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Foreign direct investment and technology spillovers: Evidence from panel data analysis of manufacturing firms in Zambia

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Abstract

The most pronounced reason for providing fiscal incentives to attract foreign direct investment (FDI) is that FDI is an effective conduit for technology transfer through technology spillovers to domestically owned firms in the host country. This study analyzes the nature and significance of productivity externalities of FDI to local firms, both in terms of intra-industry and inter-industry spillovers, using firm-level data from Zambia. The results show little evidence in support of intra-industry productivity spillovers from FDI on one hand, and significant inter-industry knowledge spillovers occurring through linkages. The net impact of FDI depends on the interaction between intra-industry and inter-industry productivity effects.

JEL classification: F2; 032; D24
Keywords: Foreign investment; Technology spillovers; Productivity; Manufacturing firms

1. Introduction

It is argued that inward foreign direct investment (FDI) can help improve the economic prospects of most African countries in several ways. First, FDI, being a non-debt source of development finance, helps to fund investment projects in the economy. Second, FDI increases the level of technical progress in the host country, which, in turn, can play a decisive role in the process of economic development. Third, technology transferred to developing countries via FDI tends to be newer than that transferred via licensing (Findlay, 1978; Mansfield and Romeo,

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1980). Apart from being an important source of development finance and a channel for technology transfer, FDI has a number of proven attributes. It improves managerial knowledge and skills, increases efficiency and productivity, and provides a wide array of goods and services to the economy. The underlying premise is that multinational corporations possess superior intangible assets including technology, managerial skills, export contacts, and reputation and good will. As such, they are able to undertake competitive investment ventures abroad and compete more favorably than local firms. Since multinational corporations possess these intangible assets and can transfer them to their subsidiaries located abroad and subsequently to local firms through technology spillover effects, then technology spillover is expected to raise productivity and efficiency at firm and sector level. Of these beneficial aspects of inward FDI, technology transfer is often singled out as of greater relevance to developing countries.

In view of these benefits, Zambia, like other developing countries, has been extremely gracious to foreign investors. It offers competitive fiscal and investment incentives to attract and retain foreign investment in the economy.[1] The most pronounced reason for providing far-reaching incentives to foreign investors is that FDI induces technology transfer through joint ventures and knowledge spillovers. The opportunity cost of fiscal incentives may, in some cases, exceed the perceived technology transfer benefits on which those incentives are based. In this case, enormous benefits can be realized, both in terms of better targeting of incentives and public resources to improve investment and technological development in poor countries such as Zambia by providing information regarding the pattern of technology spillovers and its determinants.

Productivity spillovers can occur at least through three main channels: (i) through the movement of highly trained and skilled staff from foreign firms to domestic firms; (ii) through what is referred to us "demonstration effect" arising from arm's length relationships between foreign and domestic firms, which enables the latter to learn and adopt superior production technologies and managerial and organizational skills; and (iii) through "competition effects" from foreign firms, which may force rival domestic firms to upgrade production techniques in order to remain competitive and productive (Blomstrom and Kokko, 1997). Stiff competition can also reduce productivity of domestic firms if foreign firms attract away demand from their domestic counter parts (Aitken and Harrison, 1999). The quantitative analysis of these contagion effects as important aspects in technological innovation and development for domestic firms is not firmly established, especially in the context of Africa. The meta-analysis conducted by Gorg and Strobl (2001) suggests that, apart from the study by Haddad and Harrison (1993) on Morocco, few rigorous studies have ever been conducted on foreign investment and technology spillover in Africa and Southern Africa, in particular. This is despite the interesting trend in economic and political reforms that have taken place across the entire African continent, which have been particularly pursued to attract foreign investment and strengthen regional integration. More case studies from Africa will certainly make a substantial contribution to our understanding of foreign investment and technology spillovers in developing countries and around the world. This study contributes to filling this gap in literature.

