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In Search of Environmental Spillovers

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1. INTRODUCTION

THERE is a large and growing literature that examines the relationship between foreign direct investment (FDI) and the economic performance of local firms. The traditional argument is that the productivity of local establishments benefits from the presence of foreign firms through the gradual dissemination of superior knowledge and technology. Such an argument is often used to justify the, often aggressive, FDI-seeking policies of developing country governments (see e.g. Blomström and Kokko, 1998; Aitkin and Harrison, 1999).

The productivity spillover literature assumes that multinational corporations (MNCs) transfer knowledge (encompassing both technology and 'know-how') to foreign affiliates that then somehow leaks and is absorbed by firms in the domestic economy. Such spillovers are said to increase productivity growth and/or competitiveness leading to economic gains for the host country. Much of the early literature considered only intra-industry spillovers between firms in the same sector with little empirical support (Kokko, 1994; Blomström and Kokko, 1998; Blomström and Sloholm, 1999; Görg and Strobl, 2001; Haskel et al., 2002; Lipsey, 2002; and Görg and Greenaway, 2004, for developed countries; and Haddad and Harrison, 1993; Aitkin and Harrison, 1999; Djankov and Hoekman, 2000; and Konings, 2001, for developing and transition countries). One of the reasons given for the lack of productivity spillovers is that foreign firms attempt to minimise the propagation of technology to possible competitors. More recently, Blalock (2001), Lopez-Cordova (2003), Blyde et al. (2004) and Javorcik (2004) found evidence for inter-industry productivity spillovers between firms at different stages of the production process.

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In this paper we identify a complementary strand of the FDI spillover literature that deserves attention: the relationship between FDI and the environmental performance of firms. Instead of total factor productivity we now investigate the influence of a foreign presence, and the role of spillovers, on the extent to which firms have implemented environmental management systems (EMS). To undertake this task we use a uniquely rich dataset on environmental behaviour of Argentinean manufacturing firms.

One reason we believe that environmental spillovers might exist is that, anecdotally, foreign firms have been known to directly encourage the dissemination of environmental related knowledge and technologies (Garcia-Johnson, 2000). For example, an MNC or foreign firm may choose to purchase intermediate goods only from a supplier who adheres to a given set of environmental rules or regulations specified by either the government of the host country or the foreign firm itself (possibly under pressure from stakeholders to do so). Whether a domestic firm chooses to abide by the potentially strict regime set by the foreign firm will depend on the percentage of output that the company sells to this firm, or other foreign firms, that have similar enforcement strategies. Conversely, it may be the case that foreign suppliers are only prepared to sell their goods to firms who they believe act in an environmentally responsible way. For example, the shareholders of an MNC in the chemical industry may express concern if chemicals were sold to firms who used them in a manner which degraded the environment. In addition, the indirect route for knowledge transfer continues to play a role, for example, through the movement of trained workers from foreign to domestic firms (Görg and Strobl, 2004). Such movement may occur between firms within the same sector or may involve suppliers and customers. Finally, direct competitors within the same industry may also be keen to imitate the good practice of foreign firms if they felt it would be beneficial for them to do so. Thus, firms can absorb environmental knowledge either directly or indirectly through *forward* links with suppliers and *backward* links with customers (inter-industry environmental spillovers) or *horizontal* links with competitors (intra-industry environmental spillovers). See Wallace (1996) for further discussion.[1]

The first step in the search for evidence of environmental performance spillovers is to determine whether foreign-owned firms are more likely to implement EMS than domestic firms. This investigation into the environmental behaviour of MNCs is framed by an ongoing debate within the environmental economics literature between two schools of thought. The 'pollution haven hypothesis' (PHH) states that FDI will be attracted to those countries with less stringent environmental regulations thus inducing a regulatory 'race to the bottom' in

[1] Hansen (1999) provides a broader discussion of issues related to cross-border environmental management.

order to attract higher FDI inflows from dirty sectors to the detriment of the host country's environment (Mani and Wheeler, 1998; Wheeler, 1999; Javorcik and Wei, 2004).[2] In contrast, the 'pollution halo hypothesis' argues that, as a result of the transfer of environmental knowledge via environmental spillovers, the presence of foreign-owned firms may yield substantial environmental benefits to developing countries (Zarsky, 1999; OECD, 2002). It should be noted that the PHH and the pollution halo hypotheses are not incompatible. A firm may choose to locate in a developing country to avoid a high regulatory burden but may still employ relatively cleaner production techniques and fully integrated environmental management systems to the subsequent benefit of the host country.[3]

Our quest for evidence of the existence of environmental spillovers consists of two stages. First, we identify whether foreign-owned firms are more likely to implement EMS than domestic firms by estimating the determinants of EMS implementation within our sample of Argentinean firms.[4] We find that foreign-owned firms are indeed more likely to implement EMS than domestic firms and, in addition, are more likely to implement a greater range of EMS types. Second, we identify whether the presence of foreign-owned firms in the sectors that a firm belongs to, supplies, or buys from, affects the likelihood of a firm introducing EMS. To do this we include a range of spillover variables to assess whether foreign ownership benefits the local environment via positive environmental performance spillovers and whether the ownership structure of a firm has an influence on the number of EMS implemented per firm. We take into account measures of intra-sectoral and inter-sectoral linkages following Javorcik (2004). A novel aspect of this paper is that we embrace a further element of both intra-industry and inter-industry spillovers by measuring the extent of a firm's networks defined as the degree to which a firm has formal or informal contact with its customers, suppliers and competitors at local, regional and national levels. To the best of our knowledge this paper represents the first attempt to employ such an approach in either the environmental or productivity spillover literature.

We find that firms that supply sectors with a high foreign presence and that regularly meet with their customers on a formal or informal basis are more likely to adopt EMS. We also find that firms with greater absorptive capacity are more

[2] See Rosenthal (2002) and Araya (2005) for examples where FDI has exacerbated environmental degradation.

[3] In a study of the US chemical industry, Garcia-Johnson (2000) shows how US firms such as DuPont, Dow and Monsanto relocated production to Mexico and Brazil to avoid costly regulation but also harmonised their environmental practice globally in order to maintain the industry's reputation.

[4] It should be noted that having EMS in place does not necessarily mean that a firm has lower emissions. Firms that are perceived as 'dirty' are more likely to come to the attention of the authorities and non-governmental organisations (NGOs) thus facing greater formal and informal lobbying to become 'greener' companies.

receptive to environmental spillovers. Furthermore, a firm's ownership (foreign or domestic) and export status also influence the extent to which it benefits from environmental spillovers. When we compare the experience of foreign and domestic firms separately, we find a strong inter-sectoral effect up and down the supply chain for foreign firms suggesting that environmental knowledge is transferred more efficiently from one foreign firm to another. For domestic firms we only find a positive spillover effect for domestic exporters, again, we believe, reflecting the role played by absorptive capacity. We therefore find some evidence of environmental spillovers but also, crucially, find that many firms do not benefit from such spillovers, suggesting that the mechanisms through which good practice are transferred from firm to firm are far from automatic.

The remainder of the paper is organised as follows: Section 2 reviews the recent theoretical and empirical literature while Section 3 outlines the methodology and describes our data; Section 4 presents the results and sensitivity analysis; and Section 5 concludes.

