Energy efficiency spillovers from FDI: Evidence from Turkey

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Abstract

We inspect the relationship between the presence of foreign affiliates in host economies and the energy usage of domestic firms. Our theoretical model suggests that the presence of foreign firms in upstream industries expands the availability of inputs and favours the reduction of the energy intensity of downstream buyers. We corroborate this prediction on a panel of manufacturing firms in the context of the Turkish economy over the period 2010-2015. Our empirical analysis shows that Turkish firms in sectors more likely to buy inputs from foreign affiliates tend to reduce their energy intensity, measured as the firm level ratio of energy expenditure to output.

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1 Introduction

Environmental issues are at heart of nowadays political debate and academic research is rapidly evolving to analyse the determinants and consequences of energy consumption and savings. Among the economic factors under scrutiny one of the most controversial issue is the role of FDI. In this paper, we argue that inflows of foreign direct investment (FDI) may favour energy efficiency improvements in the host country.

Theoretically, both positive and negative effects of FDI on the environment can be depicted and the same ambiguity turns out from a mixed empirical evidence (Demena and Afesorgbor, 2020). A strand of literature has explored the so-called pollution haven hypothesis which states that multinational enterprises (MNEs) are attracted to host countries with poor and less stringent environmental regulations (Cai *et al.*, 2016; Millimet and Roy, 2016; Baek, 2016). This evidence on MNEs' location choice may indeed initiate a race to the bottom in developing and emerging countries that would adopt laxer environmental regulations (Rauscher, 1995; Markusen *et al.*, 1995). As a consequence, FDI inflows would lead to higher pollution levels and environment degradation. Other contributions, instead, support a positive impact of FDI on the environment, thus arguing the existence of the halo effect (Kellenberg, 2009; Cole *et al.*, 2017; Demena and Afesorgbor, 2020). Most literature pointing at such positive nexus mainly focuses on MNEs originating from advanced countries. However, some studies support a halo effect even in the case of developing countries' MNEs. Due to reputation and financial considerations, developing countries' MNEs commit to environmental protection and generate positive spillover effects to local firms' environmental practices (Zeng and Eastin, 2012) .

More generally, the benefits from the presence of MNEs in developing and emerging economies have been widely documented by the literature. As a matter of fact, being multinationals responsible for the majority of global R&D spending (UNCTAD, 2003), they transfer knowledge to their foreign affiliates (Arnold and Javorcik, 2009) and foreign affiliates are more likely to introduce new products than their indigenous competitors (Brambilla, 2009; Guadalupe *et al.*, 2012). A large strand of the literature investigates the indirect effects of FDI on domestic firms, known as spillover effects, focusing mainly on productivity (see Görg and Greenaway, 2004 for a review). While the evidence on the effect of the presence of foreign firms in the same industry (horizontal spillovers) is mixed, several studies offer examples of the benefits accruing to domestic firms from foreign presence in downstream industries, known as spillovers through backward linkages (Javorcik, 2004; Gorodnichenko *et al.*, 2010; Javorcik *et al.*, 2018). Nonetheless, multinationals in host economies are active manufacturing and service input suppliers. The availability of a wider array of inputs is at the basis of productivity gains for domestic firms, as theoretically demonstrated by Ethier (1982) and widely corroborated by the empirical literature (Amiti and Konings, 2007). In particular, Arnold *et al.* (2011) show that foreign entry in service production spurs productivity of domestic firms, while Ciani and Imbruno (2017) show that spillovers from manufacturing MNEs in upstream industries foster the export performance of Bulgarian firms. Despite the more limited evidence and/or lower magnitude of spillovers through forward linkages from manufacturing MNEs (Javorcik, 2008; Havranek and Irsova, 2011), their potential importance and the related channels through which they could work are still a relatively unexplored research field. In particular, as for imports, foreign presence in the upstream industries could provide not only a larger variety of inputs, but also better quality and cheaper inputs which could favour local producers in downstream industries. All of these channels could positively affect downstream firms' efficiency and, through this, favour a reduction of firm level energy intensity. Also, foreign entry in energy industry production and distribution could both promote efficiency gains and access to higher quality energy inputs.

