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What happens to FDI spillovers when input-output tables go granular?

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Abstract

Multinational enterprises affect the productivity of domestic firms through FDI spillovers, especially when these firms use similar technology. The impact of spillovers varies with the technological distance between industries. More granular measurement of trade linkages across industries allows for the estimation of an additional intra-sectoral vertical component within two-digit sectors, which was part of the aggregated horizontal spillover effect before. Using Indonesian firm data reveals substantial effect heterogeneity. Horizontal spillovers within the same three-digit industry are negative, while intra-sectoral vertical spillovers across industries are positive and large in magnitude.

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1. Introduction

Foreign direct investment (FDI) is an essential element in the expansion of international market coverage among multinational enterprises (MNEs). However, only the most productive firms decide to engage in FDI, while less productive companies still rely on exports or focus solely on the domestic market (Melitz 2003). The positive selection of the most successful enterprises also affects the target economy by importing advanced technologies and other entrepreneurial skills, which can in turn be adopted by domestic firms. In terms of productivity, the literature finds positive direct effects of FDI among manufacturing plants (Javorcik and Poelhekke 2017). Earlier studies have identified only insignificant horizontal spillovers on firms in the same sector (Javorcik 2004, Blalock and Gertler 2008), while more recent studies have found a negative impact (Lu et al. 2017). Looking for vertical spillovers across industries, there is evidence of a sizable positive influence of FDI on upstream industries (backward spillovers), whereas the impact on downstream industries (forward spillovers) is smaller in size and negative (Javorcik 2004, Davies et al. 2016).[1]

Industrial linkages are typically measured using input-output (IO) tables as a proxy for trade between sectors within a country (Javorcik 2004). For a long time, IO tables have been available only on the two-digit sector level, especially for developing countries.[2] However, such aggregated horizontal spillover measures do not distinguish between firms within the same two-digit sector and identify an average effect irrespective of the industrial distance. With increasing granularity of IO tables, it has become feasible to proxy for more complex value chain relationships. In this note, I show that using more disaggregated IO linkages reveals important heterogeneities, especially within aggregated horizontal spillover effects.

The magnitude of productivity spillover effects from technology adjustment are determined by two opposing mechanisms: the MNEs' willingness to share their technology with local firms and the domestic firms' cost of adapting new technology. First, firms in the same three-digit industry are more likely to be direct competitors and thus have a strong incentive to inhibit the diffusion of knowledge within their industry. More productive MNEs may even take away market share from domestic firms in the same industry, resulting in a negative competition effect. In contrast, firms are more willing to share technology with potential suppliers in other three-digit industries, thereby enabling domestic firms to improve their productivity. Second, a successful adoption of technology will be facilitated if domestic firms and MNEs operate in the same industry and are more likely to use similar production processes (Fons-Rosen et al. 2017).[3] This results in a stronger impact on firms within the same two-digit sector whereas the effect diminishes with rising costs of technological adaptation. These costs depend on a firm's relative po-

[1] There is a parallel strand of the literature looking at spillovers from aggregate supply and demand shocks along the value chain from a macro perspective (cf., Acemoglu et al. 2015). These studies do not only consider first order effects (directly from upstream/downstream industries) but also higher order effects which manifest through aggregate reallocation and demand effects. As first order effects generally dominate the higher order effects, this note follows the micro-based literature and only considers first order vertical spillovers.

[2] See for instance the world input-output tables (WIOD) (Timmer et al. 2015).

[3] Fons-Rosen et al. (2017) use global firm data from Orbis and construct a novel measure of "technology closeness" based on US patent data to account for effect heterogeneity in vertical spillovers. Since data quality in developing countries often does not allow for such a comprehensive analysis, my approach offers a similar and more feasible alternative.

sition in the value chain and, thus, are different from the concept of absorptive capacity, which refers to the overall ability to innovate.

Splitting vertical spillovers into groups depending on technological distance will account for potential heterogeneities of cross-industry linkages. Testing this decomposition with Indonesian firm level data shows that horizontal spillovers within the same industry exhibit the expected negative sign, while spillovers across two-digit sectors turn positive (negative) for backward (forward) linkages. At the same time, backward and forward spillovers across industries within the same two-digit sector are positive and large in magnitude. This supports both more technology sharing among firms which are not in direct competition with one another, and lower adaptation costs for firms with close industrial ties to the MNE. Studies based on aggregated IO tables (like WIOD) mask this heterogeneity and capture intra-sectoral vertical linkages in the aggregated horizontal variable.