2. REVIEW OF THE LITERATURE

Before we consider the literature examining the determinants of EMS it should be noted that support for the pollution halo hypothesis hinges crucially on the assumption that foreign firms are cleaner than their domestic counterparts. Here the evidence is mixed. Huq and Wheeler (1993), Pargal and Wheeler (1996), Hartman et al. (1997) and Dasgupta et al. (2000) have suggested that foreign ownership of firms has little impact on environmental performance. In contrast, Eskeland and Harrison (2003) and Cole et al. (2008) assess the extent to which foreign ownership influences the energy intensity of firms in Côte d'Ivoire, Mexico and Venezuela, and Ghana, respectively, and in each case they find foreign ownership reduces the energy intensity of plants. However, it should be noted that energy intensity and environmental performance are overlapping but different concepts.[5]

Turning to the firm-level characteristics that influence the adoption of EMS, the theoretical literature is limited. The two exceptions are: Sinclair-Desgagne and Gabel (1997), who demonstrate how firms can design environmental audits that can improve EMS without adversely affecting other activities; and Aragon-Correa and Sharma (2003) who argue that the extent to which a firm's resources and capabilities (which include technology, managerial skills and attitudes) will

[5] In an edited volume of case studies examining whether foreign firms improve the local environment in the agricultural sector, Gentry (1998) concludes that the FDI–environment linkage is generally positive.

affect environmental management is contingent upon a number of factors including the complexity and uncertainty of the business environment and the munificence of the firm in question.

Although more numerous, empirical studies of the determinants of firms' environmental management decisions are also limited. Nakamura et al. (2001) indicate that patterns of environmental management practices across Japanese firms demonstrate considerable differences. Also for Japan, Cole et al. (2006) examine the relationship between ISO14001 certification and firm-level characteristics. Similarly, for the US, Gray and Deily (1996) examine firm-level characteristics and the decision of firms in the US steel industry to comply with air pollution regulations. The results show that some firms have incorporated environmental goals into the very heart of their decision-making processes whilst others appear to largely ignore environmental considerations or do the minimum required by legislation. Gunningham et al. (2003, 2004) show similar results for the United States. Henriques and Sadorsky (1996) examine the external pressure exerted by customers, shareholders and local communities on firms' environmental performance in Canada, while Levy (1995) examines the relationship between consumers and community pressure groups on the environmental performance of transnational corporations. Gunningham et al. (2003, 2004) continue this theme by arguing that firms are subject to a 'social license', enforced by stakeholders such as pressure groups and community action groups, which encourages firms to go beyond minimum standards, often with regard to the consequences for their reputation. It has been found that multinational firms that adhere to strict environmental standards tend to have higher market values and have no competitive penalties. Equally, research has found that poor environmental performance can lower the market valuation of a firm and reduce banks' willingness to extend credit (see e.g. Laplante and Lanoie, 1994; Hamilton, 1995; Dasgupta et al., 1997).

In a related study, Pargal and Wheeler (1996) examine the impact of informal factors such as education and income per capita on the emissions of a specific pollutant by Indonesian firms. In more recent work for Brazil, Féres and Reynaud (2006) find little evidence that informal regulation moderates firms' behaviour. Firm-specific factors have also been shown to have an impact on a firm's environmental performance. In a study for the US, DeCanio and Watkins (1998) find that firm-specific factors such as size and shareholder structure affect the decision to participate in the Green Light programme (a voluntary pollution prevention programme). Also for the US, Arora and Cason (1995, 1996) show that firm size and industry effects are important determinants of a firm's participation decision in the Environmental Protection Agency's 33/50 programme, while Khanna and Damon (1999) also show, for chemical plants entering the 33/50 programme, that participation led to a fall in toxic releases and that long-term profits were positive and significant.

The study closest to our own is Chudnovsky and Pupato (2005) who also study Argentinean firms and search for intra-sectoral environmental spillovers (but not inter-sectoral spillovers). By interacting foreign ownership with a sectoral foreign presence they find some evidence that the influence of multinationals was positive but not conclusive and that foreign-owned firms do employ more EMS than domestic firms. They conclude by stating that developing countries should not take environmental knowledge diffusion for granted but should ensure that domestic firms have the absorptive capacity to learn from foreign firms.

When it comes to the decision of a firm whether or not to implement EMS there are a large number of possible motives. First, direct cost savings may be derived through the more efficient use of raw materials and energy and there may be reduced need for expensive waste management (Sheldon, 1997). Whilst a high percentage of these savings will already have been made in developed countries, there is still considerable scope for such savings in newly industrialising countries. The other direct saving is that innovative behaviour may result in the reduction in pollution abatement costs and other regulatory costs with the consequent financial and environmental benefits.[6] Third, Diller (1997) suggests that there are also organisational benefits from the introduction of EMS where the organisational changes required to integrate EMS have a beneficial effect on the management of all systems within the company. Finally, Nash and Ehrenfeld (1997) argue that EMS implementation may also make employees aware of the environmental impact of their employment, and hence their job, and may encourage innovative behaviour to save resources.[7]

3. METHODOLOGY AND DATA

In this paper we utilise data from a manufacturing firm-level survey conducted by the National Institute of Statistics and Censuses in Argentina (INDEC).[8] The survey covers the period 1998–2001. Our data form a cross-section of approximately

[6] In a study of Greek industrial firms, Halkos and Evangelinos (2002) find that regulatory pressure is not a driver of EMS take-up. One argument is that firms do not react to legislative pressure, as they do not perceive that the pressure applies to them or that enforcement of regulations is weak.

[7] Other reasons a firm may introduce environment-related improvements include: concerns about corporate image; to reduce costs of environmental management; to meet required local regulations; to adhere to a request from a multinational client; preparation to obtain environmental certification, e.g. ISO14001; to imitate local competitors; and to meet conditions for credit. According to UNCTAD (2002), of 153 firms surveyed, the main drivers of environmental performance of foreign-owned affiliates were headquarters policies, procedures and standards (42 per cent), regulatory pressures, current and anticipated (34 per cent), local management leadership (12 per cent), consumer pressure (4 per cent), rules and pressures from international organisations (3 per cent), pressure from NGOs and media (3 per cent) and finally fear of accidents (2 per cent).

[8] INDEC (2002) 'Segunda Encuesta Nacional de Innovación y Conducta Tecnológica de las Empresas Argentinas 1998–2001', Serie de Estudios del INDEC Number 38.

1,200 firms for 1998. The environmental management questions are asked in 2001 and cover 2001 and the previous three years. To minimise endogeneity problems, we use 1998 firm-level characteristics data.[9] The data are a representative sample of Argentina's manufacturing sector and account for more than 50 per cent of total sector sales and employment and 60 per cent of total exports.[10] Argentina represents an ideal country for an empirical exercise of this type, as it is a relatively mature industrialised economy with access to the world's capital markets. Argentina also has a long history of attracting inward FDI. For more details on the construction of the dataset, see INDEC (2002).

The primary benefit of the Argentinean data is the comprehensive nature of the environmental questionnaire. The data thus allow us to study eight different aspects of a firm's EMS, covering both the management of specific environmental issues and more general structure and systems management. Hence, we are not restricted to a narrow range of environmental performance indicators that have plagued previous work in this area (e.g. Nakamura et al., 2001; Cole et al., 2006). We now outline our main hypotheses and discuss our dependent and independent variables.

a. Linkages and Networks

The literature on FDI spillovers has evolved rapidly. In this paper we follow Aitken and Harrison (1999), Javorcik (2004) and Blyde et al. (2004) to capture a variety of possible linkages between foreign firms and other firms in Argentina.

