Foreign ownership, trade and the environmental actions of firms

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Abstract

Using Argentinean firm-level data, we identify and quantify the factors that influence the environmental actions of Argentinean firms. We examine various aspects of a firm's environmental actions (EAs), including the range of EAs adopted, the motives for such adoption and the obstacles that hinder EA adoption. In each case we investigate the role played by firm-level characteristics, paying particular attention to foreign ownership, spillovers from foreign to domestic firms and networks between firms. We find that foreign firms are more likely to adopt EAs than domestic firms and environmental spillovers are more likely to move from one foreign firm to another than from foreign firms to domestic firms. Additionally, we find that foreign firms' motives for undertaking EAs and the obstacles that hinder them are often different to those experienced by domestic firms.

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Keywords: Multinational, Environment, Firm Characteristics, Management, Motives, Obstacles

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1. Introduction

Understanding the factors that influence the environmental behaviour of firms is an issue of great significance to policy makers attempting to control the environmental impact of the industrial sector. Industrial emissions are particularly a problem in developing economies where concentrations of local air pollutants still regularly exceed World Health Organisaton guidelines. The World Health Organisation (WHO) (2006) estimates that urban air pollution kills more than a million people each year, predominantly in developing countries, and over 80% of all diseases recorded by the WHO are wholly or partially attributable to environmental factors.

A small body of literature has examined the extent to which factors internal to firms (e.g. firm size, investment in innovation, management practices) and external to firms (e.g. pressure from consumers and shareholders) influence the environmental behaviour of firms (see for example Pargal and Wheeler 1997, Nakamura *et al.* 2001, Cole *et al.* 2006). However these studies tend to focus on reasonably narrow definitions of environmental performance (e.g. the adoption of ISO 14001 certification) and therefore provide little information on how internal and external factors might influence different types of environmental behaviour. Furthermore, these studies provide little insight into firms' motives for tackling environmental problems or the obstacles that might prevent them from doing so. Thus, existing studies do not indicate the extent to which environmental improvement is undertaken in order to meet environmental regulations, or to simply improve the image of the firm, or to gain access to foreign markets, for example. Similarly, we have little information on whether firms find a lack of access to environmental technology to be a constraint on their environmental actions or whether such technology is simply too expensive.

An additional deficiency of the existing literature is its neglect of a further external influence that domestically owned firms may face, particularly in developing economies, namely the existence of environmental spillovers from foreign firms. The possibility of domestic firms learning from foreign firms is implicit in the so-called pollution halo hypothesis.[1] If multinationals utilise more advanced technologies, cleaner production methods, and possess more developed environmental management systems (EMS) and organisational techniques, then these may yield substantial environmental benefits to developing countries. For example, it has been argued that OECD based multinationals will typically utilise cleaner technology and possess more sophisticated EMS than many domestic firms in developing countries, often due to the more stringent regulatory environment that exists in the OECD (Zarsky 1999). Pressure to continue to use such technologies in their affiliates in developing countries may arise because such multinationals may have large export markets in OECD countries where they have to meet the requirements of environmentally aware consumers. As Wallace (1996) and Zarsky (1999) note, such technologies may also be indirectly passed on to domestic firms via, for example, backward or forward linkages.

Utilising a rich dataset of Argentinean firms enables us to address the key shortcomings of the existing literature outlined above: First, we undertake a detailed analysis of the firm-specific characteristics that influence the environmental actions of firms, where examples of environmental actions include improving the efficiency of energy use, replacing pollution processes, treating effluents, obtaining environmental certification and developing environmentally friendly products.[2]

[1] The 'pollution halo' hypothesis contrasts with the 'pollution haven' hypothesis which argues that MNCs may take advantage of less stringent regulations in developing host countries and transfer environmentally inferior technologies and practices to their foreign affiliates or use these affiliates to market products that are banned or restricted in their home countries (Ives 1985). The empirical evidence for the pollution haven hypothesis is generally mixed (see for example Eskeland and Harrison, 2003, Smarzynska-Javorcik and Wei, 2004 and Cole and Elliott, 2005).

[2] We term these activities environmental actions rather than environmental management since the latter term is usually synonymous with environmental management systems (EMS) which refer to a more systematic approach to dealing with a firm's activities. Environmental actions may be a part of an EMS but are not, in themselves, forms of EMS.

We examine econometrically the factors that influence the adoption of a range of environmental actions (EAs), paying particular attention to characteristics such as firm size, R&D expenditure and the skill level of the workforce. Although results differ across EAs, in general we find firm size, whether or not the firm is an exporter and R&D expenditure to be important variables.

Second, the uniqueness and richness of this dataset also allows us to undertake a detailed examination of the factors that influence firms' motives for undertaking EAs. We can, for example, ascertain whether firms that undertake EAs to 'improve the image of the firm' have different characteristics to those who adopt EAs 'to meet the requirement of foreign markets'. Additionally, we consider the obstacles that hindered firms' access to environmental technology and again assess whether the type of obstacle experienced by a firm is influenced by the characteristics of that firm. We find a number of important results, including the fact that foreign firms are more likely than domestic firms to adopt EAs purely as a result of firm policy and in order to prepare for environmental certification. Similarly, the obstacles that prevent access to environmentally clean technology differ depending on ownership of the firm.

Third, we identify whether foreign owned firms are more likely to implement EAs than domestic firms. The pollution halo hypothesis hinges upon the assumption that foreign owned firms are cleaner than their domestic counterparts, yet evidence to date is rather mixed (Huq and Wheeler 1993, Pargal and Wheeler 1996, Eskeland and Harrison 2003, Cole *et al.* 2008). We find clear evidence to suggest that foreign owned firms in Argentina are more likely to undertake environmental actions than domestic firms.

Finally, we examine whether the presence of foreign owned firms in either, the sector that a firm

belongs to, supplies, or buys from, influences the environmental actions of the firm, in terms of the adoption of EAs, the motives for the adoption and the obstacles faced. We also consider the role played by informal networks and assess whether networks with customers, suppliers and competitors influence environmental actions. We find some evidence of environmental spillovers and show such spillovers to be more likely if firms also have formal and informal links with their customers. In addition, our results emphasise the importance of absorptive capacity and suggest environmental spillovers are more likely the greater a firm's absorptive capacity.

The remainder of the paper is organized as follows: Section 2 reviews the recent theoretical and empirical literature while Section 3 outlines the methodology and describes our data; Sections 4 and 5 present the results and sensitivity analysis respectively; Section 6 concludes.

2. Review of the Literature

2.1 Factors influencing the environmental practices of firms

A number of studies have examined the firm-level characteristics that appear to influence a firm's environmental behaviour. For the case of Indonesia, Kaiser and Schulze (2003) emphasise the roles played by foreign ownership and whether or not the firm exports, in determining abatement activities. Also for Indonesia, Pargal and Wheeler (1996) indicate that water pollution is a function of a firm's output, its productivity, whether or not it is state owned and informal regulatory pressure. Drawing on the organizational management literature, Aragon-Correa and Sharma (2003) argue that the extent to which a firm's resources and capabilities (which include technology, managerial skills and attitudes) will 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. In a study of the US, DeCanio and Watkins (1998) find that firm-level characteristics such as size and shareholder structure affected the decision to participate in the Green Light program (a voluntary pollution prevention program). Again for the US, Arora and Cason (1995 and 1996) show that firm size and industry effects were important determinants of a firm's participation decision in the Environmental Protection Agency's (EPA) voluntary 33/50 program. In studies of environmental management system (EMS) adoption in Japan, Nakamura *et al.* (2001) and Cole *et al.* (2006) emphasize a number of firm-specific factors, including firm size, age of employees, whether or not it exports or undertakes FDI, the physical capital intensity of firms and their productivity.