In this paper, we firstly provide a simple theoretical framework showing that the presence of foreign firms in upstream industries generates a reduction of the energy intensity of domestic firms in downstream industries.[1] Next, we explore such an FDI effect using firm-level panel data from Turkey in the 2010-2015 period. This empirical context is particularly relevant, due to the high exposure of the Turkish economy to the activity of foreign MNEs and to the growing commitment of the Turkish government to environment protection and energy savings. It is, then, crucial for an economy that is deeply involved with MNEs' production to understand to what extent and through which channels MNEs' activity is beneficial for the country's sustainable growth. Our empirical baseline results suggest that a 10 percentage-points increase in the foreign firm presence in upstream industries lowers

[1] When exploring countries and firms' environmental performance, one can focus on different dimensions and measures spanning from pollutants' emissions, environmental certifications, environmental expenditures, green employment, green innovation and energy use. The wide literature on the impact of FDI on the environment has analysed all these outcomes, but in this paper we will study how the local presence of MNEs' affect domestic firms' energy use. The reason to focus on energy intensity is threefold. First, the investigation of firms' energy use allows to directly inspect how the presence of MNEs helps indigenous firms in changing their production techniques and the input mix. We can thus directly consider how MNEs affect local firms' production function and their demand for inputs. Second, for developing and emerging countries it is difficult to collect information on pollutants' emissions which may represent the ideal variable to explore the impact of FDI on firms' environmental performance (Brucal *et al.*, 2019). Third, pursuing affordable and clean energy is one of the sustainable development goals that have set up specific targets in terms of energy efficiency. The analysis of firms' energy intensity would thus help understanding how MNEs are contributing to the sustainable development path of emerging and developing countries.

the energy intensity of domestic firms by 0.4 percentage points. This finding is roubust to serveral checks.

Our work is related to the macroeconomic studies exploring the nexus between FDI and energy intensity which have provided mixed results (Mielnik and Goldemberg, 2002; Elliott *et al.*, 2013; Hubler and Keller, 2010). Using aggregate data at the geographic level prevents the possibility to explore the mechanisms underlying the investigated nexus, and, more specifically, to understand whether the changes in energy intensity arising from FDI are due to changes within the sector (scale or technical effect), and/or resource reallocation across sectors with different energy intensity (composition effect). Indeed, a large presence of foreign firms within an industry may entail an increase in energy efficiency because foreign firms are typically more energy efficient and can indirectly transfer their knowledge to local firms. Moreover, if foreign firms operate in less energy-intensive sectors, their greater presence may lead to resources reallocation from high to low energy intensity sectors, implying an increase in aggregate energy efficiency within the host economy (Hubler and Keller, 2010). Furthermore, the analysis of industry level data precludes the chance to study whether changes in energy intensity stemming from the presence of FDI are due to changes within the firm and/or resource reallocation across firms with heterogeneous energy efficiency. Moreover, it also prevents investigations on whether within-firm gains originating from FDI arise from the direct transfer of clean technologies from the foreign parent companies to foreign-owned firms, and/or indirect effects on domestic-owned firms which may benefit from technology transfers from foreign affiliates through vertical and horizontal linkages.

In order to shed light on the complex and heterogeneous mechanisms which may explain the FDI-energy efficiency nexus, some contributions have moved from a macro/meso to a micro level approach. Our work adds to this strand of literature. Existing firm-level evidence documents that foreign-owned firms have a higher energy efficiency than domestic-owned firms in several developing countries, such as Cote d'Ivoire, Mexico, Venezuela (Eskeland and Harrison, 2003), Ghana (Cole *et al.*, 2008) and China (Bu *et al.*, 2019). In particular, Brucal *et al.* (2019) go further through exploring the impact of foreign acquisition on plant-level energy intensity in Indonesia during the period 1983-2001. Using a difference-in-differences approach combined with propensity score matching, their results suggest that subsequent to the acquisition by foreign firms, acquired plants increase total energy use due to scale effects, and decline energy intensity. This evidence on the higher energy efficiency of foreign owned firms complements the evidence on the better environmental performance and lower pollutants' emissions of foreign versus domestic firms (Jiang *et al.*, 2014).

Just few papers point at the existence of other mechanisms explaining the positive impact of the presence on MNEs on energy efficiency, i.e. resource reallocation across firms and spillover effects on indigenous firms. Using firm-level data from India during the period 1985-2004, Martin (2011) examines the impact of several international policy reforms on the industry energy efficiency and, among other results, finds evidence of both within and between firms effects. Indeed, FDI reforms led energy efficiency improvements within old firms, as well as market share reallocations from high to low energy intensity firms.

