From green investment strategies to internationalization: a firm-level investigation

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Abstract

In this paper we empirically investigate the relationship between investments in environment-oriented equipment and firm internationalization entry choices. Drawing on the Porter hypothesis and on the firm heterogeneity theory, we adopt a structural model where we first estimate the impact of green investment strategies on the level of productive efficiency (TFP). Subsequently, we assess if induced productivity influences the likelihood to engage in internationalization activities, first through exports and then through FDI or offshoring. Relying on a rich firm-level dataset on Italian manufacturing, our results show that firms increase their commitment to internationalization when their higher productivity is induced, among other factors, by a green investment strategy that integrates environmental protection with the reduction in the use of raw materials. In so doing, we provide a 'green investment-based' explanation for the link between TFP-heterogeneity and trade.

JEL Codes: Q55; Q56; F14; F18; F23

Keywords: Green investment strategy; Firm heterogeneity; TFP; Export; FDI

Acknowledgements

This work has been funded by the National Research Project PRIN-MIUR 2010-11 "Climate changes in the Mediterranean area: evolutionary scenarios, mitigation policies and technological innovation". We thank Roberto Zoboli, Giuseppe Vittucci Marzetti, Giovanni Marin and Claudia Ghisetti for useful comments. All the usual disclaimer applies.

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1. Introduction

The debate on the effect of environmental protection on economic performance has flourished in the last decades. Contrary to the traditional wisdom that environmental goals are not compatible with the sake of fostering competitiveness, another strand of literature has developed on the idea that economic and environmental performance can go hand in hand (Porter, 1991; Porter and van der Linde, 1995). In this perspective, which can be referred to the so called Porter Hypothesis (PH), the trade-off between social benefit and private costs is challenged. The idea according to which environmental protection represents a burden to industry is reconsidered. Focusing in particular on environmental regulation, Porter and van der Linde (1995) claim that: "properly designed environmental standards can trigger innovation that may partially or more than fully offset the cost of complying with them" (p. 98). Further contributions have provided finer definitions of the PH (strong, weak, narrow and narrowly-strong), considering the possible relations between regulation, innovation and competitiveness (e.g. Jaffe and Palmer, 1997 and Costantini and Mazzanti, 2012).

Within the PH framework, the relation between environmental regulation, and protection, and economic competitiveness has been investigated in several empirical studies (for a review see Iraldo et al., 2011). Without reaching unambiguous results, different types of effect have been considered: among these, the impact on productivity and internationalization. With respect to productivity, both earlier (see the review by Jaffe et al., 1995) and more recent analyses (Gray and Shadbegian, 2003; Shadbegian and Gray, 2005; Broberg et al., 2010) point to modest, non-significant or even negative effects of environmental regulation, while a fair amount of other recent studies finds support, at least partially, for the PH. This support spans over different industries and geographical contexts, like: oil refineries in U.S. (Berman and Bui, 2001); Mexican food processing industry (Alpay et al., 2002); offshore oil and gas industry in the Gulf of Mexico (Managi et al., 2005); heavily polluting manufacturing sectors in Japan (Hamamoto, 2006); manufacturing sectors in Quebec (Lanoie et al., 2006) and in Taiwan (Yang et al., 2012).

The relation between environmental regulation and internationalization has been tested by a smaller amount of contribution, which considers export activities only.[1] Evidence of a positive effect of environmental protection on exporting activities has come from: the analysis of export dynamics of EU15 countries (Costantini and Mazzanti, 2012), the export flows, from 21 OECD countries, of technologies for the energy sector (Costantini and Crespi, 2008), the export performance of U.S. environmental products manufacturers (Becker and Shadbegian, 2008).

Despite the increasing amount of empirical evidence, we believe that the literature on the PH is still affected by two gaps. The first, and more general, is that all the attention lies on the economic effects of environmental regulations,[2] without considering that environmental investments may be driven by a broader set of factors, [3] like the willingness to enter specific markets, to differentiate products, and even to sell environmental technology developed in-house (e.g. for pollution control). In addition, environmental investment can reduce the cost related to: litigations, fines and the risk associated to relations with external stakeholders which press companies to reduce their negative impact on the environment (like government, NGOs, bankers, media, ecological groups and association, trade unions and so on), the use of material and energy, to the use of capital assets (e.g. by easing the access to green or ethical mutual funds), and labor inputs (e.g. by enhancing loyalty and commitment) (Ambec and Lanoie, 2008; Portney, 2008).