2.2 Firms' motives for adopting EAs

Unlike the present study, previous research does not provide any systematic analyses of firms' motives for adopting EAs. Nevertheless, several studies provide some insights into why firms may implement such practices. Khanna and Anton (2002), for instance, find that public recognition was an important motive for firms' participation in the EPA's 33/50 program. Concern for a firm's public image is also identified as important by Cole *et al.* (2006) who find that a firm's marketing expenditure was a positive significant determinant of EMS adoption. Henriques and Sadorsky (1996) and Levy (1995) also emphasise the role played by consumer pressure as well as pressure from shareholders. Dasgupta *et al.* (2000) found regulatory pressure was an important determinant of plant-level environmental performance in Mexico, a finding mirrored by Pargal and Wheeler (1996) who particularly emphasised the role played by informal regulation by communities. However, Halkos and Evangelinos (2002) find that regulatory pressure is not a driver of EMS take-up amongst Greek firms, perhaps because of a perception that regulatory enforcement is weak.

Sheldon (1997) argues that firms who adopt EAs may experience cost savings through the more

efficient use of raw materials and energy and a reduction in the need for expensive waste management. Porter and van der Linde (1995) emphasise the potential stimulus to innovation that environmental regulations may provide. If firms become aware of such benefits this in itself may encourage the voluntary adoption of EMS. Relatedly, Diller (1997) suggests that adoption of EMS may yield organisational benefits to firms. Benefits from EMS may also take the form of an increase in the market valuation of a firm according to Laplante and Lanoie (1994).

A further factor that could, potentially, motivate a firm to adopt EAs is the increased presence of foreign firms within the industry that a firm resides in, or within the industries that a firm trades with. Such spillovers may arise for a variety of reasons: First, they may occur as a result of workers moving from foreign to domestic firms and bringing their experience and know-how with them. Second, domestic firms may adopt technologies utilised by foreign firms through imitation or reverse engineering. Finally, spillovers may move up or down the supply chain if foreign firms, concerned about their public image, require that their suppliers, or customers, adopt certain minimum environmental standards before they will do business with them. The previous literature on environmental spillovers from foreign to domestic firms is particularly limited. The closest study to our own is Chudnovsky and Pupato (2005) who find no evidence of intra-sectoral environmental spillovers in Argentina. However, they do not test for the existence of inter-industry spillovers which could pass up or down the supply chain. Cole *et al.* (2008) find some evidence that spillovers passing through human capital acquirement (from foreign to domestic firms) may reduce the energy intensity of Ghanaian firms. Other analyses tend to be in the form of case-studies of particular multi-national firms. Meyer (2003) reviewed this literature and concluded that the impact of MNCs on the host country's environment can be positive or negative.

Finally, how multinational firms manage their overseas affiliates can influence the adoption of environmental policies. For example, in a decentralized system affiliates are free to choose their own environmental policies which are the responsibility of the local CEO. More often, head quarters (HQ) will attempt to ensure foreign affiliates comply with regulations wherever they operate. In a centralized system the HQ attempts to ensure environmental management systems comply with the home standards. According to UNCTAD (2002) of 153 firms surveyed, the main drivers of environmental performance of foreign owned affiliates were HQ policies, procedures and standards (42%), regulatory pressures, current and anticipated (34%), local management leadership (12%), consumer pressure (4%), rules and pressures from international organisations (3%), pressure from NGOs and media (3%) and finally fear of accidents (2%).

3. Methodology and Data

Our analysis utilizes data from a manufacturing firm-level survey conducted by the Argentinean National Institute of Statistics and Censuses.[3] The survey covers the period 1998-2001 providing complete data for approximately 1200 firms. Although we have non-environmental data for each of the years 1998-2001, questions about firms' environmental management span the whole period rather than being year-specific. For instance, firms were asked whether they had implemented any environmental management systems during the period 1998-2001. So our environmental data, which typically forms our dependent variables, is for the whole period 1998-2001 and we regress this on independent variables for the year 1998 in order to mitigate any endogeneity bias. The data are a representative sample of Argentina's manufacturing sector and account for more than 50 per cent of

[3] Encuesta Nacional sobre la Conducta Technologica de las Empresas Industriales Argentinas. See INDEC (2002).

total sector sales and employment and 60 per cent of total exports.[4]

We use the dataset to investigate the factors that influence a number of related issues, namely: (i) the adoption of EAs; (ii) the types of EAs adopted; (iii) the reasons for the adoption of EAs; (iv) and the obstacles that hindered firms in their attempts to utilise environmental technology. We identify the firm-level characteristics that influence each of these issues, including the role played by networks and foreign linkages.

Before outlining the methodology used to examine each of the points (i) to (v), we firstly explain how our linkage and network variables are measured.

Linkages and Networking

We follow Aitken and Harrison (1999), Smarzynska Javornik (2004) and Blyde *et al.* (2004) to capture the impact of FDI within a sector (Horizontal) and on upstream (Backward) and downstream sectors (Forward). In this paper we assume that customers are upstream and that intermediate producers are downstream. Hence, if we believe customers are putting pressure on firms to implement EAs then

[4] 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%. 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.

this is a backward linkage. If, on the other hand, suppliers are putting pressure on their consumers to introduce EAs then we define this as a forward linkage.

The variable $Horizontal_{jt}$ measures the presence of foreign-owned firms in a sector. More specifically,

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

where FF_{ijt} takes the value of 1 for foreign firms, these are defined as those firms whose foreign ownership is greater than 10%, and Y_{ijt} is a firm's output. 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 output and the number of foreign firms in the sector.

The variable *Forward* captures the presence of foreign firms in industries that supply the sector to which the firm *i* belongs. This variable allows us to assess whether firms and their foreign suppliers or subsidiaries act to influence the implementation of EAs. The indicator is constructed as follows:

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

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.[5]

Likewise, *Backward* captures backward linkages by measuring the presence of MNCs in the sectors that are being supplied by the sector to which the firm in question belongs. This variable allows us to capture the possible pressure exerted by larger MNCs or MNCs from developed countries who

[5] The 1997 Input-Output matrix can be found in the Argentinean National Institute of Statistics and Censuses.

might expect their suppliers to reach a certain level of good environmental management practice. The indicator takes the form,

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

where δ_{jk} is the proportion of sector *j*'s output supplied to sector *k* according with the I/O matrix.

In addition to our spillover variables we also include direct measures of a firm's contact with other sectors. Our networking indicators are dummy variables that capture the existence of firm *j's* formal relationships (i.e. cooperation agreements or 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) and customers (backward). The three variables are *NetSuppLocal* which captures forward networking at the local level, *NetCustLocal* which captures backward networking at the local level and *NetOtherLocal* which provides a measure of horizontal networking at the local level.

We also create a more sophisticated set of linkage variables by interacting *Horizontal*, *Forward* and *Backward* with the three networking variables. This captures the idea that firms need to have established relationships with other firms in order to benefit from and be able to absorb any foreign linkages. Put another way, firms that do not have a local network and are hence more insular in their outlooks are less likely to benefit from links with foreign firms.

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. [6]

[6] Absorptive capacity refers to a firm's ability to assimilate and apply new knowledge and hence we believe the proportion of skilled workers provides a good proxy for such capacity. In addition, Harris and Li (2008) provide a clear link between

Finally, to try to control for the inherent pollution intensity of certain industries we included a 'dirty' dummy equal to 1 for the industries typically most pollution intensive in the UK and US (Cole *et al.* 2005), namely Petroleum, Pulp, Paper and Paper Products, Chemicals, Non-Metallic Minerals, and Steel and Aluminium.

We now discuss the methodology adopted to examine the five areas of interest outlined below.

(i) The Adoption of EAs.

Our aim here is to identify the characteristics of firms that make them more likely to undertake some form of EA. Our dependent variable is calculated using firms' responses to survey question 501 below. We create a dummy variable = 1 if a firm undertakes any form of EA (i.e. if the firms says yes to Q. 501 (b) to (i)) and = 0 if a firm undertakes no form of EA (i.e. if the firm says yes to Q. 501 (a)).[7]

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

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a firm's export activities and its absorptive capacity.

[7] It may appear desirable to include firms' stated motives for adopting EAs as determinants of the decision to adopt an EA. However, such an approach would not be meaningful. The inclusion of such a motive as an explanatory variable would mean we would be asking whether firms who undertook an EA for a particular reason were more likely to adopt an EA than firms who didn't adopt an EA for that reason. Furthermore, motive data are only available for firms who do have some form of EA (i.e. for whom the dependent variable = 1).

