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ARE THE FOREIGN CONTROLLED FIRMS MORE ENVIRONMENTALLY SUSTAINABLE THAN DOMESTICALLY CONTROLLED ONES?

Myriam, Anna Scaringelli

University of Foggia, Department of Science of Agriculture, Food and Environment, SAFE, Foggia 71122, Italy

E-mail: myriam.scaringelli@unifg.it

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Abstract. Do foreign controlled firms exhibit a different environmental performance from domestically controlled ones for 'developed countries'? The aim of this paper is to examine whether foreign firms are more environmentally sustainable than their domestic counterparts, i.e., the Pollution Halo Hypothesis generally analysed in developing countries. By using firm-level panel data over the time period 2002-2006, this study explores the differences in environmental performance -measured by air and water pollution emissions—of Italian dirty-firms with different types of ownership: Foreign multinational enterprises (FMNEs), National multinational enterprises (NMNEs) and Domestic enterprises (DOMESTICs). Econometric results show that foreign ownership does not influence air and water pollution emissions, suggesting the lack of evidence of a Pollution Halo Hypothesis in developed countries.

Keywords: air pollution, environmental performance, foreign ownership, pollution halo hypothesis, water pollution, sustainability

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JEL Classification: Q53, Q56, F23, F21

1. Introduction

Over the last twenty years, on an international scale, various agreements have been introduced for the protection of the environment, especially in industrialised countries. The commitment to these agreements led to the adoption of increasingly strict environmental regulation that has resulted in an increase of environmental constraints. A major concern arising from the adoption of more stringent environmental regulation relates to the international competitiveness of domestic firms. In fact, the firms that hold a comparative advantage in production with a high environmental impact may be affected by the high costs incurred in order to comply with the more stringent environmental standards. The environmental constraints are, therefore, considered a source of comparative disadvantages for the pollution-intensive goods. It follows that firms having comparative advantages in goods with a high environmental impact may find it convenient to shift production to countries with more lax (or absent) environmental regulation, damaging the environmental quality in the host countries.

The hypothesis that explains the effects of international trade on environmental regulation and the choice of production location is known as the Pollution Haven Hypothesis (PHH). Part of the literature that has analysed the PHH has been developed since the 1990s and can be classified in two streams of investigation. A first group of studies estimated the effects of environmental protection on the reduction of comparative advantage in goods with high environmental impact (Swann *et al.* 1996; Van Beers and Van den Bergh 1997; Xu 2000a, b; Harris *et al.* 2002; Copeland and Taylor 2003, 2004; Ederington and Minier 2003; Michida and Nishikimi 2007; Levinson and Taylor 2008). A second group of studies analysed the increase of foreign direct investment (FDI) determined by the choice of locating the production of more polluting goods in countries where environmental regulation is lax or absent (List and Co 2000; Neumayer 2001; Smarzynska and Wei 2001; Xing and Kolstad 2002; Keller and Levinson 2002; Fredriksson *et al.* 2003; Ljungwall and Linde-Rahr 2005; Hanna 2010; Petrović-Randjelović 2007).

There is, however, a contrary view, the Pollution Halo Hypothesis (PHalH), based on the assumption that FDI are vehicles of technology transfer from developed to developing countries and that the foreign-owned enterprises, being characterised by medium to large size, higher scientific and technological knowledge and implementing environmentally sustainable practices, are less polluting than domestic firms. Therefore, a progressively more stringent environmental law does not discourage foreign investments in countries with high environmental costs and, moreover, the presence of FDI causes a positive effect on the environmental quality in the host country (Zarsky 1999; Eskeland and Harrison 2003; Cole *et al.* 2008).

The PHalH is justified by the fact that the multinational enterprises generally use cleaner technologies and have more sophisticated environmental management systems compared to the national environmental regulation. These companies, which usually hold large market shares in the home countries, tend to adopt the same technologies in affiliated enterprises in order to meet the demand of consumers who are more sensitive toward the environment. This hypothesis is confirmed by some statistics from Italy. In fact, in the last twenty years, there has been an inflow of foreign investment in Italy, mainly coming from other developed countries such as the United States and other Western European countries. Considering the period 1990-2007, the number of Italian manufacturing firms with foreign participation has increased by 4.2 per cent for investments in subsidiaries and by 4.3 per cent for total participation (ICE- Reprint 2008). During the same period, the pollutants discharged into the air and water decreased. Emissions of sulphur oxides (SO_X) and carbon monoxide (CO) were decreased respectively by 81 and 71 per cent, nitrogen oxides (NOx), non-methane organic compounds (NMVOC) and ammonia (NH_3) were respectively decreased by 4.38 and 10 per cent. An improvement in quality has been observed even regarding water: in 2007, 48 per cent of monitored sites were in excellent and good ecological states (ISPRA 2008).

The aim of this paper is to investigate whether the reduction of pollution occurring in Italy in recent years is due not only to more efficient and effective environmental regulation with respect to several international agreements to which this country has joined but also to expansion in the presence of 'cleaner' foreign firms. The present work differs from the previous literature in two innovative aspects. The first concerns the features of the country. Previous studies have analysed the impact of foreign presence on environmental quality in a 'developed country'. The second is related to the adoption of direct environmental performance measures at firm-level[1], such as emissions in the water and in the air.