In this paper, we do not look at the effect of the environmental regulation, but we consider the economic impact of *green investment strategies* (GIS), specifically targeted at reducing the environmental impact of production. We start from the idea that GIS should not be seen as isolated from other business and production strategies, but they are part of the whole investment portfolio of the firm

[1] Some works focus also on the relation between environmental regulation and FDI. However, these studies only test whether laxer environmental regulations attract inward FDI, i.e. what is called 'pollution heaven hypothesis' (List and Co, 2000; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; He, 2006).

[2] With some exceptions (Hamamoto, 2006; Managi et al., 2005), PH-related studies largely use pollution abatement capital investment or operating costs as a proxy for environmental regulation strategies.

[3] Martin-Tapia et al. (2010), for instance, identify the importance of proactive environmental strategies, which reduce environmental impact, while simultaneously enhancing the firm's competitiveness. Similarly, Eiadat et al. (2008) recognize that perceived stakeholder pressures and managerial environmental concerns, in addition to environmental regulation, may influence the firm environmental innovation strategy and, in turn, its business performance.

(Porter and van der Linde, 1995), where they are linked to investments in other manufacturing technologies (Klassen, 2000).

The second gap we try to fill is the lack in the literature of a clear microeconomic foundation for the relationship between environmental protection and firm international competitiveness. In this respect, we study if investing in new capital assets targeted at reducing the environmental impact of production helps firms to increase their engagement into internationalization, first through exports and then adding production relocation activities in foreign countries through foreign direct investment (FDI) strategies or international outsourcing (i.e. offshoring). Our main point here is that this relationship cannot be studied, and theoretically motivated, by estimating reduced-form models. Rather, we posit that GIS indirectly influence firm internationalization entry choices, by first improving its level of technical efficiency. This assertion asks for a structural modeling approach in investigating the contribution of GIS on firm productivity, and then of firm productivity on internationalization entry modes.

For supporting this hypothesis, we borrow some key elements from the "firm heterogeneity" theory (Bernard and Jensen, 1999, 2004; Melitz, 2003; Bernard et al., 2007; Melitz and Ottaviano, 2008). Its key prediction is that firms with different levels of productivity (TFP) – the main source of firm heterogeneity – will generally engage in different modes of internationalization depending on the different levels of the sunk costs involved in the acquisition of information on foreign markets, establishment of distribution channels, and so on. According to this prediction, multinationals would be expected to outperform exporting firms, which, in turn, would be expected to outperform domestic firms. However, the sources of these productivity *premia* are generally not explained, so that firm heterogeneity is the result of a random draw (Castellani and Zanfei, 2007; Castellani and Giovannetti, 2010). If no account is taken of the drivers of firms' heterogeneity, it is not possible to understand why firms differ. Recently, few papers have tried to shed some light on the sources of firm heterogeneity and attempt to identify the drivers of different modes of internationalization. These studies show that international firms are more innovative (Costantini and Melitz, 2008; Atkeson and Burnstein, 2010; Bustos, 2011; Burnstein and Melitz, 2013), adopt superior organizational and managerial practices (Bloom and van Reenen, 2007), benefit from better market access (Lileeva and Trefler, 2010), product

diversification (Bernard et al., 2011) or agglomeration economies (Antonietti and Cainelli, 2011; Rodriguez-Pose et al., 2013).

In this paper, we argue that, among other factors like R&D and human capital, environment-oriented investments are a source of firm heterogeneity. As such, they indirectly impact the internationalization choice of firms by first affecting their level of productivity. Once controlled for confounding factors, we do expect that firms targeting fixed investments to the mitigation of the environmental impact of production show a higher level of technical efficiency (i.e. through their impact on TFP) and, for this reason, become more internationally competitive, by cumulating exporting and production relocation activities.[4]

The reminder of the paper is organized as follows. Section 2 describes the econometric model. Section 3 presents the dataset. Section 4 discusses the estimation results. Section 5 concludes and proposes some policy implications.