(g). Developed environmentally friendly products
(h). Established internal or external recycling procedures
(i). Obtained any environmental certification

The odds, or likelihood, that a firm undertakes EA can be expressed as the ratio of the probability that EA 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;

$$\text{logit}\left[\Pr(EA)=1\right]=\log\left(\frac{\Pr}{1-\Pr}\right) \quad (1)$$

Our equation to be estimated is of the form;

$$\text{logit}\left[\Pr(EA)=1\right]=\alpha+\lambda FO+\beta' X+\phi' Z+\varepsilon_i \quad (2)$$

where FO is foreign ownership, X is a vector of network and linkage variables and Z is a vector of other firm characteristics. We report our coefficients in the form of odds ratios. [8]

(ii) The Types of EA Adopted.

We continue to use firms' responses to question 501 and try to identify whether the characteristics differ of firms who undertake different types of EA. For instance, are foreign owned firms more likely to obtain environmental certification than domestically owned firms? Are large firms more likely to develop environmentally friendly products? We utilise a logit estimation based upon equation (2) which we estimate for each type of EA individually.[9] The dependent variable is a

[8] The literature on productivity spillovers, where the dependent variable is a measure of total factor productivity, has been criticised for failing to account for endogeneity (Hanson 2005). More precisely, does FDI raise productivity or is FDI attracted to industries which contain the most productive firms? As previously mentioned, our explanatory variables are lagged in order to reduce such concerns. Furthermore it seems less likely that FDI would be attracted to industries merely because they contain firms who have undertaken EAs. That said, if FDI and EAs are both functions of the stringency of environmental regulations then the coefficients on horizontal linkages may be biased. However, Backward and Forward should be unaffected since they refer to foreign presence in other industries to the one which the firm resides.

[9] One way of modelling firms' choices of EA (as well as motives and obstacles, below) is using multinomial logit whereby the respondent's decision to choose one option over the other remaining options would be modelled. However, since each firm was able to choose more than one type of EA (or more than one motive or obstacle) such an approach is not

dummy =1 if that type of EA is adopted and 0 otherwise.

(iii) Reasons for the Adoption of EAs.

The richness of the dataset is illustrated by question 502, below, which asks those firms who have undertaken some form of EA to indicate their motives for doing so. Firms can select one of 7 motives including 'to improve the image of the firm', 'to meet the requirements of foreign markets' and 'to imitate competitors in local markets'. We therefore undertake a logit analysis, again based upon equation (2), in which we seek to identify the characteristics of those firms that selected each motive. We estimate each motive individually with the dependent variable taking the form of a dummy = 1 if a firm selected that motive and 0 otherwise.

Q. 502.

What was the motivation for undertaking any of the actions outlined in Q. 501?

(a). To improve the image of the firm
(b). To meet local environmental regulations
(c). To meet the requirements of local customers
(d). Merely acting in accordance with firm policy
(e). To meet the requirements of foreign markets
(f). To prepare for environmental certification
(h). To imitate competitors in the local market

(iv) Obstacles Limiting Access to Environmental Technology.

Finally, we draw upon survey question 503 to examine the characteristics of firms who faced obstacles hindering their access to environmental technology. Question 503 provides 7 different obstacles, including 'an absence of available technologies in local markets' and 'available technologies

possible.

are too costly'. We therefore seek to identify the characteristics of firms that experienced each obstacle to establish whether certain types of firms are more likely to experience certain types of obstacle. Our estimating equation is again based upon equation (2), which we estimate individually for each obstacle. The dependent variable is a dummy =1 if a firm claimed to have experienced that obstacle and 0 otherwise.

Q. 503.
What obstacles prevent access to environmentally clean technology?

(a). An absence of appropriate technologies in international markets
(b). An absence of appropriate technologies in local markets
(c). Available technologies are not compatible with the needs of the firm
(d). Available technologies are too costly
(e). Existing technologies are protected by patents or other intellectual property rights
(f). A lack of information about sources of appropriate technologies
(g). Other

We also estimate a count model where the dependent variable is a count of the 7 potential obstacles that a firm may face. The negative binomial model takes the form,

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

Where α is the degree of overdispersion i.e. the extent to which the variance is greater than the mean. When α is zero the negative binomial has the same distribution as Poisson. [10]

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

Equation (3) can then be estimated using a Maximum Likelihood estimator.

All estimations described above include sector dummies. Since our linkage variables are measured at the industry level we are mixing plant-level and industry-level variables and therefore cluster the standard errors using the Moulton Correction (Moulton 1990). Appendix 1 lists all of our independent variables, while Appendix 2 provides summary statistics.

Table 1 presents some summary data by two-digit industry for our sample of 1187 firms. In terms of the distribution of firms across sectors, we can see that our sample contains a large number of firms from SIC 15 (Food and Beverages) and to a lesser extent SIC 24 (Chemicals), and SIC 29 (Machinery and Equipment). Although we have no specific information on the pollution intensity of each sector in Argentina, in those countries for whom data exist the most pollution intensive sectors tend to be SIC 21 (Pulp and Paper), SIC 23 (Petroleum), SIC 24 (Chemicals), SIC 26 (Non-Metallic Minerals), and SIC 27 (Steel and Aluminium).[11] Table 1 indicates that these sectors have some of the highest rates of EA adoption. There appears to be no obvious link between industries' rates of EA adoption and the percentage of foreign owned firm within industries.

[Table 1 about here]

Figures 1 to 3 provide information relating to EA types, motivation and obstacles, respectively. In each figure we distinguish between foreign and domestically owned firms. Figure 1 indicates that the most common forms of EA are 'the treatment of residuals and effluent', 'measures to achieve the

[11] For more details see Cole *et al.* (2005).

efficiency of water, energy and other inputs', and 'recycling procedures'. In terms of the distinction between foreign and domestic firms, we notice first of all that domestically owned firms are considerably more likely to have no form of EA at all. For the various types of EAs we generally observe only a minor difference between foreign and domestic firms, although foreign firms are more likely to undertake recycling than domestic firms.

With regard to Figure 2, the most common motives for the adoption of EA are 'to improve the image of the firm', 'to meet local environmental regulations', 'acting in accordance with firm policy and to prepare for environmental certification'.[12] However, in the latter two cases we see that foreign firms are significantly more likely than domestic firms to hold such motives. There is generally little difference between foreign and domestic firms for the other four motives.

Figure 3 indicates clearly that the most commonly stated obstacle limiting access to environmental technology was the fact that 'available technologies were too expensive'. This is true for foreign and domestic firms. Other obstacles were cited by between 1 and 18% of firms. Interestingly, there is little difference between the obstacles faced by foreign firms and those faced by domestic firms.

[12] We are unable to attain data on the environmental performance of Argentinean firms (e.g. emissions) or on the environmental regulations that they face. However, local environmental regulations often appear to be strict, with some regulations borrowed from the US or the EU, 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.