First, using input–output tables following the methodology of Javorcik (2004), we measure intra-sectoral spillovers, the impact of a foreign presence within a sector (horizontal linkage), and inter-sectoral spillovers, the impact of a foreign presence on downstream (backward linkage) and upstream sectors (forward linkage). For the remainder of this paper we classify customers as being downstream and the suppliers of intermediate goods or raw materials as upstream. As firms can directly participate in the spreading of environmental knowledge, backward linkages include when customers require and train suppliers to meet global standards. Likewise, if it is suppliers of the firm that encourage

[9] Estimations using four-year averages are available on request. The general conclusions remain unchanged.

[10] The National Institute of Statistics and Censuses in Argentina (INDEC) claim that the dataset is representative of the manufacturing sector in terms of employment, output and trade. However, they do not explicitly state how representative the survey is in terms of foreign presence. Nevertheless, the percentage of foreign-owned firms in the survey is 21 per cent. A recent study by the United Nations Economic Commission for Latin America and Caribbean (ECLAC) on foreign investment and multinational corporations in Argentina calculates that foreign-owned Argentinean firms account for 28 per cent of total manufacturing firms during the period 1991–2000 (Kulfas et al., 2002). This suggests that our results might be underestimating foreign presence to an extent.

EMS implementation, this is encompassed within forward linkages. By similar reasoning, a horizontal linkage is when firms learn, either directly or indirectly, about good environmental practice from firms within the same sector.

Specifically, $Horizontal_{jt}$ measures the presence of foreign-owned firms in sector j at time t and is given by,

$$Horizontal_{jt} = \frac{\sum_{i \forall i \in j} FF_{ijt} Y_{ijt}}{\sum_{i \forall i \in j} Y_{ijt}},$$

where FF_{ijt} takes the value 1 if foreign ownership is greater than 10 per cent and Y_{ijt} is a firm's output (recorded as the value of sales). Notice that we are implicitly assuming that a marginal increase in foreign ownership does not imply higher levels of spillover. The value of $Horizontal_{jt}$ increases with the share of foreign firms' output, in total output, in the sector.[11]

The variable $Forward_{jt}$ captures the presence of foreign firms in the sector that supplies the sector to which the firm i belongs at time t. We expect this variable to be positive and significant in situations where contact between firms and their foreign suppliers or subsidiaries act to motivate the implementation of EMS and is given by,

$$Forward_{jt} = \sum_{k \text{ if } k \neq j} \delta_{kj} Horizontal_{kt},$$

where the variable δ_{kj} is the proportion of sector k's output supplied to sector j as given by the I/O matrix at the two-digit ISIC level in 1997.[12]

The variable $Backward_{jt}$ is a measure of the presence of foreign-owned firms in the sector that is being supplied by the sector that firm i belongs to at time t and is given by,

$$Backward_{jt} = \sum_{k \text{ if } k \neq j} \delta_{jk} Horizontal_{kt},$$

where δ_{jk} is the proportion of sector j output supplied to sector k as given by the 1997 I/O matrix at the two-digit ISIC level in 1997.

In this paper we further develop the spillover literature by capturing the extent to which firms interact either formally or informally with other firms at the regional, local and national level. These so-called *Network* indicators are dummy

[11] In a sensitivity analysis we test 25 and 50 per cent cut-off points as well as a continuous measure of ownership. The results show it is foreign ownership *per se* that matters for EMS take-up and not the percentage owned.

[12] The 1997 input–output matrix is provided by the National Institute of Statistics and Censuses (INDEC). See www.indec.mecon.gov.ar/mip/mip.htm for details.

variables that capture the existence of firm *i*'s formal relationships (i.e. cooperation agreements, joint ventures) or informal relationships (i.e. frequent contacts established by members of the firms) with firms in the same sector (horizontal networking), suppliers (forward networking) and customers (backward networking), where backward and forward act in the same direction as the linkage variables. In the paper we concentrate on local networks. National and regional network variables were included in a sensitivity analysis but are not presented here for reasons of space.

The inclusion of linkage and network variables also allows us to test for an interaction effect between the two. Thus, these interaction variables capture the idea that over and above the individual effects, there is a likelihood that firms who have informal contact with the sector that it supplies or buys from is more likely to benefit from environmental performance spillovers.[13]

Finally, given the possibility that firms require a degree of absorptive capacity in order to benefit from spillovers, we interact our linkage variables with two proxies for absorptive capacity, namely the percentage of the workforce who are skilled and whether or not the firm is an exporter.[14]

Our dependent variables are derived from question 501 of the environmental questionnaire that asks the following:

Q. 501: Indicate if the firm has done any of the following between 1998 and 2001:

(a) None of the following.
(b) Used systems and equipment for the treatment of residuals and effluents.
(c) Taken actions for the purposes of environmental remediation.
(d) Improve efficiency of the use of water, energy and other inputs.
(e) Replaced or modified pollution processes.
(f) Replaced inputs that are pollution intensive.
(g) Developed environmentally friendly products.
(h) Established internal or external recycling procedures.
(i) Obtained any environmental certification.

Our other independent variables are derived from the INDEC (2002) survey and include measures of firm size (by output and employment), sales growth (*Salesgr*), the percentage of skilled workers (*Perskilled*), labour productivity

[13] It should be noted that, as our network variables are dummy variables based on questions concerning formal and informal relationships, they are not able to measure the depth of any relationship between two firms.

[14] Absorptive capacity refers to a firm's ability to assimilate and apply new knowledge; hence we believe the proportion of skilled workers provides a good proxy for such capacity. In addition, Harris and Li (2009) provide a clear link between a firm's export activities and its absorptive capacity.

(*Labprod*), investment expenditure as a percentage of sales (*Invsales*), a continuous measure of exports and an export dummy (*dExport*), a continuous measure of R&D and an R&D dummy (*dRD*), whether the firm is independent or part of a large group of companies (*Independent*) and finally whether the firm is part of an industry that is typically considered to be pollution intensive.[15] A description of each variable and a table of summary statistics can be found in the Appendix. Our choice of independent variable is informed by the existing empirical and theoretical literature and by data availability.

In our analysis we take two modelling approaches to our cross-section regressions. The first uses a binary dependent variable; the second uses Count data. For the binary estimations we use logistic regression analysis and report odds ratios in preference to marginal effects. The binary variable is 0 if the firm answered (a) in question 501 and 1 otherwise.[16]

We estimate our Count model using the number of yes answers (b) to (i) that a firm reports to question 501 (so the count takes the form of 0 to 8). For our Count data model, we ask what determines the number of types of EMS adopted? Since our dependent variable is a Count variable we use negative binomial estimation.

For our binary model, the odds, or likelihood, that a firm undertakes EMS can be expressed as the ratio of the probability that EMS will be adopted (Pr) to the probability that it will not be adopted (1 − Pr). We estimate a logistic transformation of this ratio, the logit of Pr, defined as:

$$\text{logit}[\Pr(EMS) = 1] = \log\left(\frac{\Pr}{1 - \Pr}\right). \tag{1}$$

Our equation to be estimated is of the form:

$$\text{logit}[\Pr(EMS) = 1] = \alpha + \lambda FO + \beta' X + \phi' Z + \varepsilon_i, \tag{2}$$

where FO is foreign ownership, X is a vector of network and linkage variables and Z is a vector of other firm characteristics.