2. Empirical methodology

Our structural model is based on two equations. The first concerns the relationship between GIS (i.e. investment in equipment and machinery targeted at reducing the environmental impact of production) and the level of productive efficiency, measured by TFP. In this equation, we also control for potential endogeneity, by separately using local CO_2 emissions and subsidies/tax reliefs as instruments. Subsequently, we use the predictions from this equation for modeling the incidence of induced TFP on the internationalization choice of the firm. In this way we test for both the direct and the indirect impact that GIS adoption have on the international competitiveness of firms. In particular, we investigate whether a strategy aimed at reducing the environmental impact of production is *per se* sufficient for influencing the internationalization entry choice of firms, or whether a mixed investment strategy is better suited for this purpose, where environmental objectives are tied to other types of objectives like,

[4] The cumulative, rather than substitutive, nature of exports and FDI/offshoring is not only confirmed by our data (where only 2 firms are engaged in FDI/offshoring without exporting), but is stressed by the international business literature (Johansson and Vahlne, 1977; Brouthers et al., 2008) and by the literature on real option theory and exports dynamics s (Rob and Vettas, 2003; Albornoz et al., 2012; Conconi et al. 2013), according to which uncertainty leads firms to follow a gradual internationalization process.

for instance, product quality improvement, reduction in the use of raw materials or reduction in the use of labor inputs.

Figure 1 provides a graphical representation of our model, which borrows some elements from the so called ‘Green CDM model’ (Crépon et al., 1998; Marin, 2012; van Leeuween and Mohnen, 2013). The upper part describes the relationship between GIS and productivity (TFP). The latter is calculated as a residual from a production function with capital and labor as main inputs, and is estimated including other traditional variables, like R&D and human capital. The second block illustrates the relationship between productivity (i.e. TFP-heterogeneity) and internationalization entry modes. The underlying idea is that GIS do not *directly* affect the decision to commit into internationalization activities, as in the recent literature on environment and trade (e.g. Martin-Tapìa et al., 2010; Costantini and Mazzanti, 2012; Elliot and Zhou, 2013). Rather, we maintain that this effect is indirect, and passes through the first-stage effect of GIS on TFP. In this way, we propose a ‘green investment-based' explanation of the link between firm heterogeneity and international competitiveness, which better explain why more ‘environment-friendly’ firms should also be more willing to export or relocate production abroad.

[FIGURE 1 around here]

2.1. The productivity equation

As a first step in our structural model we assess the relationship between GIS and productivity. We start estimating a Cobb Douglas production function using labor and capital as inputs. The TFP is then computed as the residual (*a*) from equation 1, where *y* is the log of value added (deflated by two-digit price index), *l* is labor cost (deflated by a wage index) and *k* is net tangible assets (deflated by a capital price index). In order to reduce the simultaneity bias between inputs and output, TFP is estimated using the semi-parametric method provided by Levinsohn and Petrin (2003), where raw materials and the cost for services (all deflated by proper price indexes) are used as instruments:

(1) $y_{it} = a_{it} + \beta_L l_{it} + \beta_K k_{it} + u_{it}$.

Since the level of TFP cannot be measured in any meaningful units, we compute firm-specific TFP as averages of exponential transformations of $\hat{a}_{it}$ divided by industry means. Then, these scaled values are log-transformed. Hereafter, our TFP measures will refer to relative measures of how form-specific TFPs differ from industry means during the year considered.

Subsequently, the term *a* is regressed on two vectors of variables that are supposed to influence firm's efficiency by simultaneously raising the marginal productivity of labor and capital, as in equation 2:

$$(2)\quad a_{it} = \gamma_Z \mathbf{Z}_{it-1} + \gamma_I \mathbf{I}_{it-1} + \varepsilon_{it}$$

As for the first vector (**Z**), we consider, with a set of dummies, the firm's belonging to a business group, either as a *Group leader* or as a *Group affiliate* and the multinational status (*MNE*) of the firm. We also include the level of human capital (*HC*), measured by the (log) average 2001-2003 share of white collars (i.e. top and middle managers, executives and clerks). Innovation capabilities are captured by the log of total 2001-03 R&D expenditures (*R&D*) and its squared term ($R\&D^2$). Finally, we include series of industry and NUTS-1 area dummies to control for industry- and region-specific effects.

