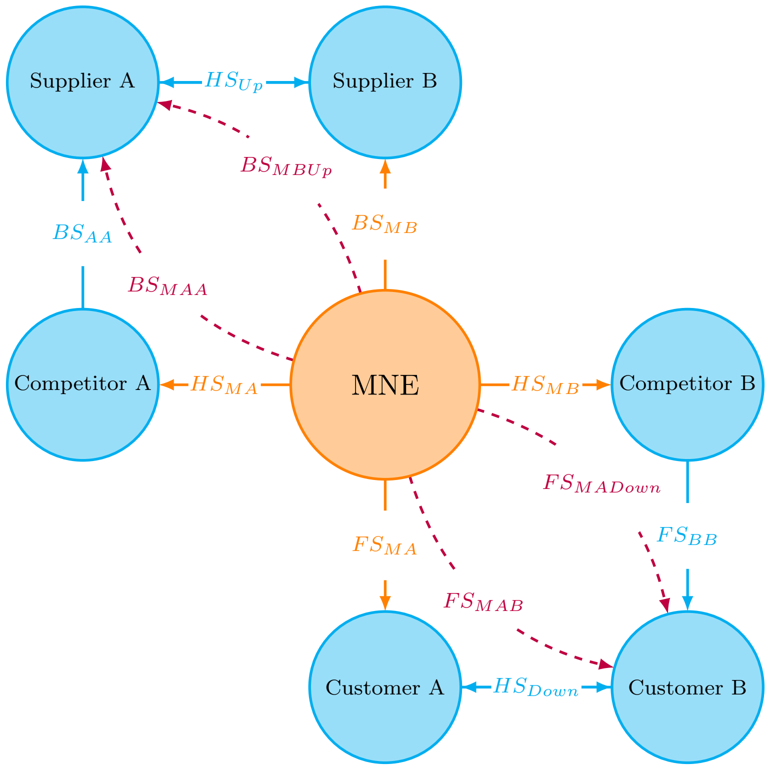

Figure 1: Possible interactions between horizontal and vertical spillovers.

Arrows show the direction of spillovers. Solid and dashed lines indicate direct and indirect spillovers respectively. BS, HS, and FS denote backward, horizontal and forward spillovers respectively.

impacts from interacting with less productive firms, estimated effects of transacting or competing with MNEs may have more to do with their productivity than their international activities. Existing studies show theoretically (Helpman et al., 2004) and empirically (Wagner, 2011) that more productive firms engage in FDI. Furthermore, as discussed above, outward FDI may also raise the productivity of multinationals themselves due to scale economies rather than knowledge transfers. This is an important distinction because the policy implications significantly differ. If outward FDI results knowledge transfers or spillovers, this would be reflected in both the impact of MNEs themselves and the indirect effect of their increased productivity, and could justify outward FDI promotion policies. However, if outward FDI does not generate any additional knowledge, there could still be positive spillovers operating through MNEs' raised productivity, but would make a less compelling case for the promotion of outward FDI in particular.

3 Empirical Approach

In this section, I describe my empirical strategy for recovering MNE spillover effects, which involves jointly estimating a firm-level production function and a productivity process that depends on a firm's interactions with MNEs and across industries. I incorporate spillovers into the productivity estimation process because, as I demonstrate in Iyoha (2021), failing to account for the way spillovers could affect a firm's input choices and output through its productivity may bias estimates TFP and spillovers. In section 3.1, I present a specification of the firm's productivity process, then outline how I embed it within the production function estimation procedure in 3.2.

3.1 The Productivity Process with MNE Spillovers

To estimate the relationship between a firm's productivity and its exposure to multinationals, researchers typically estimate an equation of the form:

$$\omega_{ist} = \beta_1 + \beta_H Horizontal_{st} + \beta_B Backward_{st} + \beta_F Forward_{st} + \beta_s + \beta_t + \eta_{it} \tag{1}$$

where ω_{ist} is the natural log of the Total Factor Productivity (TFP) of firm i in industry s at time t, and $Horizontal_{st}$, $Backward_{st}$, and $Forward_{st}$ are industry-level measures of multinational activity in the same, downstream and upstream industries respectively. β_s and β_t are industry and year fixed effects.

However, in order to disentangle direct and indirect effects, as well as distinguish between general and MNE-specific spillovers, I estimate the following specification:

$$\begin{aligned} \omega_{ist} = \quad & \alpha_1 + \delta \text{MNE}_{ist-1} + \gamma_H Horizontal_{ist} + \gamma_B Backward_{ist} + \gamma_F Forward_{ist} \\ & + \rho \omega_{ist-1} + \lambda_H \overline{\omega}^{H_i}_{jst} + \lambda_B \overline{\omega}^{B_i}_{jst} + \lambda_F \overline{\omega}^{F_i}_{jst} + \alpha_{st} + \eta_{ist} \end{aligned} \tag{2}$$

where, as before, ω_{ist} is the firm's log(TFP) in the period, and MNE_{ist-1} is the firm's multinational status in the previous period. I use lagged MNE status to allow reverse technology transfer from affiliates to take place with a one-period lag, and δ captures the *own-firm* effect of multinational experience. $Horizontal_{ist}$, $Backward_{ist}$, and $Forward_{ist}$ are the shares of a firm i's current product-market competitors, customers, and suppliers that were multinationals in the previous year. Therefore, γ_H, γ_B and γ_F measure the direct spillover effects of competing and transacting with multinationals.