This paper is organised as follows. After the second part provides a brief review of the theoretical and empirical literature on the relationship between FDI and environment, the third section reports a descriptive analysis of Italian polluting firms. The econometric model will be the presented in the fourth part. The final section draws conclusions and policy implications.

2. Brief review of the theory and empirical literature

Much of the theoretical literature on the relationship between FDI and environmental sustainability adopts an approach based on the analysis of strategic behaviour of governments in the implementation of environmental policies in the presence of FDI (Markusen *et al.* 1993; Rauscher 1995; Co *et al.* 2002; Ulph and Valentini 2002; Greaker 2003; Kayalica and Lahiri 2005; Dijstra 2006; De Santis and

[1] Some authors have used indirect measures of environmental performance such as energy efficiency (Blackman and Wu 1999; Eskeland and Harrison 2003; Cole *et al.* 2008), the implementation of environmental management systems (Dasgupta *et al.* 2000; Albornoz *et al.* 2009) and the pollution abatement costs (Hartman *et al.* 1997).

Stähler 2009). The theoretical literature exploring the influence of FDI and firm-level characteristics on the level of pollution is limited. Two works are relevant: Dasgupta *et al.* (2000) and Wang and Jin (2007). The first (Dasgupta *et al.* 2000) shows that the equilibrium level of pollution is determined by the intersection between the expected marginal penalty schedule—depending on variables such as emissions, environmental regulation, pressure from the local community, type of ownership and trade relations—and the plant's marginal abatement cost curve including the plant size, the firm size, the process technology vintage, the human resources, and the quality of environmental management as possible determinants. The second work (Wang and Jin 2007) identifies the optimal level of waste by solving an optimisation problem where the firms with different types of ownership (private including foreign participation, state and cooperative) may receive different penalties even with the same pollution discharge.

From the empirical point of view, the topic about FDI and the environmental sustainability is analysed through the effects of environmental regulation on capital movements and the relationship between environmental performance and multinational enterprises. More precisely, the empirical analysis focusses mainly on the role played by environmental regulation in the choice of location of FDI to explain the increased migration of dirty industries to the developing countries (List and Co 2000; Smarzynska and Wei 2001; Xing and Kolstad 2001; Keller and Levinson 2002; Eskeland and Harrison 2003; Cole and Elliott 2005; Waldkirch and Gophinat 2008; Wagner and Timmins 2009; MacDermott 2009). The PHH has been tested concerning the impact of national environmental regulation on FDI flows to one or more host countries, at the aggregate and sectoral level (Xing and Kolstad 2002; Eskeland and Harrison 2003; Cole and Elliott 2005; Hanna 2010; Kirkpatrick and Shimamoto 2008; Dam and Scholtens 2008; Ben Kheder and Zugravu 2008; Elliott and Shimamoto 2008; Wagner and Timmins 2009; MacDermott 2009), and on FDI inflows (List and Co 2000; Keller and Levinson 2002; Millimet and List 2004; Waldkirch and Gopinath 2008)[2].

The empirical evidence on the relationship between the environment and multinational firms is limited, and the results are controversial (Pargal and Wheeler 1996; Hartman *et al.* 1997; Blackman and Wu 1999; Eskeland and Harrison 2003; Gallagher 2004; Wang and Jin 2007; Cole *et al.* 2008; Koop and Tool 2008). In this regard, a first group of work has verified the validity of PHalH and has identified the positive influence of some factors on the level of pollutant emissions, such as the medium-large scale, the high level of scientific knowledge and technology, and the greater sensitivity for environmental protection (i.e., all those characteristics of multinational firms of the DCs) (Cole *et al.* 2005). Blackman and Wu (1999) can be considered the first work in support of PHalH. The authors show that foreign investments in power generation in China have increased energy efficiency and reduced emission levels. Subsequently, Eskeland and Harrison (2003) find that the presence of foreign firms located in four developing countries[3] is positively associated with lower levels of pollution and energy consumption. This framework is also explored by Gallagher (2004), who analyses the emissions resulting from the combustion of energy and by-products during the production process of the manufacturing industry by comparing Mexican firms with corresponding firms in the U.S. in 1984 and 1998. The results find that, on average, the environmental impact of industrial activity in Mexico is much higher than that produced by the U.S.

One last work supporting the positive relationship between environmental performance and foreign ownership is Cole *et al.* (2008), which shows how some variables such as the firm size, the use of cleaner technologies, productivity, factor intensity and exports produce positive effects on energy consumption for manufacturing enterprises in Ghana. In contrast, a second group of works did not find empirical evidence of a relationship between environmental performance and foreign ownership. Pargal and Wheeler (1996) analyse the manufacturing industry in Indonesia over the period 1989-1990 and estimate the relationship between the biological oxygen demand (BOD) and some economic variables such as the economic sector, the output, the factors of production, the age, the efficiency, and the ownership. By classifying firms according to their type of owner-

[2] This group of works also examines the regional distribution of inflow FDI into a particular country of destination (List and Co 2000; Wang and Wheeler 2000; List 2001; Keller and Levinson 2002; Millimet and List 2004; Smarzynska and Wei 2004; Dean *et al.* 2009; Ljungwall and Linde-Rahr 2005).