To the best of our knowledge, there is no work that investigates how the presence of foreign-owned firms may affect domestic-owned firms' environmental performance through vertical and horizontal linkages by focusing on energy intensity. The only work exploring environmental spillovers from FDI through both horizontal and vertical linkages and that we are aware of is the one by Albornoz *et al.* (2009). For the case of Argentina, they use firm level cross-section data, rather than panel data, and focus on the adoption of environmental management practices, rather than energy intensity. After documenting that foreign firms are more likely to adopt environmental management practices than domestic firms are, their baseline results support a positive correlation between foreign firms' adoption of environmental management practices and the foreign presence in downstream sectors, conditional on the existence of formal and informal links - cooperations, joint ventures, etc. -with foreign customers. A similar backward linkage is only found for domestic exporters.

Within this framework, our work contributes by studying theoretically and empirically how foreign input suppliers can influence the energy intensity of domestic firms (forward spillover channel) in an emerging market context and by exploiting panel data. In this respect, our paper is related to the work by Imbruno and Ketterer (2018) which studies how trade integration of input markets in Indonesia improves energy efficiency and finds that the availability of imported inputs significantly boosts firms' energy efficiency. A similar positive effect may stem from the availability of foreign MNEs' inputs in the local market.

With our work we also contribute to dissect the mechanisms behind forward spillovers originating from foreign suppliers. In particular, we investigate whether the positive impact of foreign MNEs in upstream sectors on domestic firms' energy intensity is associated to a larger variety of inputs which brings productivity gains, a lower price of inputs and/or a higher input quality. To the best of our knowledge this is the first time that such a decomposition analysis has been implemented on the within-firm energy intensity effects of FDI. Existing literature has instead focused on understanding how FDI or trade shocks drive to a standard composition and technique effect on energy use, where the technique effect has been further decomposed into across-firm, across-products-within-firms, and within firm-products by Barrows and Ollivier (2018).

Our results show that foreign presence in upstream industries reduces the energy intensity of domestic firms. This finding is robust to several checks. When we inspect the efficiency channel we find that spillovers from upstream manufacturing firms positively affect domestic firms' Total Factor Productivity (TFP).

The paper is structured as follows: Section 2 presents the theoretical motivation and background of our empirical analysis; Section 3 presents the data, the measures and the empirical model; Section 4 discusses the empirical results and Section 5 concludes the work.

2 Theoretical Background

To study how the presence of foreign firms in both energy and manufacturing intermediate sectors may affect firms' environmental performance in final good sectors, we highlight some theoretical predictions through a simple theoretical framework - based on Krugman (1980) and Ethier (1982) - in order to guide our empirical analysis.

2.1 Closed Economy

A representative downstream firm with a given exogenous productivity ϕ_y produces its final output q_y through combining inputs arising from two upstream sectors: energy (X_e) and manufacturing intermediate materials (X_m) as follows

$$
\begin{aligned}
q_y &= \phi_y X_e^{\alpha} X_m^{1-\alpha} \, with \\
X_e &= [\int_0^E x_e^{\frac{\lambda-1}{\lambda}} de]^{\frac{\lambda}{\lambda-1}} = E^{\frac{\lambda}{\lambda-1}} x_e \\
X_m &= [\int_0^M x_m^{\frac{\sigma-1}{\sigma}} dm]^{\frac{\sigma}{\sigma-1}} = M^{\frac{\sigma}{\sigma-1}} x_m
\end{aligned}
$$

where α and $(1-\alpha)$ are the factor shares of production.

Both types of input producers use labour with specific expertise for each upstream sector (either energy or manufacturing material sector), so that reallocation of workers is possible within each upstream sector, but not across them. In each upstream sector, producers generate a horizontally differentiated variety under monopolistic competition, as in Ethier (1982). Therefore, the downstream firm-level aggregate consumption in manufacturing intermediate materials or energy is a function of the number of all input varieties (M or E), the quantity consumed of each input variety (x_m or x_e), and the elasticity of substitution between them ($\sigma > 1$ and $\lambda > 1$).