2. Measuring spillovers

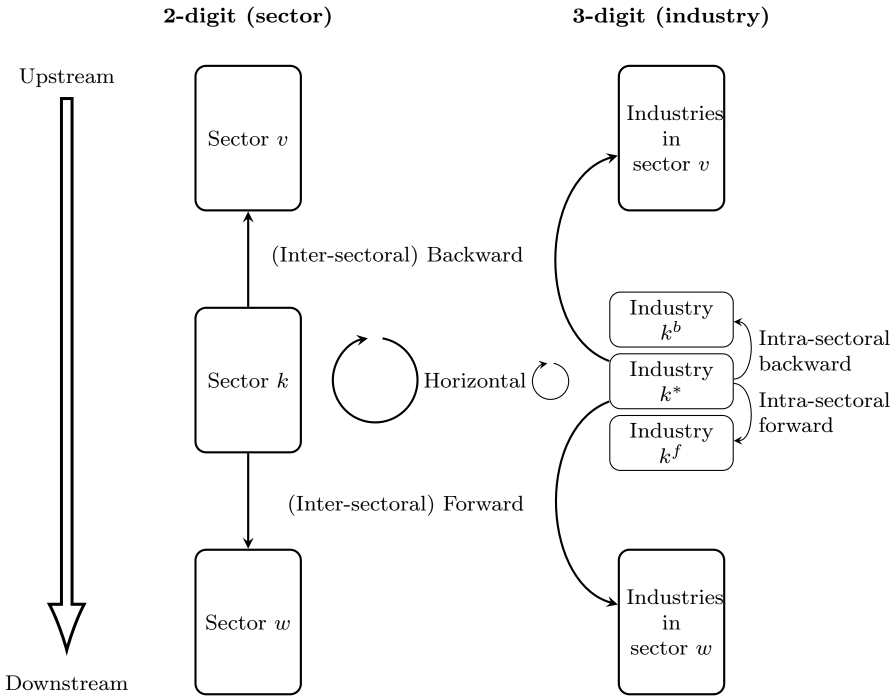
Horizontal spillovers are captured by constructing a measure of FDI presence in an industry k in year t (cf. Javorcik 2004). They are defined as the share of foreign capital within an industry weighted by each firm i's initial sales ($Horizontal_{kt} = \sum_{i \in k} FDI_{it} \times Sales_{i0} \,/\, \sum_{i \in k} Sales_{i0}$). All variation within the spillover variables stems from changes in FDI over time. Vertical FDI spillovers are defined based on the horizontal spillover variable, but use IO tables to account for each sector's input purchases from and output sales to other sectors.[4] FDI spillovers from MNEs in downstream industries v to their domestic suppliers k are $Backward_{kt} = \sum_{v \neq k} \alpha_{kv} \times Horizontal_{vt}$, where α_{kv} is the proportion of industry k's output supplied to industry v. Similarly, FDI spillovers from MNEs in upstream industries w to their domestic customer industries k are defined as $Forward_{kt} = \sum_{w \neq k} \sigma_{wk} \times Horizontal_{wt}$, where σ_{wk} is the proportion of industry k's intermediate inputs purchased from industry w.

Earlier literature used IO tables on the two-digit sector level (cf., Javorcik 2004), while more recent studies exploited the increasing granularity of IO tables (cf., Davies et al. 2016). This note distinguishes between 175 domestic industries (comparable to the three-digit industry level), allowing for a new potential layer of heterogeneous spillovers. Figure 1 illustrates that switching from two-digit to three-digit IO tables splits up the aggregated horizontal spillover variable into three components. The first component captures linkages within three-digit industry k^* and forms a new horizontal spillover variable. The second component includes backward linkages from industry k^* to industry k^b within the same two-digit sector and is referred to as intra-sectoral backward spillover. Likewise, the third component comprises intra-sectoral forward linkages to industry k^f. For example, manufacture of cement (26411) is in the same three-digit industry like manufacture of lime (26412) and linkages between both will be captured by the horizontal variable.[5] At the same time, manufacture of clay bricks (26322) is still in the same two-digit sector but any spillover will be measured by the intra-sectoral vertical spillover variables. Finally, vertical spillovers across two-digit sectors (e.g., between manufacture of natural fertilizer (24121) and manufacture of wheat flour (15321)) remain identical to the two-digit methodology

[4] See the left side of figure 1 for visualization.

