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Abstract
This paper provides new evidence on the relationship between foreign direct investment (FDI) and the productivity of domestic firms. Using a specially designed survey on a sample of over 7,500 manufacturing firms in Vietnam we uncover some of the mechanisms that explain productivity spillovers from FDI through vertical linkages along the supply chain. Our results suggest that domestic firms experience more productivity spillovers through forward linkages from foreign-input suppliers to domestic input users than through backward linkages from foreign customers to domestic producers of inputs. Productivity externalities from upstream sectors are associated with joint venture foreign investors while downstream sectors experience direct technology transfers from upstream wholly foreign owned investors. Spillovers from FDI through backward linkages are also detected but only when competition from imported intermediates is controlled for and are associated with innovations and technology investments made by firms.

Keywords: Foreign direct investment, productivity spillovers, technology transfers, absorptive capacity, Vietnam

JEL Codes: D22, F21, O12, O3

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1. Introduction

Attracting foreign direct investment (FDI) is a significant policy priority, in particular by developing countries. This is so with a view to creating jobs and injecting capital into the host economy. Moreover, FDI often comes with new technologies and innovations that can diffuse into the domestic sector through various mechanisms. The latter is potentially an important source of productivity growth for developing countries as it helps domestic industries catch up with the technology frontier. Given the policy attention resources invested by governments in attempting to attract FDI, establishing whether there is any evidence of externalities or spillovers from FDI has become the topic of a vast and influential empirical literature.

The basic premise underlying the existence of FDI spillovers is that foreign-invested firms are technologically superior to domestic firms and that through their interactions knowledge will be transferred to the domestic sector leading to productivity improvements.[1] There are many well-explored mechanisms through which such spillovers may be realized. Horizontal, or intra-sector, spillovers are those that result from knowledge and technology used by FDI firms transferring to competing firms in the same sector. Vertical, or inter-sector, spillovers are those that transfer through the supply chain from foreign intermediate suppliers to domestic producers or more commonly from foreign-invested firms to domestic input suppliers.

A large body of empirical evidence explores the extent and nature of the interaction between FDI and the productivity of domestic firms. Most of the recent literature in developing country contexts finds no evidence for horizontal spillovers and emphasizes vertical spillovers through backward linkages from foreign firms to domestic suppliers as the main source of productivity effects (see, for example, Blalock and Gertler (2008), Javorcik (2004), and Kugler (2006)). The evidence also suggests that the type of the foreign investor (whether it is a joint venture or a wholly foreign-owned firm) and the absorptive capacity of firms matter for the extent of spillovers (Giroud et al., 2012; Javorcik, 2004; Marin and Bell, 2006). Overall, however, the empirical literature is inconclusive as to the nature and extent of FDI spillovers, as highlighted in review papers by Görg and Greenaway (2004) and Görg and Strobl (2001); the evidence depends to a large extent on the specific country context, the data used, and the methods applied.

The aim of this paper is to study FDI spillovers in a developing country context, using a unique and carefully constructed dataset from Vietnam aimed at identifying possible channels through which linkages between domestic and foreign firms lead to productivity spillovers. We follow the approach pioneered by Javorcik (2004) which explores the extent to which the dominance of foreign firms within and across sectors impacts on the productivity of domestic firms. A key aspect is that we also consider the extent to which self-reported knowledge transfers between firms along the supply chain lead to productivity improvements and whether such transfers are linked with the presence of foreign-invested firms. In so doing we can separate out real knowledge transfers from other externalities associated with FDI. This approach, to the best of our knowledge, represents a novel contribution to the existing

[1] See Caves (1974), Rodriguez-Clare (1996) and Markusen and Venables (1999) for seminal work on the theoretical underpinnings of productivity spillovers from foreign to domestic firms.

literature.[2] Our approach overcomes Giroud et al.'s (2012) criticism of the current literature in that it focuses on externalities from FDI rather than identifying the direct effects of linkages between foreign and domestic firms. We also explore whether the absorptive capacity of firms impacts on the extent to which linkages generate FDI spillovers. We use data on over 7,500 manufacturing firms in Vietnam for 2009, 2010 and 2011, gathered using a specially designed questionnaire for the direct identification of technology spillovers and the absorptive capacity of firms.

Our results show that FDI spillovers are more likely to take place through vertical linkages between firms in different sectors than through horizontal linkages between firms in the same sector. Adding a new dimension to existing empirical literature, we find that forward linkages from foreign-invested input suppliers to domestic customers have a greater effect on productivity than backward linkages from foreign customers to domestic input suppliers. We also find that direct (i.e. self-reported) technology transfers from suppliers are more important for the productivity of firms than transfers from customers and that these transfers are associated with foreign ownership, and in particular, wholly foreign owned firms. Positive FDI spillovers through backward linkages are only observed when we control for exposure to competition from imported inputs associated with a dominance of foreign-owned firms in downstream sectors. Moreover, positive productivity spillovers through backward linkages are associated with certain characteristics related to the absorptive capacity of firms including technology adaptation, expanding production, variety innovations and switching sectors.

The rest of our paper is structured as follows. In section 2 we provide an overview of the related literature and also provide some background on the Vietnamese context. Section 3 outlines the empirical approach while Section 4 describes the data. Section 5 presents the empirical results and section 6 concludes.

2. Related Literature and Background

Technology externalities from FDI can occur through a number of different mechanisms (see Blalock and Gertler (2008), Kugler (2006) and Javorcik (2004) for concise overviews of the various channels). Horizontal spillovers within sectors may arise when workers move from foreign-invested firms to domestic firms, bringing with them knowledge learned. Similarly, domestic firms may observe foreign-invested firms operating in their sector and copy the technologies being used. It has become well established in the empirical literature, however, that intra-industry externalities of this kind are unlikely to exist.[3] Within sectors, foreign-invested firms compete with domestic firms and so have every incentive to prevent their embodied knowledge and technologies from leaking to their domestic competitors (Javorcik, 2004). Indeed, this is the consensus view of the large body of empirical literature that has failed to find robust evidence for productivity gains accruing to domestic firms through horizontal spillovers.[4]

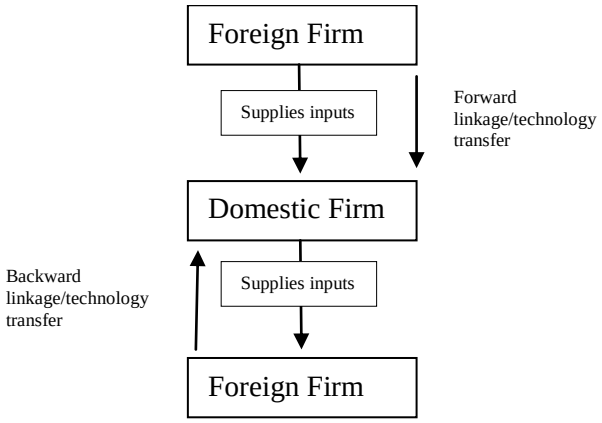
[2] Smeets (2008) points out in his overview of the literature on FDI spillovers in developing countries that technology transfers and technology spillovers are distinct, albeit related, concepts that should be considered as such in empirical analysis.

[3] It is also possible that increased competition from foreign-invested firms forces domestic firms to increase efficiency to survive. The latter can lead to the least efficient firms exiting, thereby improving overall productivity within sectors. This will lead to observed productivity improvements within sectors with a large dominance of foreign-invested firms but would not be considered a technology externality or spillover in the sense we mean in this paper.

[4] For recent examples see Barrios et al. (2011), Blalock and Gertler (2008), Bwalya (2006), Damijan et al. (2008), Javorcik (2004), and Kugler (2006), all of whom find no evidence of horizontal spillovers.

Spillovers between sectors may be more likely to occur. Figure 1 illustrates how technology spillovers from foreign firms to domestic firms in other sectors are defined.

Figure 1: Definition of linkages/technology transfers



Note: Direction of linkages is defined from the perspective of foreign firms

Spillovers through backward linkages occur when domestic firms that supply inputs to foreign-owned firms experience productivity improvements. This can happen through a number of different channels, including: deliberate knowledge transfers from foreign firms to domestic input suppliers,[5] greater incentives for domestic suppliers to improve the quality of their inputs, or the efficiency with which they are provided (due to increased competition for foreign customers), and scale economies due to greater demand for domestically-produced intermediates (Javorcik, 2004).