This paper analyses the nature and occurrence of technology spillovers from foreign to local firms in the manufacturing sector in Zambia. Both horizontal and vertical productivity spillovers are examined using 3-year firm-level data collected between 1993 and 1995. The results indicate

[1] In addition to tax holidays and several other incentives, Zambia offers a 100% repatriation of profits and has the most liberal investment climate in the southern Africa.

that, while no significant intra-industry (horizontal) spillovers exist, there are indeed significant inter-industry (vertical) technology spillovers from foreign firms in upstream sectors to local firms in downstream sectors. Results also indicate that technology spillovers may be regional rather than sectoral, suggesting that industrial clustering may speed up the rate of technology diffusion to local firms.

The rest of the paper is organized as follows. Section 2 provides a brief background on FDI performance in Zambia, followed by a discussion of the data in Section 3. The empirical model and estimation techniques are laid down in Section 4 and empirical results in Section 5. The final section concludes the paper.

2. Foreign direct investment in Zambia

Foreign investment contributes significantly to a country's gross fixed capital formation, employment and economic growth. Although inward FDI as a share of fixed capital formation remained low during the earlier years of the copper boom in the late 1970s, it became increasingly important thereafter. As the economic crisis deepened in the 1980s, Zambia embarked on a series of International Monetary Fund (IMF) and World Bank inspired pro-market economic reforms and policies to attract FDI. The response of inward FDI was remarkable. As shown in Fig. 1, the trend in FDI as a share of gross fixed capital formation increased and stayed well above the average for Africa. Despite Zambia's impressive FDI performance, absolute FDI inflows are less than those of Angola, Gabon and Nigeria, which receive substantial inflows of FDI attracted to mineral extraction, especially oil.

Nonetheless, FDI inflows to Zambia increased from US$61.57 million in 1980 to US$202.78 million in 1990, and receipts from cross-border acquisitions and mergers of state-owned enterprises during privatization increased from US$18 million in 1995 to about US$543 million

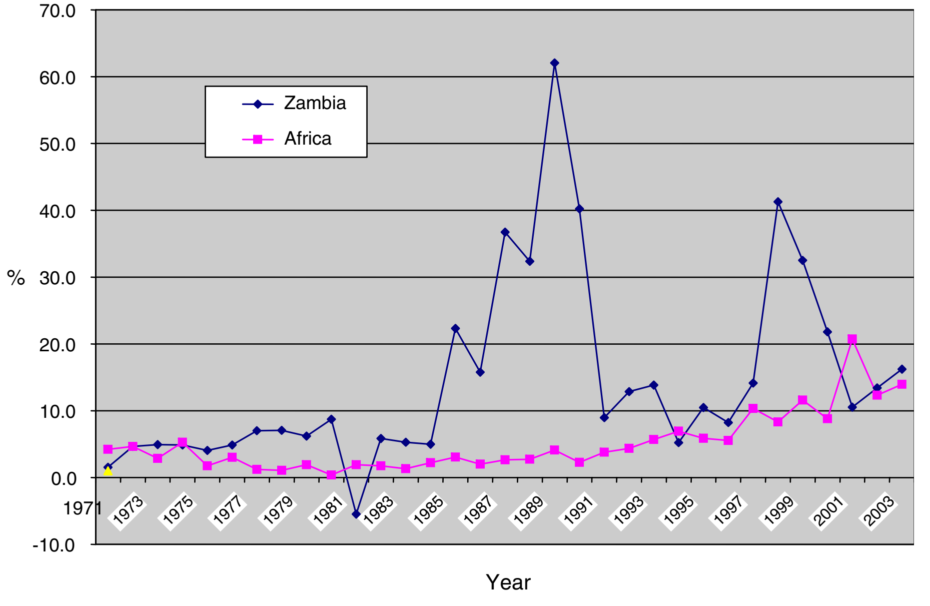

Fig. 1. Inward FDI as a percentage of gross capital formation in Zambia and Africa (1971–2003).

in 2003. Between 1990 and 1998, the manufacturing sector recorded the highest levels of pledged FDI (30%), followed by agriculture (20%) and tourism (18%).[2] It is expected that the privatization program and the recorded increases in foreign investment will promote technology transfer from foreign firms to domestic firms and subsequently help to increase productivity and efficiency in the economy. With this expectation, Zambia continues to provide generous fiscal incentives and offers the most liberal investment climate in Southern Africa, all aimed to attract foreign investment and advance technological progress in the economy.