To account for general productivity spillovers, I include $\overline{\omega}^{H_i}_{jst}$, $\overline{\omega}^{B_i}_{jst}$, and $\overline{\omega}^{F_i}_{jst}$ which are averages of the log(TFP) of firm i's current competitors, customers and suppliers, respectively. The corresponding λ_H, λ_B, and λ_F are *endogenous network effects*, that reflect the impact of competing and trading with more productive firms.

Note that, by using firm-specific measures, I am able to include industry-year fixed effects α_{st} to account for time-varying industry-wide changes in productivity and MNE exposure. Finally, I include firm i's lagged productivity ω_{ist-1} to specify an AR-1 productivity process that can be embedded in the TFP estimation procedure.

Following the network effects literature,[3] I represent (2) in a vectorized form by constructing interaction matrices: G^H_t, G^B_t and G^F_t, where element G^H_{ijt} is a weight specifying firm j's proximity

[3] See Lee (2003) and Bramoullé et al. (2009).

to firm i in the product-market space, G^B_{ijt} is firm i's sales to firm j as a share of firm i's sales to all other firms, and G^F_{ijt} is firm i's purchases from firm j as a share of firm i's purchases from all other firms. Note that these matrices are time-varying, allowing for changes in the existence and importance of firm-to-firm links. Then equation (2) becomes:

$$\begin{aligned}\omega_t = \quad & \alpha_1\iota + \delta \text{MNE}_{t-1} + \gamma_H G^H_t \text{MNE}_{t-1} + \gamma_B G^B_t \text{MNE}_{t-1} + \gamma_F G^F_t \text{MNE}_{t-1} \\ & + \rho\omega_{t-1} + \lambda_H G^H_t \omega_t + \lambda_B G^B_t \omega_t + \lambda_F G^F_t \omega_t + \alpha_{st} + \eta_t \end{aligned} \tag{3}$$

where each variable x_t is a column vector of x_{ist}'s and ι is a vector of ones.

The reduced form of this vectorized equation allows for closer examination of potential direct and indirect impacts of MNE activities. Let I be the identity matrix, $\boldsymbol{\lambda} = (\lambda_H, \lambda_B, \lambda_F)'$, $\boldsymbol{\gamma} = (\gamma_H, \gamma_B, \gamma_F)'$, $G_t(\boldsymbol{\lambda}) = \lambda_H G^H_t - \lambda_B G^B_t - \lambda_F G^F_t$, and $G_t(\boldsymbol{\gamma}) = \gamma_H G^H_t - \gamma_B G^B_t - \gamma_F G^F_t$. If $|\lambda_H| < 1, |\lambda_B| < 1,$ and $|\lambda_F| < 1$, then equation (3) can be rewritten as:[4]

$$\begin{aligned}(I - G_t(\boldsymbol{\lambda}))\omega_t &= \delta \text{MNE}_{t-1} + G_t(\boldsymbol{\gamma}) \text{MNE}_{t-1} + \rho\omega_{t-1} + \alpha_{st} + \eta_t \\ \implies \omega_t &= (I - G_t(\boldsymbol{\lambda}))^{-1} \left[\delta \text{MNE}_{t-1} + G_t(\boldsymbol{\gamma}) \text{MNE}_{t-1} + \rho\omega_{t-1} + \alpha_{st} + \eta_t\right] \\ \omega_t &= \sum_{\tau=0}^{\infty} G_t(\boldsymbol{\lambda})^\tau \left(\delta I + G_t(\boldsymbol{\gamma})\right) \text{MNE}_{t-1} + \rho \sum_{\tau=0}^{\infty} G_t(\boldsymbol{\lambda})^\tau \omega_{t-1} + \sum_{\tau=0}^{\infty} G_t(\boldsymbol{\lambda})^\tau (\alpha_{st} + \eta_t) \end{aligned} \tag{4}$$