Figure 1. Environmental Actions by Ownership Structure

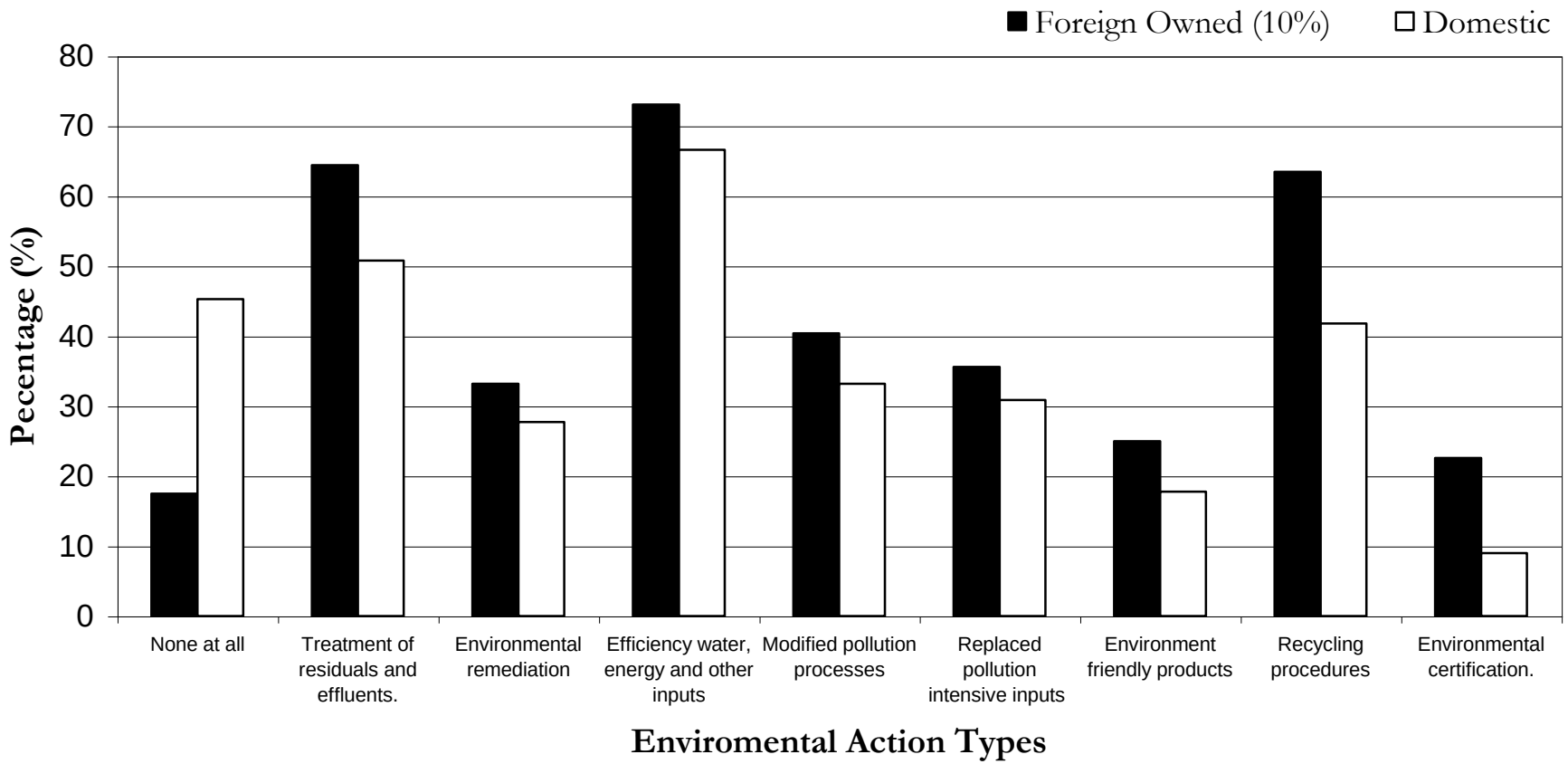


Figure 2. Motives by Ownership Structure

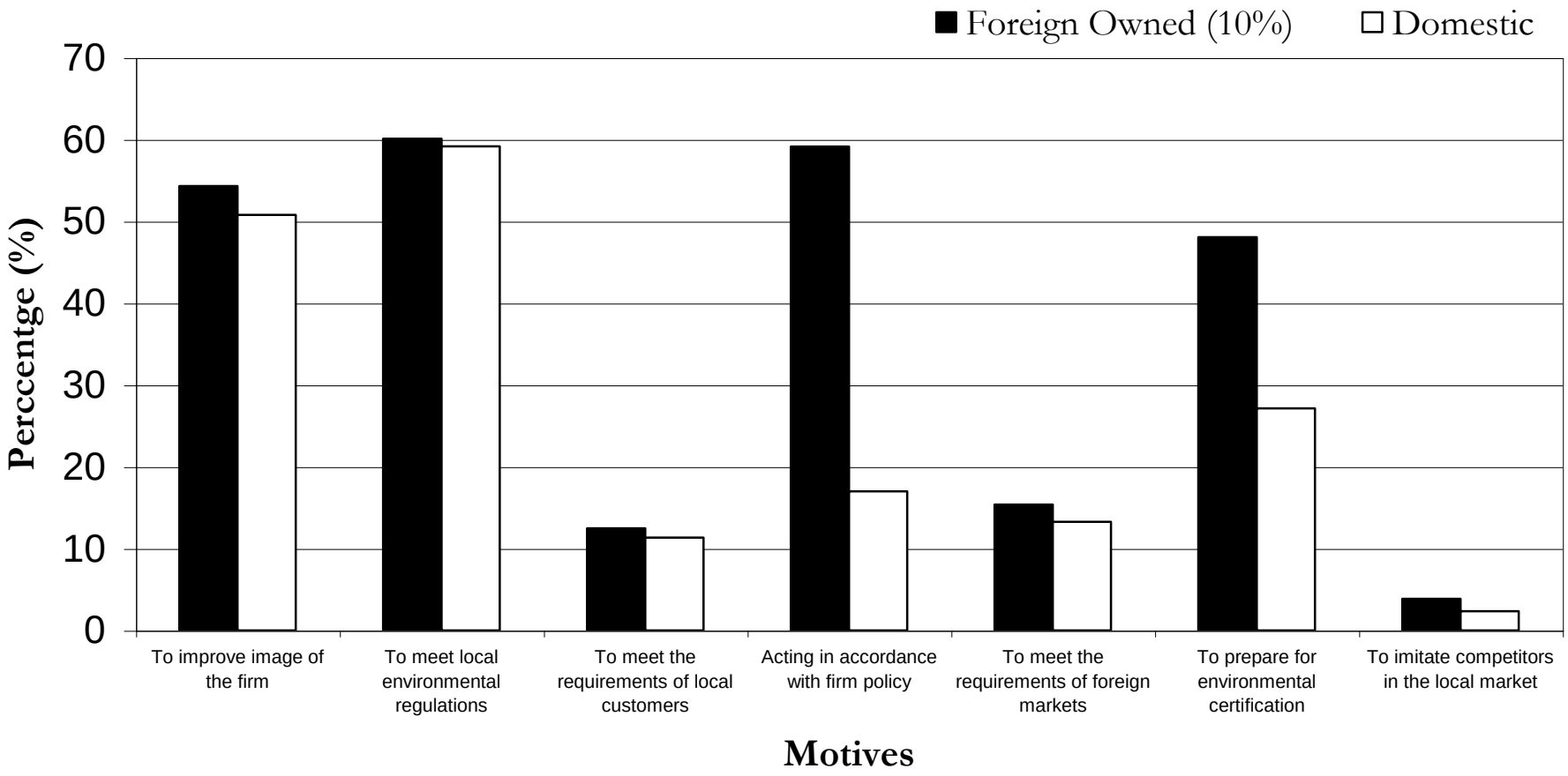
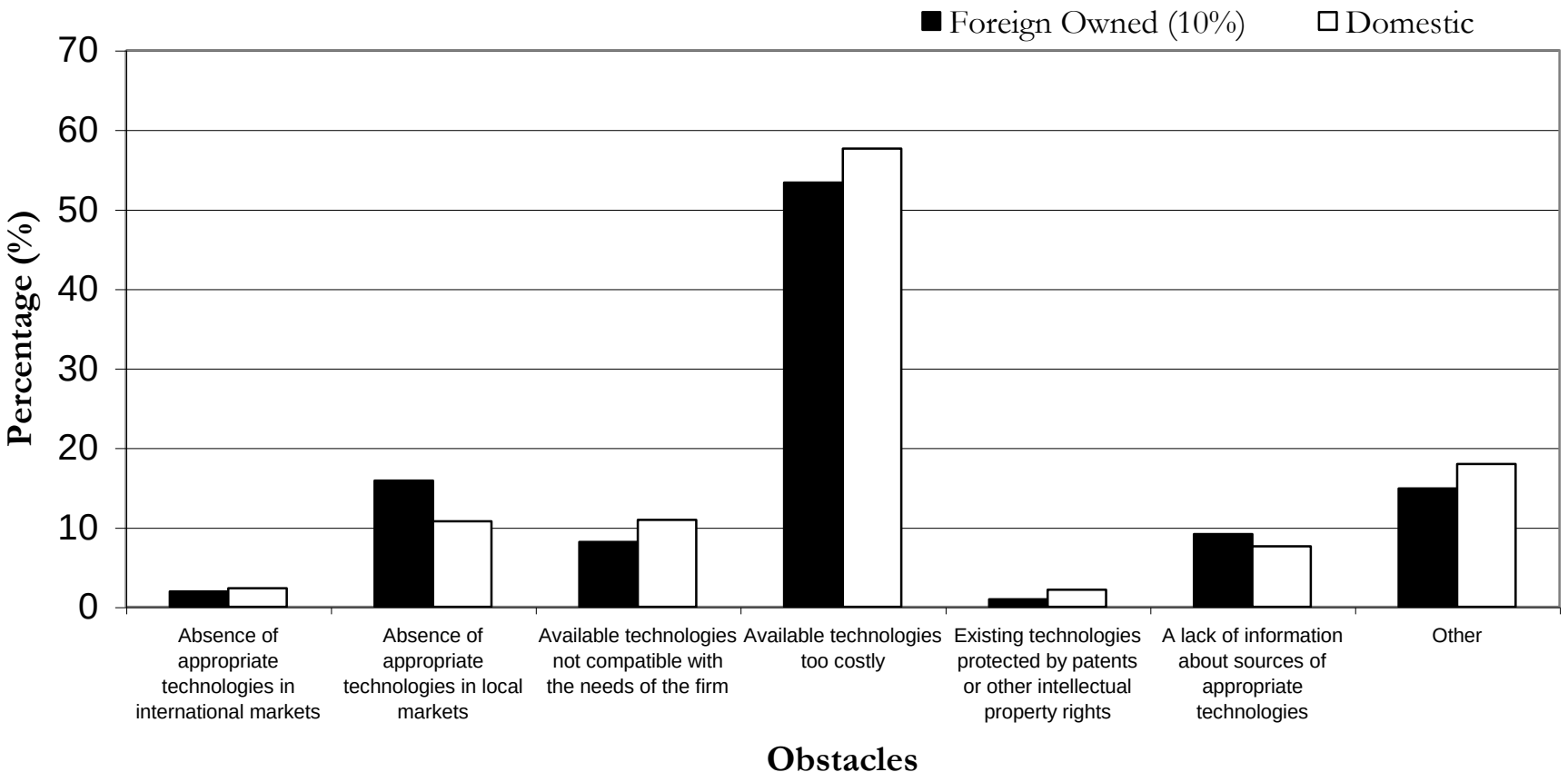