3. Data and methodology

3.1. Data sources

We use annual data on Zambian manufacturing firms collected by the World Bank through the Regional Program on Enterprise Development (RPED) survey conducted in 1993, 1994 and 1995. After examining the raw data and deleting firms with missing key information, data on 125 of 145 firms surveyed are used in this paper. This data covers the food, textiles, wood and metal industries. The survey captured information on different aspects of firm-level structure, but of interest to this paper is the data on production (output, sales, raw material costs, capital stock and employment) and ownership or foreign equity participation at the firm level. The latter enabled us to distinguish foreign from domestically owned firms. A firm is said to be "foreign" if it has at least 5% foreign shareholding in the company. In order to facilitate performance comparisons across firms and time, production data was annualized and then deflated using the appropriate firm and sector-specific deflators included with the data set.

In addition to the production and input variables, two technology spillover variables were computed. The horizontal spillover variable, *FDI_spill*, defined as a ratio of labor employed by foreign firms to total labor in the sector captures horizontal (intra-industry) productivity spillovers.[3] The regional spillover variable, *FDI_region*, is calculated as a ratio of sales of foreign firms to total sales in the region.

Additional input–output information was compiled from Hausner's 1995 social accounting matrix for Zambia to compute a variable to capture vertical productivity spillovers through backward linkages (Hausner, 1999). Due to lack of more recent data, the 1995 social accounting matrix for Zambia prepared by Hausner was used to obtain input and output information for the two digit-manufacturing sectors covered in the survey. This information was used to compute a proxy for vertical productivity spillovers. Following Javorcik (2004), a proxy for vertical spillover, *FDI_back*, was calculated as the proportion of that output, excluding services, produced by downstream sectors and supplied to upstream sectors (food, textiles, wood and metal industries) weighted by the share of foreign employment (or sales) to total employment (sales) in the industry. The resulting index is time varying and sector-specific, and its magnitude increases with foreign presence in the upstream industry. Descriptive statistics on these variables are provided in Table 1 and discussed below.

[2] The data presented here was collected from the Zambia Investment Center (various issues), and data for the figure was compiled from the UNCTAD website http://www.unctad.org/Templates/Page.asp?intItemID=1465.

[3] The ratio of labor employed by foreign firms (or ratio of sales or capital assets) to total labor employed (capita assets or sales) in sector is a proxy measure of technology spillover. Results for the spillover variable using sales or capital stock were not different and are not reported.

Table 1
Descriptive statistics and means of productivity by firm size

Variables	Mean	S.D.
Log of physical capital	8.4829	1.83518
Log of raw material	7.0971	1.22550
Log of output	7.3170	1.18177
Log of skilled labor	1.3184	0.71047
Log of unskilled labor	0.8616	0.76069
FDI_back (vertical spillover)	0.0633	0.08623
FDI_spill (horizontal spillover)	0.2194	0.15569
FDI_region (regional spillover)	0.1525	0.18378

3.2. Descriptive statistics

In terms of participation, 20% of the firms surveyed are foreign and a majority of these are concentrated in the metal (31%) and textile (14%) sectors and account for 37% and 30% of total sales in the industry, respectively. Most of these firms are located in the copper-belt region around the mining enclave. Foreign firms in the food and wood sectors account for less than 10% of total sales in the industry and are more geographically dispersed than those in the metal and textile sectors.

Table 2 summarizes output and employment in four two-digit manufacturing industries between 1993 and 1995. It is shown that employment and output declined throughout the survey period. This decline coincides with the country's implementation of pro-liberal economic and political reforms, which began in 1991. As a result, much of this decline can be attributed to increased competition from imports following trade liberalization. It is, therefore, important that these demand shocks and input adjustments are taken into account when specifying and estimating the production function on panel data.