For our Count model our dependent variable takes a value between 0 and 8. The negative binomial model takes the form:

[15] Although we have no data on pollution intensity by industry, studies of the United States and the United Kingdom, such as Cole and Elliott (2005) and Cole et al. (2005), have identified certain industries as being significantly more pollution intensive than others. We have a reasonable degree of confidence that the same would be true of Argentinean industries. These industries are: Steel and Aluminium, Chemicals, Non-metallic Mineral Products, Petroleum Products, and Pulp and Paper.

[16] We also estimated Probit regressions with odds ratios and marginal effects. The results were almost identical.

TABLE 1
Summary Information by Two-digit Industry

Two-digit SIC	*Industry*	*No. of Firms*	*% of Firms with EMS*	*% of Foreign-owned Firms*
15	Food and Beverages	245	66	18
16	Tobacco	4	50	25
17	Textiles	92	46	11
18	Clothing	31	10	6
19	Leather and Footwear	34	59	9
20	Wood and Wood Products	25	64	8
21	Pulp, Paper and Paper Products	36	67	31
22	Publishing and Printing	64	45	14
23	Petroleum	9	100	44
24	Chemicals	126	81	40
25	Rubber and Plastics	74	70	18
26	Non-metallic Minerals	61	64	25
27	Steel and Aluminium	32	72	16
28	Metals Products, except Mach. & Equip.	60	55	23
29	Machinery and Equipment	105	60	21
30	Office Machines and Computers	2	50	0
31	Electrical Machinery	49	61	20
32	Radio, TV and Comm. Equip.	16	38	50
33	Medical, Precision and Optical Equip.	14	36	14
34	Automotive and Transport Equip.	49	67	47
35	Other Transport Equip.	24	32	8
36	Furniture and Other Manufacturing	35	53	6

Source: INDEC (2002) and authors' own calculations.

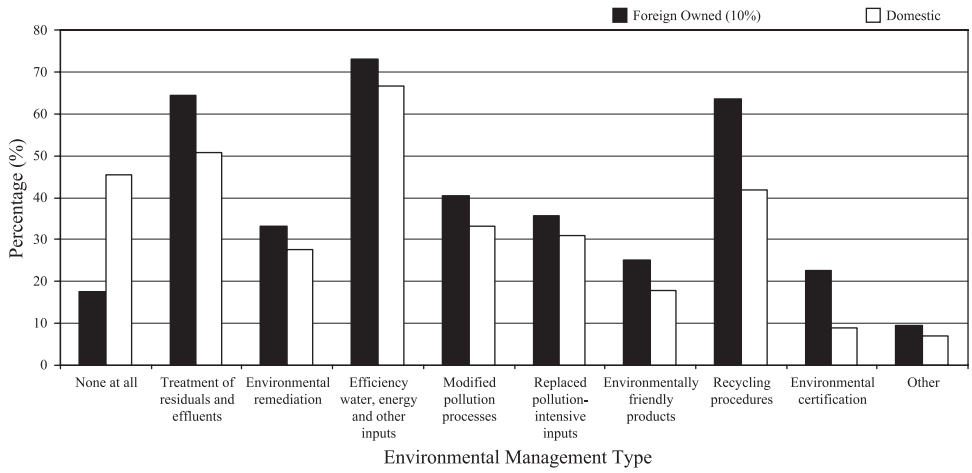
$$\Pr(y \mid x) = \frac{\Gamma(y + \alpha^{-1})}{y!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \lambda}\right)^{\alpha^{-1}}\left(\frac{\lambda}{\alpha^{-1} + \lambda}\right)^{y}, \quad y = 0, 1, 2, \ldots, 8, \qquad (3)$$

where α is the degree of overdispersion, i.e. the extent to which the variance is greater than the mean. When α is 0, the negative binomial has the same distribution as Poisson.[17] Equation (3) can then be estimated using a maximum likelihood estimator (MLE).

Table 1 presents summary information by industry for our sample of 1,187 firms. It is noteworthy that there are more foreign-owned firms in the more capital-intensive (and hence dirtier) sectors. However, firms in these sectors are also likely to be larger. There is no clear link between a sector's dirtiness and EMS implementation, although there is some suggestion that the cleaner sectors such as SIC 18 (Clothing) and SIC 33 (Medical, Precision and Optical Equipment) have a lower percentage of firms with EMS.

[17] Since the variance is larger than the mean in our sample, a standard Poisson estimation is not appropriate.

FIGURE 1
Environmental Management by Ownership Structure



The answers to question 501 are presented in Figure 1 after splitting the sample into foreign-owned and domestic firms. The clearest indication that foreign firms are more likely to have EMS in place can be seen from the first column that shows that close to 45 per cent of domestic firms have no EMS in place, whereas less than 20 per cent of foreign-owned firms are in the same position.

When we consider individual EMS we can see that foreign firms have a consistently higher propensity for implementing each type of EMS. The EMS showing the largest differences are: Environmentally friendly products (column 7); Recycling procedures (column 8); and Environmental certification (column 9).

Finally, it is worth providing a brief overview of the Argentinean economy during and leading up to our period of analysis. From the late 1980s to early 1990s Argentina fundamentally changed its economic policy regime. After a period of hyperinflation, price stability was achieved through a currency board scheme that, between 1991 and 2001, pegged the peso to the dollar. Other policies that the government implemented during this time included the liberalisation of trade and capital markets, privatisation of nearly all state-owned firms and widespread deregulation. The result was high growth between 1991 and 1998 equal to 6 per cent a year (with the Tequila crisis in 1995). However, from 1998 there was economic stagnation and a steep fall in GDP during 2001 and 2002 coupled with a financial and institutional crisis. During this time there was significant firm restructuring. The result was that the majority of innovation investment tended to go on technology acquisition and less on in-house R&D.

In spite of the rapid economic development and subsequent slump, Argentina remained a significant destination for FDI. Between 1991 and 2001, over US$76,000 million was invested with the number of foreign affiliates among the 1,000 largest firms increasing from 199 to 472 with an increase in sales from 39 per cent to 67 per cent. The manufacturing sector received 22 per cent of FDI flows.

Unfortunately, there is little information about the environmental performance of Argentinean firms because no official statistics exist. Local environmental regulations often appear to be strict (with regulations often borrowed from the United States or the European Union) but Argentina lacks a strong institutional framework. The consensus is that regulation enforcement is weak and the authorities have insufficient resources to monitor the environmental performance of firms. Even so, the number of firms who have obtained ISO14001 certification rose from nine in 1997 to 343 by 2004.

4. RESULTS

We begin by investigating the determinants of EMS implementation. Our results suggest that foreign ownership has a consistently positive and significant effect on the probability of a firm having at least some EMS in place.

The most striking result from Table 2 is that our foreign ownership variable (*FO10*) is positive and significant across all specifications. In the baseline regression (column 1) we find that, *ceteris paribus*, foreign-owned firms are nearly twice as likely as domestic firms to have implemented EMS. This is a strong finding. In our full specifications (columns 3 and 4) the odds ratios for foreign ownership are 1.799 and 1.84, suggesting that foreign-owned firms are approximately 1.8 times more likely to have implemented EMS than domestic firms. This completes the first stage of our two-stage quest for environmental spillovers and suggests that there is at least the potential for environmental spillovers from foreign firms.