It is also possible that backward linkages could lead to negative spillovers. For example, if foreign firms have more bargaining power during contract negotiations with domestic input suppliers it may result in lower profits for domestic firms which will appear as a loss in measured productivity (Girma et al., 2008). Rodriguez-Clare (1996) proposes that a pre-condition for positive spillovers through backward linkages is that domestic input suppliers produce varieties that are similar to the input requirements of the foreign firm. Accordingly, domestic firms may experience negative productivity impacts if they attempt to provide inputs that they are not suited to producing. An implication of this is that domestic firms that are capable of making changes to production processes or varieties that suit the input needs of foreign firms may be more likely to experience spillovers. As such, the absorptive capacity of firms in terms of their adaptability may matter for spillovers through backward linkages. Negative spillovers through backward linkages are also possible through a competition channel. If, for example, foreign firms import intermediates, and competition from imports results in a loss in customers for domestic input suppliers, it will reduce profits for domestic upstream firms which will negatively impact on measured productivity.[6]

[5] Moran (2001) uses a number of different case studies to show that deliberate technology transfers of this kind are common with foreign firms often offering, for example, technical assistance, management experience or quality assurance systems to their suppliers.

[6] Aitken and Harrison (2009) propose a similar competition channel as an explanation for negative horizontal spillovers whereby foreign firms compete directly with domestic firms.

Forward linkages also have the potential to yield spillovers from foreign-invested suppliers of inputs to downstream domestic firms, although they are given much less attention in the literature. One possible channel is that intermediates provided by foreign-invested firms may embody new, more advanced technologies from which domestic firms can learn (Grossman and Helpman, 1991). In contrast to imported intermediates, these inputs could be accompanied by services or other forms of support that impact on the productivity of domestic users (Javorcik, 2004). It is also possible that an increase in foreign investment in upstream sectors increases competitive pressures forcing all input suppliers in those sectors to eliminate inefficiencies or slack in the production process or use their inputs more efficiently in order to survive. As a result, downstream domestic firms that use any inputs from these sectors may experience productivity improvements due to more efficiently-produced inputs by all upstream firms.

The argument for state intervention to attract foreign investors hinges on the existence of externalities. Spillovers through vertical linkages are desirable from a policymaker's perspective if the productivity gains exceed those internalized through deliberate arrangements between domestic and foreign firms. Much of the recent empirical research investigating the existence of such FDI externalities in developing country contexts focuses on vertical linkages, particularly backward linkages. Some of the most notable recent contributions include Javorcik (2004). She finds evidence for productivity spillovers through backward linkages between domestic suppliers and partially foreign-invested customers in Lithuania during its transition period when there was a large influx of foreign investment. She finds no evidence for intra-sector spillovers or spillovers from foreign-invested input suppliers and domestic firms. Blalock and Gertler (2008) also find evidence of productivity gains among firms that supply inputs to foreign-invested firms in Indonesia. Kugler (2006) finds similar evidence for FDI spillovers that can be attributed to the outsourcing of inputs by foreign firms to domestic suppliers in Columbia. Of relevance to our paper is that there is a particularly notable dearth of evidence in the literature on the existence of FDI spillovers through forward linkages from foreign-invested firms to domestic suppliers.

As found by Javorcik (2004), the characteristics of the foreign firms themselves may be a determining factor in the extent to which externalities from foreign firms exist. She finds that spillovers are only evident through backward linkages from partially foreign-owned firms to domestic firms but not wholly foreign-owned firms. Her explanation is that the former are more likely to be better linked with the local economy in locally sourcing inputs compared to fully foreign-invested firms. Giroud et al. (2012) and Marin and Bell (2006) find that the technological activities of the foreign firms themselves may be an important determinant of whether spillovers are realized. They suggest that for policy aimed at attracting FDI to be effective in generating technology externalities, the knowledge-creation activities and technological capabilities of the foreign-invested firms as well as the extent to which they are linked with the local economy are both important considerations.

A body of literature also exists highlighting the importance of the absorptive capacity of firms involved in realizing externalities from FDI (see Crespo and Fontoura (2007) for an overview). Blomstrom and Sjoholm (1999) find that the export status of firms is an important determinant of absorptive capacity while Aitken and Harrison (1999) find that firm size may play an important role. Marin and Bell (2006) also highlight the importance of the absorptive capacity of firms in realizing technology externalities. They find that firms that invest in capital embodied technology and skills training experience productivity effects attributable to FDI spillovers while research and development activities are not important. Moreover, recent

work by Giroud et al. (2012) critiques the focus in the literature on externalities from FDI highlighting that it fails to identify the direct effects of linkages between foreign and domestic firms through, for example, technology transfers.

In this paper we explore each of these issues in the context of Vietnam, an economy whose rapid growth rate over the last decade has been fuelled in part by a burgeoning local manufacturing sector and increasing levels of foreign direct investment and trade. Vietnam represents an illustrative case of economies in transition. The liberalization of the Vietnamese economy began in 1986 with the adoption of a range of policy measures under *Doi Moi* ("Renovation"), in particular relating to the promotion of foreign direct investment (FDI) and trade liberalization. FDI promotion was a gradual process that took place through successive revisions to investment laws between the late 1980s and the mid-2000s.[7] Trade liberalization took the form of the removal of export taxes and non-tariff barriers and the negotiation of various trade agreements with ASEAN, the US and the EU, ultimately leading to WTO accession in 2007.

Foreign-invested firms contribute in significant ways to the Vietnamese economy, particularly in the manufacturing sector. In 2011 FDI net inflows accounted for approximately six percent of GDP. Moreover, Table 1 illustrates the contribution to output and employment of foreign-invested firms by sector between 2009 and 2011. In 2011 foreign-invested firms accounted for 47 percent of output (revenues) and 49 percent of employment. The variability in importance of foreign investment across regions (north-south) and sectors is also of note. The contribution of firms with some share of foreign ownership to output and employment is twice as high in the south compared to the north. It accounts for over three-quarters of output and employment in ISIC 2-digit sectors 19 (tanning/dressing leather) and 33 (medical, precision and optical equipment), for example, while in other, more traditional, sectors such as sector 15 (food and beverages) and sector 20 (wood and wood products) they account for much less.

[7] For an overview of the reform to investment laws in Vietnam between 1986 and 2000 see Jenkins (2006).

Table 1: Regional and sector level contribution of foreign investors to output and employment

	2009	2010	2011
	Output contribution (%)		
All manufacturing	43.02	44.51	47.31
North	13.80	15.93	19.10
South	29.22	28.58	28.20
15: Food products and bev.	32.91	30.84	33.84
16: Tobacco products	15.38	17.68	15.93
17: Textiles	55.49	55.64	61.33
18: Wearing apparel	52.17	50.99	51.98
19: Tanning/dressing leather	80.06	80.92	84.15
20: Wood and wood products	18.67	17.97	18.13
21: Paper and paper products	28.76	29.11	28.89
22: Publishing, printing, etc.	9.81	8.57	8.02
23: Coke, refined petroleum	16.96	5.86	3.57
24: Chemicals and chem. products	45.63	44.19	45.97
25: Rubber and plastics	31.72	44.34	41.40
26: Other non-metallic mineral	34.74	24.88	23.80
27: Basic metals	19.86	28.99	32.56
28: Fabricated metals	39.31	40.13	39.34
29: Machinery and equipment	42.70	48.44	52.57
30: Office equipment	98.17	99.36	99.39
31: Electrical machinery	57.91	58.03	57.61
32: Radio, television, etc.	89.23	92.25	98.05
33: Medical, precision and opt.	93.11	88.25	86.11
34: Motor vehicles, transport	60.64	75.95	70.97
35: Other transport equip.	58.65	81.89	85.62
36 Furniture	47.26	54.29	52.95
	Employment contribution (%)		
All manufacturing	43.77	44.97	48.71
North	13.09	13.85	16.15
South	30.67	31.12	32.55
15: Food products and bev.	17.22	17.65	19.49
16: Tobacco products	5.88	6.08	5.78
17: Textiles	37.83	39.03	43.66
18: Wearing apparel	56.10	53.44	55.15
19: Tanning/dressing leather	71.90	73.52	77.70
20: Wood and wood products	12.31	12.03	13.73
21: Paper and paper products	22.07	21.83	24.83
22: Publishing, printing, etc.	13.02	11.84	10.74
23: Coke, refined petroleum	15.49	13.45	12.37
24: Chemicals and chem. products	24.36	25.66	25.85
25: Rubber and plastics	45.61	44.91	45.21
26: Other non-metallic mineral	9.97	9.72	11.01
27: Basic metals	14.86	14.96	19.23
28: Fabricated metals	32.52	35.33	35.99
29: Machinery and equipment	29.24	33.53	37.06
30: Office equipment	98.07	96.57	99.26
31: Electrical machinery	73.62	62.74	70.35
32: Radio, television, etc.	89.34	92.76	94.82
33: Medical, precision and opt.	80.78	81.74	86.71
34: Motor vehicles, transport	51.84	58.38	72.89
35: Other transport equip.	43.86	51.78	57.73
36 Furniture	52.20	52.31	53.49