[3] Ivory Coast, Morocco, Mexico and Venezuela.

ship in state, private and multinational companies[4], the authors show that foreign participation does not have a significant effect on the intensity of pollution. Conversely, public ownership appears to be strongly associated with high environmental impact products. Conflicting results have also been achieved by Hartman *et al.* (1997), who analyse the relationship between the abatement costs and some characteristics of plants such as technology, age, ownership (state, private and multinational), the quality of management and human resources available, relating to 26 companies in four different Asian countries (Bangladesh, India, Indonesia and Thailand) operating in the manufacture of pulp, paper and paper products for 1992. The authors demonstrate that the least environmental impact is positively associated with size and competitiveness and negatively influenced by public ownership; conversely, multinationality, financial activity and the willingness to export do not result in significant effects. The recent work of Koop and Tool (2008) finds a negative relationship between foreign presence and environmental quality. The authors attempt to determine the presence of substantial differences between the firms related to FDI country origins (developing or developed countries). The analysis, in contrast with the previous works about the manufacturing sector, refers to the mining industry and, specifically, to the gold mines (419 observed in the period 1996-2005). Their analysis also focusses on the level of pollution of the old mines controlled by foreign companies, in comparison with their national correspondents. Through the method of Bayesian stochastic frontier, the authors analyse the multiple nature of the output from gold production and the fact that the mines produce huge amounts of waste pollutants.

Some of the main features of the mentioned empirical works (as Pargal and Wheeler 1996; Hartman *et al.* 1997; Blackman and Wu 1999; Dasgupta *et al.* 2000; Eskeland and Harrison 2003; Gallagher 2004; Wang and Jin 2007; Koop and Tool 2008; Cole *et al.* 2008) are shown in Table 1. Following the main literature and its limit related to the host countries type (the PHalH is analysed in developing countries) the present work is to assess the existence of a positive relationship between foreign multinationality and emissions of pollutants, relative to firms located in a developed country. In addition, since most of the previous works have used indirect measures of environmental performance (such as energy consumption or energy efficiency, the use of fuel, pollution abatement costs or the amount of waste), this work is based on a direct measure of the amount of pollutants released into the environment (twenty-nine substances emitted into the water and forty into the air). This is possible due to the availability of data at the firm level. The description of the sample under analysis and the econometric model are given in the Table 1.

Table 1. Previous studies investigating the PHalH

Paper	Countries	Period	Sectors	Environmental Variable
Evidence of the PHalH				
Blackman and Wu (1999)	China	1995 – 2000	Power Sector	Energy Efficiency
Eskeland and Harrison (2003)	Mexico, Venezuela, Morocco Cote d'Ivoire	1977-1987 1984-1990 1983-1988 1985-1990	Manufacturing sector	Energy use
Gallagher (2004)	Mexico	1984-1998	Manufacturing sector	Energy use SOx, NOx, e PT emissions
Cole, Elliott and Strobl (2008)	Ghana	1991-1997	Food processing; bakeries; textiles and garments; wood products; furniture; metals and machinery	Energy use
No Evidence of the PHalH				

[4] Foreign ownership is measured by the authors through the share of capital owned by the foreign firm, while the share of capital owned by regional and national governments is the state-owned.

Pargal and Wheeler (1996)	Indonesia	1989-1990	Manufacturing sector	Biological oxygen demand (BOD)
Hartman, Huq and Wheeler (1997)	Bangladesh, India, Indonesia and Thailand	1992	Pulp and paper industry. (26 plants)	The pollution abatement efforts
Dasgupta, Hettige and Wheeler (2000)	Mexico	1994	Total Industry	Management efforts: adoption of ISO 14001 and use of personnel for environmental inspection and control
Wang and Jin (2007)	China	2000	Total Industry	Waste water treatment facility and environmental investment
Koop and Tool (2008)	World	1996-2005	Gold mining industry (419 mines)	Waste production

Source: author

3. Data description and methodology

3.1. Data Issues

The empirical analysis has been conducted by using firm-level data obtained from the intersection of two databases: the AIDA database (Analisi Informatizzata Delle Aziende) and the Ines Registry. AIDA is a database of Bureau Van Dijk, which provides financial, business and personal data of about 700,000 corporations operating in Italy. The AIDA database collects annual accounts of Italian corporate enterprises and contains information on a wide set of economic and financial variables, such as name, social security number, sector, firm size, firm age, value added, property, equipment and raw materials, in addition to the proprietary nature of the enterprise. By knowing the owner state, the firms are divided in three groups: foreign multinationals (FMNE) (i.e., Italian companies whose ultimate owner is foreigner), national multinationals (NMNE) (i.e., Italian companies with subsidiaries located in foreign countries), and domestic firms (DOMESTIC). The second database is represented by the Ines Registry Inventory of emissions and their sources) from ISPRA (Institute for the Protection and the Environmental Research) (former APAT). The registry collects quantitative information about the releases into the air and water of specific pollutants from major industries and establishments of large capacity (IPPC) on the national territory. It contains information about the name, whole name, social security number, sector of activity, task list with codes IPPC and NOSE, main activity and emissions data in air and in water (pollution, emission value total units measurement, allocation of emissions between the activities and sources of sewage treatment outside). In particular, the regulatory criteria require that an establishment in which one or more activities are carried out, the IPPC (Appendix I Legislative Decree no. 372/99) is required to submit a declaration to INES if at least one pollutant in Table 1.6.2 and 1.6.3 of the Ministerial Decree of 23th November 2001 exceeds the corresponding threshold. From the intersection of the two databases, by aggregating information at firm-level and omitting all observations for which the necessary data are incomplete, an unbalanced panel of about 2,185 observations over the period 2002-2006 is obtained.

