THE ENVIRONMENTAL PERFORMANCE OF FOREIGN-OWNED ENTERPRISES: EVIDENCE FROM ITALY

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Abstract

By using a firm-level database, this paper investigates the environmental behaviour of foreign-owned enterprises (FOE) operating in Italy. In doing this, we firstly examine whether the ownership status may affect the probability of a firm of being polluting. Secondly, we explore whether the environmental performance of FOE spills-out towards companies operating both at horizontal and at backward and forward level, by testing the extent to which environmental spillovers may be affected by the absorptive capacity of enterprises. Thirdly, we explore whether the environmental outcome of FOE is influenced by policy stringency in their origin country, by employing a measure of spillover calculated on the basis of the countries' environmental performance. We found that: (i) FOE are more likely to pollute than Italian-owned firms (direct impact) and that their environmental performance spills-out towards companies operating both at intra- and inter-industry level (indirect impact); (ii) the absorptive capacity of enterprises matters for vertical spillovers but not for horizontal ones; (iii) the presence of FOE from countries with a higher level of environmental policy stringency than Italy increases the probability of polluting for companies operating in the domestic market at intra-industry and backward level while decreasing the probability of polluting at forward level.

Keywords*:* MNEs, FDI, environmental spillovers, pollution haven hypothesis, pollution halo hypothesis

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1. Introduction

The worldwide diffusion of Foreign Direct Investment (FDI) from Multinational Enterprises (MNEs) has led to a growing debate about their impact on the host countries' environment. On the one hand, MNEs can be cleaner than local companies due to the use of more eco-innovative technologies and environmental management systems (Zhang and Zhou, 2016); on the other, they may contribute significantly to the massive depletion of natural resources by delocalizing their more polluting production processes to low regulation countries (Chakraborty and Mukherjee, 2013). Consequently, along with the traditional studies that focus on the *economic* impact of inward-FDI on the receiving countries, a new strand of literature has emerged that aims to investigate the *environmental* consequences of FDI on domestic economies.

In this regard, two alternative hypotheses have been proposed. The first claims that less stringent environmental standards attract MNEs' dirty investment, thus creating 'pollution havens' which boost a global "race to the bottom" ("pollution haven hypothesis" - PHavH) (Dechezleprêtre and Sato, 2017; Cai et al., 2016; Rezza, 2013). The second asserts that MNEs may positively contribute to the environmental conditions of FDI-receiving countries by bringing superior technologies and cleaner production methods ("pollution halo hypothesis" - PHalH) (Wang, 2017; Cole et al., 2008). It is worth noting that the possibility for MNEs to bring negative or positive consequences to the host country's environment can happen both directly and indirectly (Albornoz et al., 2014). In other words, the environmental performance of MNEs may not only contribute directly to worsening or improving the local environment but can also result in negative or positive "environmental spillovers" towards the domestically-owned enterprises (DOEs), thus indirectly influencing the host country's environment (Chudnovsky et al., 2005; Cole et al., 2005).

In this framework, the present paper contributes to the empirical literature on the environmental impact of MNEs by investigating the environmental performance of foreign-owned enterprises (FOEs) in the Italian market. To this end, we attempt to address the following three research questions: (i) What is the relationship between companies' foreign ownership and their environmental behaviour? (ii) Does the environmental performance of FOEs spill-out to DOEs? (iii) To what extent is the environmental outcome of FOEs affected by environmental policy stringency in their country of origin?

To answer the abovementioned questions, the paper exploits an original firm-level database obtained by matching and merging different sources of data. In particular, the contribution provided to the existing studies is threefold. Firstly, the paper explores a void in the literature since, to the best of our knowledge, no similar investigation has analysed the environmental impact of FOE in a developed country. Secondly, while previous research has focused mainly on the environmental effects of inward-FDI at the country- or industry-level, this paper is among the very few studies to carry out a firm level analysis, by searching for the existence of environmental spillovers not only at horizontal but also at backward and forward level. Thirdly, this paper employs a novel measure of environmental spillover calculated according to the level of environmental stringency in the FOEs' country of origin.

The remainder of the work is as follows. Section 2 reviews the main literature on the link between inward-FDI and the environment. Section 3 describes data and econometric methodology employed. Section 4 discusses the empirical findings. Finally, section 5 ends with some concluding remarks.

2. Literature review

The ongoing debate about the effects of foreign presence on the host country's environment is divided between two contrasting views, namely the pollution haven and halo hypotheses. On the one hand, in fact, countries with lax environmental regulations are considered to be attractive for MNEs' dirty investment, thus becoming potential "pollution havens" (Cai et al., 2016); on the other, MNEs are conceived as possible vehicles for a better environmental performance in the host countries due to their superior technology and environmental management systems (Wang, 2017). Both the PHavH and PHalH may stem from the combination of a direct and indirect effect of MNEs on the domestic country. Indeed, the environmental performance of FOEs may not only determine a *direct* impact on the local environment but can also spills-out towards DOEs, therefore *indirectly* affecting the host country's environment (Chudnovsky et al., 2005). In particular, environmental spillover can occur both at intra-industry level (i.e. horizontal spillovers) and inter-industry level, the latter arising from the presence of MNEs in the downstream sectors (i.e. backward spillovers) and in the upstream sectors (i.e. forward spillovers) (Albornoz et al., 2014). In other words, backward spillover occurs when the presence of a MNE affects the environmental performance of its domestic suppliers (i.e. local companies that *supply* goods and services *to* the MNE) while forward spillover occurs when a MNE influences the environmental performance of its domestic customers (i.e. local companies that *buy* goods and services *from* the MNE).