Source: Authors' own calculations based on Vietnam Enterprise Survey 2009-2011

3. Empirical Approach

The first step in our empirical approach is to establish the extent to which we can detect positive productivity spillovers associated with FDI presence within and across sectors using standard measures applied in the literature. We follow Javorcik (2004) and consider three measures: i) the proportion of total revenue within each 4-digit sector accounted for by foreign-owned firms to capture horizontal spillovers (equation (1)); ii) the proportion of total revenue in upstream sectors accounted for by foreign-owned firms to capture forward linkages (equation (2)); and iii) the proportion of total revenue in downstream sectors accounted for by foreign-owned firms to capture backward linkages (equation (3)).

$$H_{jt} = \sum_{i=1}^{k} R_{ijt} \Big/ \sum_{i=1}^{n} R_{ijt} \tag{1}$$

where *k* is the subset of firms that are foreign-owned and R is revenue. Firms are denoted by the subscript *i*, sectors by *j* and time by *t*.

$$F_{jt} = \sum_{u=1}^{J-1} \alpha_{ut} H_{ut} \tag{2}$$

where α_{ut} is the proportion of inputs into sector *j* that are purchased from sector *u* in time *t* and H_{ut} is the proportion of foreign-owned firms in upstream sector *u*.

$$B_{jt} = \sum_{d=1}^{J-1} \alpha_{dt} H_{dt} \tag{3}$$

where α_{dt} is the proportion of output from sector *j* sold to sector *d* in time *t* and H_{dt} is the proportion of foreign-owned firms in downstream sector *d*.

As in Javorcik (2004) we examine the correlation between the intensity of FDI investment within sectors and between sectors on the productivity of firms by including these variables directly in a firm-level production function given in equation (4).

$$ln\, Y_{ijt} = \alpha_i + \beta_l\, ln\, L_{ijt} + \beta_k\, ln\, K_{ijt} + \delta_H H_{jt} + \delta_F F_{jt} + \delta_B B_{jt} + s_j + \tau_t + e_{ijpt} \tag{4}$$

where Y is value added, L is the total labor input, and K is capital inputs. The model includes firm (α_i), 4-digit sector (s_j) and time (τ_t) fixed effects.

Our point of departure from this standard approach is to include a new firm-level measure of spillovers that captures the technology transfer channel. We supplement the model of equation (4) with two additional measures: i) an indicator for whether a firm reported receiving a technology transfer from a downstream firm (*tech_back*); and ii) an indicator for whether a firm reported receiving a technology transfer from an upstream firm (*tech_for*). The interaction between these variables and B_{jt} and F_{jt}, respectively, allows us to determine whether FDI spillovers are directly associated with quantifiable technology

transfers, or whether there is some other externality at work. The full model is given in equation (5).

$$\begin{aligned} &ln\,Y_{ijt} = \alpha_i + \beta_l\, ln\, L_{ijt} + \beta_k\, ln\, K_{ijt} + \delta_H H_{jt} + \delta_B B_{jt} + \delta_F F_{jt} \\ &+ \beta_{TB} tech_back_{ijt} + \beta_{TF} tech_for_{ijt} \\ &+ \varphi_B tech_back_{ijt} \times B_{jt} + + \varphi_F tech_for_{ijt} \times F_{jt} \\ &+ s_j + \tau_t + e_{ijt} \end{aligned} \tag{5}$$

The coefficients φ_B and φ_F measure the proportion of backward and forward FDI spillovers attributable to direct technology transfers, while δ_B and δ_F measure the extent of backwards and forward linkages attributable to other external effects.[8]

In addition to the specification given in equation (5), we also consider a number of alternative specifications that help uncover some of the mechanisms underlying spillovers and technology transfers. First, we consider a disaggregation of foreign ownership into wholly foreign-owned and joint-venture firms. Second, we include interaction terms between spillovers and the absorptive capacity of firms using indicator variables for innovations undertaken by the firm such as investments, changes in products and varieties, research and development and technology adaptations. Third, we consider a competition channel whereby domestic input suppliers are impacted by competition from imported inputs as a result of foreign firms in downstream sectors.

4. Data

Our data are from three rounds of the Vietnam Technology and Competitiveness Survey (TCS) which gathered detailed information on innovation, investment, technology adaptation, technology transfers and other topics for a nationally representative sample of over 8,000 Vietnamese manufacturing enterprises in 2009, 2010 and 2011 (CIEM 2011; CIEM 2012; CIEM 2013). The sample is a sub-set of manufacturing firms covered by the Vietnam Enterprise Survey (VES) administered annually by the General Statistics Office. The full list of manufacturing sectors and the number of firms covered by our data in each year are presented in Table A1 of the Appendix.

We included the TCS as an additional module for the sampled firms in these years and match these data with information on firms' activities and financial accounts gathered using the main VES instrument. This produces a rich database that allows us to explore in detail the link between productivity, technology transfers, and the underlying mechanisms at work.

Table 2 presents summary statistics for the variables used in our analysis. Of the firms in our sample approximately 75 percent are privately-owned domestic firms which are the focus of our analysis. Descriptive statistics presented in the table relate to the sub-sample of private firms.

[8] As implied by the specifications in equations (4) and (5), we estimate the effects of spillovers from FDI on the productivity residual from a real value-added, rather than unit output, production function. Unfortunately, we cannot directly measure average unit-value output in our data. As a robustness check on our results we disentangle the effects of market power through mark-ups and productivity gains by focusing on competitive sectors where individual firms lack market power so value-added closely tracks output quantities. Doing so confirms our core findings

Table 2: Summary Statistics

	All years n = 23,271		2009 n = 7,412		2010 n = 7,849		2011 n = 8,010	
Full sample:	%		%		%		%	
Private	74.8		74.0		75.5		74.8	
Foreign	21.8		22.3		21.3		22.0	
State	3.4		3.7		3.2		3.3	
Firm characteristics:	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Production Function:								
Value added	3,842	13,517	3,711	11,588	3,876	14,327	3,932	14,277
Capital	13,725	57,458	13,756	57,957	14,405	63,793	13,024	49,897
Labor	119	347	124	343	121	365	114	331
Tech Transfers:								
Tech Transfer Forwards	0.205	0.404	0.096	0.295	0.214	0.410	0.300	0.458
Tech Transfer Backwards	0.133	0.339	0.068	0.251	0.173	0.379	0.154	0.361
Absorptive capacity:								
New Machinery	0.130	0.336	0.184	0.388	0.117	0.321	0.093	0.290
New ICT	0.163	0.370	0.248	0.432	0.133	0.340	0.114	0.318
Process Innovation	0.504	0.500	0.284	0.451	0.591	0.492	0.625	0.484
Quality Innovation	0.779	0.415	0.777	0.416	0.763	0.425	0.797	0.402
Expand Variety	0.440	0.496	0.480	0.500	0.416	0.493	0.427	0.495
Expand Product	0.148	0.355	0.161	0.367	0.146	0.353	0.138	0.345
Switch Sector	0.029	0.167	0.021	0.145	0.029	0.169	0.035	0.184
Tech Adaptation	0.117	0.322	0.219	0.414	0.078	0.268	0.060	0.238
R&D	0.106	0.308	0.120	0.324	0.104	0.306	0.095	0.293
Sector characteristics:								
Sector Concentration	0.053	0.078	0.067	0.096	0.053	0.076	0.040	0.058
Log exports	22.47	2.82	22.31	1.80	22.67	1.83	22.41	4.11
Log imports	21.92	2.72	21.93	1.72	22.16	1.74	21.66	3.97
FDI Spillovers:								
Horizontal	0.284	0.213	0.280	0.213	0.277	0.208	0.295	0.217
Forwards	0.290	0.202	0.294	0.192	0.294	0.206	0.282	0.207
Forwards 100%	0.237	0.189	0.227	0.175	0.243	0.191	0.240	0.198
Forwards JV	0.053	0.038	0.067	0.041	0.051	0.036	0.043	0.035
Backwards	0.382	0.163	0.378	0.158	0.380	0.165	0.388	0.165
Backwards 100%	0.282	0.142	0.276	0.143	0.270	0.141	0.299	0.140
Backwards JV	0.100	0.059	0.102	0.059	0.110	0.062	0.089	0.056