Firm-level demands in energy and intermediate materials are respectively:

$$
\begin{aligned}
X_e &= \frac{q_y}{\phi_y} (\frac{\alpha}{1-\alpha})^{1-\alpha} (\frac{P_m}{P_e})^{1-\alpha} \\
X_m &= \frac{q_y}{\phi_y} (\frac{1-\alpha}{\alpha})^{\alpha} (\frac{P_e}{P_m})^{\alpha}
\end{aligned}
$$

While the firm-level demand of a single input variety m or e is given by

$$
\begin{aligned}
x_e &= (\frac{p_e}{P_e})^{-\lambda} X_e \\
x_m &= (\frac{p_m}{P_m})^{-\sigma} X_m
\end{aligned}
$$

where p_e and p_m represent the price of energy variety e and the price of manufacturing intermediate variety m respectively, $P_e = [\int_0^E p_e(e)^{(1-\lambda)de]^{\frac{1}{1-\lambda}} = E^{\frac{1}{1-\lambda}} p_e}$ is the aggregate energy price, and $P_m = [\int_0^E p_m(m)^{(1-\sigma)dm]^{\frac{1}{1-\sigma}} = M^{\frac{1}{1-\sigma}} p_m}$ is the aggregate intermediate input price. We define the firm-level energy intensity ε_y as the actual purchase of energy inputs $Z_e = E z_e$ over the total output produced

q_y:

$$\varepsilon_y = \frac{Z_e}{q_y} = \frac{1}{\phi}(\frac{\alpha}{1-\alpha})^{1-\alpha}(\frac{p_m}{p_e})^{(1-\alpha)}(E^{\alpha}M^{1-\alpha})^{\frac{1}{1-\sigma}} \tag{1}$$

From the equation above, we can notice that energy intensity is decreasing in both the number of manufacturing material inputs M and the number of energy inputs E.

2.2 FDI integration of manufacturing intermediates markets

We now study how FDI integration of manufacturing intermediate materials across $(1+n)$ symmetric countries influence firm-level energy intensity. The abolition of all FDI barriers in the manufacturing upstream sectors allows all input producers to establish affiliates abroad in order to supply firms in the downstream sector. Consequently, a downstream firm is able to use all manufacturing intermediate varieties produced by foreign-owned suppliers in addition to those provided by domestic suppliers, as follows

$$\begin{aligned} q_y^A &= \phi_y X_e^{\alpha}(X_m^A)^{1-\alpha} \; with \\ X_e &= [\int_0^E x_e^{\frac{\lambda-1}{\lambda}} de]^{\frac{\lambda}{\lambda-1}} = E^{\frac{\lambda}{\lambda-1}} x_e \\ X_m^A &= [(1+n)\int_0^M x_m^{\frac{\sigma-1}{\sigma}} dm]^{\frac{\sigma}{\sigma-1}} = [(1+n)M]^{\frac{\sigma}{\sigma-1}} x_m \end{aligned}$$

Notice that the number of manufacturing intermediate varieties increases to $M^A = (1+n)M$, while the related average price p_m remains unchanged. As a result, we are able to show that following FDI integration of intermediate material markets, energy intensity declines:

$$\varepsilon_y^A = \frac{1}{\phi}(\frac{\alpha}{1-\alpha})^{1-\alpha}(\frac{p_m}{p_e})^{(1-\alpha)} E^{\frac{\alpha}{1-\sigma}}[(1+n)M]^{\frac{1-\alpha}{1-\sigma}} < \varepsilon_y \tag{2}$$

PROPOSITION A *Firms decrease their energy intensity following FDI integration of manufacturing intermediate markets. In other words, an increasing presence of foreign-owned producers of manufacturing materials leads to energy efficiency gains, implying benefits for the environment.*

2.3 FDI integration of energy markets

We now analyse how FDI integration of energy markets across $(1+n)$ identical countries affects firm-level energy intensity. Through removing FDI barriers in the energy sectors, all input suppliers establish affiliates abroad to provide energy to firms in the downstream sector. Therefore, a downstream firm can use all energy input varieties produced by foreign-owned suppliers in addition to those provided by domestic energy companies, as follows

$$\begin{aligned} q_y^B &= \phi_y (X_e^B)^{\alpha} (X_m)^{1-\alpha} \; with \\ X_e^B &= [(1+n)\int_0^E x_e^{\frac{\lambda-1}{\lambda}} de]^{\frac{\lambda}{\lambda-1}} = [(1+n)E]^{\frac{\lambda}{\lambda-1}} x_e \\ X_m &= [\int_0^M x_m^{\frac{\sigma-1}{\sigma}} dm]^{\frac{\sigma}{\sigma-1}} = M^{\frac{\sigma}{\sigma-1}} x_m \end{aligned}$$