Despite the well-shaped theoretical framework, the empirical evidence about the existence of the PHavH or PHalH seems quite inconclusive. The main studies carried out so far can be organised into three different groups according to the type of results obtained. The first group includes works that are supportive of the PHavH, such as Smarzynska and Wei (2004), Acharyya (2009), Cole et al. (2011), Chakraborty and Mukherjee (2013), and Cai et al. (2016). The second group comprises the studies that provide evidence of the PHalH, such as Blackman and Wu (1999); Eskeland and Harrison (2003), Chudnovsky et al. (2005), Wang and Jin (2007), Cole et al. (2008), Albornoz et al. (2009), Albornoz et al. (2014), Yildirim (2014), Anh (2015), Mert and Bölük (2016), and Zhang and Zhou (2016). Finally, the third group includes the studies that fail to find any evidence of the PHavH or PHalH, such as Pargal and Wheeler (1996), Hartman et al. (1997), Dasgupta et al. (2000), Koop and Tool (2008), and Scaringelli (2014).

Details about these studies in terms of (i) countries, period and sector analysed, (ii) environmental proxy used, (iii) methodology adopted, and (iv) effects tested (i.e. whether direct or indirect) are synoptically reported in Table 1.

Table 1 Empirical evidence on the PHavH and PHalH – most relevant studies

Author(s)	**Country(ies)/ Period(s)/ Sector(s)**	**Environmental proxy(ies)**	**Methodology**	**Testing for direct/indirect effect**	**Findings**
Pargal and Wheeler (1996)	Indonesia/1989-1990/ Manufacturing sector	Biological oxygen demand	Log-log regression	Only direct	No evidence of PHavH/PHalH
Hartman et al. (1997)	Bangladesh-India-Indonesia-Thailand/1992/ Pulp and paper industry	Pollution abatement efforts	Ordinary least squares	Only direct	No evidence of PHavH/PHalH
Blackman and Wu (1999)	China/1995-2000/ Power Sector	Energy efficiency	Descriptive statistics	Only direct	Evidence of PHalH
Dasgupta et al. (2000)	Mexico/1994/ Total Industry	Adoption of ISO 14001 and expanded use of personnel for environmental inspection and control	Two-stage system: linear and probit equations	Only direct	No evidence of PHavH/PHalH
Eskeland and Harrison (2003)	Mexico-Venezuela-Morocco-Cote d'Ivoire/Various between 1977 and 1990/ Manufacturing sector	Energy use	Fixed effects model	Only direct	Evidence of PHalH
Smarzynska and Wei (2004)	Various European countries/1997/Manufacturing sector	Pollution emissions and abatement costs	Probit model	Only direct	Evidence of PHavH
Chudnovsky et al. (2005)	Argentine/1998–2001/ Manufacturing sector	EMAS adoption	Multinomial logit (MNL) model; probit model	Direct and indirect	Evidence of PHalH
Wang and Jin (2007)	China/2000/Total industry	Waste water treatment facility and environmental investment	Generalized method of the moments (GMM)	Only direct	Evidence of PHalH
Cole et al. (2008)	Ghana/1991-1997/Various manufacturing	Energy use	Trans log specification	Only direct	Evidence of PHalH
Koop and Tool (2008)	Various countries/1996-2005/Gold mining Industry	Waste production	Bayesian econometric methods	Only direct	No evidence of PHavH/PHalH

Albornoz et al. (2009)	Argentine/1998-2001/ Manufacturing sector	Environmental management systems (ISO14001 certification)	Logistic regression analysis; negative binomial model	Direct and indirect	Evidence of PHalH
Acharyya (2009)	India/1980-2003/Various	CO2 emissions	Cointegration	Only direct	Evidence of PHavH
Cole et al. (2011)	China/2001-2004/Various	Waste water and petroleum-like matter, waste gas, sulphur dioxide, soot, and dust	Fixed effects	Only direct	Evidence of PHavH
Chakraborty and Mukherjee (2013)	114 countries/2000-2010/Various	Environmental performance index (EPI)	Fixed effects	Only direct	Evidence of PHavH
Scaringelli (2014)	Italy/2002-2006/ Total Industry	Air and water emissions	Ordinary least squares and random effects model	Only direct	No evidence of PHavH/PHalH
Yildirim (2014)	Various countries/1980–2009/All sectors	Energy use and CO2 emission	Bootstrap-corrected panel causality test and cross-correlation analysis	Only direct	Only partial evidence of PHalH
Albornoz et al. (2014)	Argentine/1998-2001/ Manufacturing sector	Environmental actions	Maximum likelihood method	Direct and indirect	Evidence of PHalH
Anh (2015)	Vietnam/2007-2009/ Manufacturing sector	Environmental management system	Random panel logistic regressions	Only direct	Evidence of PHalH
Mert and Gülden Bölük (2016)	Various countries/Various periods/All sectors	CO2 emissions, renewable energy consumption, fossil fuel energy consumption	Panel cointegration framework	Only direct	Evidence of PHalH
Cai et al. (2016)	China/1996 and 2001/Various	SO2 emissions	Difference-in-differences analysis	Only direct	Evidence of PHavH
Zhang and Zhou (2016)	China/1995-2010/All sectors	CO2 emissions	Different panel data models	Only direct	Evidence of PHalH

Source: own elaboration

It is interesting to note from Table 1 how empirical investigations have so far searched mainly for the existence of the direct environmental impact exerted by MNEs, whereas very little attention has been paid to the possible existence of inward FDI-related environmental spillovers. Among the few studies investigating the spillover effect (all supportive of the PHalH), Chudnovsky et al. (2005) reveal the existence of positive horizontal environmental spillovers, while Albornoz et al. (2009) and Albornoz et al. (2014) show how spillovers - at both horizontal and vertical level - move from a FOE to another rather than from FOEs to DOEs. In this framework, it is worth observing that the absorption capabilities of DOEs seem to play a very relevant role in favouring the environmental performance FOEs to spill-out to local economies. Indeed, in all the aforementioned studies, companies with a greater capacity to assimilate new environmental technologies are found to be more receptive to environmental spillovers.