The output variable included in our production function (as specified in equations (4) and (5)) is value added computed using data on profits and wages deflated using an annual GDP deflator. Consistent with a growing manufacturing sector we find that average real value added of private domestic firms increases over the three years of our data. Capital is measured as the deflated value of assets at the end of the year while labor is the total number of workers employed. Both are declining between 2009 and 2011. Coupled with the increase in value added this suggests rising average productivity levels in Vietnam's manufacturing sector.

As mentioned above, our paper's key innovation is the inclusion of firm-level information on technology transfers to supplement Javorcik's (2004) FDI spillover measures. This responds to Zanfei's (2012) and Giroud et al.'s (2012) critique of the standard approach which identifies *externalities* from FDI rather than direct *effects* through intentional knowledge flows between foreign firms and domestic suppliers or customers. Accordingly, in our TCS module, firms are asked whether contracting relationships with suppliers result in technology transfers from the supplier to the enterprise. For firms that report that they do we regard this

as a forward technology transfer from a producer of intermediate inputs to the firm (*tech_for*). Similarly, for firms that report that they have contracting relationships with customers that lead to technology transfers we regard this as a backward technology transfer from a customer to the firm (*tech_back*). On average, 13 percent of private domestic firms report forward technology transfers while almost 21 percent of firms report backward technology transfer. There is some variation over time with fewer firms reporting such transfers in 2009 compared with the other years. This may be due to the fact that the question was asked in a slightly different way in 2009 and so our measure may not capture the full extent of transfers experienced by firms in that year. To the extent that this is problematic, it biases us against finding evidence of externalities through self-reported technology transfers.

We also include a number of variables in our analysis to capture the absorptive capacity of firms. First, we consider investments in new machinery and information and communications technologies. In the TCS module firms are asked to name the two most important production technologies (machines and equipment) and the two most important information and communications technologies (ICT) used by the firm. They are also asked to report when these technologies were acquired by the firm. For the purpose of our analysis, we consider firms that acquired the technologies during the previous year as having made an investment in new machinery or ICT, as the case may be. On average, 13 and 16 percent of firms invest in new machinery or ICT, respectively. We also consider a range of indicators of innovations undertaken by the firm. Firms are asked whether they engaged in any type of innovations to improve their performance. The options given include: improvements in process organization (such as time saving procedures); improvements in product quality; an expansion of product variety; an expansion of activities into a new sector; or changing to a new sector. A large number of firms report that they engage in process innovations (51 percent) and quality innovations (78 percent). Fewer firms, less than half in each year, report that they expand the variety of products that they produce. Significant changes to production are much less common with only 18 percent and 3 percent of firms respectively reporting that they expand the sectors in which they produce or switch to producing a product in a different sector. We also consider whether firms engage in adaptations to technologies and research and development activities. In the case of the former, firms are asked whether they modify existing production or process technologies in order to, for example, adapt them to the specific needs of the firm, increase efficiency or make them work faster or better. Approximately, 12 percent of firms, on average, report that they engage in technology adaptation of this kind. Fewer firms, less than 11 percent on average, report that they engage in R&D activities. The proportion of firms engaging in either of these activities is declining over time.

Summary statistics for the sector specific spillover measures are also presented in Table 2. These measures are computed as defined in equation (1) for horizontal spillovers, equation (2) for vertical spillovers through forward linkages, and equation (3) for vertical spillovers through backward linkages. They can be interpreted as the proportion of revenue, on average, generated by foreign-invested firms in the same sector in the case of (1), in upstream sectors in the case of (2) and in downstream sectors in the case of (3). Linkages for the vertical spillover measures are constructed using the Vietnam Supply-Use Tables (SUT) for 2007. The SUT maps the use of 138 commodities in 112 production activities.[9] We link these production activities to the 4-digit ISIC codes used in the Vietnam Enterprise Survey to

[9] See Arndt et al. (2010) for a full description of the 2007 social accounting matrix for Vietnam and details of its construction.

produce 44 comparable sector codes. The SUT data are used to construct the weights in equations (2) and (3) that capture linkages between sectors. For example, for linkages with upstream sectors (i.e. α_{ut} in equation (2)), for each (SUT) sector *j*, their link with upstream (SUT) sector *u* is the proportional contribution of output from sector *u* to its total input base. Similarly for linkages with downstream sectors (i.e. α_{dt} in equation (3)), for each (SUT) sector *j*, their link with downstream (SUT) sector *d* is the proportional contribution of output from sector *j* to the input base of sector *d*. These weights are used to compute a weighted average of foreign dominance in upstream and downstream sectors, respectively.[10] Also presented in Table 2 are the foreign dominance measures for wholly foreign-owned firms and joint ventures.[11]

To illustrate the kind of linkages we are identifying consider, for example, the 2-digit ISIC sector 15, namely food products and beverages. The SUT weights (not shown) suggest that one of the main suppliers of the food products and beverages sector is the chemicals and chemical products sector (sector 24). Inputs from chemicals and chemical products are likely to be in the form of additives or preservatives added to food and beverage items. Consider, for example, a case where there is a dominance of foreign firms supplying chemicals and chemical products to domestic producers of food and beverages. This could result in productivity spillovers due to forward linkages if foreign firms offer new varieties of preservatives or additives, not available from domestic producers, that lead to more efficient production by domestic downstream food and beverage producers. If such a spillover is due to a direct technology transfer it will be picked up in our firm specific measure of technology transfers. If not, it will appear as an externality or spillover effect. On the other hand if there is a dominance of foreign owned firms in the food products and beverages sector that are being supplied by domestic producers of chemicals and chemical products we might expect to see productivity spillovers through backward linkages if the foreign-owned food and beverage producers provide domestic producers of chemicals with new technologies to improve their production techniques or quality standards. As for forward linkages, if the spillover is due to a direct technology transfer it will be picked up in our firm-specific measure. If not, it will appear as a positive spillover through backward linkages.

Each of the sector level measures are computed using the full census of manufacturing firms included in the Vietnam Enterprise Survey. We also include a control for sector-level concentration measured at the 4-digit sector level using the standard Herfindahl-Hirschman Index (HHI), constructed as:

$$HHI_{jt} = \sum_{i=1}^{n} rs_{ijt}^2 \qquad (6)$$

where rs_{ijt} is the revenue share of firm *i* in sector *j* at time *t*. As shown this measure averages around 0.05 suggesting a high degree of competition within the sectors included in our analysis.

[10] Recent work by Barrios et al. (2011) highlights the potential measurement problems in using weights of this kind to measure linkages between downstream foreign affiliates and upstream domestic firms given that the former are likely to have a different pattern of input sourcing. They propose that using home country input-output tables to construct these weights is a more accurate approach. Unfortunately, we do not have data on the country of origin of the foreign affiliates and so cannot use this approach. It will not, however, affect our measure of linkages between downstream domestic firms and upstream foreign affiliates.

[11] It should be noted that while these measures do not appear to vary much on average over time, within sectors there is a significant amount of variation across the years.