Equation 4 implies that a firm's productivity is influenced by an infinite series of combinations of direct and indirect spillovers from multinational activity in its network. Given the assumption that the λ's are bounded in absolute value by 1, then the indirect effects, operating through the endogenous network effects, lessen in importance as the degrees of separation between firms within the network increases. Taking a closer look at the first two terms in the first summation on the right-hand side of equation (4):

$$\begin{aligned}\sum_{\tau=0}^{1} G_t(\boldsymbol{\lambda})^\tau \left(\delta I + G_t(\boldsymbol{\gamma})\right) \text{MNE}_{t-1} &= \left(\delta I + G_t(\boldsymbol{\gamma}) + \delta G_t(\boldsymbol{\lambda}) + G_t(\boldsymbol{\lambda}) G_t(\boldsymbol{\gamma})\right) \text{MNE}_{t-1} \\ &= \delta \text{MNE}_{t-1} + G_t(\delta\boldsymbol{\lambda} + \boldsymbol{\gamma}) \text{MNE}_{t-1} + G_t(\boldsymbol{\lambda}) G_t(\boldsymbol{\gamma}) \text{MNE}_{t-1} \end{aligned} \tag{5}$$

$G_t(\delta\boldsymbol{\lambda} + \boldsymbol{\gamma})\text{MNE}_{t-1}$ in equation 5 shows that without controlling for general productivity spillovers among firms, the total effect of interacting with MNEs can be decomposed into a direct effect (γ) that is MNE-specific and an indirect effect ($\delta\boldsymbol{\lambda}$) that operates through the impact of an MNE's activities on their own productivity. $G_t(\boldsymbol{\lambda})G_t(\boldsymbol{\gamma})\text{MNE}_{t-1}$ also highlights some of the rich second-order interactions of spillover effects such as $\lambda_F \gamma_H G^F_t G^H_t \text{MNE}_{t-1}$, which is the effect of a firm's suppliers competing with multinationals or $\lambda_B^2 (G^B_t)^2 \text{MNE}_{t-1}$, the effect of a firm supplying inputs to MNEs' suppliers.

[4] The constant has been suppressed for ease of exposition.

3.2 Estimating TFP

To recover firm-level TFP estimates, along with the spillover coefficients, I use my modification of the Gandhi et al. (2020) approach for estimating gross output production functions introduced in Iyoha (2021). I estimate a Hicks-neutral production function of labor, capital, and intermediate inputs:

$$
\begin{aligned}
Y_t &= F(L_t, K_t, M_t)e^{\omega_t+\varepsilon_t} \\
\iff y_t &= f(\ell_t, k_t, m_t) + \omega_t + \varepsilon_t \qquad (6)
\end{aligned}
$$

I assume materials are flexible, labor and capital have dynamic implications and the error terms ε_t are unconditionally independent.

The procedure consists of two stages. The first stage exploits first order conditions from profit maximization to estimate the elasticity of intermediate inputs with respect to output. Given the production technology above, the firm chooses materials to maximize profits:

$$
\max_{M_t} P_t E[F(L_t, K_t, M_t)e^{\omega_t+\varepsilon_t}] - P_t^M M_t \qquad (7)
$$

where P_t and P_t^M are the prices of output and materials respectively. The static first order condition with respect to materials implies:

$$
\begin{aligned}
s_t &= \ln\left(\frac{\partial}{\partial m_t} f(\ell_t, k_t, m_t)\right) + \ln(\mathcal{E}) - \varepsilon_t \qquad (8) \\
\implies s_t &= \ln D^{\mathcal{E}}(\ell_t, k_t, m_t) - \varepsilon_t \qquad (9)
\end{aligned}
$$

where $s_t \equiv \ln(\frac{P_t^M M_t}{P_t Y_t})$ is the log of materials expenditure share of revenue, $D^{\mathcal{E}}(\ell_t, k_t, m_t) \equiv \dfrac{\partial}{\partial m_t} f(\ell_t, k_t, m_t) \times \mathcal{E}$ and $\mathcal{E} \equiv E[e^{\varepsilon_t} | \mathcal{I}_t] = E[e^{\varepsilon_t}]$. I approximate $D^{\mathcal{E}}(\ell_t, k_t, m_t)$ by a second-degree polynomial in labor, capital and materials, and estimate equation (9) using non-linear least squares. Using the estimated coefficients, I compute the implied materials elasticity:

$$
\widehat{D}(\ell_t, k_t, m_t) = \frac{\widehat{D}^{\mathcal{E}}(\ell_t, k_t, m_t)}{\widehat{\mathcal{E}}} \qquad (10)
$$

where $\widehat{\mathcal{E}}$ is the mean of the first-stage residuals. By the fundamental theorem of calculus:

$$
\begin{aligned}
\int D(\ell_t, k_t, m_t) dm_t &= f(\ell_t, k_t, m_t) + \mathcal{C}(\ell_t, k_t) \qquad (11) \\
\implies y_t - \int D(\ell_t, k_t, m_t) dm_t - \varepsilon_t &= -\mathcal{C}(\ell_t, k_t) + \omega_t \qquad (12)
\end{aligned}
$$