In light of the limited empirical investigation concerning the indirect environmental effects arising from FOEs, the present study aims, therefore, to broaden the literature by providing new evidence on the existence of inward FDI-related environmental spillovers at both horizontal and vertical level.

3. Methodology

3.1. Data sources

Our empirical analysis has been carried out by employing a dataset resulting from different sources, namely: the E-PRTR (*European Pollutant Release and Transfer Register*), the AIA (*Autorizzazione Integrata Ambientale*), the AIDA (*Analisi Informatizzata delle Aziende*), the ISTAT (Italian National Institute for Statistics), and the EPI (*Environmental Performance Index*).

The E-PRTR is a Europe-wide database that provides environmental data from industrial facilities across the EU countries. The registry collects quantitative information about releases into the air, water and land for specific pollutants (e.g. heavy metals, pesticides, greenhouse gases) from large capacity establishments (IPPC) operating in the major industries. It is worth noting that - as established by the Italian Legislative Decree no. 372/99 - an IPPC is required to submit a declaration to E-PRTR only if the quantity of at least one pollutant, in at least one plant, exceeds a specific threshold, as defined in (the) Annex II - EC Regulation no. 166/2006. In this way, the E-PRTR database provides firm level information about the most polluting companies, i.e. those that exceed the pollution-control thresholds set by law other than about the type and quantity of pollutants they release.

The AIA database was obtained from the Italian "Ministry for the Environment, Land, and Sea" and supplies information about the Italian enterprises that have been authorised according to the Integrated Pollution Prevention and Control (IPPC) directive (EC Directive no. 1/2008). The IPCC regards new or existing industrial and agricultural enterprises that, due to their high pollution potential, are required to have a permit. This permit (the so called 'Integrated Environmental Authorization' - AIA) replaces any other environmental visa, authorization, etc. and can be issued only if certain environmental conditions are met, so that the firms themselves are responsible for preventing and/or reducing their polluting activities.

The AIDA database - supplied by the Bureau Van Dijk - contains the annual accounts of Italian enterprises. The database includes a number of valuable information facts on a wide set of economic and financial variables, e.g. number of employees, start-up year, value-added, fixed tangible assets, sector of activity, ownership status, etc.

The ISTAT provided the input-output matrix (which shows how the output and input of a single sector can be distributed among the economic sectors of the economy) as well as information about the emission level at sectoral level for a number of pollutants, including carbon dioxide, nitrogen oxides, particulate, etc.

Finally, the EPI - published by the Yale Center for Environmental Law and Policy (YCELP, 2016) - represents a widely used composite index representative of the environmental policy outcomes across countries (Brunel and Levinson, 2016). Starting from several environmental indicators (e.g. urban particulates, energy efficiency, renewable energy, CO2 per GDP, etc.), the EPI aggregates different environmental policy categories (e.g. air quality, sustainable energy, water resources, etc.) into the two broad objectives of environmental health and ecosystem vitality.

In order to obtain our final dataset, we started by merging the E-PRTR with the AIA databases. In this way, we identified all polluting companies (i.e. companies that exceed the pollution-control threshold set by law) within the universe of potentially more polluting enterprises (i.e. companies that received the AIA permit). We then intersected the resulting dataset with the AIDA database to acquire additional firm-level information, such as ownership status[1], company size, age, and other economic and financial variables. After dropping enterprises with incomplete records and excluding those with abnormal values that seemed to stem from possible errors, we obtained an unbalanced firm-level sample of approximately 8,500 observations for the period 2006-2013. The input-output matrix provided by the ISTAT was then used to derive the spillover variables at vertical level while data from ISTAT on emissions was used to identify the pollution-intensity at sectoral level. Finally, we employed the EPI to rank the FOEs' countries of origin according to their level of environmental policy stringency.

3.2. Econometric model and variables

To address our research questions, we followed a three-step estimation strategy.

In the first step, we explored whether the possibility for an enterprise to be pollutant (i.e. to exceed the threshold) is influenced by the firm's ownership (domestic *versus* foreign). On the one hand, indeed, MNEs may be among the main sources of pollution due to the wide range of dirty activities that they carry out and that, in turn, make it difficult for them to be controlled at the international level. On the other, they have the potential capability to positively affect the change towards more environmentally friendly ways of producing (Erdogan 2014). Accordingly, it should be expected that the presence of FOEs may provoke either negative or positive consequences on the local environment (*direct* impact).

In the second step, we tested whether the environmental performance of FOEs can spill-out to the local economy. More specifically, since FOEs and DOEs may interact with each other through horizontal and vertical linkages (the latter occurring when FOEs integrate local firms into their value chain as customers or suppliers), we tested for the presence of environmental spillovers at both intra and inter-industry level. On this terrain, the presence of FOEs in a country may affect the environmental behaviour of DOEs either positively or negatively. On the one hand, indeed, it can happen that local enterprises at intra-sectoral level may adapt to the polluting behaviour of FOEs with the aim of remaining competitive in the market. Additionally, FOEs could pursue cost minimization strategies by purchasing from the most affordable, but also polluting, domestic suppliers

[1] Generally, users of AIDA microdata extract information on ownership status only for the year of data acquisition. However, in our paper, in order to capture how foreign ownership changes over time, we extracted firm level observations year-by-year.

or by selling their dirty product to their local customers (Markusen and Trofimenko, 2008). By contrast, FOEs may encourage the dissemination of their environmental good practices to DOEs by pushing local competitors within the same industry to replicate their environmental behaviour. They can also choose to buy intermediate goods only from suppliers who behave in an environmentally responsible way and to supply goods exclusively to firms that comply with specific environmental rules (Brambilla et al., 2009). As with the *direct* effect, therefore, environmental spillover (i.e. the *indirect* effect) should also be expected to be either negative or positive.