5. Results

The results of the baseline specification (equation (4)) are presented in column (2) of Table 3.[12] We first consider forward linkages and find a positive and well-determined relationship between our measure of upstream FDI dominance and the productivity of downstream domestic firms that use inputs from these sectors. Despite a large theoretical literature proposing reasons as to why productivity spillovers through forward linkages might exist (see section 2) there is little empirical evidence to suggest that they are an important source of productivity growth for domestic firms in developing countries. Our results suggest that, at least in the Vietnamese case, forward linkages are a more important source of productivity growth than linkages from foreign customers to domestic suppliers.

Table 3: Impact of FDI spillovers and technology transfers on productivity

Dependent Variable: lnY	(1)	(2)	(3)	(4)	(5)	(6)
lnL	0.519***	0.519***	0.518***	0.518***	0.518***	0.517***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)
lnK	0.223***	0.223***	0.222***	0.222***	0.222***	0.221***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
FDI Spillovers:						
Horizontal		-0.071	-0.079	-0.076	-0.053	-0.050
		(0.135)	(0.135)	(0.135)	(0.132)	(0.133)
Forward		0.405**	0.396**	0.373**	0.346**	0.321*
		(0.179)	(0.180)	(0.180)	(0.173)	(0.176)
Backward		-0.647**	-0.656**	-0.657**	3.962***	4.168***
		(0.260)	(0.260)	(0.265)	(1.523)	(1.526)
Tech Transfers:						
Tech_for			0.025***	0.005	0.025***	0.004
			(0.008)	(0.013)	(0.008)	(0.014)
Tech_back			0.003	-0.021	0.003	-0.028
			(0.011)	(0.025)	(0.010)	(0.024)
Interactions:						
FDI For*Tech_for				0.068*		0.070*
				(0.040)		(0.040)
FDI Back*Tech_back				0.063		0.083
				(0.064)		(0.062)
FDI Back *lnimp					-0.211***	-0.220***
					(0.071)	(0.071)
Sector controls:						
lnexp	-0.006	-0.001	-0.002	-0.002	-0.001	-0.002
	(0.018)	(0.016)	(0.016)	(0.017)	(0.016)	(0.016)
lnimp	0.009	0.005	0.005	0.005	0.097***	0.102***
	(0.017)	(0.016)	(0.016)	(0.016)	(0.035)	(0.025)
HHI4	0.055	0.118	0.118	0.118	0.134	0.136
	(0.098)	(0.095)	(0.094)	(0.095)	(0.095)	(0.095)
R^2	0.803	0.802	0.803	0.803	0.803	0.803
Firms	7,767	7,767	7,767	7,767	7,767	7,767
Obs	17,497	17,497	17,497	17,497	17,497	17,497

Note: Each model is estimated using firm-level fixed effects, year dummies and 4-digit sector time invariant controls. A control for the 4-digit sector level concentration is also included in each model. Robust standard errors clustered at the sector-time level are presented in parenthesis. ***p<0.01, **p<0.05, *p<0.10.

In column (3) we add the firm-level measures of technology transfers and find a positive and statistically significant effect of forward technology transfers (i.e. from upstream input

[12] Here and throughout, we report clustered standard errors at the sector-year level.

producers to downstream private firms) but we do not find any effect of backward technology transfers from downstream customers. In column (4) we interact these measures with the indicators for FDI presence upstream and downstream (equation (5)). We find that the impact of technology transfers from upstream sectors is entirely driven by linkages with sectors that have a high intensity of foreign investors. The inclusion of the interaction term reduces slightly the coefficient on the forward FDI spillover measure suggesting that only a small part of the spillover is due to direct technology transfers. A large part remains unexplained empirically and could be attributed to one of the many theoretical arguments put forward for the existence of FDI spillovers through forward linkages. For example, they could be due to the possibility that inputs from foreign firms embody better technology or are of a higher quality (Grossman and Helpman, 1991), or that inputs from foreign firms are accompanied by support services that impact on downstream domestic firms (Javorcik, 2004). It is also possible that foreign competition forces all firms in upstream sectors to become more efficient and this leads to positive productivity impacts on downstream firms that use inputs from these sectors. The fact that a large part of the spillover remains unexplained once we factor out the part that is due to direct technology transfers is in support of Giroud et al.'s (2012) criticism that the standard sector-level measures used focus on externalities rather than the effects of linkages that we capture here through the firm-specific technology transfer measure.

Turning to backward linkages, we also find in column (2) that FDI spillovers through backward linkages have a negative and statistically significant impact on domestic firms. This is in contrast with much of the other evidence on the nature of linkages between FDI and domestic firms where positive productivity spillovers due to backward linkages are often found. As discussed in section 2, the negative relationship found for the Vietnamese case could be explained by a number of factors including asymmetry in contracts, a mismatch between the inputs required by downstream foreign-owned firms and the capabilities of upstream domestic firms or competition effects induced by foreign firms importing inputs that compete with domestic producers.

To explore the extent to which the negative effect might be due to competition from imports we include an interaction term between the FDI backward spillover measure and the level of imports into the sector. We find that the interaction term is negative and statistically significant while the level effect is positive and significant. The latter can be interpreted as the impact of foreign owned firms in downstream sectors on the productivity of domestic firms when imports into upstream sectors are zero, i.e. when competition effects are netted out. Taken together, this suggests that the negative impact of backward FDI linkages is due to an expansion in imported intermediates that compete directly with domestic input suppliers, squeezing their profits and resulting in a loss in measured productivity. Once these competition effects are accounted for, positive productivity impacts due to backward linkages between FDI and domestic firms are present, consistent with other findings in the literature. In column 6 we include all interaction terms simultaneously and our results hold.

Table 4 disaggregates the impact of FDI spillovers by intensity of foreign ownership. We include two measures of forward (backward) linkages: one which measures the proportion of total revenue generated in upstream (downstream) sectors by wholly (100%) foreign-owned firms and the other which measures the proportion of total revenue generated in upstream (downstream) sectors by joint ventures. In column (1) we include these sector-level measures and the firm-level measures of technology transfers. Our results suggest that FDI spillovers from upstream sectors are due to joint ventures between foreign-owned firms and domestic

firms (private or state). This is consistent with Javorcik (2004) who finds in the Lithuanian case that FDI spillovers (backwards in her case) are attributable to joint ventures rather than wholly foreign-owned firms. It is also consistent with the idea that partially foreign-owned firms are likely to be more successful than wholly foreign-owned firms in finding domestic downstream customers to sell their products to. Having a local partner is also likely to increase the probability that spillovers will take place.

Table 4: Impact of FDI spillovers disaggregated by type of ownership and technology transfers on productivity

Dependent Variable: lnY	(1)	(2)	(3)	(4)
lnL	0.517***	0.516***	0.517***	0.516***
	(0.014)	(0.013)	(0.013)	(0.013)
lnK	0.222***	0.221***	0.222***	0.221***
	(0.013)	(0.013)	(0.013)	(0.013)
FDI Spillovers:				
FDI Horizontal	-0.043	-0.044	-0.037	-0.037
	(0.135)	(0.136)	(0.136)	(0.136)
FDI For 100%	0.045	-0.016	0.075	0.017
	(0.216)	(0.219)	(0.218)	(0.220)
FDI For JV	1.515***	1.612***	1.289***	1.379***
	(0.419)	(0.426)	(0.457)	(0.464)
FDI Back 100%	-0.895***	-0.915***	1.752	1.846
	(0.274)	(0.276)	(1.838)	(1.838)
FDI Back JV	-0.069	-0.106	2.670	2.690
	(0.453)	(0.453)	(2.146)	(2.154)
Tech Transfers:				
Tech_for	0.023***	0.009	0.005	0.010
	(0.008)	(0.013)	(0.014)	(0.013)
Tech_back	0.003	-0.025	-0.024	-0.030
	(0.010)	(0.024)	(0.024)	(0.024)
Interactions:				
FDI For 100%*Tech_for		0.130***		0.127***
		(0.046)		(0.046)
FDI For JV*Tech_for		-0.335		-0.351
		(0.216)		(0.217)
FDI Back 100% *Tech_back		0.046		0.056
		(0.076)		(0.075)
FDI Back JV*Tech_back		0.165		0.173
		(0.169)		(0.167)
FDI Back 100% * lnimp			-0.119	-0.124
			(0.092)	(0.083)
FDI Back JV * lnimp			-0.130	-0.133
			(0.099)	(0.100)
Sector controls:				
lnexp	0.001	-0.0001	0.0004	-0.0003
	(0.016)	(0.016)	(0.016)	(0.015)
lnimp	0.003	0.003	0.056	0.059
	(0.015)	(0.015)	(0.039)	(0.039)
HHI4	0.148	0.141	0.152	0.145
	(0.097)	(0.096)	(0.098)	(0.097)
R^2	0.802	0.803	0.802	0.803
Firms	7,767	7,767	7,767	7,767
Obs	17,497	17,497	17,497	17,497

Note: Production function parameters not presented for ease of illustration but are available on request. Each model is estimated using firm-level fixed effects, year dummies and 4-digit sector time invariant controls. A control for the 4-digit sector level concentration is also included in each model. Robust standard errors clustered at the sector-time level are presented in parenthesis. ***p<0.01, **p<0.05, *p<0.10.