Figure 3. Obstacles by Ownership Structure



4. Results

Table 2 provide estimates of equation (2) where the dependent variable is a dummy variable equal to one if a firm undertakes any form of environmental management and zero otherwise. Columns (1) and (2) are estimated using all firms in the sample, columns (3) and (4) are estimated for only domestic firms and columns (5) and (6) only for foreign firms.

[Table 2 about here]

Focusing first on all firms, we see foreign ownership is a positive and statistically significant determinant of EA adoption. These results suggest that foreign owned firms are approximately 1.8 times more likely to have implemented EAs than domestic firms.

Turning to the other independent variables, and considering all 6 columns, we see that size and Size squared are significant across all specifications and have the expected odds ratio of greater than one and less than one, respectively. That is to say, EA implementation increases with size but at a decreasing rate. For all firms and domestic firms we find that sales growth and whether or not the firm exports are positive and significant determinants of EA adoption. Research and Development expenditure is a positive and significant determinant for all firms, domestic and foreign alike. Labour productivity, the skill level of the workforce and whether or not the firm is independent are either not significant at all or not consistently significant across models.

We turn now to our network and linkage variables. Firstly, we note that the individual linkage variables (*Backward, Forward* and *Horizontal*) are not statistically significant for all firms or domestic firms, but are significant for foreign firms in column (6). However, our absorptive capacity interaction terms yield more consistent results. For 'all firms' we find that 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 EAs the greater the percentage of skilled workers within their workforce. Column (2) partially supports this result by finding Backward linkages to be significant for firms who export. No such finding is made for Forward linkages. When we consider foreign and domestic firms separately, we find that Backward interacted with skilled labour is significant for foreign firms while Backward interacted with exports is significant for domestic firms. Again this indicates that absorptive capacity does increase the likelihood of a firm experiencing environmental spillovers from foreign firms and perhaps suggests that exports better proxies absorptive capacity for domestic firms while skilled labour is more effective for foreign firms.

In terms of the remaining linkage variables, for 'all firms' we find that Backward interacted with local customer networks (NetCustLocal) is positive and significant. This suggests that firms are more likely to implement EAs if they have both formal and informal links with their customers *and* if they supply customers in industries with a large proportion of foreign firms. For domestic firms, the odds ratios for these interaction terms are greater than one although they are not statistically significant. However, such interactions are significant for foreign firms suggesting that foreign firms may be influenced by the presence of other foreign firms, particularly if the firm is part of a network with local customers.

Finally, we note that being part of a network with other local firms does not, in itself, increase the likelihood of adopting EAs.

[Table 3 about here]

We now examine the factors that influence which types of EAs that firms adopt. Specifically, we identify the characteristics of those firms that adopt each type of EA, allowing us to assess, for example, whether foreign firms are more likely to undertake certain types of EA and whether linkages and networks influence the types of EAs adopted. The results are contained within Table 3.

[Table 3 about here]

Note that in order to present our results in a more manageable fashion we combine some of the management types to reduce the number from 8 down to 5. Referring to Q.501, we now merge EA types (e) and (f) into one ('replaced or modified pollution processes' and 'replaced inputs that are pollution intensive', denoted actionEF), we merge types (i) and (g) into one ('obtained any environmental certification' and 'developed environmentally friendly products', denoted actionIG) and we merge (b) and (c) into one ('used systems and equipment for the treatment of residuals and effluents' and 'taken actions for the purposes of environmental remediation', denoted actionBC). EA type (d) and EA type (h) are reported individually and referred to as actionD and actionH, respectively. Merging the EA types in this manner does not substantially change the results. [13] Note also that we include the various motives for the adoption of EA, as provided by firms' answers to Q.502, as independent variables. This allows us to see whether firms who undertake EAs for certain reasons are more likely to choose particular types of EA. Finally, given the large number of explanatory variables included in these estimates, and in order to conserve space, any variable that is not statistically significant for any of the 5 models in Table 3 has been omitted from the table.

Referring to Table 3, we can see that foreign owned firms are less likely than domestic firms to

replace or modify pollution processes/ replace inputs that are pollution intensive (actionEF). For the other EA types we see no statistical difference between domestic and foreign owned firms. Table 3 also reveals that large firms are more likely to adopt environmental certification/environmental friendly goods (actionIG), recycling (actionH) and the treatment of residuals/environmental remediation (actionBC). Similarly, exporters are more likely to replace or modify pollution processes/ replace inputs that are pollution intensive and improve the efficiency of the use of water, energy and other inputs.

We find a number of the network and linkage variables are statistically significant although odds ratios are often close to one, suggesting the magnitude of any such effects is reasonably small.[14] Finally, Table 3 also includes firms' motives for adopting EAs as explanatory variables. We can see, for instance, that firms who claimed to adopt EAs to improve the image of the firm, were more likely to implement actionEF, actionH and actionBC than firms who did not claim to hold such a motive. Similarly, firms who undertake EAs to meet local environmental regulations were more likely to adopt actionEF and action BC, both of which relate directly to pollution processes and residuals. Those most concerned about meeting their local customers' needs were more likely to improve the efficiency of the use of water, energy and other inputs (actionD), while those simply following firm policy were more likely to adopt all forms of EAs, except actionBC. An intuitive finding is that firms meeting the requirements of foreign markets were more likely to obtain environmental certification (actionIG), presumably since this is often required in order to enter OECD export markets. Finally, firms who undertake EAs to meet the requirements of such certification were more likely to undertake all forms of EA except actionD.

[13] Results for all individual EA types are available upon request.
[14] For reasons of space, when proxying absorptive capacity only linkages interacted with skilled labour are reported in Tables 3, 4 and 5. Results including interactions with exports are available upon request. Similarly, results splitting the sample into foreign and domestic firms are also available from the authors.