In this step of our analysis, we also checked whether the existence of environmental spillovers can be affected by the absorptive capacity of DOEs. In fact, the environmental externalities arising from FOEs may occur not only through the competition brought by their presence into a country (i.e. the market channel) but also through the technology transfer and licensing from foreign to DOEs (i.e. the technological channel) (Albornoz et al. 2009; Perkins and Neumayer, 2009; Huber 2008). In this framework, the most technologically advanced firms (i.e. those characterised by a low technological gap) should be expected to be able to absorb the technology brought by FOEs more easily than the companies relying on old and out-of-date technologies.

Finally, in the third step of our methodology, we explored to what extent the environmental outcome of FOEs can be affected by environmental policy stringency in their home country. Indeed, FOEs can employ the most polluting technologies abroad to avoid the cost of environmental regulation compliance in their country of origin or, on the other hand, they may use the same environmental standards and practices in all their markets in order to achieve economies of scale and managerial simplicity (Perkins and Neumayer 2008; Angel et al. 2007). From this viewpoint, finding that a stringent environmental policy in the home country negatively affects the environmental outcome of FOEs should significantly contribute to providing evidence in favour of the PHavH.

Although the E-PRTR database provides precise information about type and quantity of pollutants, facility location, etc., we could not employ a continuous indicator of emission intensity at the firm level due to the number of missing values in the dataset. Consequently, we could only exploit information about whether a company exceeds or not the pollution-control threshold set by law (binomial variable). We are conscious that such an indicator for being environmentally harmful does not provide any information, in relative terms and on a continuous scale, about the firms' environmental behaviour since it simply signals how large is the absolute level of pollution a company is responsible for. From this point of view, it may be that a firm exceeds the threshold set by law simply due to the business it performs and its dimension but, in relative terms, it behaves more efficiently than smaller firms or than firms operating in less emitting sectors. It is worth noting that this problem affects also those studies employing environmental actions or management systems as an indicator for a company's environmental behaviour (see, for instance, Albornoz et al., 2009; 2014) since also these proxies provide information about the environmental outcome of enterprises exclusively in absolute terms and on a discrete scale. In order to overcome this problem, we therefore considered a number of control variables in our model, including the company size and the type of sector. More specifically, we operationalised our analysis by implementing a probit model which is well-suited to analysing data in the case of qualitative dependent variables with two possible outcomes. In other words, we observed the company status variable (y_{it}) - which is either being polluting ($y_i = 1$) or not ($y_i = 0$) - but we defined the dependent variable as a latent variable y^* (i.e. the probability of polluting) as a function of (i) the foreign ownership (FO), (ii) a vector of control variables (X), and (iii) the FDI-related spillover effect (SPILL):

$$\begin{gathered} y_i = 0 \text{ if } y_i^* = 0 \\ y_i = 0 \text{ if } y_i^* > 0 \\ y_i^* = f(FO, X, SPILL) \end{gathered} \qquad [1]$$

More specifically, the model we estimated was of the form[2]:

$$POLL^*_{ijt} = \alpha + \theta FO_{it-1} + \beta' X_{it-1} + \lambda' SPILL1_{jt-1} + \delta_t + \delta_j + \delta_r + \varepsilon_{ijt} \qquad [2]$$

where:

- the FO variable accounts for the firms' ownership (whether Italian or foreign);
- the X vector includes a number of variables likely to influence the probability of an enterprise being pollutant, namely productivity, absorptive capacity, size, capital-intensity, age, and sectoral pollution-intensity.
- the SPILL1 vector includes the environmental spillovers occurring both at intra-industry level (horizontal spillovers), and inter-industry level (vertical spillovers), the

[2] We lagged all regressors in order to take into account the risk for endogeneity to occur.

latter arising from the presence of FOEs in the downstream sectors (backward spillovers), and in the upstream sectors (forward spillovers);

- δ_t, δ_j are time and sector dummies included to capture, respectively, business cycle effects and industry characteristics, while δ_r is a set of regional (NUTS) dummies included to control for characteristics of regions that we might not having directly captured and that could affect the probability of polluting;
- $\varepsilon_{ijt} \sim$ IID $(0, \sigma^2)$ is the error term which accounts for the possible stochastic shocks at firm level that may affect the dependent variable.

We lagged all regressors in response to the risk of endogeneity and ran the model for the subsamples of foreign and DOEs as well as for the entire sample. This was to check whether the environmental behaviour of FOEs may spill-out towards DOEs alone, or also towards other FOEs.

To investigate whether the probability for a FOE to pollute is affected by the level of environmental policy stringency in its country of origin, we estimated the following model[3]:

$$POLL^*_{ijt} = \alpha + \phi FO_{it-1} + \omega' X_{it-1} + \eta' SPILL2_{jt-1} + \lambda_t + \lambda_j + \lambda_r + \xi_{ijt} \qquad [3]$$

where FO and X are the same as in equation [2], λ_t, λ_j and λ_r are time, sector and regional dummies while the SPILL2 vector includes a novel measure of horizontal, backward and forward environmental spillovers calculated according to the environmental stringency in the FOEs' country of origin. To this end, we firstly split the sample of FOEs into two different groups depending on the EPI in their domestic country (i.e. whether lower or higher than the Italian EPI) and then calculated the environmental spillover for each group. In this way, we obtained two different proxies of spillovers tailored, respectively, to the level of environmental stringency in the FOEs' country of origin.