Also revealed in column (1) of Table 4 is that the negative spillovers due to backward linkages are attributed to the dominance of wholly-owned foreign firms in downstream sectors. This is consistent with our finding that such negative spillovers are due to competition effects from imported intermediates given that wholly foreign owned firms are more likely to rely on imported inputs as opposed to sourcing inputs locally.[13]

Column (1) of Table 4 also shows that firm-level technology transfers from upstream sectors have a positive impact on productivity. In column (2) we include interaction terms between these measures and sector level measures of spillovers disaggregated by intensity of foreign ownership. We find that productivity enhancing technology transfers are from upstream sectors with a high concentration of wholly foreign-owned firms. The positive impact of FDI spillovers from joint ventures holds with the inclusion of these interaction terms. There is, however, no evidence to suggest that these spillovers are due to direct technology transfers. Taken together, the results suggest that externalities from FDI spillovers from upstream sectors are due to joint ventures while productivity-enhancing direct technology transfers are from upstream wholly foreign-owned input suppliers to downstream domestic private firms.

The final stage of our analysis attempts to disentangle whether the FDI spillovers detected are associated with the characteristics of domestic firms, in particular measures of their absorptive capacity (Crespo and Fontoura, 2007; Marin and Bell, 2006). While we do consider the full range of measures of absorptive capacity presented and discussed in Section 3, for ease of exposition we only present those where well-determined relationships are found. For all measures, we find no evidence of a link between firm behavior in relation to improving absorptive capacity and forward spillovers from FDI. We do, however, find evidence for productivity spillovers through backward linkages for firms that engage in innovations and technology investments that may increase their absorptive capacity.[14] This is consistent with Rodriguez-Clare's (1996) proposition that positive spillovers through backward linkages will depend on whether domestic firms are suited to producing the inputs required by downstream foreign firms. Where firms are capable of innovating to adapt to the opportunities provided by downstream foreign firms, spillovers may be more likely.

In Table 5a we consider whether spillovers are linked with process and variety innovations made by firms. We first interact each of our sector- and firm-specific spillover measures with an indicator for whether the firm reported making an innovation to improve production processes in the last year. As revealed in columns (1) and (3), we find positive productivity effects of backward FDI spillovers associated with joint ventures for firms that make such innovations. We do not find any evidence that they are linked to direct technology transfers but rather that they explain part of the positive spillovers from downstream joint-venture foreign firms to upstream domestic input suppliers. Also in Table 5a, we present the results for a similar set of models that interact the spillover and technology transfer measures with an indicator for firms that engage in variety innovations. We also find evidence of interactive effects between the introduction of new varieties and FDI spillovers through backward linkages, but this time through backward linkages with wholly foreign owned firm; Firms that

[13] In column (3) we include interaction terms between downstream foreign presence (both wholly foreign owned and joint ventures separately) and the level of imports. We find that the signs on our coefficients corroborate our story however they are not well determined.

[14] In each case we control for negative spillovers due to competition effects (i.e. each model includes an interaction term between the level of imports into the sector and the dominance of foreign-owned firms in downstream sectors) and so help to explain positive backward productivity spillovers once competition from imports is netted out.

produce new varieties experience positive productivity spillovers from downstream sectors with a high level of wholly foreign-owned firms.[15] This suggests that an ability to adapt and innovate in terms of the types of products produced may be necessary in order for firms to benefit from linkages with wholly foreign-owned customers.

Table 5a: Firm specific measures and impact of FDI spillovers and technology transfers – Process and variety innovations

Dependent Variable: lnY	(1)	(2)	(3)	(4)	(5)	(6)
Measure:	Process Innovation			Variety Innovation		
FDI Spillovers:						
FDI Horizontal	-0.040	-0.040	-0.041	-0.045	-0.043	-0.042
	(0.135)	(0.135)	(0.136)	(0.135)	(0.135)	(0.135)
FDI For 100% For	0.054	0.044	0.056	0.060	0.044	0.069
	(0.222)	(0.216)	(0.223)	(0.215)	(0.216)	(0.216)
FDI For JV	1.533***	1.504***	1.553***	1.464***	1.515***	1.472***
	(0.429)	(0.420)	(0.432)	(0.416)	(0.420)	(0.418)
FDI Back 100%	-0.935***	-0.894***	-0.954***	-0.954***	-0.899***	-0.979***
	(0.278)	(0.274)	(0.281)	(0.274)	(0.274)	(0.279)
FDI Back JV	-0.194	-0.078	-0.227	-0.017	-0.071	-0.048
	(0.457)	(0.454)	(0.462)	(0.468)	(0.453)	(0.470)
Tech Transfers:						
Tech_for	0.024***	0.024***	0.024***	0.024***	0.023***	0.024***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Tech_back	0.003	0.005	-0.055	0.002	-0.006	-0.094**
	(0.010)	(0.016)	(0.041)	(0.010)	(0.015)	(0.037)
Process Innovation	-0.046**	-0.018**	-0.052**	-0.027	0.002	-0.048*
	(0.019)	(0.007)	(0.021)	(0.025)	(0.008)	(0.027)
Interactions:						
FDI Back 100% * Measure	0.028		0.041	0.137**		0.182***
	(0.045)		(0.050)	(0.057)		(0.059)
FDI Back JV* Measure	0.202*		0.221*	-0.078		-0.024
	(0.112)		(0.124)	(0.134)		(0.145)
Tech_back* Measure		0.003	0.049		0.019	0.148***
		(0.019)	(0.053)		(0.020)	(0.052)
Tech_back*FDI Back 100%			0.152			0.220**
			(0.115)			(0.094)
Tech_back*FDI Back JV			0.179			0.274
			(0.245)			(0.240)
Tech_back*FDI Back 100%*Measure			-0.134			-0.341***
			(0.156)			(0.120)
Tech_back*FDI BackJV* Measure			-0.146			-0.331
			(0.298)			(0.306)
R^2	0.802	0.802	0.802	0.802	0.802	0.802
Firms	7,767	7,767	7,767	7,767	7,767	7,767
Obs	17,497	17,497	17,497	17,497	17,497	17,497

Note: As for Table 4.

In Table 5b we consider whether productivity enhancing spillovers and technology transfers are related to firms that expand production by producing products in new sectors or firms that switch sectors completely. In column (3) we find a weak association between backward spillovers from joint venture FDI firms and diversification through expanding the number of products produced by firms. Taken with our results for variety innovations presented in Table 5a, this suggests that smaller innovations to the variety of products increase the absorptive capacity of firms in relation to FDI spillovers from downstream wholly foreign owned firms while more substantive changes in the types of products produced, i.e. an expansion into

[15] We do not find any association between investments in machinery, ICT or quality innovations and the absorptive capacity of firms for productivity enhancing FDI spillovers suggesting that this result is very specific to process and variety innovations by firms.

other sectors, increase the absorptive capacity of firms in relation to FDI spillovers from joint ventures. Given that the latter is a more risky investment it suggests that firms might be more willing to make big changes to production plans to supply inputs to downstream joint ventures but are more conservative when it comes to changing processes to provide inputs to wholly foreign owned firms.