[Table 4 about here]

Table 4 now considers the reasons why firms adopt EAs and identifies whether firms with certain characteristics are more likely to hold certain motives for the adoption of EAs. The different motives are labelled with letters corresponding to Q. 502. Referring to Table 4, we firstly see that foreign owned firms are more likely than domestic firms to adopt EAs due to firm policy (motiveD) (presumably following orders from overseas headquarters) and to prepare for environmental certification (motiveF). Secondly, we find that large firms are more likely than small to adopt EAs to improve image (motiveA), to meet local environmental regulations (motiveB) (perhaps because such firms are more visible to environmental regulators) and to prepare for environmental certification (motiveF). This latter point is consistent with Table 3 which found large firms to be more likely than small to adopt environmental certification. Table 4 also indicates that independent firms are far less likely to adopt EAs because of firm policy (motiveD), to meet the requirements of foreign markets (motiveE), and to prepare for environmental certification (motiveF) but are far more likely to adopt EAs to imitate local competitors (motiveH). Reassuringly, we find that exporters are far more likely than non-exporters to adopt EAs to meet the requirements of foreign markets (motiveE). Exporters are also more likely to implement EAs in order to prepare for environmental certification (motiveF). We also find that firms with backward linkages and who are in networks with local customers are more likely to adopt EAs to imitate local competitors (motiveG). Similarly, skilled firms with backward and forward linkages are more likely to adopt EAs to prepare for environmental certification. [15]

[15] Again, for reasons of space we do not report the equivalent models to those in Table 4 with the sample split into foreign and domestic firms. These results provide few insights over and above those in Table 4, although we do find that domestically owned exporters are more likely to adopt EAs to meet the requirements of foreign markets than foreign owned exporters. One explanation for this would be that foreign owned firms have a greater awareness of the requirements of foreign markets and hence have already ensured that their EAs meets such requirements.

[Table 5 about here]

Table 5 identifies the characteristics of firms that claimed to face certain obstacles to environmental technology. The obstacles are labelled with letters corresponding to those in survey question 503. For reasons of space we do not report results for obstacleA and obstacleE. These obstacles were chosen for omission because the independent variables had the least statistical significance. Table 5 firstly examines 5 individual obstacles but then also considers an obstacle 'count' variable which simply sums the number of different obstacles faced by each firm.[16] This allows us to assess whether firms with certain characteristics tend to face a greater number of obstacles.

A number of observations can be made about the results in Table 5. Firstly, we find that foreign owned firms are more likely to experience a lack of appropriate technology in local markets (obstacleB) than domestic firms, suggesting that FO firms are less likely to know the local market and more likely to use sophisticated technology that is not available locally. Foreign owned firms are also less likely to find environmental technology to be too costly (obstacleD). For the other obstacles we find no statistical difference between foreign and domestic firms. Second, like foreign firms we also find that large firms are more likely to experience a lack of technology in local markets (obstacleB) but unlike foreign firms large firms are *more* likely to find environmental technology to be too costly (obstacleD). In contrast, large firms are less likely to suffer from a lack of information regarding environmental technology (obstacleF). Third, we find that exporters are more likely to complain of environmental technology being too costly (obstacleD), but less likely to suffer from a lack of information (obstacleF), perhaps because of their experiences in overseas markets. Regarding the obstacle count results in column (6), we see

that foreign ownership is negative but not significant. It is worth mentioning that the use of alternative measures of foreign ownership, such as a continuous measure or a 50% ownership measure, yields negative, statistically significant, coefficients. This provides weak evidence that foreign firms may face fewer obstacles. We also see that rapidly growing firms and those with high levels of investment tend to face a greater number of obstacles, while those with a skilled workforce face fewer obstacles. None of the network or linkage variables are significant.[17]

5. Sensitivity Analysis

In order to examine the robustness of our findings we have undertaken a wide range of sensitivity analyses. For reasons of space we are unable to report further results, but all are available upon request. In addition to establishing that our results are not unduly influenced by outliers (through the use of dfbetas), we also utilise alternative measures of our variables where available.[18] Thus, we have tested continuous measures of foreign ownership as well dummies based on 25% and 50% ownership thresholds. We have measured size as output rather than total employment and included continuous measures of R&D and exports rather than dummies. We also tested national and regional measures of our network variables rather than the local measures reported here. TFP, measured following Olley and Pakes (1996), replaced labour productivity, albeit for a much smaller sample. In terms of estimation methods, a probit model was used instead of logit estimations and Poisson estimations replaced the negative binomial models. In all of the above cases, our key findings were unaffected leading us to conclude that our results are robust.

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[16] Our count data are based on the full 7 obstacles, although using only 5 does not notably change the results.

[17] Estimating the models in Table 5 separately for foreign and domestic firms provides few new insights.

[18] Dfbetas focus on one coefficient and measure the difference between the regression coefficient when the *i*th observation is included and excluded, the difference being scaled by the estimated standard error of the coefficient. Bollen and Jackman (1990) argue that an observation is deserving of special attention if $|\text{dfbeta}| > 1$, implying that the observation shifted the estimated coefficient by at least one standard error. We find no dfbetas that exceed 1.

6. Conclusions

Using a dataset of Argentinean firms, this paper has undertaken a detailed examination of the factors that influence firm-level environmental practices. We find a number of important results. First, our results indicate that foreign firms are more likely to implement EAs than domestic firms, suggesting that foreign firms may be less environmentally damaging per unit of output than domestic firms. Second, we find some evidence of environmental spillovers. More precisely, firms are more likely to implement EAs if they have both formal and informal links with their customers *and* if they supply customers who are based in industries containing a large proportion of foreign firms. Furthermore, we also find evidence to suggest that absorptive capacity is important. The effect of foreign presence in increasing the likelihood of EA adoption is greater the greater the firm's absorptive capacity. Surprisingly, we also find strong evidence of spillovers from foreign firms to other foreign firms, again perhaps emphasising the role of absorptive capacity.

We also find that motives for undertaking EAs may differ between foreign and domestic firms. For instance, foreign firms are more likely than domestic firms to adopt EAs purely as a result of firm policy and in order to prepare for environmental certification. Similarly, the obstacles that prevent access to environmentally clean technology differ depending on ownership of the firm. Foreign owned firms are more likely to experience a lack of appropriate technologies in local markets, perhaps because they are less likely to know the local market and more likely to use sophisticated technology that is not available locally. In addition, foreign firms are less likely to find environmental technology to be too expensive. It is also worth emphasising the strong result provided by Figure 3. By some distance the most commonly stated obstacle preventing access to environmental technology is cost. A recent US-EU proposal to reduce trade barriers

on environmental goods and services, particularly clean energy technologies, may therefore be much needed.

Whatever the reasons for the adoption of EAs, or the obstacles faced in the process, the greater likelihood of foreign firms to undertake EAs suggests that foreign investment in developing countries may be less damaging to the environment than might have been expected. However, if the output of foreign firms is in addition to that of domestic firms, rather than at the expense of domestic output, then foreign investment is still likely to result in a net increase in pollution and resource use. Furthermore, our results do not preclude the possibility that foreign affiliates in LDCs are still more pollution intensive than those in developed countries and hence may be taking advantage of lax or poorly enforced regulations.

An obvious deficiency of our dataset is the lack of a time-series dimension. In future research we hope to be able to re-examine these issues using panel data, either for Argentina or for another country at a similar stage of development. An additional direction for future research is to examine the role played by exporters. Throughout our results we find a firm's decision to export or not to be a key determinant of the EA process. For instance, exporters are more likely to adopt EAs and appear to adopt EAs for different reasons to non-exporters, for instance to meet the requirements of foreign markets or to prepare for environmental certification. In future research we hope to investigate this interesting facet of our results. Furthermore, if exporters are considered to be successful, competitive, firms we would like to examine whether environmental spillovers pass from exporters to other firms.

Appendix 1:

Our independent variables are as follows:

FO10 – A dummy variable that is 1 if the firm is more than ten-percent foreign owned.

Size – measured as the total number of workers. We also include SIZE squared.

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

Perskilled – percentage of worker force that are technical workers.

Invsales – investment expenditure as a percentage of sales.

Backward – to capture backward linkages measured at the 2-digit industry level.

Forward – to capture forward linkages measured at the 2-digit industry level.

Horizontal – to capture horizontal linkages measured at the 2-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.

BackNetCust – interaction term to capture whether backward linkages only work if the firm has close contact with customers.

ForwNetSupp - interaction term to capture whether forward linkages only work if the firm has close contact with suppliers.