As for model [2], we lagged all regressors to control for endogeneity and ran the model for the subsamples of foreign and DOEs as well as for the entire sample.

The detailed description of variables included in models [2] and [3] as well as their expected signs are reported in Table 2. It is worth noting that, since the POLL variable is equal to 1 when an enterprise exceeds the pollution-control threshold set by law, a positive sign of the FO variable should suggest that foreign ownership increases the probability of

[3] See note no. 2

polluting, while a negative sign means that foreign ownership decreases the probability of polluting. For the same reason, a positive sign on the spillovers variables should suggest that the presence of FOEs contributes to increasing the probability for DOEs to pollute. By contrast, a negative sign on the spillovers variables should suggest that the foreign ownership contributes to decreasing the probability for DOEs of polluting. Finally, the summary statistics are reported in Table 3.

Table 2 - Description of variables and expected signs

Name	Measure	Source	Expected sign
Dependent variable			
POLL	Firm pollution, proxied by a dummy variable = 1 if the firm exceeds the pollution threshold and = 0, otherwise.	E-PRTR AIA	N/A
Foreign ownership			
FO	Dummy variable = 1 if the Italian firm "i" is owned by a foreign owner at year t and = 0 otherwise.	AIDA	+ → if the foreign ownership increases the probability of polluting. - → the opposite.
X vector			
PROD(*)	Firm productivity proxied by the firm value added per employee.	AIDA	- → more productive firms are expected to decrease the probability of polluting.
GAP_PROD(*)	Firm absorptive capacity proxied by the gap productivity: $\mathbf{GAP\_PROD_{ijt}} = \frac{\mathbf{PROD_{ijt}}}{\mathbf{max\ PROD_{jt}}}$.	AIDA	+ → less technologically advanced firms (i.e. with a large technological gap) are expected to increase the probability of polluting.
SIZE	Firm size. In particular: SIZE1 = 1-49 employees; SIZE2 = 50-249 employees; SIZE3 = more than 250 employees.	AIDA	- → SME are expected to decrease the probability of polluting.
KL(*)	Firm capital-intensity calculated as the fixed assets over total employment.	AIDA	+ → capital-intensive production processes are expected to increase the probability of polluting.
AGE(*)	Firm age, defined as the difference between the year of observation t and the official year of incorporation of the firm.	AIDA	+ → older firms are expected to use more polluting technologies than newer firms.
ENV	Sectoral pollution-intensity, proxied by a dummy variable = 1if the Italian firm i is active in a sector with a lower environmental impact, and = 0 otherwise. Sectors with a lower environmental impact are those with a weighted average of carbon dioxide, nitrous oxide, methane, nitrogen oxides, sulphur oxides, ammonia, non-volatile organic compounds, carbon monoxide, particulate matter, and fine particulate matter below the mean value.	ISTAT	- → firms operating in less dirty industries are expected to decrease the probability of polluting.
SPILL1 vector			
HS	Horizontal spillover, calculated as: $HS_{jt} = \frac{FOR\_employees_{jt}}{ALL\_employees_{jt}}$ where FOR_employees is the number of workers employed by FOEs in sector j at year t, and ALL_employees is the number of workers employed by all firms in sector j at year t.	AIDA	+ → if the presence of FOEs contributes to increasing the probability to pollute for enterprises at intra-industry level. - → the opposite.
BS	Backward spillover, calculated as: $BACK_{jt} = \sum_{k,k\neq j} \gamma_{jkt} HS_{kt}$ where γ_{jkt} is the proportion of the j's output supplied to sourcing sectors k obtained from the input-output table.	AIDA ISTAT	+ → if the presence of FOEs contributes to increasing the probability to pollute for enterprises in the upstream sectors. - → the opposite.
FS	Forward spillover, calculated as: $FORW_{jt} = \sum_{k,k\neq j} a_{jkt} HS_{kt}$ where α_{jkt} is the proportion of inputs purchased by industry j from industry k obtained from the input-output table.	AIDA ISTAT	+ → if the presence of FOEs contributes to increasing the probability to pollute for enterprises in the downstream sectors. - → the opposite.