3.2. The econometric analysis

In order to analyse the impact of foreign presence in Italian firms on environmental performance, we use a variant of the model proposed by Cole *et al. (2008) that environmental quality is a function of foreign ownership and other control variables including firm size, capital intensity, age, total factor productivity and production inputs:*

$$E_{it} = f(OWNERSHIP_{it}, X_{it}, \delta_{it}, \mu_{it}) + \varepsilon_{it} \quad (1)$$

In (1), E is the proxy of environmental performance, i.e., the emission of pollutants in water and air; OWNERSHIP means being multinational or not; X is a vector of additional control variables; δ is the time dummy; μ is the dummy 'industry' for industry j; and ε is the usual error term. All variables are in logarithm form and are specified in the following way:

E is a direct measure of environmental quality that is the total emissions of the pollutants in the water and in the air. Emissions are expressed in kg/year. For the calculation of the environmental variable, were added emissions of the pollutants listed in Annex I to DM 23/11/2001, by firm, year and environmental sector. Since we expected a different threshold value for each type of pollutant, emissions have been weighted to the "weight" that each substance has on pollution data from the complement to one of the composition ratio between the threshold value pollutant i-th and the sum of the threshold value of all pollutants.

OWNERSHIP is a qualitative variable that reflects the proprietary nature of the enterprise. To this end, the following dummies are introduced depending on the specifications of the model:
FMNE = 1 if the firm is foreign-owned, 0 otherwise.
DOMESTIC = 1 if the firm is a multinational, 0 otherwise.
NMNE Italian = 1 if the firm has holdings abroad.

The foreign presence is used as a proxy for the degree of access to technology. Since the occurrence of the phenomenon of pollution halo implies that foreign-invested enterprises are less polluting than domestic firms, we expect a negative sign for the FMNE (Pargal and Wheeler 1996; Cole *et al.* 2008);

AGE: the variable indicating the age of the firm has been used as a proxy for technological innovation. The expected relationship is positive, since the companies most 'young people' might be using have the most modern technologies and are cleaner than the 'older' companies in which the emissions would increase with advancing age (Hartman *et al.* 1997) although most of the empirical studies have found that the age of the firm does not produce any effect on the environment (Pargal and Wheeler 1996; Eskeland and Harrison 2003; Cole *et al.* 2008)[5].

SIZE: indicates the size of the firm measured by the total number of employees (Hartman *et al.* 1997). The underlying assumption is that the larger companies have a number of potential advantages compared to smaller firms with regard to the introduction of environmental management systems, and as a result would be cleaner than small firms (Cole *et al.* 2006). The relationship with the emissions is expected to be negative (Cole *et al.* 2008). KW: measures the intensity of physical capital per worker and is calculated by dividing the stock of physical capital by the number of employees. The expected relationship is positive, because the capital-intensive production processes are typically more dirty, with the result that emissions tend to increase for the more capital-intensive establishment (Copeland and Taylor 2003; Cole and Elliott 2003).

IMM: indicates the amount of tangible assets. The expected negative sign is based on the assumption that firms with more assets are also those most skilled at introducing cleaner technologies and those most likely to adopt environmental management tools in order to meet the obligations imposed by regulation (Cole *et al.* 2006; Cole *et al.* 2008).

All estimates are made to include sector and time dummies. We also included dummies for the geographical area through which the country is divided into four main areas: North-West, North-East, Central and South. All economic variables included in the database are expressed in thousands of Euros and were deflated through the price index provided by ISTAT (Italian Institute of Statistics). The analysis covers the period 2002-2006 considering, i.e., the year dating back to the first statements provided by the DM of 26.04.2002.ty-six sectors are analysed, classified according to the classification NACE 2002 in the two digits[6].

[5] Although the AIDA dataset provides information on patents and research, there are many missing data. Consequently, it is preferred to use age as a proxy of technological innovation, as well by Pargal and Wheeler (1996); Cole *et al.* (2008).

[6] Table 3A in the Appendix shows the list and the name of the sectors included in the analysis.

Table 2. Test for equality of means

Variables	Mean_1	Mean_2	Mean_3	diff_1_2	t	diff_1_3	t	diff_2_3	t
	FMNE	NMNE	DOMESTIC						
EMI_WATER	12343.78	13493.60	5804.10	-1149.83	-0.24	6538.78	1.56	7688.61	2.53
EMI_ARIA	6395.45	52460.03	11653.05	-46064.58	-3.47	-5257.60	-1.69	40806.98	8.17
AGE	25.94	32.06	19.67	-6.12	-2.47	6.27	4.14	12.39	9.57
SIZE (employees)	658.84	2156.54	402.20	-1497.70	-4.68	256.64	3.43	1754.34	13.82
KW	6166.00	1603.01	10568.31	4562.99	3.00	-4402.31	-0.59	-8965.30	-1.64
IMM_MAT	881492.70	3936431	1238321	-3054938	-2.83	-356828	-0.82	2698110	5.18

Source: authors' calculations

Tables 2 and 3 provide a summary of the characteristics of the variables used in the model together with the test of equality of means for the three types of firms[7]. The results of t-tests performed on three groups of firms show that multinational companies, both foreign and domestic, on average emit more pollutants, both in water and in the air, compared to the national non- multinational firms. With regard to economic variables, the tests show that the multinationals are older and larger (in terms of employees) than domestic firms or non-multinationals. In addition, the foreign-owned firms are, on average, less polluting, younger, smaller but more capital-intensive (per worker) than Italian multinationals.