At this stage it is worth commenting on the sign and significance of our other independent variables. As expected, *Size* and *Size squared* ($Size^2$) are significant across all specifications and have the expected odds ratios of greater than one and less than one respectively. That is to say, EMS implementation increases with size but at a decreasing rate. Similarly, Sales growth (*Salesgr*) is significant with an odds ratio greater than one, suggesting that a firm that exhibits positive growth is more likely to implement EMS. A similar result is found for the percentage of skilled labour (*Perskilled*). For both sales growth and skilled labour the odds ratio is close to one. In contrast, the variable with the largest odds ratio is our R&D dummy (*dRD*) with an odds ratio consistently above two, suggesting that firms that engage in R&D spending are more than twice as likely to implement EMS. The export dummy (*dExport*) is always greater than one and significant at

TABLE 2
Determinants of EM (dep. var. is EMS yes/no). Logistic regression

	(1)	*(2)*	*(3)*	*(4)*
FO10	1.960***	1.862***	1.799***	1.840***
	(4.2)	(4.2)	(4.2)	(3.8)
Size	1.252***	1.230***	1.230***	1.233***
	(3.6)	(3.6)	(3.6)	(3.5)
$Size^2$	0.997***	0.997***	0.997***	0.997***
	(3.1)	(2.9)	(2.9)	(2.8)
Independent	0.779	0.807	0.804	0.771
	(1.2)	(1.1)	(1.2)	(1.3)
Salesgr	1.015***	1.016***	1.017***	1.016***
	(3.3)	(2.8)	(3.0)	(2.7)
Labprod	1.031	1.085	1.070	1.080
	(0.2)	(0.5)	(0.4)	(0.4)
dExport	1.125	1.328*	1.295*	1.897***
	(0.8)	(1.8)	(1.8)	(2.6)
dRD	2.332***	2.187***	2.186***	2.169***
	(4.7)	(4.7)	(4.6)	(4.8)
Perskilled	1.009***	1.006*	0.995	1.006**
	(3.0)	(1.9)	(1.0)	(2.1)
Invsales	0.956	1.000	1.036	1.001
	(0.1)	(0.0)	(0.1)	(0.0)
Backward		1.015	0.999	1.006
		(1.2)	(0.1)	(0.3)
Forward		1.024	0.976	1.043
		(0.7)	(0.6)	(0.8)
Horizontal		0.999	1.005	1.001
		(0.1)	(0.4)	(0.1)
NetSuppLocal		1.219	1.324	1.171
		(0.5)	(0.6)	(0.4)
NetCustLocal		0.661	0.662	0.693
		(1.0)	(1.0)	(1.1)
NetOtherLocal		0.900	0.918	0.980
		(0.1)	(0.1)	(0.0)
*Back * NetCust*		1.025**	1.023**	1.026**
		(2.5)	(2.5)	(2.5)
*Forw * NetSupp*		1.037	1.030	1.038
		(1.1)	(0.9)	(1.1)
*Horiz * NetOther*		1.001	1.001	0.999
		(0.1)	(0.1)	(0.1)
*Backward * Skilled*			1.001*	
			(1.7)	
*Forward * Skilled*			1.002**	
			(2.1)	
*Horizontal * Skilled*			1.000	
			(1.3)	
*Backward * Export*				1.025*
				(1.8)
*Forward * Export*				0.967
				(0.9)
*Horizontal * Export*				0.993
				(0.6)
Dirty	0.298***	0.691*	0.694*	0.693*
	(9.0)	(1.7)	(2.0)	(1.7)
Observations	1,187	1,187	1,187	1,187
Pseudo-R^2	0.18	0.16	0.17	0.17

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

the 10 per cent level in three of the four columns. Finally, we note that the dirty industry dummy is consistently significant with an odds ratio of less than one, suggesting that firms in pollution-intensive industries are *less* likely to implement EMS. This conflicts with the findings of Cole et al. (2006) for Japan but is consistent with the raw Argentinean data which tell us that 62 per cent of firms in 'clean' industries undertake EMS compared with only 56 per cent of firms in dirty industries. This reveals a perhaps predictable difference in the behaviour of firms located in developing and developed countries.

Investment expenditure as a percentage of sales (*Invsales*) and labour productivity (*Labprod*) were both insignificant determinants of EMS implementation. Perhaps surprisingly, firm independence (*Independent*) was insignificant, suggesting that being part of a larger group does not increase the odds of EMS implementation.

We turn now to our network and linkage variables. Column 1 omits all network and linkage variables, column 2 includes them all except the interactions between linkages and proxies for absorptive capacity. Finally, columns 3 and 4 include these latter interactions, firstly using skilled labour and then the export dummy as proxies for absorptive capacity. The individual linkage and network variables are not statistically significant in any of the three specifications (columns 2–4). However, we do find a significant odds ratio of greater than one for the interaction between backward linkages and customer networks in all three models. This suggests that environmental spillovers are only observable in those firms who sell goods to sectors with a large percentage of foreign firms but only when there is also an active network between customers and suppliers. This is an important result. Turning to the linkage–absorptive capacity interactions, column 3 indicates that *Backward* and *Forward* are statistically significant when interacted with the percentage of skilled labour. This suggests that firms who trade (both buy and sell) with sectors containing a large percentage of foreign firms are more likely to adopt EMS the greater the percentage of skilled workers within their workforce. Column 4 partially supports this result by finding *Backward* linkages to be significant for firms who export. No such finding is made for *Forward* linkages. These results do therefore suggest that absorptive capacity, here proxied by skilled workers and whether or not the firm exports, does increase the likelihood of a firm experiencing environmental spillovers from foreign firms.

To investigate further, Tables 3 and 4 split the sample into domestic and foreign firms. Table 3 considers domestic firms only using the same specifications as Table 2. The sign and significance of the main independent variables are almost identical across all specifications. For our network and linkage variables there is now less statistical significance than in Table 1. We now find only *Backward* linkages interacted with the export dummy to be statistically significant, indicating that it is only domestic exporters who are likely to benefit from environmental spillovers from foreign firms. This finding is highly plausible.

TABLE 3
Determinants of EM for Domestic Firms Only (dep. var. is EMS yes/no). Logistic Regression

	(1)	*(2)*	*(3)*	*(4)*
Size	1.223***	1.220***	1.222***	1.218***
	(2.7)	(2.8)	(2.8)	(2.7)
$Size^2$	0.997**	0.997**	0.997**	0.997**
	(2.3)	(2.2)	(2.2)	(2.1)
Independent	0.727	0.741	0.736	0.722
	(1.4)	(1.4)	(1.5)	(1.5)
Salesgr	1.012***	1.013**	1.014**	1.013**
	(2.6)	(2.2)	(2.3)	(2.1)
Labprod	0.989	1.055	1.051	1.031
	(0.1)	(0.3)	(0.3)	(0.2)
dExport	1.151	1.321*	1.290*	2.344***
	(1.0)	(1.8)	(1.7)	(3.0)
dRD	2.355***	2.257***	2.242***	2.226***
	(4.6)	(4.7)	(4.5)	(4.6)
Perskilled	1.007**	1.004	0.997	1.005*
	(2.2)	(1.5)	(0.7)	(1.7)
Invsales	0.976	0.937	0.982	0.921
	(0.1)	(0.2)	(0.1)	(0.2)
Backward		1.013	0.999	1.000
		(1.0)	(0.1)	(0.0)
Forward		0.995	0.960	0.999
		(0.2)	(1.0)	(0.0)
Horizontal		1.005	1.011	1.012
		(0.4)	(0.8)	(0.7)
NetSuppLocal		1.329	1.432	1.221
		(0.6)	(0.8)	(0.4)
NetCustLocal		0.775	0.774	0.787
		(1.2)	(1.2)	(1.1)
NetOtherLocal		0.731	0.748	0.855
		(0.4)	(0.4)	(0.2)
*Back * NetCust*		1.016	1.014	1.018
		(1.2)	(1.2)	(1.3)
*Forw * NetSupp*		1.034	1.027	1.044
		(0.9)	(0.8)	(1.2)
*Horiz * NetOther*		1.006	1.006	1.002
		(0.4)	(0.4)	(0.1)
*Backward * Skilled*			1.000	
			(1.2)	
*Forward * Skilled*			1.001	
			(1.2)	
*Horizontal * Skilled*			1.000	
			(0.7)	
*Backward * Export*				1.035**
				(2.4)
*Forward * Export*				0.968
				(0.8)
*Horizontal * Export*				0.985
				(1.1)
Dirty	0.465***	0.672**	0.676**	0.691*
	(5.0)	(2.1)	(2.3)	(2.0)
Observations	930	935	935	935
Pseudo-R^2	0.14	0.12	0.13	0.13