HorizNetOther - interaction term to capture whether horizontal linkages only work if the firm has close contact with the other firms in its sector.

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).

Appendix 2:

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	3.191
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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Table 1: Summary statistics

2 Digit SIC	Industry	No. of Firms	% of Firms with EAs	% 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.

Table 2. Determinants of Environmental Actions

	(1)	(2)	(3)	(4)	(5)	(6)
	All Firms		Domestic Firms		Foreign Firms	
FO10	1.799***	1.882***				
	(4.2)	(4.0)				
Size	1.230***	1.233***	1.222***	1.218***	1.315*	1.377*
	(3.6)	(3.5)	(2.8)	(2.7)	(1.8)	(1.8)
Size2	0.997***	0.997***	0.997**	0.997**	0.996	0.995
	(2.9)	(2.8)	(2.2)	(2.1)	(1.5)	(1.6)
Independent	0.804	0.785	0.736	0.722	1.071	1.144
	(1.2)	(1.2)	(1.5)	(1.5)	(0.2)	(0.3)
Salesgr	1.017***	1.016***	1.014**	1.013**	1.028	1.029
	(3.0)	(2.8)	(2.3)	(2.1)	(0.9)	(0.8)
Labprod	1.070	1.078	1.051	1.031	0.912	0.967
	(0.4)	(0.5)	(0.3)	(0.2)	(0.1)	(0.1)
dExport	1.295*	2.023***	1.290*	2.344***	1.427	3.326
	(1.8)	(2.7)	(1.7)	(3.0)	(0.9)	(1.2)
dRD	2.186***	2.189***	2.242***	2.226***	2.196***	2.227***
	(4.6)	(4.7)	(4.5)	(4.6)	(2.9)	(3.0)
Perskilled	0.995	1.006**	0.997	1.005*	0.988	1.015*
	(1.0)	(2.0)	(0.7)	(1.7)	(0.6)	(1.9)
Invsales	1.036	0.988	0.982	0.921	1.356	1.684
	(0.1)	(0.0)	(0.1)	(0.2)	(0.1)	(0.2)
Backward	0.999	1.007	0.999	1.000	0.996	1.060*
	(0.1)	(0.5)	(0.1)	(0.0)	(0.2)	(1.9)
Forward	0.976	1.042	0.960	0.999	1.072	1.340***
	(0.6)	(0.9)	(1.0)	(0.0)	(0.7)	(3.8)
Horizontal	1.005	1.001	1.011	1.012	0.976	0.950
	(0.4)	(0.0)	(0.8)	(0.7)	(1.1)	(0.9)
Back*skilled	1.001		1.000		1.001*	
	(1.7)*		(1.2)		(1.7)	
For*skilled	1.002**		1.001		1.002	
	(2.1)		(1.2)		(0.8)	
Horiz*skilled	1.000		1.000		1.000	
	(1.3)		(0.7)		(0.2)	
Back*export		1.025*		1.035**		0.959
		(1.8)		(2.4)		(1.1)
For*export		0.964		0.968		0.814
		(1.0)		(0.8)		(1.0)
Horiz*export		0.993		0.985		1.041
		(0.5)		(1.1)		(1.4)
NetSuppLocal	1.324	1.169	1.432	1.221	0.378	0.420
	(0.6)	(0.4)	(0.8)	(0.4)	(0.8)	(0.7)
NetCustLocal	0.662	0.683	0.774	0.787	0.300	0.324
	(1.0)	(1.4)	(1.2)	(1.1)	(1.4)	(1.3)
NetOtherLocal	0.918	0.975	0.748	0.855	0.982	1.031
	(0.1)	(0.0)	(0.4)	(0.2)	(0.0)	(0.0)
Back*NetCust	1.023**	1.026**	1.014	1.018	1.072***	1.078***
	(2.5)	(2.6)	(1.2)	(1.3)	(2.6)	(2.6)
Forw*NetSupp	1.030	1.040	1.027	1.044	1.133	1.136
	(0.9)	(1.1)	(0.8)	(1.2)	(1.2)	(1.1)
Horiz*NetOther	1.001	0.999	1.006	1.002	0.990	0.986
	(0.1)	(0.1)	(0.4)	(0.1)	(0.5)	(0.6)
Observations	1187	1187	935	935	252	252

Robust z-statistics in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%

The dependent variable is a dummy variable capturing whether or not firms undertake any form of EAs. The coefficients are reported in the form of odds ratios.

Table 3. The Characteristics of Firms for Each EA Type (Dep. Var. is EM type yes/no).

	(1) actionEF	(2) actionIG	(3) actionH	(4) actionBC	(5) actionD
FO10	0.627**	0.863	1.116	0.881	0.684
	(2.5)	(0.7)	(0.3)	(0.4)	(1.3)
Size	1.033	1.123***	1.041*	1.294***	1.023
	(0.8)	(2.7)	(1.8)	(4.2)	(0.6)
Size2	0.999	0.998*	0.999	0.996***	1.000
	(0.8)	(1.8)	(1.0)	(4.1)	(0.6)
Salesgr	0.996**	1.001	0.998	1.000	1.000
	(2.1)	(1.4)	(1.5)	(1.0)	(0.9)
Labprod	0.953	1.039	1.689**	8.780**	1.369
	(0.1)	(0.1)	(2.1)	(2.4)	(0.8)
dExport	1.560***	1.105	1.114	1.057	1.518**
	(3.0)	(0.5)	(0.5)	(0.3)	(2.5)
dRD	0.781*	0.861	1.173	1.049	1.101
	(1.8)	(0.5)	(0.7)	(0.3)	(0.5)
Invsales	0.403**	0.642	1.220	1.914	2.089
	(2.0)	(0.7)	(0.4)	(0.8)	(1.0)
Backward	0.999	1.018	1.007	0.927**	0.992
	(0.1)	(0.8)	(0.5)	(2.4)	(0.5)
Forward	1.060**	0.933	1.066	0.912	1.104
	(2.0)	(1.2)	(1.2)	(1.0)	(1.5)
Horizontal	0.981**	1.007	0.973	1.045*	0.994
	(2.2)	(0.5)	(1.6)	(1.8)	(0.3)
Back*skilled	1.000	1.000	1.000	1.002***	1.000
	(0.7)	(1.1)	(0.6)	(2.8)	(1.4)
Horiz*skilled	1.000	1.000	1.001*	0.999**	1.000
	(0.6)	(0.1)	(1.8)	(2.2)	(0.7)
NetSuppLocal	0.806	0.996	1.475	0.630*	1.533
	(0.8)	(0.0)	(0.7)	(1.7)	(1.5)
NetOtherLocal	5.681**	0.274	0.192*	1.020	0.602
	(2.2)	(1.3)	(1.9)	(0.0)	(1.1)
Forw*NetSupp	1.026	1.019	0.951	0.992	0.960**
	(1.4)	(0.9)	(1.4)	(0.5)	(2.0)
Horiz*NetOther	0.971**	1.021	1.029*	1.001	1.018*
	(2.2)	(1.1)	(1.9)	(0.0)	(1.9)
Improve firm image	2.713***	1.171	1.838***	2.139***	1.451*
	(5.6)	(0.7)	(3.4)	(4.1)	(1.9)
Meet env regs	1.935***	0.816	1.418	3.697***	1.097
	(5.0)	(1.3)	(1.4)	(6.6)	(0.5)
Local customers	1.816	1.445	1.456*	0.832	2.544**
	(1.6)	(1.3)	(1.7)	(0.8)	(2.5)
Firm policy	2.382***	1.545**	2.653***	1.296	2.458***
	(3.6)	(2.5)	(5.7)	(0.6)	(3.1)
Foreign markets	1.319	2.939***	1.035	1.494	1.043
	(0.9)	(3.0)	(0.2)	(1.3)	(0.2)
Environmental certification	1.552***	4.036***	2.154***	1.860***	1.381
	(2.7)	(6.7)	(2.8)	(2.8)	(1.1)
Observations	719	719	719	719	719

Robust z-statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: where actionEF refers to 'Replacing or modifying pollution processes' or 'replacing inputs that are pollution intensive'; actionIG refers to 'obtaining environmental certification' or 'developing environmentally friendly products'; actionH refers to 'establishing internal or external recycling procedures'; actionBC refers to the 'use of systems and equipment for the treatment of residuals and effluents' or 'actions for the purpose of environmental remediation' and actionD refers to improving 'efficiency of the use of water, energy and other inputs'.