Table 3 presents means of productivity measured by regressing productivity variables on time, industry and ownership dummies on four firm sizes define above. A firm is a micro-firm if it has less than six employees, small if it employs between 6 and 29 workers, medium if it has between 30 and 99 employees, and large firms if it employs more than 99 employees. Coefficients on dummies of firm size are used as proxy measures of mean firm productivity across the four firm size categories. Results show that mean productivity decreases as one moves from large to micro-firms. Capital intensity, skill intensity and average wage per employee are at

Table 2
Changes in output and employment in manufacturing sector (1993–1995)

Sector		1993	1994	1995	1993–1995 (% change)
Food	Output	363.64 (745.91)	444.62 (852.80)	264.22 (585.63)	27.3
	Employment	196.56 (280.06)	158.31 (209.18)	142.59 (216.08)	27.5
Textiles	Output	355.93 (680.11)	154.22 (391.99)	186.90 (609.03)	47.5
	Employment	157.36 (296.34)	111.06 (257.57)	111.89 (310.85)	28.9
Wood	Output	40.24 (158.26)	42.02 (92.97)	34.09 (77.27)	15.28
	Employment	86.57 (167.80)	62.39 (121.61)	53.75 (97.06)	37.9
Metal	Output	226.47 (772.83)	158.57 (316.33)	94.74 (143.02)	58.2
	Employment	91.66 (98.53)	69.97 (75.27)	65.90 (73.22)	28.1

Output is million of Zambia Kwacha.
Figures in parenthesis are standard deviations.

Table 3
Means of productivity purged of sectoral, ownership and time effects

Variables	Large	Medium	Small	Micro
Log of output per worker	5.81 (1.06)	5.63 (1.03)	5.60 (1.01)	5.40 (1.14)
Log of annual average wage/worker	5.18 (0.92)	4.88 (0.87)	4.88 (0.76)	4.66 (1.20)
Log of output–capital ratio	3.72 (1.84)	3.68 (1.77)	3.44 (1.70)	3.01 (1.90)
Log capital–labor ratio	9.54 (2.09)	9.32 (1.77)	9.06 (1.76)	8.43 (1.78)
Log of output–raw material ratio	0.31 (1.09)	0.23 (1.01)	0.24 (1.01)	0.21 (1.14)
Number of firms	86	117	110	59

Means represent coefficients on firm size variables obtained by regressing productivity measures on dummies of firm size, sector dummies, time dummies and dummies on type of ownership.

least 50% higher among larger firms than smaller firms, but only modest differences exist between large, medium and small firms. These differences may be an indication of the importance of unobservable factors, such as managerial and organization abilities, quality of the workforce and other intangible firm-specific assets in explaining productivity differences across firms.

3.3. The model

The empirical framework utilizes a constant returns to scale Cobb-Douglas production function specified as:

$$y_{it} = \alpha y_{it-1} + \sum_k \beta_k x_{kit} + v_i + \varepsilon_{it}, \tag{1}$$

where y is the logarithm of output, x is the vector of logarithms of inputs (i.e., total cost of materials, skilled and unskilled labor, and replacement value of physical capital stock), i and t are firm and time subscripts, and k denotes the number of production inputs. v_i captures unobserved firm-specific effects and ε_{it} is the usual equation error term. y_{t-1} is the lagged logarithm of output included to capture adjustments to demand shocks as well as to account for part of the serial correlation in the equation error (Nickell, 1996). In this case, α may be interpreted as the speed of adjustment to long-run output following a production or demand shock. β is the vector of input share parameters to be estimated.