[5] Product codes refer to KBLI (*Klasifikasi Baku Lapangan Usaha*) sector classification as published by BPS (Indonesian Statistical Office, *Badan Pusat Statistik*).

Figure 1: Spillover effects using different aggregation levels of IO tables



Note: The figure depicts supply chain relationships relative to sector k or industry k^*. Sector v (w) is a representative upstream supplier (downstream consumer) of k. Industry k^b (k^f) is an upstream (downstream) industry of industry k^* within the same two-digit sector k.

and will be referred to as inter-sectoral backward or forward linkages in the following.

Using this method of decomposition allows us to explore an additional layer of heterogeneous spillover effects. Two firms within the same three-digit industry may be competitors, trying to prevent technology transfers while potentially even stealing market shares from each other. This will yield an insignificant or even negative productivity spillover effect. For firms operating in distinct industries with larger technological distance, competition becomes less relevant and MNEs have the incentive to share their technology with domestic suppliers to improve the quality of their locally produced intermediate inputs. In this case, technology sharing outweighs the competition effect. Similarly, local downstream firms may benefit from a higher quality of intermediate inputs which are produced and sold to them by MNEs.

However, technology transfers across two-digit sectors may be more difficult since the adoption of new procedures requires certain overlapping in terms of the production process (Fons-Rosen et al. 2017). Such knowledge transfers may be easier between two firms within the same two-digit sector. The costs of adapting new technology increase with industrial distance since the production technology differs more. This mechanism counteracts the positive effect from reduced competition between both firms.

Positive horizontal spillovers within the same three-digit industry underline the importance of low adaptation costs, whereas positive inter-sectoral vertical spillovers (across two-digit sectors) suggest that technology sharing outweighs difficulties of adaptation. Positive intra-sectoral vertical spillovers are in line with both effects since technology adaptation is still feasible at a relatively low cost and MNEs are more willing to share technology along their value chain.

3. Results

Using a panel of medium-sized and large Indonesian manufacturing firms over the period 2000-2015, the empirical specification estimates the effect of FDI and its spillovers on firm productivity in first differences:

$$\begin{aligned} \Delta \mathit{ln(TFP)}_{it} = \quad & \beta_1 \times \Delta \mathit{FDI}_{it} + \ \beta_2 \times \Delta \mathit{Horizontal}_{kt} \\ & + \beta_3 \times \Delta \mathit{Intra\text{-}sectoral\ vertical}_{kt} + \ \beta_4 \times \Delta \mathit{(Inter\text{-}sectoral)\ vertical}_{kt} \\ & + \Delta \boldsymbol{X}'_{it}\beta_5 + \ \gamma_{rt} + \psi_s + \varepsilon_{it}. \end{aligned} \tag{1}$$

To account for simultaneity bias from a firm's endogenous input choice, I apply an approach suggested by Wooldridge (2009). Total factor productivity (TFP) is separately estimated for each three-digit industry, which allows for varying importance of input factors.[6] $\Delta \mathit{ln(TFP)}_{it}$ then is the growth rate of productivity of firm i in year t. $\mathit{Horizontal}_{kt}$ and $\mathit{Intra\text{-}sectoral\ vertical}_{kt}$ are spillover effects in year t within the same two-digit sector. Those may work either horizontally within the same three-digit industry k, or vertically (backward and forward) along the value chain. $\mathit{(Inter\text{-}sectoral)\ vertical}_{kt}$ are vertical spillovers across two-digit sectors. $\boldsymbol{X}_{it}$ are additional time-variant controls (firm age and an indicator for state-owned enterprises). γ_{rt} and ψ_s are island-year and two-digit sector fixed effects. Column 1 of table I replicates findings from previous studies by using vertical spillover variables based on two-digit IO coefficients in 2005 taken from the world input-output database (WIOD) (Timmer et al. 2015). The remaining columns use more granular IO coefficients from the Indonesian statistical office (BPS). Column 2 still aggregates cross-industrial linkages to the sector level for comparison with the WIOD-based estimates, while column 3 splits the horizontal spillover variable into within and across three-digit industry effects to account for heterogeneity.