Therefore I can compute:

$$\widehat{\mathcal{Y}}_t = y_t - \int \widehat{D}(\ell_t, k_t, m_t) dm_t - \widehat{\varepsilon}_t \tag{13}$$

In the second stage of the procedure, I approximate $\mathcal{C}(\cdot)$ by a second-degree polynomial, normalized to contain no constant, and estimate it using two-step generalized method of moments (GMM) as follows. Starting with a guess $\widetilde{\mathcal{C}}(\cdot)$,[5] I compute:

$$\begin{aligned} \widetilde{\omega}_t &= \widehat{\mathcal{Y}}_t - \widetilde{\mathcal{C}}(\ell_t, k_t) \\ \text{and } \widetilde{\omega}_{t-1} &= \widehat{\mathcal{Y}}_{t-1} - \widetilde{\mathcal{C}}(\ell_{t-1}, k_{t-1}) \end{aligned}$$

Then estimate:

$$\widetilde{\omega}_t = \alpha_1 \iota + \rho \widetilde{\omega}_{t-1} + G_t(\boldsymbol{\lambda})\widetilde{\omega}_t + \delta \text{MNE}_{t-1} + G_t(\boldsymbol{\gamma})\text{MNE}_{t-1} + \alpha_{st} + \eta_t$$

by two-stage least squares, with $G_t^H \widetilde{\omega}_{t-1}$, $G_t^B \widetilde{\omega}_{t-1}$, $G_t^F \widetilde{\omega}_{t-1}$ and $\{G_t^q G_t^r MNE_{t-1}\}_{r,q \in \{H,B,F\}}$ as instruments for $G_t^H \widetilde{\omega}_t$, $G_t^B \widetilde{\omega}_t$, $G_t^F \widetilde{\omega}_t$. Then I find a new set parameters of $\widetilde{\mathcal{C}}(\cdot)$ that satisfy the moments:

$$E[\eta_t \circ \ell_t, k_t, \ell_t k_t, \ell_t^2, k_t^2] = 0 \tag{14}$$

where $\circ$ is the Hadamard product and the empirical moments are constructed using $\widetilde{eta}_t$ obtained the estimation above. The process is repeated until the parameters converge to a solution $\widehat{\mathcal{C}}(\cdot)$ and $(\widehat{\rho}, \widehat{\delta}, \widehat{\alpha}_{1,\widehat{\gamma}}, \widehat{\boldsymbol{\lambda}})$.

4 Data

In this section, I describe the sources of data used in my analysis, examine the characteristics of my sample, and discuss some of the advantages and limitations of the data.

4.1 Data Sources

This study uses *Compustat* data from 1989-2016 on non-agricultural publicly-listed companies in the US. Firms' financial information is obtained from their annual reports filed with the Securities and Exchange Commission (SEC). I construct measures of inputs and output from the firms' reported expenditures and sales, deflated by industry-level price indices from the Bureau of Economic Analysis (BEA).[6] I restrict the sample to domestic US firms and multinationals with US-based parent companies by dropping firms with headquarters located outside the US.

[5] I use OLS estimates as starting values.

[6] See the appendix for details on variable construction.

Information on firms' international activities are collected from the *Compustat* Business Segments file containing information on the geographic segments in which the firm operates. I classify a firm as a multinational if it has subsidiaries in any non-US location. Therefore, $MNE_{t-1} = 1$ if a firm had any subsidiaries outside the US in the previous year, and is 0 otherwise.

Firm-level buyer-supplier linkages are obtained from the *Compustat* Customer Segments file. Financial Accounting Standards no. 14 requires firms to report major customers that are responsible for 10% or more of a firms' sales in a year. I match reported customers to the balance sheet data to obtain a sample of the buyer-seller network among publicly-listed companies, similar to the dataset used in Atalay et al. (2011). This enables me to directly identify multinationals' buyers and suppliers, rather than relying on input-output tables. As Barrios et al. (2011) show, industry-based vertical spillover measures of exposure to multinationals are sensitive to assumptions about the use of domestic and imported inputs, as well as MNEs' input-sourcing decisions.

Horizontal linkages between firms are obtained from Hoberg and Phillips (2010) and Hoberg and Phillips (2016) which measures proximity within the product-market space based on the similarity between firms' business descriptions. Identifying competitors in this way is particularly advantageous in my setting for two reasons. First, this yields granular measures of who multinationals' competitors are. Secondly, unlike typical industry classifications, the product similarity measure does not impose transitivity: that firms i and j, and j and k are close competitors does not automatically imply that i and k are also close competitors. Therefore, the interaction matrix constructed using this product-market similarity measure satisfies the linear independence condition needed to identify endogenous productivity spillovers.

I restrict the sample period to 1989-2016 because 1989 is the first year in which the horizontal linkage data is available and 2016 is the last year with matched customer-supplier data. I also drop firms with no vertical or horizontal links. The resulting sample is a set of 5,466 unique firms and 33,723 firm-year observations. The vertical relationship data contains 12,139 unique buyer-supplier links and 47,468 dyad-year observations, while the horizontal network consists of 138,303 unique competitor pairs and 572,303 horizontal links across all years.