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 4
Determinants of EM for Foreign Firms Only (dep. var. is EMS yes/no). Logistic Regression

	(1)	*(2)*	*(3)*	*(4)*
Size	1.364	1.339*	1.315*	1.377*
	(1.6)	(1.9)	(1.8)	(1.8)
$Size^2$	0.993	0.996*	0.996	0.995
	(1.2)	(1.7)	(1.5)	(1.6)
Independent	0.944	1.131	1.071	1.144
	(0.1)	(0.3)	(0.2)	(0.3)
Salesgr	1.032	1.030	1.028	1.029
	(1.1)	(0.9)	(0.9)	(0.8)
Labprod	1.091	1.003	0.912	0.967
	(0.2)	(0.0)	(0.1)	(0.1)
dExport	1.025	1.418	1.427	3.326
	(0.1)	(0.8)	(0.9)	(1.2)
dRD	3.052***	1.982**	2.196***	2.227***
	(3.9)	(2.3)	(2.9)	(3.0)
Perskilled	1.025***	1.014*	0.988	1.015*
	(3.0)	(1.9)	(0.6)	(1.9)
Invsales	1.805	1.426	1.356	1.684
	(0.2)	(0.2)	(0.1)	(0.2)
Backward		1.037	1.05*	1.060*
		(1.5)	(1.7)	(1.9)
Forward		1.169***	1.072*	1.340***
		(3.1)	(1.7)	(3.8)
Horizontal		0.974	0.976	0.950
		(1.5)	(1.1)	(0.9)
NetSuppLocal		0.389	0.378	0.420
		(0.8)	(0.8)	(0.7)
NetCustLocal		0.322	0.300	0.324
		(1.5)	(1.5)	(1.6)
NetOtherLocal		1.114	0.982	1.031
		(0.1)	(0.0)	(0.0)
Back ∗ NetCust		1.074***	1.072***	1.078***
		(2.6)	(2.6)	(2.6)
Forw ∗ NetSupp		1.140	1.133	1.136
		(1.2)	(1.2)	(1.1)
Horiz ∗ NetOther		0.986	0.990	0.986
		(0.7)	(0.5)	(0.6)
Backward ∗ Skilled			1.001*	
			(1.7)	
Forward ∗ Skilled			1.002	
			(0.8)	
Horizontal ∗ Skilled			1.000	
			(0.2)	
Backward ∗ Export				0.959
				(1.1)
Forward ∗ Export				0.814
				(1.0)
Horizontal ∗ Export				1.041
				(1.4)
Dirty	0.037***	1.024	0.941	1.059
	(7.0)	(0.0)	(0.2)	(0.1)
Observations	231	252	252	252
Pseudo-R^2	0.24	0.21	0.23	0.23

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

It is a well-established fact that firms that export are more productive, pay higher salaries, exhibit greater skill and capital intensity and are more innovative.[18] Furthermore, if exporters are subjected to the more demanding environmental standards of certain export markets they may be better placed to embrace the environmental good practice of foreign firms when they come into contact with it. This finding therefore provides evidence of the need for absorptive capacity, although linkages interacted with skilled labour, whilst having an odds ratio greater than one, is not statistically significant.

In Table 4 we consider foreign firms only. We now observe significant odds ratios of greater than one for both forward and backward linkages suggesting that foreign-owned firms that supply and buy from sectors with a large foreign presence are more likely to have implemented EMS. This provides the first strong evidence of a link between foreign firms and environmental performance spillovers. The network variables are insignificant when included individually, but the interaction between backward linkages and networking with customers is significant and greater than one in all models, as it was in Table 2. The linkage variables interacted with absorptive capacity provide little information, perhaps because all foreign firms have a similar, relatively high, level of absorptive capacity. That said, *Backward* interacted with skilled labour is significant at the 10 per cent level.

It appears, therefore, that foreign firms are susceptible to the positive influence of other foreign firms both as suppliers and customers. This perhaps suggests that 'environmental knowledge' is transferred more efficiently from one foreign firm to another. While we therefore find only limited evidence of spillovers from foreign to domestic firms (i.e. only for exporters) the evidence of spillovers from foreign firms to other firms is far more compelling. In general, these results would appear to be driven by the greater assimilative capacity of domestic exporters and foreign firms.

To investigate the role of environmental spillovers further, Tables 5, 6 and 7 report the determinants of the number of EMS that firms have implemented using a negative binomial estimation procedure.

Aside from the linkage and network variables, the sign and significance of the explanatory variables in Table 5 are broadly similar to those in Table 2. Key determinants of the number of EMS implemented are foreign ownership, size, whether the firm exports, whether it undertakes R&D and the proportion of the workforce who are skilled. In contrast to Table 2, we now find a firm's independence to be statistically significant, with independent firms likely to adopt fewer types of EMS. Furthermore, the dirty dummy is no longer significant.

[18] See Bernard et al. (2007) for US firms, Mayer and Ottaviano (2007) for European firms and Albornoz and Ercolani (2007) for Argentinean exporters.

TABLE 5
Determinants of the Number of Types of EM (dep. var. is EMS no. count). Negative Binomial Estimation