Within the second vector (**I**), we include variables measuring fixed investment strategies related to the purchase of new machinery and equipment over the period 2001-2003. These variables are created as follows. In a first specification of equation 2, we only take the variable measuring total fixed investments in 2001-03 ($Log\_investments_{2001\text{-}03}$), properly deflated by a business investment price index and log-transformed. In a second specification, we interact it with a series of dummy variables which capture the objectives of these investments. Firms in the questionnaires are asked to rank the importance (high, medium, low) of seven objectives to which their investments are targeted: (i) improving the quality of existing products (*prodimprov*), (ii) increasing the amount of production of existing products (*incrprod*), (iii) producing new products (*newprod*), (iv) lowering the environmental impact (*environment*), (v) lowering the use of raw materials (*lessraw*), (vi) reducing the employment of labor inputs (*lessemp*), (vii) and other (*other*) objectives. For each option, we define a dummy equal to 1 if

the firm assigned a *high* importance to the specific goal[5]. The rationale behind the creation of these interacted investment variables is the need to capture both the objectives of firm investment and the corresponding amount in Euros. Only creating continuous variables we will be able to estimate the investment elasticity of TFP. Table 1 shows the sample distribution of the seven dummy variables.

[TABLE 1 around here]

At the end of this process we come up with seven (log-transformed) continuous variables: *Log_prodimprov*, *Log_incrprod*, *Log_newprod*, *Log_environment*, *Log_lessraw*, *Log_lessemp* and *Log_other*. [6] Among these, *Log_environment* is the one directly measuring the GIS of the firm.

[TABLE 2A around here]

[TABLE 2B around here]

Since firms can pursue more than one objective (see Table 1), our investment variables overlap with each other. From Tables 2a and 2b, this does not seem to represent a critical issue for the empirical analysis, since the level of the pairwise correlation remains low[7]. In order to capture the existence of potential interactions between the aforementioned GIS variable and the other six investment strategies, we also include a series of interaction effects where *Log_nvestments*$_{2001\text{-}03}$ multiplies six dummies, which are equal to 1 when the firm *simultaneously* assigns a high importance to the pursuing of environmental goals and one of other six objects. We obtain the following six new GIS variables: *Log_prodimprov*env*, *Log_incrprod*env*, *Log_newprod*env*, *Log_lessraw*env*, *Log_lessemp*env,* and *Log_other*env*. Appendix Table A1 shows some descriptive statistics on all these variables. The

[5] In unreported estimates we use seven alternative dummies where the *medium importance* option is added to the high importance one. Results do not change significantly.

[6] Appendix Table A1 shows the sample statistics on log fixed investments.

[7] Table 1 also shows that only a small fraction of firms (around 14% on average) declare to pursue only one single objective when investing in new machinery and equipment. The major part of them, instead, adopts a mixed investment strategy involving more than one objective.

level of productivity that corresponds to each investment variable is shown in Table 3. Here we note that investing in new capital assets is associated to a 1.6% average productivity premium with respect to the industry mean, in front of a loss of almost 7% for firms not investing at all. When looking at the strategic goal of investments, we note that the highest productivity premium, both in 2004 and on in 2004-06, is related, first, to investments reducing the use of raw materials and, secondly, to investments reducing the environmental impact of production. All the other types of investments are associated with a lower level of productivity in 2004 and they show a declining productivity premium over time.

Subsequently, we distinguish between the effect of 'end-of-pipe' and of 'cleaner production' technologies. The former refer to solutions that do not directly alter the production process (like filters), but are simply designed for reducing the environmental impact to comply with standards and regulation. The latter integrate the production process, and substitute or improve existing technologies with cleaner ones (Frondel et al., 2007). To this aim, in addition to the six aforementioned GIS variables that integrate the reduction of the environmental impact with changes in the production and methods, we include *Log_environment_only* that captures an investment strategy solely aimed at reducing the environmental impact (i.e. not affecting the production technologies).

[TABLE 3 around here]

Equation 2 is estimated by Ordinary Least Squares (OLS) and the coefficients γ_l are considered as the elasticity of TFP with respect to the corresponding types of investment strategies. Although measuring TFP in 2004 and the explanatory variables in 2001-03 should avoid potential simultaneity bias, the impact of (green) fixed investments on TFP may be due to unobserved factors that make *ex ante* more productive firms self-select into investment in capital assets (including the environmental ones). If this is the case, OLS coefficients hide a potential reverse causality effect. We address this issue by using a two-stage least square (2SLS) approach. Since we cannot assign a specific instrument for each type of investment, we choose to separately instrument both the *Log_environment* and the broader $Log\_investments_{2001\text{-}03}$ variables, where the latter have been used for generating all the other investment variables.