SPILL2 vector			
HS_low_epi	Horizontal spillover arising from FOEs coming from countries with a lower level of environmental stringency than Italy. It was calculated as: $HS\_low\_epi_{jt} = \frac{low\_epi\_employees_{jt}}{ALL\_employees_{jt}}$ where low_epi_employees is the number of workers employed by FOEs from countries with a lower EPI than the Italian-owned companies in sector j at year t.	AIDA; YCELP	+ → if the presence of FOEs from countries with a low environmental stringency level contributes to increasing the probability to pollute for enterprises at intra-industry level. - → the opposite.
HS_high_epi	Horizontal spillover arising from FOEs coming from countries with a higher level of environmental stringency than Italy. It was calculated as: $HS\_high\_epi_{jt} = \frac{high\_epi\_employees_{jt}}{ALL\_employees_{jt}}$ where high_epi_employees is the number of workers employed by FOEs from countries with a higher EPI than the Italian-owned companies in sector j at year t.	AIDA; YCELP	+ → if the presence of FOEs from countries with a high environmental stringency level contributes to increasing the probability to pollute for enterprises at intra-industry level. - → the opposite.
BS_low_epi	Backward spillover arising from FOEs coming from countries with a lower level of environmental stringency than Italy. It was calculated as: $BACK\_low\_epi_{jt} = \sum_{k,k\neq j}\gamma_{jkt}HS\_low\_epi_{kt}$	AIDA YCELP ISTAT	+ → if the presence of FOEs from countries with a low environmental stringency level contributes to increasing the probability to pollute for enterprises in the upstream sectors. - → the opposite.
BS_high_epi	Backward spillover arising from FOEs coming from countries with a higher level of environmental stringency than Italy. It was calculated as: $BACK\_high\_epi_{jt} = \sum_{k,k\neq j}\gamma_{jkt}HS\_high\_epi_{kt}$	AIDA YCELP ISTAT	+ → if the presence of FOEs from countries with a high environmental stringency level contributes to increasing the probability to pollute for enterprises in the upstream sectors. - → the opposite.
FS_low_epi	Forward spillover arising from FOEs coming from countries with a lower level of environmental stringency than Italy. It was calculated as: $FORW\_low\_epi_{jt} = \sum_{k,k\neq j}a_{jkt}HS\_low\_epi_{kt}$	AIDA YCELP ISTAT	+ → if the presence of FOEs from countries with a low environmental stringency level contributes to increasing the probability to pollute for enterprises in the downstream sectors. - → the opposite.
FS_high_epi	Forward spillover arising from FOEs coming from countries with a higher level of environmental stringency than Italy. It was calculated as: $FORW\_high\_epi_{jt} = \sum_{k,k\neq j}a_{jkt}HS\_high\_epi_{kt}$	AIDA YCELP ISTAT	+ → if the presence of FOEs from countries with a high environmental stringency level contributes to increasing the probability to pollute for enterprises in the downstream sectors. - → the opposite.

Note: (*) in logarithm terms

Table 3. Summary statistics(*)

	Obs	Mean	Std. Dev.	Min	Max
POLL	8,576	0.195	0.396	0	1
FO	7,481	0.066	0.249	0	1
PROD	7,127	7.736	1.683	0	13.726
GAP_PROD	7,127	0.123	0.157	0	0.693
SIZE1	8,576	0.475	0.499	0	1
SIZE2	8,576	0.363	0.481	0	1
SIZE3	8,436	0.148	0.355	0	1
KL	7,206	5.102	1.325	0	12.090
AGE	7,481	2.997	0.800	0	4.625
ENV	8,565	0.503	0.500	0	1
HS	6,604	0.078	0.084	0	0.558
BS	6,604	0.110	0.155	0	0.589
FS	6,604	0.151	0.222	0	1.103
HS_low_epi	7,428	0.029	0.040	0	0.403
HS_high_epi	7,428	0.040	0.054	0	0.437
BS_low_epi	7,428	0.013	0.041	0	0.359
BS_high_epi	7,428	0.051	0.087	0	0.393
FS_low_epi	7,428	0.017	0.054	0	0.266
FS_high_epi	7,428	0.070	0.134	0	0.807

All variables are lagged and in log terms.

4. Empirical results

The results from the probit estimation of model [2] are reported in Table 4.[4]

[4] The model was estimated by using the STATA 13 software.

Table 4 Model [2] estimation results

	Total sample		Total sample		DOEs	
	β	dy/dx	β	dy/dx	β	dy/dx
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
L.FO	0.410***	0.089***	0.386***	0.080***		
	(0.117)	(0.026)	(0.118)	(0.024)		
L.PROD	-0.140**	-0.030**	-0.141*	-0.029*	-0.153*	-0.030*
	(0.0705)	(0.015)	(0.0769)	(0.016)	(0.0844)	(0.016)
L.GAP_PROD	-0.586	-0.127	-0.216	-0.045	-0.125	-0.025
	(0.372)	(0.081)	(0.552)	(0.114)	(0.560)	(0.112)
L.SIZE1	-0.685***	-0.149***	-0.716***	-0.148***	-0.686***	-0.137***
	(0.149)	(0.031)	(0.184)	(0.037)	(0.201)	(0.039)
L.SIZE2	-0.437***	-0.095***	-0.463***	-0.096***	-0.427***	-0.085***
	(0.127)	(0.027)	(0.132)	(0.027)	(0.161)	(0.031)
L.KL	0.195***	0.042***	0.203***	0.042***	0.182***	0.036***
	(0.0350)	(0.007)	(0.0442)	(0.008)	(0.0480)	(0.009)
L.AGE	0.0553	0.012	0.0602	0.012	0.0313	0.006
	(0.0341)	(0.007)	(0.0408)	(0.008)	(0.0427)	(0.008)
ENV	-0.424***	-0.092***	-1.230***	-0.254***	-1.224***	-0.244***
	(0.142)	(0.030)	(0.114)	(0.027)	(0.129)	(0.028)
L.HS			2.058*	0.426*	1.741*	0.347*
			(1.231)	(0.256)	(0.908)	(0.182)
L.BS			0.127	0.026	0.272	0.054
			(0.390)	(0.081)	(0.355)	(0.071)
L.FS			-0.962***	-0.199***	-1.016***	-0.202***
			(0.259)	(0.054)	(0.192)	(0.039)
L.HS_GAP_PROD			-6.566	-1.359	-5.815	-1.159
			(7.135)	(1.473)	(6.812)	(1.357)
L.BS_GAP_PROD			-6.998	-1.448	-8.747**	-1.744**
			(4.739)	(0.994)	(4.448)	(0.904)
L.FS_GAP_PROD			6.395***	1.323***	7.050***	1.405***
			(1.789)	(0.380)	(1.745)	(0.363)
Constant	-0.300		0.554		0.794	
	(0.603)		(0.632)		(0.704)	
Observations	6,982		6,170		5,706	
Pseudo R2	0,2285		0,2598		0,2403	
Wald chi2	1166.99***		1148.93***		941.15***	
Year dummies	YES		YES		YES	
NACE dummies	YES		YES		YES	
NUTS2 dummies	YES		YES		YES	

Notes:
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Looking at columns (i) and (ii), the first relevant result emerging from our investigation is that being a FOE contributes to increasing the probability of exceeding the pollution-control threshold set by law. More specifically, FOEs are approximately 9% more probable of being pollutant compared to DOEs. As expected, the most productive firms are also the less polluting ones, while the capital-intensive enterprises are the dirtiest. Considering the other control variables, our results suggest that the probability of polluting is affected by companies' size (the SME being cleaner than larger enterprises) but not by the firms' age and the technological gap, whose coefficients are not statistically significant. Finally, as expected, companies operating in less dirty sectors result to be the cleanest.