Following the earlier literature three productivity spillovers variables, *FDI_spill* (horizontal spillovers), *FDI_back* (vertical spillovers) and *FDI_region* (agglomeration or region spillovers) are then included in the model to gauge their effects on productivity.[4] The full augmented Cobb-Douglas production function is stated in its first difference as:

$$\Delta y_{it} = \Delta\alpha y_{it-1} + \sum_k \beta_k \Delta x_{kit} + \lambda \Delta FDI\_spill_{jt} + \gamma \Delta FDI\_back_{jt} + \delta \Delta FDI\_region_{rt} + \varepsilon_{it} \tag{2}$$

where r indexes the three regions (Lusaka, Copperbelt and Southern provinces) covered by the survey.

[4] Some of the early studies include Caves (1974), Globerman (1979), Blomstrom and Wolff (1983), Blomstrom and Persson (1989), and more recently Haddad and Harrison (1993), Aitken and Harrison (1999) and Javorcik (2004).

Foreign presence can raise the productivity of local firms through technology diffusion, spillovers from foreign firms to local firms within the sector (*intra*-industry) and linkages with local firms in downstream or upstream sectors (*inter*-industry spillover). Foreign presence can also induce greater competition in both the product and factor markets, thereby forcing domestic firms to back up their average cost curves and reduce capacity utilization and productivity. This may eventually lead to shutdowns. But this competitive environment can also help furnish incentives for domestic firms to become more innovative and productive, and thereby raise efficiency within the industry. These two effects are expected to exert a negative and positive impact, respectively, on domestic firm productivity. If positive productivity effects occur, either through spillovers or backward and forward linkages, the overall effect of FDI on productivity of local firms will be positive. In practice, the overall impact will depend on the relative magnitude of benefits generated through *intra*-industry spillovers and *inter*-industry linkages. As such, the expected sign on λ, γ and δ cannot be ascertained *a priori*.

3.4. Econometric approaches

In order to obtain consistent parameter estimates from the production function, a number of econometric concerns need to be addressed. Most of these arise from the very nature of the equation error ε_{it}. If the equation error term is independently and identically distributed and hence uncorrelated with input choices, the ordinary least squares (OLS) estimates will be consistent but inefficient, while random and fixed effects estimators are both consistent and efficient. In this case, one can use the Hausman specification test to choose between the fixed and random effects estimates. On the other hand, if input choices are correlated with unobservable factors (factors normally observable to the firm manager but unobservable to the analyst) or omitted variables for that matter, parameter estimates will be inconsistent and oversized. Unobservable factors can arise from difficulties in observing and quantifying differences in the quality of human capital, capital intensity and effects of demand shocks across firms and industries. This information is hardly captured by a survey and hence bulged in the random term causing input variables to be correlated with the error term. In this case, both capital and labor may be endogenous (Nickell, 1996).[5] Moreover, most firm-level data from developing countries, especially data on physical capital, is poorly recorded and likely to be measured with errors. This can lead to biased estimates.

These estimation problems are dealt with as follows: Permanent unobserved heterogeneity is addressed by differencing the data to remove possible correlation between explanatory variables and firm-specific effects. Input endogeneity is addressed by adopting an instrumental variable estimation procedure, where lagged levels are used as instruments in the production function. If the random, ε_{it}, is non-persistent, a standard generalized method of moments estimator (GMM) will be both consistent and efficient (Arelleno and Bond, 1991). However, when the dynamic error processes are highly persistent, lagged levels have been shown to be poor instruments for contemporaneous differences and lead to finite sample biases (Blundell and Bond, 1998; Blundell et al., 2000). Following Blundell and Bond (1998), both lagged differences and lagged levels are used as instruments in estimating parameters of the production function, and the resulting system GMM estimator is both consistent and efficient. Standard errors are robust and corrected for finite

[5] Labor is split between skilled and unskilled, and demand shocks (including competition effects) to the production function are captured by including lagged output and time trend among the explanatory variables.

sample biases based on Windmeijer (2000).[6] This estimator, SYS-GMM estimator, also encompasses the standard GMM estimator.[7] Results from ordinary least squares, within group estimator and standard and system GMM estimators are reported and compared below.