It is worth noting that that the number of energy varieties increases to $E^B = (1+n)E$ while the related average price p_e remains unchanged. As a result, we are able to demonstrate that FDI integration of energy markets leads to a decline in energy intensity

$$\varepsilon_y^B = \frac{1}{\phi}(\frac{\alpha}{1-\alpha})^{1-\alpha}(\frac{p_m}{p_e})^{(1-\alpha)}[(1+n)E]^{\frac{\alpha}{1-\sigma}} M^{\frac{1-\alpha}{1-\sigma}} < \varepsilon_y \tag{3}$$

PROPOSITION B *Firms decrease their energy intensity following FDI integration of energy markets. In other words, an increasing presence of foreign-owned producers of energy leads to energy efficiency gains, implying benefits for the environment.*

3 Empirical Strategy

3.1 Data sources and sample

Our sample covers all manufacturing firms with more than 20 employees operating in Turkey in the period 2010-2015. The main data source is the Structural Business Statistics (SBS) available from the Turkish National Statistical Office from which we retrieve information on firms' output, input costs, employment and foreign ownership. We follow the OECD definition and classify as foreign those firms whose foreign capital asset share is higher than or equal to 10% (OECD, 2008). The SBS are the fundamental data source to measure energy intensity of firms as the ratio of energy purchases - electricity and fuels - over total output. We further gather information on firm import and export activities from the Foreign Trade Statistics (FTS) that record trade flows by product and partner countries for all Turkish firms. In order to inspect the channels through which foreign presence in upstream industries affects the energy intensity of downstream firms we further rest on the use of the Turkish Annual Industrial Product Statistics (AIPS) from which we get information on firms' production at 10-digit PRODTR classification.[2] For each product, we know its code, volume of production, value of production and sales for the years 2010-2015 for all manufacturing firms with more than 20 employees. We are therefore able to compute for each industry the number of varieties - firm-product combinations - pertaining to foreign and domestic firms, their average adjusted price and quality and to use this piece of information to inspect the operating of spillovers from foreign firms on domestic firms' energy intensity.

3.2 Measuring FDI spillovers

To capture the impact of foreign firms' presence on the export intensity of Turkish firms, we use the standard proxies for horizontal and vertical spillovers employed by the literature (see, e.g., Javorcik (2004)). We compute these proxies at the industry-year level, thus exploiting the cross-industry variation in the presence of foreign owned firms over time. Sectors are defined at the 2-digit NACE Rev.2 level, with a total of 24 manufacturing sectors.

Our spillovers proxies are compiled based on the information on foreign owned firms with more than 20 employees, their sector of activity and output available from the SBS.[3] A proxy for horizontal (intra-industry) spillovers in sector j at time t is defined as the average foreign equity share, $ForeignShare$, in firms in the industry cell weighted by each firm $i's$ share in the cell's output in a given year:

[2] The PRODTR is a national product classification whose first 6-digits correspond to CPA (Classification of Products by Activity) codes and which includes about 3,700 different products.

[3] Since the SBS collect information for just a rotating sample of firms with fewer than 20 employees, we focus on the population of firms with more than 20 employees. We believe that the exclusion of small firms from the calculation does not represent a severe problem due to the small share of output accounted for by this part of firms' population and due to the evidence that most of foreign owned firms are large.

$$Horizontal\ FDI_{jt} = \frac{\sum_{i=1}^{N_{jt}} Y_{it} * ForeignShare_{it}}{\sum_{i=1}^{N_{jt}} Y_{it}} \quad (4)$$

with N_{jt} indicating the number of firms which are active in sector j and year t, and Y_{it} denotes the output of firm i in year t.[4]

To create a proxy for the foreign presence in downstream (input sourcing) and upstream (input supplying) sectors, and thus investigate potential vertical spillovers, we combine the $Horizontal\ FDI$ indicator in equation 4 with the national Input-Output table (for domestic production) for Turkey in the year 2012.[5] We, then, build the following proxies for spillovers through backward and forward linkages, respectively:

$$Downstream\ FDI_{jt} = \frac{\sum_{s=1}^{S} HorizontalFDI_{st} * Sales_{js}}{\sum_{s=1}^{S} Sales_{js}} \quad (5)$$

$$Upstream\ FDI_{jt} = \frac{\sum_{s=1}^{S} HorizontalFDI_{st} * Purchases_{js}}{\sum_{s=1}^{S} Purchases_{js}} \quad (6)$$

where $Sales_{js}$ and $Purchases_{js}$ are respectively the total sales and purchases of manufacturing sector j to/from an industry s. [6]

3.3 Econometric model

In order to test the impact of foreign presence in the same, upstream and downstream industries on the energy intensity of domestic firms we estimate the following model:

[4] We also compute weights on the basis of firms' employment shares and we test the robustness of our findings to the use of spillover measures based on employment.