4.2 Descriptive Statistics

Table 1 summarizes some characteristics of firms in the sample across all years. Because this study only examines publicly-listed companies, firms in the sample tend to be large across the board, and MNEs comprise more than half of firm-year observations. MNEs are, on average, larger than domestic firms with about 7.65 billion (2009 USD) in annual sales over the sample period, compared to 3.2 billion for domestic firms. MNEs also tend to have larger capital stocks, purchase more intermediate inputs, and hire more employees on average than their domestic counterparts. However, they also tend to vary more in size, with higher standard deviations across all of these measures.

The network characteristics in Table 1 are all weighted sums or averages, with weights corresponding to the product-space similarity scores for the horizontal links, and dyad-specific sales for the vertical links. Domestic firms are less likely to reported as major customers, with an average in-degree of 0.69 while about 1.49 suppliers are identified per MNE. There does not appear to be a substantial difference between the number of major customers reported by domestic firms and MNEs. Firms of both types also tend to have similar shares of MNEs among their customers. However, MNEs have a higher average share of MNEs as suppliers at 21% compared to 9% for domestic firms. This may again be function of the reporting threshold, with domestic firms less likely to be reported by larger MNEs than by smaller domestic firms.

The horizontal network is much denser than the vertical network, with about 14.65 and 17.29 competitors on average for domestic and multinational firms respectively. MNEs tend to compete closely with each other, with an average of 12.22 horizontal links to MNEs and with multinationals comprising 59% of their competitors on average. Domestic firms also predominantly compete with other domestic firms, with MNEs only making up 25% of their competitors on average. These sorting patterns in the product-market space would be obscured by industry-level measures, which typically assume that all firms within the same industry face equal exposure to MNEs.

Table 1: Firm Characteristics

	Domestic		Multinational	
	Mean	SD	Mean	SD
Sales	3.2	10.04	7.65	23.68
Employees (thousands)	10.62	32.93	22.69	80.08
Capital stock	3.08	10.62	5.2	20.08
Materials	2.26	7.53	5.51	20.06
No. of suppliers	0.69	2.6	1.49	5.73
No. of customers	1.13	1.13	1.08	1.36
No. of competitors	14.65	22.54	17.29	23.99
No. of MNE suppliers	0.31	1.66	1.03	4.67
No. of MNE customers	0.69	0.85	0.85	1.17
No. of MNE competitors	5.12	10.43	12.22	18.27
MNE share of suppliers	0.09	0.27	0.21	0.39
MNE share of customers	0.45	0.47	0.5	0.48
MNE share of competitors	0.25	0.31	0.59	0.39
Observations	16443		17280	

This table reports means and standard deviations of characteristics of firms in the sample over the period 1989-2016. Monetary values are in 2009 billion USD. All supplier, customer and competitor characteristics are weighted by the value purchased, value sold, and product-market distance respectively.

5 Results

5.1 TFP Estimates

This section presents results of the model presented in section 3 on the data described above. I estimate three specifications: the first includes network effects from MNE exposure but no endogenous productivity spillovers, the second contains MNE-specific and general network effects, and the third accounts for both types of spillovers and controls for network cluster-specific productivity shocks in each year. All specifications include industry-year and region fixed effects, and control for a firm's MNE status in the production function.

The estimated production function parameters are similar across all specifications, with elasticities of output with respect to labor, capital and intermediate inputs at about 0.25, 0.15 and 0.52 respectively. Figure 2 depicts the distribution of estimated productivity in 2016 from each specification, which does not differ substantially in mean or variance.

Estimated productivity does differ across MNEs and domestic firms, and between domestic firms that compete or trade with MNEs and those that do not. Figure 3 shows how average log(TFP) from the third specification compares over the sample period across firm types. In the first panel, I compare all firms based on their multinational status. MNEs are more productive than domestic firms on average, except for the period between 2000 and 2005 when average productivity growth for both types of firms proceeded at a similar pace. In the other three panels, I only examine domestic firms, and categorize them by whether or not they have at least one MNE customer, supplier or competitor. Throughout the sample period, domestic firms that purchase from MNEs tend to be more productive than their counterparts that do not, while the opposite pattern holds for domestic suppliers of MNEs. MNE competitors and non-competitors are on similar productivity growth paths at the beginning of the sample, but their trajectories begin to diverge in 2000, with MNE competitors exhibiting greater productivity.