4. Estimation results

In testing technology spillover hypotheses, results from three estimation techniques are presented and discussed. Table 4 summarizes results for the total sample. Results from OLS and fixed effects (within estimates) are presented in columns 1 and 2, and GMM estimates shown in columns 3 through 6. Results in column 3 are those of the standard two-step GMM estimator with robust standard errors corrected for finite sample biases. Column 4 reports SYS-GMM estimates with robust standard errors. All other GMM estimates are based on a two-step SYS-GMM estimator with robust standard errors adjusted for finite sample biases as explained above. As expected, the OLS results overstate returns to scale on skilled labor and physical stock, which are supposedly endogenous and underestimate the coefficient on raw material inputs. The overall long-run returns to scale are 10% larger than assumed under constant returns to scale (CRS), while those from the fixed effects estimator are severely understated. The OLS diagnostic results fail to reject autoregressive errors in the model. This is also confirmed by imprecise estimates from the standard GMM estimation where only lagged levels are used as instruments. Note that coefficients on skilled labor and raw materials are poorly estimated, and the standard GMM estimator violates CRS. However, estimates based on SYS-GMM estimator are consistent with the underlying Cobb-Douglas production technology, and estimates of input share parameters are reasonably sized. Unless stated otherwise, subsequent discussion uses results from the two-step SYS-GMM estimator with robust standard errors corrected for finite sample bias.

The first hypothesis examines the presences of horizontal spillovers in the sector and is captured by *FDI_spill* variable. The coefficient on this variable is positive only in Table 4 columns 4 and 6, albeit statistically insignificant in all the equations. Similarly, the coefficient on the vertical productivity spillover variable (*inter*-industry spillovers) carries the expected positive sign, suggesting positive inter-industry productivity spillovers from FDI. But the coefficient of *FDI_back* is also statistically insignificant. While competition for market share happens at the national level, technology tends to spillover more rapidly between adjacent firms in regions with a high concentration of foreign firms. This possibility was captured by including the regional FDI variable (*FDI_region*) in the model. *FDI_region* carries a positive but statistically insignificant coefficient. This implies that, although its impact is small and insignificant, increased foreign presence is associated with intra-industry and inter-industry productivity spillovers.

Adverse “competition effects” can reduce productivity of domestic firms if foreign firms attract away demand from their domestic counterparts (Aitken and Harrison, 1999). Competition effects are likely to be important to those local firms that cannot withstand the competition or venture into the export markets. Table 5 summarizes results from a sub-sample of domestic firms, excluding firms with greater than 5% foreign equity, and utilizing short-term dynamics to examine the effect of increased foreign presence on productivity of local firms. OLS and within

[6] The dynamic panel data package for Ox version 3.30 was used to estimate the model.

[7] The alternative would be to use the Olley and Pakes (1996) approach to deal with the problem of input endogeneity. Because the panel data used in this study has small time-series component (T=3), a system GMM estimation was adopted.

Table 4
Estimating productivity spillovers using the generalized methods of moments

Variables	OLS [1]	WITHIN [2]	GMM(2step) [3]	GMM-SYM(a) [4]	GMM-SYS [5]	GMM-SYS [6]
Output(−1)	0.084 (3.07)**	−0.0116 (0.32)	0.029 (0.50)	0.108 (1.11)	013 (0.313)	0.043 (0.938)
Skilled labor	0.323 (3.01)***	0.005 (0.09)	0.0168 (0.27)	0.262 (3.11)***	0.158 (1.75)*	0.138 (1.71)*
Unskilled labor	0.11 (1.43)	0.006 (0.11)	0.012 (0.20)	0.130 (1.83)*	0.119 (1.62)*	0.111 (1.65)*
Physical capital	0.20 (3.71)***	0.173 (2.89)***	0.177 (2.84)***	0.197 (3.37)***	0.152 (1.76)*	0.164 (2.25)**
Raw material	0.47 (4.21)***	0.235 (2.03)**	0.249 (2.13)**	0.43 (3.96)***	0.598 (5.00)***	0.601 (5.84)***
FDI_spill	−0.167 (0.99)	−0.221 (0.64)	−0.130 (0.36)	−0.228 (1.36)	0.037 (0.22)	0.036 (0.36)
FDI_region	0.079 (1.53)	0.116 (1.64)*	0.124 (1.67)*	0.121 (2.12)**	0.058 (1.02)	0.082 (1.52)
FDI_back	1.14 (0.92)	2.357 (0.43)	4.28 (0.67)	1.82 (1.50)	0.372 (0.31)	
Constant	2.80 (2.36)*		−1.358 (2.95)**	3.25 (2.24)**	3.713 (2.61)***	3.088 (2.42)**
Time dummy 1995	−1.53*** (3.40)		−1.38 (3.08)***	−1.40 (2.96)***	−1.150 (1.79)*	−1.176 (2.17)**
AR(1)	0.099	0.000				
Sargan test	–	–	–	0.011	0.177	0.342
Long run returns to scale	1.04	0.96	0.62	1.01	1.03	1.01
Observations	125	125	250	250	250	250