There is no evidence of a direct effect of FDI on firm productivity across all specifications, and the horizontal spillover estimates in columns 1 and 2 show a positive sign. The latter effect is in contrast with studies finding an insignificant or even negative coefficient (Lu et al. 2017). Narrowing the scope of horizontal spillovers to the same three-digit industry in columns 3 reverses the sign of the coefficient, which is in line with the hypothesis that MNEs disproportionately inhibit knowledge transfers to their direct competitors. At the same time, intra-sectoral vertical spillovers are positive and highly significant in column 3. This can be explained by an increase in technology sharing by MNEs and relatively low costs of technology adaptation. The stronger intra-sectoral backward effect suggests that the spillover is slightly more beneficial for domestic suppliers. This is in line with the dominant backward FDI spillover often found in the literature (cf., Fons-Rosen et al. 2017). However, downstream firms also experience productivity gains as they learn from high quality inputs supplied by MNEs which are still within close industrial distance.

Inter-sectoral backward spillovers exhibit the well-known significantly positive impact on firm productivity, irrespective of the level of aggregation (cf. Davies et al. 2016). Column 3 further shows that the inter-sectoral backward estimate is significantly smaller in magnitude compared to its intra-sectoral counterpart. This highlights that knowledge

[6] See Genthner and Kis-Katos (2019) for a detailed description of the data cleaning process and variable generation.

Table I: FDI spillover effects on total factor productivity

Dependent variable: Δ ln(TFP)	WIOD	BPS	
	(1)	(2)	(3)
Δ Foreign capital share	−0.015	−0.014	−0.016
	(0.028)	(0.028)	(0.028)
Δ Horizontal	0.247***	0.218***	−0.088***
	(0.048)	(0.049)	(0.022)
Δ Intra-sectoral backward			1.670***
			(0.065)
Δ Intra-sectoral forward			1.176***
			(0.101)
Δ (Inter-sectoral) Backward	0.723***	0.756***	1.314***
	(0.100)	(0.114)	(0.124)
Δ (Inter-sectoral) Forward	0.151	−0.348***	−0.140*
	(0.106)	(0.072)	(0.073)
Basic controls	Yes	Yes	Yes
Island-year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Level of aggregation	2-digit	2-digit	3-digit
Observations	172,149	172,149	172,149
Firms	25,535	25,535	25,535
R-squared	0.016	0.016	0.032

Note: The dependent variable is change in ln(total factor productivity) as estimated by Wooldridge (2009). Column 1 uses spillovers based on two-digit IO coefficients from WIOD while columns 2 and 3 use spillovers based on three-digit IO coefficients from BPS. Basic controls include categories of firm age and a public enterprise indicator. Robust standard errors are clustered on firm level and reported in parentheses. Significance at or below 1 percent (***), 5 percent (**) and 10 percent (*).

transfer across sectors entails higher cost relative to transfers within the same sector. Finally, inter-sectoral forward FDI spillovers are insignificant when using WIOD-based coefficients, and turn negative in columns 2 and 3. Downstream domestic firms with larger industrial distance to the MNE are not able to realize productivity gains by using its advanced intermediate inputs because of higher adoption costs.[7] Contrary to the backward spillover, the MNE has no incentive to help its customer firms with the technology adoption process (by reducing adoption costs), but may rather prefer to produce the downstream product in-house.

4. Conclusion

More granular IO tables allow for a more nuanced estimation of FDI spillovers effects on productivity. This note decomposes aggregated horizontal spillovers into a more narrowly defined horizontal component within three-digit industries and two further intra-sectoral vertical elements. The decomposition reveals an important layer of heterogeneous indirect effects of FDI: while three-digit horizontal spillovers are negative and small, intra-sectoral spillovers are positive and large in magnitude. A potential explanation for this is the

[7]Upstream MNEs may even have market power which allows them to charge higher prices, thereby increasing costs for domestic customer firms and lowering their productivity.

interplay of low technology adaptation costs within the same two-digit sector and the MNEs' increasing willingness to share advanced knowledge with domestic firms when they are not direct competitors. Studies relying on more aggregated IO tables fail to identify the positive intra-sectoral spillover which may be masked by a composition effect. The latter may be insignificant or negative because negative price effects outweigh benefits from lower costs due to technological closeness.

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