Table 3. Descriptive statistics of the sample

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_EMI_WATER	2185	3.87	4.22	0.00	16.07
ln_EMI_AIR	2185	7.52	5.74	0.00	20.39
FMNE	2185	0.09	0.28	0.00	1.00
NMNE	2185	0.15	0.36	0.00	1.00
DOMESTIC	2185	0.76	0.42	0.00	1.00
ln_AGE	1805	2.74	0.99	0.00	4.96
ln_AGE_sq	1805	5.31	2.11	0.00	9.90
ln_SIZE	1595	5.45	2.11	0.69	10.11
ln_KW	1595	6.91	1.47	0.00	14.69
ln_IMM	1753	12.25	2.27	0.00	18.78

Source: authors' calculations

3.3. The results

A direct analysis to study the impact of foreign presence on the level of pollution of the companies operating in Italian territory is carried out by estimating the following two equations:

$$lnE_{it} = \alpha+\beta_1 FMNE_{it} + \beta_2 NMNE_{it} + \beta_3 lnAGE_{it} + \beta_4 ln(AGE)^2_{it} + \beta_5 lnSIZE_{it} + \beta_6 lnKW_{it} + \beta_7 lnIMM_{it} + \delta_{it} + \mu_{it} + \varepsilon_{it} \quad (2)$$

$$lnE_{it} = \alpha + \beta_1\, OWNERSHIP_{it} + \beta_2 lnAGE_{it} + \beta_3 ln(AGE)^2_{it} 2+\beta_4 lnSIZE_{it}+ \beta_5 lnKW_{it}+\beta_6 lnIMM_{it} + \delta_{it} + \mu_{it}+\varepsilon_{it} \quad (3)$$

To this end we have employed two types of environmental indicators: emissions in water and those in air[8]. Both equations are estimated both by OLS and the random effects (REM)[9].

7 For the correlation between the variables, see Table 4A in the Appendix.

8 Emissions into water in the dataset are divided into direct and indirect discharges. In this report, we consider the total emissions, emissions from the sum of direct and indirect discharges.

9 The result obtained from the Breusch and Pagan test indicates that the hypothesis of homoscedasticity is rejected and, therefore, that the OLS estimator is inefficient. The Hausman specification test indicates that the stochastic effects are not correlated with the regressors, suggesting a preference for the random effects model. It follows that the comment is limited to random effects.

Table 4. Determinants of pollutant emissions in water and in air

	ln_EMI_WATER		**ln_EMI_AIR**	
	(1) **OLS**	(2) **REM**	(3) **OLS**	(4) **REM**
FMNE	-0.216	-0.224	-0.162	-0.090
	(-0.78)	(-1.09)	(-0.38)	(-0.35)
NMNE	0.882***	0.330*	-0.148	0.022
	(3.04)	(1.79)	(-0.43)	(0.12)
ln_AGE	1.542	-0.718	-1.801	-2.213
	(0.54)	(-0.40)	(-0.62)	(-1.45)
ln_AGE _sq	-0.901	0.159	0.963	1.173
	(-0.68)	(0.19)	(0.71)	(1.63)
ln_SIZE	4.375***	1.540**	10.175***	3.428***
	(2.74)	(2.09)	(7.97)	(4.20)
ln_KW	3.578**	1.162*	9.933***	3.275***
	(2.27)	(1.67)	(7.84)	(4.15)
ln_IMM	-3.608	-1.285*	-9.185***	-2.984***
	(-2.32)	(-1.92)	(-7.46)	(-4.10)
_cons	1.667	3.321	-5.270***	1.646
	(0.28)	(2.06)	(-3.42)	(0.66)
Temporal Dummy	Yes	Yes	Yes	Yes
Sectoral Dummy	Yes	Yes	Yes	Yes
Geographical distribution	Yes	Yes	Yes	Yes
Numb. Obs	1538	1538	1538	1538
R^2	0.335		0.456	
R-within		0.011		0.011
R-between		0.318		0.461
R-overall		0.301		0.426
Hausman test		13.510 [0.261]		6.980 [0.935]
BP test	1680.70 [0.000]		1691.210 [0.000]	

Source: authors' calculations

Note: The estimates were made using the White's test for heteroskedasticity
*** statistically significant at the 1% level , ** statistically significant at the 5% level , * statistically significant at the 10% level
t-statistic in round brackets
p-values in square brackets

Table 4 shows the estimates of equation (2) in which are included the two dummies (FMNE and NMNE). For the water quality, the national corporation status has a negative effect on emissions associated with a significance level of 10 per cent (column 2). Column 4 shows, however, that the status of multinational itself produces no effect on air pollution. This result, in line with some previous works (Pargal and Wheeler 1996; Hartman *et al.* 1997), suggests the lack of validity of the hypothesis that foreign firms are less polluting than domestic firms.