All variables, except *FDI_back*, are in logarithms.
Figures in parenthesis are *t*-statistics.
(***), (**) and (*) denote significance at 1%, 5% and 10%, respectively.
OLS and within estimates include sector dummies.

Table 5
Estimating productivity spillovers using sub-sample of domestic firms and exploiting short-term dynamics for GMM

Variables	Domestically owned firms				All firms	
	OLS [1]	Within [2]	GMM-SYM [3]	GMM-SYM [4]	GMM-SYS [5]	GMM-SYS [a] [6]
Output(−1)	0.056 (1.88)*	−0.104 (2.02)**	0.077 (0.65)	−0.259 (1.47)	−0.10 (0.98)	−0.013 (0.25)
Skilled labor	0.109 (0.95)	−0.048 (0.35)	0.052 (0.26)	0.0108 (0.09)	0.068 (1.25)	0.236 (2.16)**
Skilled labor(−1)				0.30 (2.22)**	0.479 (3.30)***	
Unskilled labor	0.295 (3.39)***	0.002 (.019)	0.201 (1.19)	0.0797 (0.63)	0.010 (0.89)	0.207 (2.33)**
Unskilled labor(−1)				0.113 (1.33)	0.062 (1.40)	
Physical Capital	0.367 (4.85)***	0.407 (5.54)***	0.444 (3.11)***	0.293 (3.29)**	0.142 (2.24)**	0.094 (1.83)*
Physical capital(−1)				−0.027 (0.33)	0.0047 (1.21)	
Raw material	0.276 (3.16)***	0.127 (1.09)	0.329 (2.26)**	0.239 (1.75)*	0.415 (3.78)***	0.567 (3.91)***
Raw material(−1)				0.257 (1.68)*	0.117 (1.27)	
FDI_spill	−0.297 (1.62)*	−0.675 (1.61)*	−0.455 (1.12)	−1.229 (3.30)***	−0.041 (0.21)	−0.051 (0.32)
FDI_spill(−1)				−0.016 (0.06)	−0.108 (0.80)	
FDI_region			0.151 (1.11)	−0.085 (0.79)	0.024 (0.34)	0.009 (0.16)
FDI_region(−1)				0.181 (1.90)**	0.019 (0.37)	
FDI_back	0.55 (0.36)	−17.0 (2.77)***	1.34 (0.44)	4.67 (1.93)**	1.27 (1.12)	0.73 (0.66)
FDI_back(−1)				5.35** (2.15)	−0.47 (0.40)	
Constant	3.29 (2.14)**	3.62 (3.99)***	0.856 (0.24)	4.19 (1.89)	5.296 (4.43)***	5.04 (2.18)**
Time 1995	2.95 (2.24)**	–	2.70 (1.79)*	2.77 (3.17)	−1.064 (2.08)**	−0.841 (1.84)*
AR(1)	0.238	0.000	–	–	–	–
Sargan test	–	–	0.007	0.137	0.389	0.661
Long-run returns to scale	1.05	0.684	1.026	na	na	na
Observations	192	168	168	168	168	160

All variables, except FDI_back, are in logarithms.
Figures in parenthesis are *t*-statistics.
(***), (**) and (*) denote significance at 1%, 5% and 10%, respectively.
OLS and within estimates include sector dummies.
[a] Excludes all micro-firms from the sample.

estimates are reported in columns 1 and 2, respectively, and estimates from the SYS-GMM are reported in columns 3 and 4. Column 5 reproduces results based on the entire sample as before but now includes short-term dynamics. The last column reports estimates from a sub-sample of firms, excluding micro-firms.