[5] The industry definintion of the Turkish IO is slightly more aggregate than the 2-digit NACE Rev.2 and includes 21 different industries.

[6] Sector j is a firm's main sector of activity. In order to separate intra-industry and inter-industry effects, in a robustness check we exclude sourcing and supplying relationships taking place within the sector.

$$\frac{Energy}{Output}_{ijt} = \alpha_1 Horizontal\ FDI_{jt-1} + \alpha_2 Upstream\ FDI_{jt-1} + \\ + \alpha_3 Downstream\ FDI_{jt-1} + \beta' X_{it-1} + \lambda_i + \gamma_j + \delta_t + \epsilon_{it} \tag{7}$$

where $\frac{Energy}{Output}_{it}$ is the ratio of energy expenditures to output of firm i, and $Horizontal\ FDI_{jt-1}$, $Upstream\ FDI_{jt-1}$ and $Downstream\ FDI_{jt-1}$ respectively measure the presence of foreign firms in the same industry j or in $j's$ upstream or downstream industries. X_{it-1} is a vector of firm-level controls all measured at $t-1$. We account for firm size (log of persons employed) and average wage (log of average wages and salaries) as well as for firm export, import, outsourcing and subcontracting activities by means of dummy variables taking value 1 for firms in the specific status and 0 otherwise. Our baseline specification includes firm fixed effects λ_i, industry fixed effects γ_j and year fixed effects, δ_t, while ϵ_{it} represents the idiosyncratic error term. We estimate model 7 by means of OLS and we cluster standard errors by industry (Moulton, 1990).

Table 1: Baseline Results - Energy Intensity and Spillovers from FDI

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$Horizontal\ FDI_{jt-1}$	0.001	0.003			0	0.002		
	[0.006]	[0.006]			[0.006]	[0.006]		
$Upstream\ FDI_{jt-1}$	-0.039***		-0.039***		-0.046***		-0.046***	
	[0.014]		[0.014]		[0.014]		[0.014]	
$Downstream\ FDI_{jt-1}$	-0.004			-0.031	0.017			-0.014
	[0.057]			[0.056]	[0.058]			[0.057]
$Outsourcer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Sub-contractor_{it-1}$	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Importer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Exporter_{it-1}$	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Size_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$wage_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	105980	105980	105980	105980	105980	105980	105980	105980
R-squared	0.72	0.72	0.72	0.72	0.723	0.723	0.723	0.723
Fixed Effects								
Firm	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	no	no	no	no
NUTS2-Year	no	no	no	no	yes	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets

4 Results

Table 1 shows results from the estimation of model 7. From the Table a positive role for firm-level energy efficiency of foreign-owned input suppliers emerges. As a matter of fact, the coefficient associated to $Upstream\ FDI_{jt-1}$ is negative and statistically significant both when the spillover measure is included individually and when it is included with the remaining horizontal and downstream spillover measures. The estimated coefficient implies that an average increase of 10 percentage points in the foreign output share in upstream industries would reduce energy intensity of domestic firms in downstream industries by 0.4 percentage points.

It is worth highlighting that Table 2 proves that the effect is robust both in its significance and magnitude when we calculate upstream and downstream linkages by excluding industry the firm's own industry j from the array of supplying and buying industries.

Also, the same insights can be gathered when we compute the horizontal spillover at the 4-digit NACE Rev.2 level as in Table 3, when we use the log of the energy intensity in Table 4 and when we include labour productivity among the right hand side firm-level controls in Table 5. It is worth mentioning that the inclusion of the latter control leads to the use of a lower number of observations which motivates its exclusion from the baseline specification.