	(1)	*(2)*	*(3)*	*(4)*
FO10	1.183***	1.142**	1.135**	1.144**
	(2.8)	(2.3)	(2.2)	(2.3)
Size	1.093***	1.088***	1.088***	1.089***
	(4.6)	(4.8)	(4.8)	(4.7)
$Size^2$	0.998***	0.999***	0.999***	0.999***
	(3.9)	(4.1)	(4.1)	(4.0)
Independent	0.799**	0.814**	0.811**	0.810**
	(2.4)	(2.1)	(2.2)	(2.2)
Salesgr	1.000	1.000	1.000	1.000
	(0.4)	(0.1)	(0.1)	(0.4)
Labprod	1.086	1.124	1.123	1.141
	(0.7)	(0.9)	(0.9)	(1.0)
dExport	1.238***	1.342***	1.340***	1.570***
	(3.5)	(4.2)	(4.5)	(3.4)
dRD	1.391***	1.380***	1.380***	1.383***
	(3.1)	(3.0)	(3.0)	(3.1)
Perskilled	1.004***	1.004***	1.001	1.004***
	(3.4)	(2.9)	(0.2)	(3.1)
Invsales	1.064	1.051	1.061	1.044
	(0.4)	(0.3)	(0.3)	(0.2)
Backward		1.004	1.000	1.000
		(0.6)	(0.1)	(0.0)
Forward		1.027	1.022	1.034
		(1.3)	(0.9)	(1.0)
Horizontal		1.000	0.999	1.001
		(0.1)	(0.1)	(0.1)
NetSuppLocal		1.152	1.149	1.145
		(0.8)	(0.8)	(0.8)
NetCustLocal		1.025	1.028	1.040
		(0.2)	(0.2)	(0.3)
NetOtherLocal		0.814	0.849	0.805
		(0.7)	(0.5)	(0.7)
*Back * NetCust*		1.005	1.004	1.005
		(0.9)	(0.8)	(0.9)
*Forw * NetSupp*		1.000	1.000	1.000
		(0.0)	(0.0)	(0.0)
*Horiz * NetOther*		1.001	1.001	1.001
		(0.3)	(0.1)	(0.3)
*Backward * Skilled*			1.000	
			(1.1)	
*Forward * Skilled*			1.000	
			(0.8)	
*Horizontal * Skilled*			1.002	
			(0.9)	
*Backward * Export*				1.008
				(0.9)
*Forward * Export*				0.989
				(0.4)
*Horizontal * Export*				0.997
				(0.4)
Dirty	0.254***	0.902	0.911	0.898
	(24.5)	(0.8)	(0.7)	(0.8)
Observations	1,187	1,187	1,187	1,187

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 6
Determinants of the Number of Types of EM for Domestic Firms Only (dep. var. is EMS no. count). Negative Binomial Estimation

	(1)	*(2)*	*(3)*	*(4)*
Size	1.107***	1.112***	1.114***	1.109***
	(4.7)	(4.6)	(4.5)	(4.5)
$Size^2$	0.998***	0.998***	0.998***	0.998***
	(3.8)	(3.8)	(3.8)	(3.7)
Independent	0.850	0.851	0.846	0.844
	(1.4)	(1.3)	(1.4)	(1.4)
Salesgr	1.000***	1.000	1.000	1.000
	(9.6)	(1.1)	(1.2)	(0.3)
Labprod	1.110	1.216	1.233	1.190
	(0.4)	(0.6)	(0.6)	(0.6)
dExport	1.299***	1.377***	1.367***	1.726***
	(3.4)	(3.7)	(3.9)	(2.9)
dRD	1.390***	1.413***	1.405***	1.413***
	(2.6)	(2.8)	(2.7)	(2.9)
Perskilled	1.005***	1.004**	1.000	1.005***
	(2.7)	(2.4)	(0.1)	(2.6)
Invsales	1.050	0.965	1.000	0.954
	(0.3)	(0.1)	(0.0)	(0.2)
Backward		1.001	0.994	0.995
		(0.1)	(0.6)	(0.5)
Forward		1.009	1.000	1.012
		(0.4)	(0.0)	(0.3)
Horizontal		1.004	1.004	1.007
		(0.4)	(0.4)	(0.5)
NetSuppLocal		1.136	1.146	1.135
		(0.5)	(0.6)	(0.5)
NetCustLocal		1.064	1.066	1.062
		(0.4)	(0.5)	(0.4)
NetOtherLocal		0.659	0.708	0.680
		(1.1)	(0.9)	(1.0)
*Back * NetCust*		1.003	1.001	1.004
		(0.4)	(0.2)	(0.5)
*Forw * NetSupp*		1.006	1.006	1.007
		(0.4)	(0.4)	(0.4)
*Horiz * NetOther*		1.007	1.006	1.006
		(1.0)	(0.8)	(0.8)
*Backward * Skilled*			1.000	
			(1.3)	
*Forward * Skilled*			1.000	
			(1.0)	
*Horizontal * Skilled*			1.002	
			(0.9)	
*Backward * Export*				1.012
				(1.2)
*Forward * Export*				0.990
				(0.3)
*Horizontal * Export*				0.994
				(0.6)
Dirty	0.771***	0.912	0.921	0.908
	(3.3)	(0.7)	(0.6)	(0.7)
Observations	935	935	935	935

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 7
Determinants of the Number of Types of EM for Foreign Firms Only (dep. var. is EMS no. count). Negative Binomial Estimation

	(1)	*(2)*	*(3)*	*(4)*
Size	1.058***	1.065***	1.064***	1.063***
	(3.2)	(3.3)	(3.1)	(3.3)
$Size^2$	0.999**	0.999***	0.999**	0.999***
	(2.2)	(2.7)	(2.5)	(2.6)
Independent	0.771**	0.768**	0.767**	0.771**
	(2.2)	(2.2)	(2.3)	(2.2)
Salesgr	0.999***	0.999***	0.999***	0.999***
	(2.6)	(2.7)	(2.8)	(2.7)
Labprod	1.287***	1.296***	1.295***	1.294***
	(3.4)	(3.5)	(3.5)	(3.2)
dExport	1.056	1.068	1.067	0.944
	(0.6)	(0.7)	(0.6)	(0.2)
dRD	1.380***	1.289***	1.297***	1.307***
	(4.2)	(3.0)	(3.0)	(3.3)
Perskilled	1.002	1.001	1.000	1.001
	(0.8)	(0.6)	(0.0)	(0.7)
Invsales	1.181	1.255	1.250	1.256
	(0.6)	(0.8)	(0.8)	(0.8)
Backward		1.008	1.007	1.009
		(1.3)	(0.7)	(0.7)
Forward		1.045**	1.039*	1.074*
		(2.6)	(1.7)	(1.9)
Horizontal		0.996	0.996	0.987
		(0.6)	(0.6)	(1.1)
NetSuppLocal		1.010	1.003	0.994
		(0.1)	(0.0)	(0.0)
NetCustLocal		1.076	1.081	1.085
		(0.4)	(0.5)	(0.4)
NetOtherLocal		0.933	0.928	0.934
		(0.2)	(0.3)	(0.2)
Back ∗ NetCust		1.003	1.003	1.003
		(0.4)	(0.4)	(0.3)
Forw ∗ NetSupp		1.003	1.003	1.004
		(0.3)	(0.3)	(0.4)
Horiz ∗ NetOther		0.998	0.998	0.998
		(0.4)	(0.4)	(0.4)
Backward ∗ Skilled			1.000	
			(0.1)	
Forward ∗ Skilled			1.000	
			(0.4)	
Horizontal ∗ Skilled			1.002	
			(0.9)	
Backward ∗ Export				0.998
				(0.2)
Forward ∗ Export				0.967
				(1.1)
Horizontal ∗ Export				1.011
				(1.2)
Dirty	0.91***	0.946	0.945	0.960
	(2.4)	(0.5)	(0.5)	(0.4)
Observations	252	252	252	252

Notes:
Robust *z*-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Turning to the linkage and network variables, we now find none to be statistically significant. We therefore find clear evidence that networks and foreign linkages have no influence over the *number of types* of EMS adopted.

Tables 6 and 7 again split our sample into domestic and foreign firms and some subtle differences are observable. For domestic firms, exporting and the percentage of the workforce who are skilled increase the number of EMS but this is not the case for foreign firms. For foreign firms, labour productivity and independence are statistically significant, but the same is not true of domestic firms. However, with regard to the linkage and network variables, again none are statistically significant.

a. Sensitivity Analysis

Although not reported for reasons of space, we undertook a broad test of the sensitivity of our foreign ownership, export and R&D variables. For foreign ownership, in addition to the 10 per cent boundary, we tested whether our results hold for 25 and 50 per cent and a continuous measure of ownership. The odds ratio for foreign ownership was remarkably stable although it dropped a little when a continuous variable was included. This suggests that there is a threshold effect on foreign ownership and that increasing ownership above the 10 per cent level does not increase the chances of EMS implementation for a firm.