Two fundamental results are highlighted. First, the coefficient on *FDI_spill* (horizontal spillovers) is negative and statistically significant in columns 1, 2 and 4 of Table 5 and only insignificant in column 4, suggesting that FDI substitutes, rather than complements, capital formation and productivity of local firms in the sector. This result is anticipated because FDI firms seek to consolidate their market share and profits by protecting leakage of technical information to their potential competitors within the sector, but may encourage selective and mutually beneficial knowledge spillovers to non-rival firms through backward and forward linkages. The coefficients on the *inter*-industry spillover variable (*FDI_back*) and its first lag are both positive and significant (column 4). This result is consistent with the vertical productivity spillover hypothesis and many of the recent empirical findings (Javorcik, 2004; Krugler, 2000). The regional spillover variable lagged one period carries the expected positive coefficient and is statistically significant. Introducing short-term dynamics (column 5) and excluding micro-firms (column 6) did not change the basic result reported in Table 1. The key results from this exercise indicate absence of *intra*-industry technology spillovers but significant inter-industry spillovers through backward and forward linkages.

5. Conclusion and final remarks

This paper examines the nature of productivity spillovers from foreign to local firms using firm-level data on manufacturing firms in Zambia. A Cobb-Douglas production function augmented to include measures of horizontal and vertical productivity spillovers is estimated using the GMM estimation approach. This estimator enables one to control for input endogeneity, possible measurement errors, unobservable effects and persistent errors often encountered in panel estimations. The estimated long-run return to scale is consistent with the underlying homothetic production technology with constant returns to scale.

With respect to productivity spillovers, this paper finds little evidence in support of productivity spillovers from foreign firms to local firms through horizontal channels. Results indicate that productivity of local firms decreases as foreign presence in the sector increases, which may be an indication of adverse competition effects of inward FDI. The results also indicate that significant knowledge spillovers occur through backward linkages from foreign firms in upstream sectors to local firms in downstream sectors. This result is consistent with the vertical technology spillover hypothesis. Foreign firms have an incentive to facilitate knowledge transfer to local firms to enable them produce intermediate inputs more efficiently, thereby making them available to foreign firms upstream at a lower cost. There is also evidence to suggest that regional concentration of foreign investment facilitates rapid technology spillover from foreign firms to domestic firms in the manufacturing sector.

The implication of the first result, lack of intra-industry spillovers, suggests that discriminatory provision of fiscal incentives in the form of tax holidays to foreign firms and not to local firms exacerbates the hegemony of foreign firms over potentially competitive local firms operating in the FDI sector. Productivity loses arising from adverse competition effects within the sector should be weighed against any productivity gains through input–output relationship across sectors. This information can then be used to rationalize and improve the design of fiscal incentives to maximize productivity benefits from FDI.

Two key limitations are worth noting. First, this paper uses a short panel data set to examine productivity spillovers and as such may underestimate those spillovers that occur with a significant time lag. In this context, increasing the time series component of the data may improve the estimates. Second, the study uses limited and highly aggregated input–output data to calculate a proxy for vertical spillovers. A better data set, which would allow identification of firm-level contacts especially between foreign and local firms within and across industries and sectors, would sharpen our estimates and understanding of productivity spillovers (horizontal and vertical) and their determinants. These limitations notwithstanding, the main findings in this paper are reasonably consistent with much of the recent literature on productivity spillovers from inward FDI in developing countries and economies in transition.

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