These results are broadly confirmed when the spillover effect is taken into account (columns (iii) and (iv)). Again, FOEs are found to be dirtier than DOEs and the corresponding estimated marginal effects remain substantially unchanged. The probability of being pollutant still decreases for more productive companies, SMEs, and for those enterprises operating in less dirty sectors, while it increases for capital-intensive companies. No influence on the likelihood of polluting is exerted by firm's age and the absorptive capacity.

Turning our analysis to the environmental spillovers, our results reveal the existence of a negative horizontal spillover (the sign of the HS variable being positive), meaning that the negative environmental performance of FOEs spills-out towards companies operating in the same industry. FOEs, therefore, are not only more polluting than DOEs (provoking, therefore, a direct effect on the host country's environment) but they also contribute to increasing the probability of exceeding the pollution-control threshold for those companies that operate at intra-industry level (indirect effect). Moreover, the not significance of the "HS_GAP_PROD" interaction term interestingly suggests that the technological distance between companies does not matter when explaining the environmental externalities. In other words, negative horizontal spillover occurs exclusively through the market channel and not through the technological one.

At the same time, our findings show the existence of a positive forward spillover (the sign of the FS variable being negative), proving that the presence of FOEs reduces the probability of exceeding the pollution-control threshold for those companies that buy goods and services from them. In other words, despite being more polluting than DOEs, FOEs anyway produce “clean” products, contributing thus to the positive environmental performance of their customers in the host country. Contrarily to horizontal spillover, however, forward spillover seems to be affected by the technological gap, the corresponding interaction term being statistically significant. In particular, the positive environmental externalities from FOEs occur exclusively towards the most technologically-advanced enterprises, i.e. those characterised by a low technological gap. This supports the findings from Albornoz et al. (2009; 2014) who find that firms which buy from sectors with a large presence of FOEs are more likely to be less polluting the greater is the degree of their absorptive capacity. Finally, our findings provide no evidence of backward environmental spillovers suggesting that the negative environmental performance of FOEs does not spill-out towards firms operating in the upstream sectors in the host country. These results are generally confirmed when the sample is limited to DOEs only (columns (v) to (vi)). In this case, however, the absorptive capacity of enterprises is found to matter not only for companies operating at the forward level but also for those operating at the backward level.

Tables 5 and 6 report the results achieved from the probit estimation of model [3] for FOEs originating, respectively, in countries with a lower and a higher EPI than Italy.

Table 5 Model [3] estimation results for lower EPI countries than Italy

	Total sample		DOEs	
	β	dy/dx	β	dy/dx
	(i)	(ii)	(iii)	(iv)
L.FO	0.397***	0.086***		
	(0.119)	(0.026)		
L.PROD	-0.134*	-0.029*	-0.142*	-0.080*
	(0.0701)	(0.015)	(0.0744)	(0.015)
L.GAP_PROD	-0.253	-0.055	-0.176	-0.037
	(0.392)	(0.085)	(0.385)	(0.081)
L.SIZE1	-0.682***	-0.148***	-0.661***	-0.139***
	(0.152)	(0.032)	(0.170)	(0.035)
L.SIZE2	-0.441***	-0.095***	-0.408***	-0.086***
	(0.130)	(0.028)	(0.157)	(0.032)
L.KL	0.189***	0.041***	0.172***	0.036***
	(0.0358)	(0.007)	(0.0359)	(0.007)
L.AGE	0.0553*	0.012*	0.0306	0.006
	(0.0331)	(0.007)	(0.0345)	(0.007)
ENV	-0.394***	-0.085***	-0.367**	-0.077**
	(0.146)	(0.031)	(0.158)	(0.033)
L.HS_low_EPI	0.505	0.109	0.446	0.094
	(0.944)	(0.204)	(1.031)	(0.217)
L.BS_low_EPI	-1.542	-0.334	-0.618	-0.130
	(2.954)	(0.637)	(2.917)	(0.612)
L.FS_low_EPI	1.361	0.294	0.742	0.156
	(2.048)	(0.441)	(1.937)	(0.406)
L.HS_low_EPI_G	-16.73***	-3.620***	-17.21***	-3.615***
	(6.323)	(1.380)	(6.254)	(1.325)
L.BS_low_EPI_G	-5.781	-1.251	-8.688	-1.825
	(22.44)	(4.864)	(22.05)	(4.640)
L.FS_low_EPI_G	6.460	1.398	8.925	1.874
	(14.52)	(3.149)	(14.01)	(2.953)
Constant	-0.354		-0.237	
	(0.591)		(0.613)	
Observations	6,951		6,481	
Pseudo R2	0,2294		0,2068	
Wald chi2	1167.66***		931.56***	
Year dummies	YES		YES	
NACE dummies	YES		YES	
NUTS2 dummies	YES		YES	

Notes:
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 Model [3] estimation results for higher EPI countries than Italy