With regard to firm-specific characteristics, the non-linearity of the model (in quadratic form), would indicate that younger companies have a better environmental performance. The expected sign of the variable AGE is positive: the more newly established the companies, the lower the level of emissions. The results, contrary to those expected, indicate that the age of the firm is not significant for the level of emissions. This result is, however, consistent with the work of Pargal and Wheeler (1996) and with Eskeland and Harrison (2003). Specifically, it is supported by Cole *et al.* (2008) who showed how the age of the firm is a positive determinant if the environmental quality is measured by the consumption of liquid fuel and solids[10]. As expected, the variables KW and IMM both

[10] The authors estimate the relationship between foreign presence and environmental performance through three indirect measures: a first estimate covers the total energy consumption, while in the other two energy consumption is factored in use of fuels (liquid and solid), and use of electricity.

have a significant and positive coefficient to confirm that the intensity of capital contributes to increase of the emissions. The allocation of assets reduces the level of pollution, as firms with more fixed assets are also more adept at introducing cleaner technologies (columns 2 and 4). As concerns the other firm-specific characteristics, the estimates show that the positive sign of the size variable (SIZE), opposite to what was expected, indicates instead that larger firms are more polluting (column 2 and 4); such a relationship could exist in the case of constant returns to scale, that is, when the emissions are proportional to production. As a result, larger companies, producing larger volumes of output compared to smaller firms, emit high levels of pollutants (Cole and Elliott 2005). Also, the implementation of environmental management systems for the reduction of emissions in an enterprise that consists of the coordination of multiple people, businesses with greater dimensions, is more complex and more expensive (Dasgupta *et al.* 2000).

Table 5. Determinats of pollutant emissions in water

	Dependent variable: ln_EMI_WATER					
	(1) OLS	**(2) REM**	**(3) OLS**	**(4) REM**	**(5) OLS**	**(6) REM**
FMNE	-0.438	-0.264				
	(-1.60)	(-1.27)				
NMNE			0.923***	0.350*		
			(3.24)	(1.88)		
DOMESTIC					-0.431*	-0.105
					(-1.93)	(-0.77)
ln_AGE	1.317	-0.614	1.610	-0.600	1.639	-0.450
	(0.47)	(-0.34)	(0.57)	(-0.33)	(0.58)	(-0.25)
ln_AGE _sq	-0.772	0.119	-0.936	0.101	-0.939	0.035
	(-0.58)	(0.14)	(-0.71)	(0.12)	(-0.71)	(0.04)
ln_SIZE	4.860***	1.586**	4.355***	1.517**	4.635***	1.535**
	(2.96)	(2.14)	(2.73)	(2.06)	(2.85)	(2.07)
ln_KW	3.974**	1.199*	3.562**	1.139	3.791**	1.150
	(2.45)	(1.71)	(2.26)	(1.63)	(2.36)	(1.64)
ln_IMM	-3.997**	-1.318*	-3.594**	-1.265*	-3.824**	-1.275*
	(-2.49)	(-1.96)	(-2.31)	(-1.89)	(-2.41)	(-1.89)
_cons	-0.064	3.157*	0.506	3.348**	0.693	3.347**
	(-0.04)	(1.94)	(0.3)	(2.08)	(0.4)	(2.04)
Temporal Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Sectoral Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Geographical distribution	Yes	Yes	Yes	Yes	Yes	Yes
Numb. obs	1538	1538	1538	1538	1538	1538
R^2	0.330		0.331		0.334	
R-within		0.010		0.010		0.009
R-between		0.317		0.312		0.312
R-overall		0.301		0.296		0.296
Hausman test		11.550 [0.759]		6.630 [0.317]		9.170 [0.516]
BP test	1672.94 [0.000]		1678.85 [0.000]		1671.78 [0.000]	

Source: authors' calculations

Note: The estimates were made using the White's test for heteroskedasticity
*** statistically significant at the 1% level , ** statistically significant at the 5% level , * statistically significant at the 10% level
t-statistic in round brackets
p-values in square brackets

The results presented above are confirmed by the estimates obtained from the specification of the model proposed by equation (3), respectively, for water and for air, where OWNERSHIP is the proprietary nature of the enterprise (Tables 5 and 6). This variable classifies companies according to their proprietary nature through three dummies: FMNE, if the firm is foreign-owned, Italian NMNE if the firm has holdings abroad and DOMESTIC if the firm is not a multinational corporation.