Table 5b: Firm specific measures and impact of FDI spillovers and technology transfers – Expand to new sectors and switch sectors

Dependent Variable: lnY	(1)	(2)	(3)	(4)	(5)	(6)
Measure:		Expand Sector			Switch Sector	
FDI Spillovers:						
FDI Horizontal	-0.042	-0.042	-0.038	-0.044	-0.044	-0.041
	(0.135)	(0.135)	(0.135)	(0.135)	(0.135)	(0.135)
FDI For 100% For	0.047	0.047	0.050	0.045	0.040	0.043
	(0.216)	(0.216)	(0.216)	(0.216)	(0.217)	(0.218)
FDI For JV	1.520***	1.519***	1.546***	1.504***	1.513***	1.524***
	(0.420)	(0.419)	(0.422)	(0.418)	(0.419)	(0.421)
FDI Back 100%	-0.891***	-0.893***	-0.914***	-0.885***	-0.894***	-0.900***
	(0.274)	(0.273)	(0.277)	(0.269)	(0.273)	(0.272)
FDI Back JV	-0.087	-0.070	-0.134	-0.058	-0.066	-0.094
	(0.455)	(0.453)	(0.460)	(0.446)	(0.451)	(0.447)
Tech Transfers:						
Tech_for	0.023***	0.024***	0.024***	0.024***	0.024***	0.024***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Tech_back	0.003	-0.003	-0.045*	0.003	0.002	-0.020
	(0.010)	(0.011)	(0.026)	(0.010)	(0.010)	(0.024)
Expand to new sectors	-0.022	-0.009	-0.040	0.019	-0.037	0.045
	(0.022)	(0.011)	(0.026)	(0.063)	(0.025)	(0.074)
Interactions:						
FDI Back 100% *Measure	0.007		0.017	-0.152		-0.238*
	(0.063)		(0.068)	(0.128)		(0.139)
FDI Back JV*Measure	0.170		0.267*	-0.050		-0.075
	(0.138)		(0.157)	(0.360)		(0.407)
Tech_back*Measure		0.033	0.094		0.029	-0.187
		(0.025)	(0.060)		(0.054)	(0.123)
Tech_back*FDI Back 100%			0.072			0.037
			(0.087)			(0.075)
Tech_back*FDI Back JV			0.212			0.118
			(0.186)			(0.160)
Tech_back*FDI Back 100%*Measure			-0.035			0.782**
			(0.166)			(0.309)
Tech_back*FDI Back JV*Measure			-0.515			-0.200
			(0.434)			(0.881)
R^2	0.802	0.802	0.802	0.802	0.802	0.802
Firms	7,767	7,767	7,767	7,767	7,767	7,767
Obs	17,497	17,497	17,497	17,497	17,497	17,497

Note: As for Table 4.

We also consider whether sector switching impacts on the extent to which firms benefit from FDI spillovers. Newman et al. (2013) explore sector switching in Vietnam and find it is an important source of productivity growth. In particular, they find that firms tend to switch into sectors where there are opportunities for productivity gains, although they tend to avoid sectors with a large presence of foreign-owned firms. This does not rule out the possibility that firms switch into sectors that supply inputs to FDI firms.[16] In other words, switching firms may be more likely to experience productivity spillovers through these channels if they

[16] It is also possible that domestic firms switch to producing different products due to the availability of new or better quality inputs supplied by foreign-invested firms. We do not, however, find any evidence for this in our case (result not shown but available on request).

are switching to avail of the new opportunities created by foreign investors. Indeed, we find in column (6) of table 5b that firms that switch sector are more likely to experience productivity enhancing technology transfers from wholly foreign-owned FDI intensive downstream sectors. This suggests that backward linkages lead to technology transfers from wholly foreign-owned firms to private domestic firms that are willing to switch sector in order to buy or sell the products being sold or bought by foreign firms. Taken together with our findings in relation to variety innovations, this suggests that firms are willing to make small changes such as changing varieties to benefit from externalities from wholly foreign-owned firms. Our results for sector switching suggests that where there are quantifiable direct technology transfers to be experienced from wholly foreign-owned firms, domestic firms are willing to drastically change the products that they are producing to benefit from them.

Table 5c considers interaction terms between the spillover and technology transfer variables and firms that engage in technology adaptations or R&D investments. We find some evidence to suggest that firms that invest in technology adaptation are more likely to benefit from FDI spillovers from joint venture firms in downstream sectors (column (3)). These spillovers, however, are not related to quantifiable technology transfers but are related to other unidentifiable external effects that impact on domestic suppliers of inputs. This result is in line with Marin and Bell (2006) who find that firms that invest in technology are more likely to experience FDI spillovers. We also find some evidence (in column (6)) for positive productivity spillovers from wholly owned foreign downstream sectors for firms that engage in research and development activities. These spillovers, however are conditional on receipt of direct technology transfers from downstream firms as indicated by the significance of the triple interaction term (*FDI Back 100% * Tech_back *R&D*). As with our results for sector switching, this suggests that where there are quantifiable technology transfers to be experienced from wholly foreign-owned firms, private domestic firms are willing to make larger, more risky investments to benefit from them.

Table 5c: Firm specific measures and impact of FDI spillovers and technology transfers – Technology adaptation and R&D investments

Dependent Variable: lnY	(1)	(2)	(3)	(4)	(5)	(6)
Measure:	Technology Adaptation			R&D Investment		
FDI Spillovers:						
FDI Horizontal	-0.043	-0.043	-0.043	-0.044	-0.043	-0.043
	(0.135)	(0.136)	(0.135)	(0.136)	(0.135)	(0.135)
FDI For 100% For	0.044	0.046	0.048	0.042	0.042	0.044
	(0.211)	(0.216)	(0.212)	(0.216)	(0.216)	(0.216)
FDI For JV	1.477***	1.518***	1.494***	1.493***	1.507***	1.517***
	(0.413)	(0.420)	(0.418)	(0.420)	(0.420)	(0.422)
FDI Back 100%	-0.882***	-0.895***	-0.902***	-0.906***	-0.894***	-0.923***
	(0.271)	(0.274)	(0.277)	(0.273)	(0.274)	(0.277)
FDI Back JV	-0.055	-0.072	-0.158	-0.088	-0.068	-0.106
	(0.449)	(0.454)	(0.455)	(0.450)	(0.453)	(0.453)
Tech Transfers:						
Tech_for	0.023***	0.023***	0.023***	0.023***	0.023***	0.023***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Tech_back	0.003	0.008	-0.051*	0.002	-0.0003	-0.044
	(0.010)	(0.011)	(0.028)	(0.010)	(0.011)	(0.028)
Technology Adaptation	-0.044*	0.006	-0.073***	-0.020	0.016	-0.044
	(0.027)	(0.012)	(0.028)	(0.031)	(0.015)	(0.040)
Interactions:						
FDI Back 100%*Measure	0.081		0.115	0.117		0.202*
	(0.072)		(0.076)	(0.098)		(0.117)
FDI Back JV*Measure	0.235		0.489***	0.075		0.045
	(0.148)		(0.160)	(0.184)		(0.235)
Tech_back*Measure		-0.031	0.164***		0.012	0.102
		(0.028)	(0.061)		(0.025)	(0.064)
Tech_back*FDI Back 100%			0.096			0.131
			(0.085)			(0.082)
Tech_back*FDI Back JV			0.325*			0.071
			(0.169)			(0.171)
Tech_back*FDI Back 100%*Measure			-0.231			0.384**
			(0.182)			(0.194)
Tech_back*FDI Back JV*Measure			-1.307***			0.150
			(0.410)			(0.389)
R^2	0.802	0.802	0.802	0.802	0.802	0.802
Firms	7,767	7,767	7,767	7,767	7,767	7,767
Obs	17,497	17,497	17,497	17,497	17,497	17,497

Note: As for Table 4.

We run a range of robustness checks on our results and summarize our findings in Table 6. In column (1) we highlight the core results from the main models presented in Tables 3 to 5. In column (2) we report the findings when we estimate productivity using Olley and Pakes (1996) approach to correct for simultaneity in the choice of inputs and unobserved productivity. Using this approach to estimating productivity 'demands' more of the data as it requires that firms have positive investments and excludes some sectors due to too few observations. Moreover, it imposes a rigid structure on the underlying behavior of firms and does not describe the underlying data-generating process when such behavior does not hold.[17] As such, we do not consider it as reliable a measure of productivity as our one-step fixed effects approach. Nevertheless, we include it here as a check on our core results given that it is commonly applied in the relevant literature. In column (3) we report the findings when outliers are removed.[18] In column (4) we estimate each model using a balanced panel.