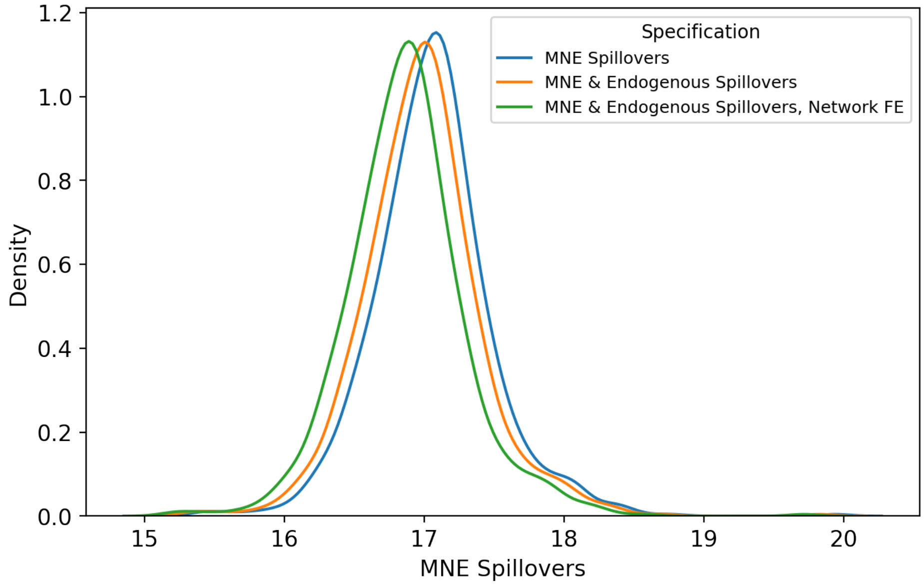

Figure 2: Distribution of ln(TFP) in 2016

This figure shows the distributions of ln(TFP) in 2016, estimated on a sample of firms in *Compustat* using the Iyoha (2021) modification of the Gandhi et al. (2020) procedure to allow for productivity spillovers from MNEs, endogenous network effects, and network fixed effects.

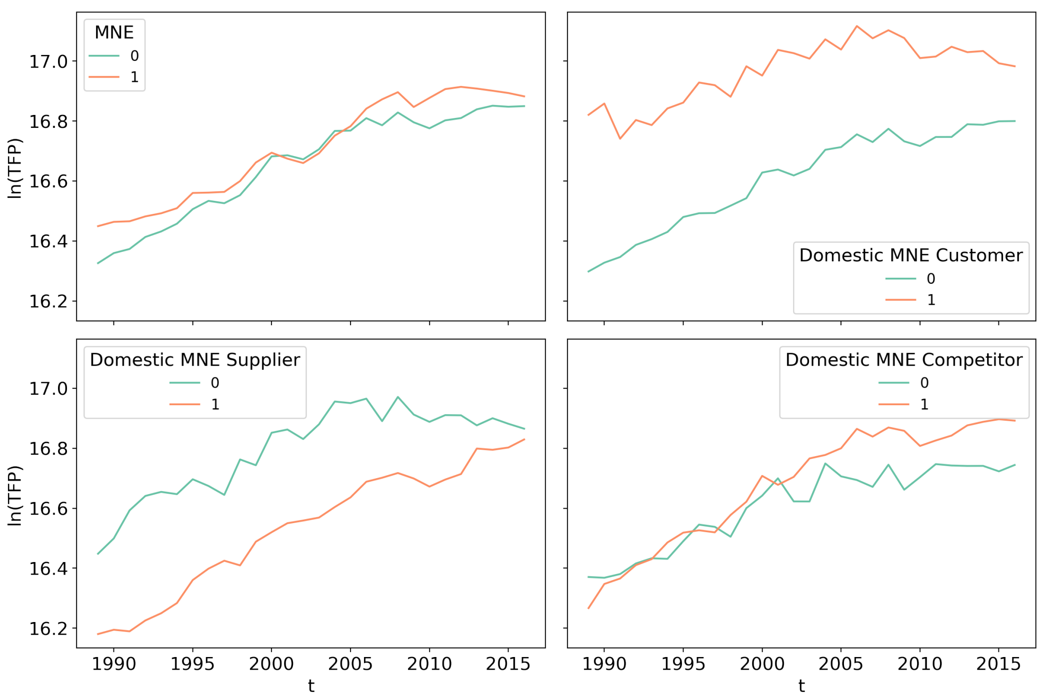

Figure 3: Average Productivity by Firm Type and Trading Partner

The first panel of this figure compares estimated productivity of all firms by MNE status. The other three panels compare domestic firms by whether or not they buy from, supply to or compete with at least one MNE.

5.2 Productivity Spillovers from MNEs

These patterns reflect the productivity process coefficients and spillovers estimates in Tables 2 and 3. In Table 3, Columns (1) and (2) are network effects estimated within the same productivity process for domestic firms and MNEs without endogenous network effects, the next two columns report coefficients from the second specification with endogenous effects, and columns (5) and (6) reports estimates from the third specification that accounts for common productivity shocks with network fixed effects. In Table 2, each column represents the three respective specifications mentioned above.