Table 6. Determinats of pollutant emissions in air

	Dependent Variable: ln_EMI_ARIA					
	(1) OLS	**(2) REM**	**(3) OLS**	**(4) REM**	**(5) OLS**	**(6) REM**
FMNE	-0.124	-0.092				
	(-0.30)	(-0.37)				
NMNE			-0.116	0.030		
			(-0.34)	(0.16)		
DOMESTIC					0.154	0.023
					(0.53)	(0.14)
ln_AGE	-1.758	-2.206	-1.744	-2.166	-1.799	-2.157
	(-0.61)	(-1.45)	(-0.60)	(-1.43)	(-0.62)	(-1.43)
ln_AGE _sq	0.939	1.170	0.935	1.150	0.963	1.148
	(0.69)	(1.63)	(0.69)	(1.61)	(0.71)	(1.61)
ln_SIZE	10.093***	3.434***	10.160***	3.421***	10.178***	3.431***
	(8.04)	(4.22)	(7.96)	(4.20)	(8.00)	(4.20)
ln_KW	9.866***	3.281***	9.921***	3.268***	9.935***	3.277***
	(7.90)	(4.16)	(7.84)	(4.15)	(7.87)	(4.15)
ln_IMM	-9.119***	-2.989***	-9.175***	-2.978***	-9.187***	-2.986***
	(-7.52)	(-4.11)	(-7.46)	(-4.10)	(-7.49)	(-4.10)
_cons	-5.186***	1.630	-5.247***	1.653	-5.427***	1.597
	(-3.42)	(0.66)	(-3.41)	(0.67)	(-3.36)	(0.64)
Temporal Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Sectoral Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Geographical distribution	Yes	Yes	Yes	Yes	Yes	Yes
Numb. obs	1538	1538	1538	1538	1538	1538
R^2	0.4562		0.4562		0.4563	
R-within		0.0107		0.0106		0.0106
R-between		0.4606		0.4608		0.4607
R-overall		0.4264		0.4264		0.4263
Hausman test		7.76 [0.8591]		8.54 [0.8070]		6.17 [0.9397]
BP test	1690.53 [0.000]		1691.50 [0.000]		1691.26 [0.000]	

Source: authors' calculations

Note: The estimates were made using the White's test for heteroskedasticity
*** statistically significant at the 1% level , ** statistically significant at the 5% level , * statistically significant at the 10% level
t-statistic in round brackets
p-values in square brackets

In this model, the status of a multinational company has a positive and significant at 10 per cent to pollution in water (Table 5, column 4), while no effect is observed in the case of the investee companies and the domestic ones (Tables 5 and 6, columns 2 and 6). As regards the economic variables, the results confirm those obtained with the estimate of equation (2) too: note how the intensity of capital per worker, for the sector of water, is significant at 10 percent, and the positive sign is only for the FMNE (Table 5, column 2).

Conclusions

The considerable expansion of global flows of FDI occurring in the last two decades has been accompanied by a growing interest about its environmental implications. The empirical literature that has analysed the effect of foreign presence on the environmental performance of firms covered only the developing countries, highlighting how the liberalisation of FDI can help to shift, from the country of origin to the host country, cleaner technologies and environmental management systems often derived from more sophisticated types of national environmental regulation. Taking a cue from this limit, the present work has concerned the mechanism by which passive multinationalisation can support or damage the quality of the environment, analysing the case of a developed country, Italy. Specifically, the pollution halo, the hypothesis that foreign firms, adopting the most advanced technologies and more sustainable production methods, are less polluting than domestic firms, has been tested for a sample of about 437 companies on the Italian territory which, in 2002-2006, issued large amounts of pollutants in water and air. In doing so, the companies were divided in relation to the proprietary nature, in foreign multinationals, domestic multinationals and non-multinational firms. The contribution of this paper is twofold. First, it is the first study that analyses the impact on the environmental quality of the proprietary nature of the companies operating in a developed country. Secondly, through analysis at the firm level, we use a direct measure of environmental quality, such as the level of emissions in the water and in the air.

The empirical analysis showed that the presence of foreign control in firms has no effect on environmental quality in the case of Italy. Significant results are obtained instead for the determinants of environmental indicators within the firm as the intensity factor, the allocation of fixed asset and firm size: the larger companies that use more capital than labour are the most polluting. Conversely, companies with greater assets are the cleanest.

The invalidity of PHalH in the case of a developed country is the main result obtained in this work. However, the analysis shows the proposed limit on the non-identification of the country of origin and/or destination of FDI; it does not allow distinguishing multinational firms from developed countries to those originating from least developed countries. In fact, the factors associated with the activity of multinationalisation (active and passive) that positively affect the environmental performance of a company concern environmental regulation, which is closely linked to the geographical origin of foreign investment, as well as the size of the company, the intensity of production factors and the scientific and technological knowledge. For this reason, we propose to enrich the present research with future studies, including information regarding the origin of FDI, making it possible to identify those firms that are typically newer, more clean and equipped with the best technologies and environmental management systems, often resulting from more stringent environmental regulation. These companies, which belong to the developed countries and which usually hold significant market shares in the countries of origin, are, in fact, more sensitive to demand coming from green consumers and could use FDI as a vehicle for the dissemination of the best production techniques in the world.

APPENDIX

Table 1A. List of pollutants in water to be reported if threshold value is exceeded

Pollutants	Identification	Thresholds water in kg/yr
1 – Nutrients		
Nitrogen	Total - Nitrogen as N	50 000
Phosphorus	Total - Phosphorus as P	5 000
2 - Metals and compounds (inorganic and organic compounds, expressed as arsenic elementary)		
Arsenic (As) and its compounds	Total	5
Cadmium (Cd) and its compounds	Total	5
Chromium (Cr) and compounds	Total	50
Copper (Cu) and compounds	Total	50
Mercury (Hg) and its compounds	Total	1
Nickel (Ni) and compounds	Total	20
Lead (Pb) and its compounds	Total	20
Zinc (Zn) and compounds	Total	100
Selenium (Se) and compounds	Total	
3 - Chlorinated organic substances		
Dichloro-1, 2 (DCE)	Total	10
Dichloromethane (DCM)	Total	10
Chloralkanes (C10-13)	Total	1
Hexachlorobenzene (HCB)	Total	1
Hexachlorobutadiene (HCBD)	Total	1
Hexachlorocyclohexane (HCH)	Total	1
Pentachlorobenzene	Total	
Halogenated organic compounds	Total (espressed as AOX)	1 000
4 - Other organic compounds		
Benzene, toluene, Ethylbenzene, xylenes	Total (expressed as the sum of the individual compounds)	200
Brominated diphenyl ether	Total (expressed as bromine Br)	1
Organotin compounds	Total (expressed as tin Sn)	50
Polycyclic aromatic Hydrocarbons	Sum of 6 PHA Borneff	5
Phenols	Total (expressed as C)	20
Nonylphenol	Nonylphenol ethoxylate and related substances	
Total organic carbon	expressed as C or COD / 3	50 000
5 - Other compounds		
Chloride	Total (expressed as Cl)	2 000 000
Canide	Total (expressed as CN)	50
Cluoride	Total (expressed as F)	2000