[17] Bond and Soderbom (2005) argue that where inputs are costly to adjust the Olley and Pakes estimator and other control function approaches do not work well.

[18] We consider outliers to be firms in the top and bottom 1 percentile of the distribution of value added and/or capital inputs in each year.

In addition, in column (5) of Table 6 we present the results including controls for the sector level concentration. The rationale for this robustness check is that we only have data on the value of inputs and outputs and so cannot estimate physical productivity. This implies that using our measure, productivity changes will embody both within-firm efficiency gains and changes in prices and/or mark-ups that cannot be easily disentangled. By focusing on the productivity effects in competitive sectors, where mark-ups are lower, we attenuate the possibility that the observed productivity effects are due to changes in mark-ups as opposed to real productivity improvements (Amiti and Konings, 2007). Our empirical model is adapted to take account of sector level concentration (given by equation (6)) through the inclusion of interaction terms between the various measures of FDI spillovers and the HHI. The results presented in column (5) of Table 6 show the relationship between FDI/technology transfers and the productivity of firms in competitive sectors.

Table 6: Robustness Checks

Result	(1) Main Model	(2) Olley-Pakes	(3) Outliers Removed	(4) Balanced Panel	(5) Controlling for HHI4[r]
FDI For	+**	+ ***	+**	+***	+**
Tech_for	+***	+ (p=0.52)	+***	+ (p=0.11)	+ **
FDI For * Tech_for	+*	+**	+ (p=0.23)	+ (p=0.32)	+ (p=0.30)
FDI Back	+***	- (p=0.97)	+ **	+ **	+***
FDI Back * Imports	-***	- (p=0.96)	- **	- ***	-***
FDI For JV	+***	+***	+***	+***	+ ***
FDI For 100%*Tech_for	+***	+***	+**	+**	+ **
FDI Back JV * Process	+*	+ (p=0.67)	+ **	+ (p=0.31)	+ (p=0.69)
FDI Back 100% * Variety	+***	+ (p=0.74)	+***	+***	+ **
FDI Back JV* Expand	+*	+ (p=0.17)	+*	+*	+ (p=0.12)
Tech_for* FDI For 100% * Switch	+**	+ (p=0.16)	+ (p=0.30)	+ *	+ (p=0.94)
Tech_back * FDI Back 100% * Switch	+**	+**	+**	+**	+ ***
FDI Back JV* Adapt	+***	+ **	+***	+ ***	+ **
Tech_back * FDI Back JV* Adapt	-***	-***	-***	- ***	- (p=0.80)
FDI Back 100% *R&D	+*	+ (p=0.33)	+*	+**	+ (p=0.43)
Tech_back*FDI Back 100% *R&D	+**	+ (p=0.41)	-*	-*	- **
Firms	7,767	6,799	7,648	3,962	7,765
Obs	17,497	12,626	17,125	11,886	17,495

[r]By including interaction terms between each variable and the measure of sector level concentration (HHI4) we can isolate the impact of technology transfers and spillovers in competitive sectors. Any observed effects in competitive sectors are likely to be due to real productivity improvements rather than increases in mark-ups.
***p<0.01, **p<0.05, *p<0.10

Our robustness tests confirm the majority of our core results. We find that forward linkages lead to productivity spillovers in all cases. We also find that forward technology transfers are productivity enhancing particularly when they are linked with wholly foreign-owned upstream firms. Evidence for forward FDI spillovers from joint venture foreign-invested firms through upstream vertical linkages are also confirmed in all models. Productivity-enhancing backward spillovers are found in most cases once the interaction between backward FDI linkages and imports is controlled for (i.e. once negative competition effects are netted out).

The results for the interaction between backward spillovers and the indicators for changes made to the absorptive capacity of firms are less robust. Yet, we can conclude with some confidence (i.e. based on the robustness checks) that backward spillovers from joint ventures are associated with firms that adapt technologies or expand sectors. Moreover, backward

spillovers from wholly foreign owned firms are associated with firms that engage in variety innovations or switch sectors. The latter only holds when spillovers are associated with direct technology transfers.

6. Conclusion

This paper explored the impact of FDI on the productivity of domestic firms in Vietnam. Using data from a specially designed survey on technology and competitiveness we analyze whether foreign investment leads to productivity spillovers and the extent to which these spillovers are due to real technology transfers or other external effects. We focus on vertical linkages through the supply chain from upstream foreign-invested firms supplying inputs to downstream domestic firms and also from downstream foreign-invested firms who purchase inputs from domestic firms. We consider whether spillovers from wholly foreign-owned firms are different to those from joint ventures and also whether investments and innovations made by domestic firms increase their absorptive capacity.

Overall, our results suggest that domestic firms experience more productivity spillovers through *forward* linkages than through backward linkages along the supply chain. This finding is novel in a developing country context. We also show that productivity spillovers from upstream joint ventures are more likely than from wholly foreign owned firms. These spillovers are, however, unexplained in the sense that they cannot be attributed to real transfers of knowledge between firms. Identifying the supplemental channels through which these spillovers occur represents an important area of future research. We find that firms linked with upstream sectors dominated by wholly foreign-owned firms experience significant productivity spillovers through direct technology transfers.

Positive FDI spillovers through backward linkages are only observed when we control for exposure to import competition associated with a dominance of foreign-owned firms in downstream sectors. Positive productivity spillovers through backward linkages are associated with certain characteristics related to the absorptive capacity of firms. Spillovers from downstream joint ventures are experienced by firms that adapt their technologies and expand production into other sectors while spillovers from downstream wholly foreign owned firms are associated with variety innovations by upstream firms and with firms that switch sectors. The latter only occurs where firms report direct technology transfers from downstream firms.

Our findings provide new evidence on the interaction between FDI and private domestic firms that can help inform the debate on the desirability of attracting FDI. The results of our investigation show that there are in fact additional externalities associated with FDI that provide benefits beyond those internalized through market transactions. This suggests that policies aimed at attracting FDI should be continued but also that attention should be paid to the nature of FDI.

We conclude, in particular, that governments should continue to support joint ventures between foreign and domestic investors given that there is evidence for productivity externalities that filter along the supply chain. Our findings also suggest a role for wholly foreign-owned projects in enhancing the productivity of domestic firms in certain circumstances. Policies aimed at attracting fully foreign-owned firms should be coupled with conditions for the direct transfer of knowledge between firms and the local sourcing of inputs. Furthermore, government needs to provide support to domestic firms to enable them

to innovate and adapt to the new opportunities created by foreign entry. This is potentially an important source of productivity improvements that can help underpin overall economic development.

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Appendix

Table A1: TCS sample disaggregated by manufacturing sectors (2-digit)

	(1) Full Sample	(2) 2009	(3) 2010	(4) 2011
15: Food products and bev.	3,140	993	1,081	1,066
16: Tobacco products	2	1	0	1
17: Textiles	795	277	252	266
18: Wearing apparel	1,067	327	346	394
19: Tanning/dressing leather	336	114	109	113
20: Wood and wood products	1,516	472	531	513
21: Paper and paper products	1,040	343	346	351
22: Publishing, printing, etc.	431	137	150	144
23: Coke, refined petroleum	4	0	2	2
24: Chemicals and chem. products	666	219	226	221
25: Rubber and plastics	1,259	430	407	422
26: Other non-metallic mineral	2,149	674	729	746
27: Basic metals	551	179	183	189
28: Fabricated metals	1,875	593	639	643
29: Machinery and equipment	524	171	167	186
30: Office equipment	11	4	5	2
31: Electrical machinery	248	83	88	77
32: Radio, television, etc.	81	26	30	25
33: Medical, precision and opt.	40	14	12	14
34: Motor vehicles, transport	104	34	36	34
35: Other transport equip.	359	133	119	107
36 Furniture	1,388	429	467	492
Total	17,586	5,653	5,925	6,008



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