For exports and R&D we replaced the dummy variable with a continuous measure of the value of exports and R&D spending. Our results show that exporting becomes an insignificant determinant of the probability of implementing EMS when it is measured continuously, again suggesting that it is exporting *per se* that matters and not the level of exports. However, for R&D there was little difference in the results.

Finally, we compared different measures of our network variable. Instead of local network links we include regional and national network links. Whilst we expect that local networks will have the strongest effect, we included regional and national network effects in case there is some larger effect that operates at the national level, for example if there is one large multinational that is driving EMS implementation along its supply chain across Argentina. Our regional and national network variables and the interaction terms were all insignificant, indicating that only local network effects matter.

In addition we also investigated the sensitivity of our results to changes in other variables. These included: measuring size using output instead of employment; including a dirty dummy for those industries considered the most highly polluting, spillovers measured at the three-digit level instead of the current two-digit level; and re-estimating all our models using an average of 1998–2002 data instead of 1998 data. The results were broadly supportive of those presented in the paper.

5. DISCUSSION AND CONCLUSIONS

This paper represents a first search for inter-industry and intra-industry environmental spillovers. To this end we measure forward, backward and horizontal linkages and also include a dummy variable to capture a firm-specific measure of how closely a firm is connected to the firms that it supplies, buys from and directly competes with. We have made a number of interesting discoveries. First, we find that foreign-owned firms are more likely to implement EMS than domestic firms. If the adoption of EMS results in improved environmental performance it could be argued that globalisation could be good for the environment if it meant cleaner foreign firms were displacing dirtier domestic firms. However, a foreign presence in a developing country may mean an increase in output that would otherwise not have occurred, thus contributing to higher local pollution levels. Our second finding is that foreign ownership also increases the number of types of EMS adopted. Thus, foreign-owned firms are more likely to adopt EMS than domestic firms and are also more likely to adopt a wider range of EMS.

In this paper we perform estimations on the sample containing all firms and then separately on the sub-samples of domestic firms and foreign firms. When considering all firms, we find that those firms that supply a sector with a large foreign presence *and* who have formal or informal links with their customers are more likely to implement EMS. This result could come through two channels: the first is the standard leakage of technology and skills from one firm to another via the movement of labour; the second is that foreign customers and suppliers are directly encouraging other firms in their extended supply chain to implement EMS for their own benefit, perhaps related to the maintenance of a good corporate image. However, the consistently insignificant coefficient on our horizontal linkage variable indicates that, whilst foreign firms may be willing to transfer environmental knowledge within supply chains, such generosity does not appear to extend to direct competitors. This supports the insignificant intra-sectoral environmental spillover results of Chudnovsky and Pupeto (2005). The strongest evidence for environmental spillovers was found in the foreign firm sample where firms with both forward and backward linkages were found to be more likely to implement EMS. Furthermore, those foreign firms that supply a sector with a large foreign presence *and* who have formal and informal links with their customers are again found to be more likely to implement EMS. No such result was found for domestic firms. We therefore have evidence of spillovers moving from one foreign firm to another, rather than from foreign to domestic firms as may have been expected. It is notable that none of the spillover or network variables are significant in the EMS count estimations, suggesting that if spillovers do exist, they influence the likelihood to adopt EMS rather than influencing the number of different types of EMS adopted.

Our analysis also investigates the role played by a firm's absorptive capacity. We find that a foreign presence amongst a firm's suppliers is more likely to result in the adoption of EMS if the firm has a higher proportion of skilled workers or if the firm is an exporter. We interpret the proportion of skilled workers and whether or not a firm exports as proxies for absorptive capacity and hence believe these results provide evidence to suggest that firms with absorptive capacity are more likely to benefit from foreign spillovers.

Overall, we believe we have found some tentative evidence for the existence of environmental spillovers. Since networks are shown to be important if firms are to benefit from spillovers it suggests that one possible policy prescription is for governments to attempt to encourage local firms (both foreign and domestic) to network more closely with foreign firms perhaps through the setting up of informal industry working groups. Similarly the development of business parks may be beneficial where both domestic and foreign firms can geographically cluster, raising the probability of worker transfers and informal mixing between companies. However, it is clear that governments cannot take environmental knowledge diffusion for granted.

With regard to future research, we need to more closely examine firms' motivation for implementing EMS to observe, for example, whether instruction from headquarters or pressure from suppliers or customers plays an active role. It would also be useful to examine the obstacles that firms suggest are preventing them from implementing EMS. Such an analysis is likely to lead to important policy prescriptions for how host countries can best utilise the presence of foreign firms to improve the local environment. Finally, there is scope to further investigate the learning-by-exporting and self-selection hypotheses in the context of environmental spillovers.

APPENDIX

Data Definitions and Summary Statistics

FO10 – A dummy variable that is 1 if the firm is more than 10 per cent foreign owned.

Size – measured as the total number of workers. We also include $Size^2$.

Independent – measures whether a firm is independent or part of a larger group.

Salesgr – Sales growth captures the idea that a growing firm is likely to be financially stronger.

Labprod – labour productivity is included as a proxy for TFP.

dExport – export dummy that is 1 if the firm exports and 0 otherwise.

dRD – an R&D dummy that is 1 if the firm engages in R&D and 0 otherwise.

Perskilled – percentage of workforce that are technical workers.

Invsales – investment expenditure as a percentage of sales.

Backward – to capture backward linkages measured at the two-digit industry level.

Forward – to capture forward linkages measured at the two-digit industry level.

Horizontal – to capture horizontal linkages measured at the two-digit industry level.

NetSuppLocal – a firm-level measure of whether a firm has contact with local suppliers.

NetCustLocal – a firm-level measure of whether a firm has contact with local customers.

NetOtherLocal – a firm-level measure of whether a firm has contact with other local firms.

Dirty – a dummy equal to 1 if a firm is within a traditionally pollution-intensive industry (Steel and Aluminium, Chemicals, Non-metallic Minerals, Petroleum Products, Pulp and Paper).

The *Forward*, *Backward* and *Horizontal* linkage variables are also interacted with each appropriate network variable. These linkage variables are also interacted with two proxies for absorptive capacity, *dExport* and *Perskilled*.

TABLE A1
Summary Statistics

Variable	*Mean*	*Std. Dev.*	*Min.*	*Max.*
FO10	0.21	0.41	0	1
Size	2.27	4.70	0.01	59.77
Independent	0.73	0.45	0	1
Salesgr	2.49	11.00	–0.99	140.87
Labprod	0.15	0.31	0.00085	8.14
dExport	0.53	0.50	0	1
dRD	0.60	0.49	0	1
Perskilled	0.34	28.51	0	100
Invsales	0.056	0.17	0	3.19
Backward	10.78	10.82	0	62.37
Forward	10.096	5.95	0	31.64
Horizontal	40.33	22.30	0	96.44
NetSuppLocal	0.25	0.43	0	1
NetCustLocal	0.18	0.38	0	1
NetOtherLocal	0.080	0.27	0	1
Dirty	0.16	0.36	0	1

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