Source: Ines Registry

Table 2A. List of pollutants in air to be reported if threshold value is exceeded

Pollutants	Identification	Threshold value kg/yr
1 – Conventional and greenhouse gases		
Methane (CH4)	Total	100 000
Carbon monoxide (CO)	Total	500 000
Carbon dioxide (CO2)	Total (according to published guidelines used by the IPCC in 1996 UNFCCC that exclude CO_2 emissions from biomass and bunkers)	100 000 000
Hydrofluorocarbons (HFCs)	Total (sum of: HFC-23, HFC-32, HFC-41, HFC-43-10mee, HFC-125, HFC-134, HFC-134a, HFC-152a, HFC-143, HFC-143a, HFC-227ea, HFC-233fa, HFC-245ca)	100
Nitrous oxide (N2O)	Total	10 000
Ammonia (NH3)	Total	10 000
Non-methane volatile organic compounds (NMVOC)	Total volatile organic compounds except methane	100 000
Oxides of nitrogen (NOx)	Sum of nitric oxide (NO) and nitrogen dioxide (NO2), expressed as NO2	100 000
Polifluorocarburi (PFC)	Total (sum of: CF4, C2F6, C3F8, C4F10, c-C4F8, C5F12, C6F14)	100
Sulfur hexafluoride (SF6)	Total	50
Oxides of sulfur (SOx)	Sum dioxide (SO_2) and sulfur trioxide (SO_3) expressed as SO_2	150 000
2 - Metals and compounds		
Arsenic (As) and its compounds	Total (inorganic and organic compounds, expressed as arsenic elementary)	20
Cadmium (Cd) and its compounds	Total (inorganic and organic compounds, expressed as cadmium elementary)	10
Chromium (Cr) and compounds	Total (inorganic and organic compounds, expressed as chromium elementary)	100
Copper (Cu) and compounds	Total (inorganic and organic compounds, expressed as copper elementary)	100
Mercury (Hg) and its compounds	Total (inorganic and organic compounds expressed as elemental mercury)	10
Nickel (Ni) and compounds	Total (inorganic and organic compounds expressed as elemental nickel)	50
Lead (Pb) and its compounds	Total (inorganic and organic compounds, expressed as lead elementary)	200
Zinc (Zn) and compounds	Total (inorganic and organic compounds expressed as elemental zinc)	200
Selenium (Se) and compounds	Total (inorganic and organic compounds expressed as elemental selenium)	
3 - Chlorinated organic substances		
Dichloro-1, 2 (DCE)	Total	1 000
Dichloromethane (DCM)	Total	1 000
Hexachlorobenzene (HCB)	Total	10
Hexachlorocyclohexane (HCH)	Total	10
P-dioxins (PCDDs)	Expressed as total Teq	0,001
Pentachlorophenol (PCP)	Total	2 000
Tetrachlorethylene (PER)	Total	100
Tetrachloromethane (TCM)	Total	10
+ Polidiclorobenzofurani (PCDF)	Total	10
Trichlorobenzenes (TCB)	Total	100
Trichloroethane-1, 1,1 (TEC)	Total	2 000
Trichloroethylene (TRI) trichloromethane	Total	500
Polychlorinated biphenyls (PCBs)	Total	

4 - Other organic compounds		
Benzene (C6H6)	Total	1 000
Polycyclic aromatic hydrocarbons (PAHs)	Sum of 6 IPA Borneff	50
5 - Other compounds		
Chlorine and inorganic compounds	Total (inorganic compounds of chlorine as HCl)	10 000
Fluorine and inorganic compounds	Total (inorganic compounds of fluorine expressed as HF)	5 000
hydrogen cyanide	Expressed as total HCN	200
PM	Total	50 000
PM10	Total particulate matter with a diameter <10μm (within the meaning of Council Directive 199/30/EC of April 22, 1999)	50 000

Source: Ines Registry

Table 3A. Correlation Matrix

	FMNE	NMNE	AGE	AGE _sq	SIZE	KW	IMM
FMNE	1.000						
NMNE	-0.165	1.000					
AGE	0.062	0.172	1.000				
AGE_sq	0.054	0.161	0.910	1.000			
SIZE	-0.016	0.339	0.000	0.033	1.000		
KW	-0.012	-0.038	-0.063	-0.037	-0.027	1.000	
IMM	-0.033	0.132	-0.089	-0.041	0.4202	0.036	1.000

Source: authors' calculations

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