My results suggest that the own-firm effect is positive: MNEs are about 0.7 to 1% more productive in the short run. Given that productivity is highly persistent with an AR1 parameter of 0.89, this implies a long-run effect of 7 to 10%. Across all specifications, firms that have a higher share of MNEs among their competitors or suppliers are more productive, while firms with a greater share of MNE customers are less productive.

However, the magnitudes of these effects differ depending on whether or not endogenous effects are included in the productivity process. Results in column (1) of Table 3 suggest that domestic firms who only compete with MNEs are about 2.8% more productive than domestic firms who compete only with other domestic firms, but columns (3) and (5) indicate an effect size of about 1.5%. The difference is even starker for multinational firms: without accounting for endogenous effects, there is 1% productivity advantage of competing with only other MNEs as compared to only domestic firms, but it diminishes to a statistically insignificant 0.2% when we factor in the effect of being in a more competitive product-market in general.

Focusing on the third specification reported in columns (5) and (6) of Table 3, spillover estimates vary between MNEs and domestic firms. Multinational firms experience a smaller positive impact of competing with MNEs and negative effect of supplying to MNEs than domestic firms do. The opposite holds for the impact of purchasing from a greater share of MNEs; the effect is higher for multinationals who experience a short-run 1.3% productivity boost compared to 0.96% for domestic firms.

These disparities are further exacerbated by the differences in the actual observed interactions with MNEs. The average multinational for whom MNEs comprise 21% of its suppliers experiences a 0.27% productivity gain compared to the average domestic firm's gain of 0.086% from the MNEs that make up 9% of its suppliers. Furthermore, when I consider spillovers to the average domestic firm from its interactions with MNEs across vertical and horizontal linkages, the overall effect is quite modest: a 0.375% gain from 25% of its competitors, a 0.581% decline due to 45% of its customer base, and a 0.086% effect from 9% of its suppliers, yields a combined negative impact of 0.12%.

Indirect impacts of trading and competing with multinationals are also relatively muted in comparison to the direct spillovers. Given the own-firm effect in Table 2 and the endogenous productivity spillovers in Table 3, domestic firms that compete with only MNEs get an additional 0.0012% productivity boost due to the increased TFP that MNEs enjoy from their international activities.

My results differ from the findings by Tang and Altshuler (2015) who find positive but insignificant horizontal spillovers from US multinationals to domestic firms, significant positive spillovers from MNEs in downstream sectors to domestic firms upstream (backward spillovers), and marginally significant negative forward effects of MNEs in upstream industries on domestic firms downstream (forward spillovers). There are several reasons for these differences. First, as discussed earlier, Tang and Altshuler (2015) construct measures of MNE exposure at the industry level. In my case, I focus on firm-specific exposure based on the observed interactions between firms. Therefore, the inclusion of industry-year fixed effects eliminates the kind of variation that was used to identify spillovers in Tang and Altshuler (2015). Finally, I estimate a gross output production function on all non-agricultural sectors, rather than a value-added production function on the manufacturing sector.

The positive impact of MNEs on their customers rather than their suppliers is the reverse of what has been found in the literature on host-country effects. This may suggest an important difference between the value of MNE operations at home and abroad: an MNE in a foreign country may be substantially closer to the technological frontier than domestic firms and can serve as an important source of innovation for their suppliers, whereas in the home country, MNEs and their domestic suppliers may be proximate in the technology space. Therefore, the added benefit of MNEs at home may arise mainly from their ability to supply inputs at a lower cost, higher quality, or more efficient pace to their customers, due to their experience with organizing complex supply chains globally.

5.3 Alternative Measures of MNE Exposure

So far, I have measured multinational activity by whether or not a firm reported a foreign subsidiary in the previous year. Now, I consider how my results change if multinational status is measured by how active these foreign affiliates are, as proxied by their sales abroad. I construct two alternative measures: an indicator for whether the firm had any international sales in the preceding year and a firm's foreign sales as a share of total revenue. Table 4 reports estimates from a specification including both endogenous productivity spillovers and network fixed effects.

Both measures yield qualitatively similar results: positive horizontal and forward spillovers, and negative backward spillovers for both domestic firms and MNEs. However, intensity of foreign activity as captured by the share of international sales, appears to matter. Compared to the benchmark 1.5% short-run productivity boost to domestic firms from competing exclusively with MNEs, there is a 4.67% gain if those multinationals are predominantly active abroad (i.e. have a foreign sales share close to 1).