	Total sample		DOEs	
	β	dy/dx	β	dy/dx
	(i)	(ii)	(iii)	(iv)
L.FO	0.397***	0.086***		
	(0.112)	(0.024)		
L.PROD	-0.155**	-0.033**	-0.164**	-0.034**
	(0.0655)	(0.014)	(0.0698)	(0.014)
L.GAP_PROD	-0.343	-0.074	-0.226	-0.047
	(0.447)	(0.097)	(0.452)	(0.095)
L.SIZE1	-0.660***	-0.143***	-0.629***	-0.132***
	(0.149)	(0.031)	(0.167)	(0.034)
L.SIZE2	-0.421***	-0.091***	-0.384**	-0.081**
	(0.127)	(0.027)	(0.155)	(0.032)
L.KL	0.187***	0.040***	0.169***	0.036***
	(0.036)	(0.007)	(0.037)	(0.007)
L.AGE	0.058*	0.012*	0.034	0.007
	(0.034)	(0.007)	(0.035)	(0.007)
ENV	-0.467***	-0.101***	-0.434***	-0.091***
	(0.143)	(0.031)	(0.154)	(0.032)
L.HS_high_EPI	2.160*	0.467*	2.042*	0.428*
	(1.272)	(0.274)	(1.134)	(0.238)
L.BS_ high_EPI	0.610*	0.132*	0.663	0.139
	(0.344)	(0.074)	(0.414)	(0.087)
L.FS_ high_EPI	-1.200***	-0.259***	-1.231***	-0.258***
	(0.315)	(0.067)	(0.291)	(0.061)
L.HS_high_EPI_GAP_PRO	-1.765	-0.381	-2.331	-0.489
	(7.429)	(1.604)	(7.979)	(1.673)
L.BS_high_EPI_GAP_PRO	-11.91**	-2.575**	-13.32***	-2.794***
	(4.720)	(1.040)	(4.877)	(1.040)
L.FS_high_EPI_GAP_PRO	8.093***	1.749***	8.603***	1.804***
	(1.574)	(0.348)	(1.628)	(0.354)
Constant	-0.197		-0.0824	
	(0.558)		(0.592)	
Observations	6,951		6,481	
Pseudo R2	0,23		0,2076	
Wald chi2	1180.07***		933.25***	
Year dummies	YES		YES	
NACE dummies	YES		YES	
NUTS2 dummies	YES		YES	

Notes:
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The findings support the existence of spillovers both at horizontal and vertical level in case of FOEs coming from countries with a higher EPI than Italy (Table 6) while there is no evidence of spillovers when FOEs originate from countries with a lower EPI (Table 5). Focusing therefore on Table 6 and, in particular, looking at columns (i) and (ii), our results show the presence of a negative horizontal and backward spillover (the sign of the HS_high_EPI and BS_high_EPI variables being significant and positive), suggesting that the presence of FOEs whose country of origin has a higher level of environmental policy stringency than Italy increases the probability of exceeding the pollution-control threshold for those firms that operate at intra-industry level and in the upstream sectors. In contrast, FOEs originating from countries with higher EPI provoke a positive forward spillover, by reducing the probability of exceeding the pollution-control threshold for those firms that operate in the downstream sectors. Finally, the absorptive capacity is found to affect vertical environmental spillovers but not the horizontal ones. As earlier, these results are generally confirmed when the sample is limited to DOEs (columns (iii) to (iv)), although in this case we don't find any evidence of backward environmental spillovers.

5. Conclusions

The present paper has provided an in-depth analysis of the FOEs' environmental performance in the Italian case, by carrying out a threefold analysis. Firstly, it has investigated whether the ownership status of a company (domestic *versus* foreign) may affect the probability of an enterprise being polluting. Secondly, it has tested whether the environmental performance of FOEs spills-out towards other companies in the local market through both intra- and inter-industry linkages. Finally, it has explored whether the environmental performance of FOEs is affected by the level of environmental policy stringency in their countries of origin.

We find that FOEs are more likely to pollute than the Italian-owned firms, thus determining a (negative) direct impact on the host country's environment. This result may be due to the different management models of FOEs. Indeed, although FOEs may use modern and cleaner technologies, their environmental strategy is generally the responsibility of the local CEO, with the result that affiliates may set their environmental policies independently from the parent company.

Moreover, our findings show that the environmental performance of FOEs spills-out to companies operating both at intra- and inter-industry level. This means that other than causing a direct effect, FOEs also provoke an indirect effect on the host country's environment by affecting the environmental performance of companies operating in the domestic market through horizontal and vertical linkages. Moreover, the absorptive capacity of enterprises does not affect the horizontal spillovers but only the vertical ones. Finally, the presence of MNEs from countries with a higher level of environmental policy stringency than Italy increases the probability of polluting for companies operating in the domestic market at intra-industry level and in the upstream sectors while decreases the probability of polluting for those firms operating in the downstream sectors. These findings seem, therefore, to be supportive of the PHavH occurring at horizontal and backward level and of the PHalH occurring at forward level. In particular, the PHavH may be due to the lower environmental regulatory stringency that characterises Italy compared to other developed economies. Indeed, although Italian environmental policy falls under EU environmental legislation, its stringency-level still seems quite moderate according to the EPI, thus making the country potentially attractive for the MNEs' dirty investment. In contrast, the PHalH at forward level may be due to the ability of foreign-owned companies to manage the dirtiest stages of the production process, thus having the possibility to sell 'clean' products to their suppliers.

Further lines of research should be addressed towards the investigation of environmental spillovers occurring in other developed countries. An in-depth analysis of the MNEs' environmental decisions should also be carried out in order to investigate to what extent the polluting behaviour of foreign affiliates in a country is independent of the parent's environmental strategies.

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