Table 2: Exclusion of own industry from Vertical Spillovers

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$Horizontal\ FDI_{jt-1}$	0.002	0.004			0	0.002		
	[0.006]	[0.006]			[0.006]	[0.006]		
$Upstream\ FDI_{jt-1}$	-0.038***		-0.039***		-0.045***		-0.045***	
	[0.014]		[0.013]		[0.014]		[0.013]	
$Downstream\ FDI_{jt-1}$	-0.016			-0.043	0.007			-0.024
	[0.057]			[0.056]	[0.058]			[0.057]
$Outsourcer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Sub-contractor_{it-1}$	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Importer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Exporter_{it-1}$	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Size_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$wage_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	108152	108152	108152	108152	108152	108152	108152	108152
R-squared	0.717	0.717	0.717	0.717	0.719	0.719	0.719	0.719
Fixed Effects								
Firm	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	no	no	no	no
NUTS2-Year	no	no	no	no	yes	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets

Table 3: Horizontal Spillovers at 4-digit

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$Horizontal\ FDI_{jt-1}$	-0.002	-0.002			-0.002	-0.002		
	[0.003]	[0.003]			[0.003]	[0.003]		
$Upstream\ FDI_{jt-1}$	-0.039***		-0.039***		-0.046***		-0.046***	
	[0.014]		[0.014]		[0.014]		[0.014]	
$Downstream\ FDI_{jt-1}$	-0.009			-0.031	0.013			-0.014
	[0.057]			[0.056]	[0.058]			[0.057]
$Outsourcer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Sub-contractor_{it-1}$	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Importer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Exporter_{it-1}$	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$Size_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$wage_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	105,981	105,981	105,981	105,981	105,981	105,981	105,981	105,981
R-squared	0.72	0.72	0.72	0.72	0.723	0.723	0.723	0.723
Fixed Effects								
Firm	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	no	no	no	no
NUTS2-Year	no	no	no	no	yes	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets

Table 4: Log of Energy Intensity

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$Horizontal\ FDI_{jt-1}$	0.002	0.003			0.001	0.002		
	[0.005]	[0.005]			[0.005]	[0.005]		
$Upstream\ FDI_{jt-1}$	-0.036***		-0.037***		-0.043***		-0.042***	
	[0.012]		[0.011]		[0.012]		[0.011]	
$Downstream\ FDI_{jt-1}$	-0.006			-0.032	0.012			-0.017
	[0.048]			[0.047]	[0.049]			[0.048]
$Outsourcer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Sub-contractor_{it-1}$	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Importer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Exporter_{it-1}$	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Size_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$wage_{it-1}$	0	0	0	0	0	0	0	0
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	105,980	105,980	105,980	105,980	105,980	105,980	105,980	105,980
R-squared	0.737	0.737	0.737	0.737	0.74	0.74	0.74	0.74
Fixed Effects								
Firm	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	no	no	no	no
NUTS2-Year	no	no	no	no	yes	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets

Table 5: Inclusion of Labour Productivity

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$Horizontal\ FDI_{jt-1}$	0.002	0.004			0	0.002		
	[0.006]	[0.006]			[0.006]	[0.006]		
$Upstream\ FDI_{jt-1}$	-0.035***		-0.036***		-0.041***		-0.041***	
	[0.012]		[0.012]		[0.012]		[0.012]	
$Downstream\ FDI_{jt-1}$	-0.005			-0.03	0.005			-0.022
	[0.051]			[0.050]	[0.052]			[0.051]
$Labour\ Productivity_{it-1}$	-0.007***	-0.008***	-0.007***	-0.008***	-0.007***	-0.007***	-0.007***	-0.007***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Outsourcer_{it-1}$	-0.001	-0.001	-0.001	-0.001	0	0	0	0
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Sub-contractor_{it-1}$	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Importer_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Exporter_{it-1}$	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$Size_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$wage_{it-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	101,288	101,288	101,288	101,288	101,288	101,288	101,288	101,288
R-squared	0.754	0.754	0.754	0.754	0.757	0.757	0.757	0.757
Fixed Effects								
Firm	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	no	no	no	no
NUTS2-Year	no	no	no	no	yes	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets

4.1 Channels

In progress

5 Conclusion

With this paper we have contributed to the existing literature on the nexus between FDI and energy efficiency by theoretically modeling and providing empirical evidence on the spillovers effects that the presence of MNEs generates on indigenous firms active in downstream sectors. By using firm-level panel data from Turkey in the 2010-2015 period, we find that firms in sectors more likely to buy inputs from foreign affiliates tend to improve their energy intensity. This points at one important mechanism through which FDI are beneficial for host countries' sustainable growth. Our findings prove robust to the control of other measures of spillovers.

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