Table 4. Motives for EA (dep. var. is motive yes/no)

	(1) motiveA	(2) motiveB	(3) motiveC	(4) motiveD	(5) motiveE	(6) motiveF	(7) motiveG
FO10	0.798	0.905	1.035	3.459***	0.641	1.336*	2.947
	(0.7)	(0.5)	(0.1)	(3.4)	(1.5)	(1.9)	(1.3)
Size	1.080*	1.084**	1.054	1.051	1.046	1.073***	1.391
	(2.0)	(2.3)	(0.7)	(1.0)	(0.9)	(3.3)	(0.9)
Size2	0.998**	0.999**	0.999	0.999	0.999	0.999*	0.905**
	(2.1)	(2.5)	(0.7)	(0.5)	(0.8)	(1.9)	(2.1)
Independent	0.890	1.038	1.013	0.403***	0.611***	0.702**	3.174**
	(0.6)	(0.2)	(0.0)	(4.8)	(2.7)	(2.0)	(2.1)
Salesgr	1.000	1.001*	1.001**	0.996***	0.999**	0.999	0.985
	(0.6)	(1.8)	(2.2)	(4.3)	(2.2)	(1.6)	(0.8)
Labprod	1.012	0.852	0.687	5.944***	1.390	3.341***	1.209
	(0.0)	(0.7)	(0.8)	(4.3)	(1.4)	(4.0)	(0.3)
dExport	1.101	1.143	1.027	1.179	2.864***	1.504*	0.662
	(0.6)	(0.6)	(0.1)	(0.8)	(2.9)	(1.8)	(0.6)
Invsales	0.640	0.678	0.394	4.062*	0.634	3.751***	1.737
	(1.1)	(0.6)	(0.9)	(1.7)	(1.1)	(2.8)	(0.5)
Backward	0.993	0.966**	1.032	0.985	0.994	0.984	1.044*
	(0.4)	(2.1)	(1.0)	(0.6)	(0.4)	(1.6)	(1.8)
Forward	0.951	0.901*	1.176***	0.973	0.962	1.004	0.909
	(0.9)	(1.8)	(2.6)	(0.4)	(0.8)	(0.1)	(1.1)
Horizontal	1.038*	1.042**	0.982	1.017	1.019	1.013	1.029
	(1.8)	(2.1)	(0.9)	(1.1)	(1.6)	(1.0)	(1.1)
Back*skilled	1.000*	1.001	0.999**	1.001	1.001	1.001***	1.000
	(1.8)	(1.5)	(2.2)	(1.4)	(1.3)	(2.8)	(0.1)
For*skilled	1.001	1.000	0.998	1.002**	1.002*	1.002*	1.004*
	(1.6)	(0.4)	(1.3)	(2.0)	(1.7)	(1.9)	(1.7)
Horiz*skilled	0.999**	1.000	1.001	1.000	0.999	0.999**	0.999*
	(2.1)	(1.3)	(1.3)	(0.9)	(1.6)	(2.3)	(1.6)
NetCustLocal	1.223	0.802	1.769	2.646***	0.794	1.641	4.413**
	(1.1)	(0.6)	(1.4)	(2.6)	(0.4)	(1.4)	(2.5)
NetOtherLocal	0.348*	0.658	2.162	1.059	1.939	0.965	1.507
	(1.9)	(0.9)	(0.9)	(0.1)	(0.7)	(0.1)	(0.5)
Back*NetCust	0.979*	1.024	1.025	0.972*	1.026	0.979	0.982
	(1.9)	(1.1)	(1.1)	(1.9)	(0.9)	(1.5)	(1.0)
Forw*NetSupp	0.972**	1.009	1.002	0.960	1.031	1.017	0.980
	(2.1)	(0.3)	(0.1)	(1.5)	(1.0)	(0.9)	(0.4)
Observations	719	719	719	719	719	719	719

Robust z-statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: where motiveA refers to 'improving the image of the firm'; motiveB refers to 'meeting local environmental regulations'; motiveC refers to 'meeting the requirements of local customers'; motiveD refers to 'acting in accordance with firm policy'; motiveE refers to 'meeting the requirements of foreign markets'; motiveF refers to 'preparing for environmental certification' and motiveG refers to 'imitating competitors in the local market'.

Table 5. Obstacles to Environmental Technology (dep. var. is obstacle yes/no, or obstacle count in column 6)

	(1) obstacleB	(2) obstacleC	(3) obstacleD	(4) obstacleF	(5) obstacleG	(6) Count
FO10	1.572*	0.860	0.775*	1.305	0.829	-0.079
	(1.6)	(1.0)	(1.7)	(1.2)	(1.4)	(1.4)
Size	1.094**	1.020	1.056*	0.929**	0.954	0.014*
	(2.3)	(0.4)	(1.8)	(2.0)	(1.5)	(1.7)
Size2	0.999	0.999	1.000	1.001*	1.000	-0.000
	(1.1)	(0.8)	(0.4)	(1.8)	(0.0)	(0.8)
Independent	1.056	1.678**	0.999	1.341	0.647***	-0.035
	(0.2)	(2.1)	(0.0)	(1.1)	(2.8)	(0.7)
Salesgr	0.994	1.001*	1.001**	0.972**	0.999	0.000***
	(1.3)	(1.8)	(2.3)	(2.0)	(1.2)	(5.8)
Labprod	0.830	1.505*	0.910	0.794	0.911	0.013
	(0.8)	(1.8)	(0.5)	(0.2)	(0.5)	(0.2)
dExport	1.041	0.905	1.217*	0.758*	1.243	0.043
	(0.2)	(0.7)	(1.7)	(1.7)	(1.2)	(1.1)
Perskilled	0.974***	1.000	0.996	0.992	1.006	-0.002*
	(4.3)	(0.0)	(1.1)	(1.2)	(1.2)	(1.7)
Invsales	0.926	2.294*	2.240**	1.171	0.748	0.181***
	(0.1)	(1.8)	(2.1)	(0.5)	(0.6)	(6.5)
Forward	0.870**	1.001	1.016	0.958	1.028	-0.002
	(2.3)	(0.0)	(0.4)	(1.1)	(0.6)	(0.2)
Back*skilled	1.000	1.000	1.000*	1.000	1.000	-0.000
	(0.5)	(0.6)	(1.9)	(0.1)	(0.3)	(1.1)
For*skilled	1.002***	1.001	1.000	1.000	0.998**	-0.000
	(2.7)	(0.9)	(0.6)	(0.3)	(2.6)	(0.4)
NetSuppLocal	0.556	1.763	1.510	2.309**	0.431**	0.027
	(1.1)	(1.3)	(1.5)	(2.0)	(2.2)	(0.4)
NetCustLocal	1.914	0.878	0.820	0.919	1.651*	0.105
	(1.6)	(0.6)	(0.8)	(0.3)	(2.0)	(1.6)
NetOtherLocal	1.415	0.070***	0.900	0.977	1.251	-0.131
	(0.6)	(2.7)	(0.2)	(0.0)	(0.3)	(1.2)
Back*NetCust	1.004	1.034	1.024**	0.948	0.992	0.003
	(0.2)	(1.6)	(2.0)	(1.6)	(0.5)	(1.0)
Forw*NetSupp	1.002	0.959	0.991	0.965	1.054**	-0.000
	(0.1)	(1.2)	(0.4)	(1.0)	(2.0)	(0.1)
Horiz*NetOther	0.984*	1.035**	0.997	1.011	0.996	0.000
	(1.7)	(2.5)	(0.3)	(0.8)	(0.3)	(0.2)
Observations	1179	1179	1179	1179	1179	1179

Robust z-statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: obstacleB refers to 'an absence of appropriate technologies in local markets'; obstacleC refers to 'available technologies are not compatible with the needs of the firm'; obstacleD refers to 'available technologies are too costly'; obstacleF refers to a lack of information about sources of appropriate technologies' and obstacleG refers to 'other' obstacles. The dependent variable in column (6) is a count of the 8 potential obstacles faced by each firm.