Table 2: Productivity Process Coefficients

	Dependent Variable: $\ln\text{TFP}_t$		
	(1)	(2)	(3)
$\ln(TFP)_{t-1}$	0.887	0.887	0.886
	(0.005)	(0.005)	(0.005)
MNE_{t-1}	0.007	0.011	0.012
	(0.004)	(0.005)	(0.005)
Constant	1.947	1.88	1.878
	(0.093)	(0.09)	(0.091)
Network FE	No	No	Yes

This table reports coefficients of a linear productivity process from a productionfunction estimated on US firms in Compustat (in logs) with the Iyoha (2021) modification of the Gandhi et al. (2020) procedure. Standard errors are in parentheses. All specifications include industry-year and region fixed effects.

Table 3: Productivity Spillovers

	Dependent Variable: $\ln\text{TFP}_t$					
	Domestic	MNE	Domestic	MNE	Domestic	MNE
	(1)	(2)	(3)	(4)	(5)	(6)
Competitors' MNE_{t-1}	0.0278	0.0104	0.0149	0.0024	0.0151	0.0016
	(0.005)	(0.0035)	(0.0059)	(0.0049)	(0.006)	(0.0049)
Customers' MNE_{t-1}	-0.014	-0.0098	-0.0129	-0.0108	-0.0129	-0.0104
	(0.0038)	(0.0029)	(0.0047)	(0.0047)	(0.0047)	(0.0047)
Suppliers' MNE_{t-1}	0.0137	0.0228	0.009	0.0122	0.0096	0.0127
	(0.004)	(0.003)	(0.0045)	(0.0038)	(0.0046)	(0.0039)
Competitors' $\ln(TFP)_t$			0.001	0.0008	0.001	0.0007
			(0.0002)	(0.0003)	(0.0002)	(0.0003)
Customers' $\ln(TFP)_t$			0.0006	0.0005	0.0006	0.0005
			(0.0003)	(0.0003)	(0.0003)	(0.0003)
Suppliers' $\ln(TFP)_t$			0.001	0.0013	0.001	0.0013
			(0.0003)	(0.0002)	(0.0003)	(0.0003)
Network FE	No	No	No	No	Yes	Yes

This table reports network effects from a production function estimated on US firms in Compustat (in logs) with the Iyoha (2021) modification of the Gandhi et al. (2020) procedure.Standard errors are in parentheses. All specifications include industry-year and region fixed effects.

Table 4: Productivity Spillovers with Alternative Measures of MNE Exposure

	Dependent Variable: $\ln\text{TFP}_t$			
	Domestic	MNE	Domestic	MNE
	(1)	(2)	(3)	(4)
Competitors' any foreign sales$_{t-1}$	0.0154	0.0007		
	(0.006)	(0.0049)		
Competitors' foreign sales share$_{t-1}$			0.0467	0.0024
			(0.0137)	(0.008)
Customers' any foreign sales$_{t-1}$	-0.0132	-0.0102		
	(0.0047)	(0.0046)		
Customers' foreign sales share$_{t-1}$			-0.0373	-0.0225
			(0.0102)	(0.007)
Suppliers' any foreign sales$_{t-1}$	0.0104	0.0131		
	(0.0046)	(0.0039)		
Suppliers' foreign sales share$_{t-1}$			0.0228	0.023
			(0.0121)	(0.0069)
Competitors' $\ln(TFP)_t$	0.001	0.0007	0.0011	0.0007
	(0.0002)	(0.0003)	(0.0002)	(0.0002)
Customers' $\ln(TFP)_t$	0.0006	0.0005	0.0005	0.0004
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
Suppliers' $\ln(TFP)_t$	0.001	0.0012	0.001	0.0014
	(0.0003)	(0.0003)	(0.0003)	(0.0002)

This table reports network effects from a production function estimated on US firms in Compustat (in logs) with the Iyoha (2021) modification of the Gandhi et al. (2020) procedure. Standard errors are in parentheses. All specifications include network, industry-year, and region fixed effects.

6 Conclusion

Overall, the findings of this study suggest that there are home-country spillovers from MNEs to domestic firms in the United States. By using observed horizontal and vertical relationships between firms, I am able to identify effects that operate directly and indirectly through these linkages. These results do not, however, provide a strong case for subsidizing outward FDI. For the average domestic firm, the combined impact of all types of interactions with MNEs is modest and negative.

Nevertheless, the findings of this study should interpreted with caution because of several limitations. First, the composition of the sample and observed vertical links means that the findings here may not be representative of the population of US firms. Secondly, I cannot directly test the channels through which these spillovers occur. For example, this study does not distinguish between the transmission of exchange-rate shocks and productivity gains. Future work could examine the impact of additional factors such as affiliate location: if reverse technology transfers from affiliates to the parent company are taking place, then one would expect greater spillovers from firms with subsidiaries in technologically advanced locations.

Another limitation, shared by many other studies of productivity spillovers, is that I estimate productivity using revenues rather than physical output. Consequently, my estimates reflect overall impacts on profitability rather than simply physical productivity. Given that the observed vertical linkages tend to be between firms and their major customers, this may partly explain the negative backward spillovers, especially if MNEs are adept at securing discounts from their suppliers.

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