Since our dataset does not provide any information on energy prices (a variable utilized, for instance, by van Leeuwen and Mohnen, 2013), as instrument for *Log_environment* we decided to use CO_2 emissions per unit of value added, computed for year 2000 at the level of Italian NUTS-3 regions, which correspond to 103 Administrative Provinces.[8] In so doing, we both provide a proxy also for the stringency of sub-national environmental regulations, and we take into account local-specific effects, particularly in terms of different industrial specialization. Our identification assumption here is that, conditional on other covariates, our variable for local CO_2 emissions and environmental regulations in 2000 have no effect on TFP in 2004 other than through the effect of green investments in 2001-03.

We also control for the endogeneity of the original $Log\_investments_{2001\text{-}03}$ variable. In this case, as instrument, we use a dummy equal to 1 if, in 2001-03, firms benefited from subsidies or tax reliefs for making investments in new tangible assets. Our identification assumption is that, conditional on the controls included in the regression, tax reliefs in 2001-03 have no effect on TFP in 2004 other than through the effect on fixed investments.

2.2. The internationalization equation

After estimating Equation 2, we extract the predicted value of TFP and we use it as a regressor in the following internationalization equation:[9]

$$(3)\quad INT_{it} = \alpha_0 + \alpha_{TFP} TFP_{it-1}^{PRED} + \alpha_{GIS} GIS_{it-1} + \alpha_X \mathbf{X}_{it-1} + \varepsilon_{it}$$

where **X** is a vector including a subset of covariates also included in Equation 2, like industry and area dummies and total R&D expenditures in 2001-03.[10] A positive and statistically significant coefficient α_{TFP} is the sign of the indirect effect of GIS on firm internationalization. In order to control if GIS have also a direct effect on *INT*, we still include *Log_environment* (and, alternatively, other

[8] Data on CO_2 emissions come from the provincial inventory of air emissions provided by ISPRA (*Istituto Superiore per la Protezione e la Ricerca Ambientale*): http://www.sinanet.isprambiente.it/it/inventaria/disaggregazione_prov2005/Emissioni%20provinciali/view

[9] We also properly correct the standard errors through a bootstrapping method.

[10] In order to meet all the identification conditions, we consider here only a subset of explanatory variables previously included in Equation 1.

significant GIS variables emerging from estimates of Equation 2), and we test for the statistically significance of the coefficient α_{GIS}. A statistically significant α_{GIS} would mean that GIS have also a direct effect on firm internationalization, whereas a non-significant α_{GIS} and a significant α_{TFP} would be the proof that GIS affect firm internationalization only indirectly, through induced TFP.

The use of the predicted value of TFP helps mitigating the risk of reverse causality between internationalization and productivity, as it would be predicted by the *learning by exporting and strategic asset seeking* hypotheses (Dunning, 1993; Salomon and Shaver, 2005). Although we cannot fully eliminate this problem because of the cross-sectional nature of our data, we mitigate it by measuring *INT* in year 2006 and the observed TFP in year 2004. In addition, TFP_{2004} is regressed on variables measured in the previous three years (2001-2003). We think that a three-year lag between the two covariates should avoid the possibility that firms become more productive because of interactions with foreign partners[11].

INT is an ordinal variable taking the value of 0 for purely domestic firms, 1 for firms only exporting goods, and 2 for firms who are engaged both in exporting and in FDI or offshoring[12] activities in 2006. Table 4 shows the distribution of internationalized firms and the corresponding value of productivity over 2004-06. In line with the firm heterogeneity hypothesis, we note that internationalized firms are characterized by higher value added and higher TFP.

[TABLE 4 around here]

Because of the ordinal nature of the dependent variable, we estimate Equation 3 through an ordered logit model, from which we separately compute the marginal effect of predicted TFP on export and FDI/offshoring. We use a Brant test of parallel regression assumption (or proportional odds assumption) in order to test if the slope coefficients in the model are the same across response categories

[11] Using the IX Unicredit Survey on manufacturing firms (2001-2003), Antonietti and Cainelli (2011b) show that, where present, the reverse effect of exports on productivity is much lower than the opposite one.

[12] We choose to join FDI and offshoring (i.e. international outsourcing) for maintaining a sufficiently high amount of observations and because we do not want to discriminate here between producing abroad through affiliates or through international subcontracting. In our sample, only seven firms choose FDI, and all of them do also relocate production abroad through offshoring.

(and lines of the same slope are parallel). Differently from the standard LR test, the Wald test by Brant is useful since it tests the parallel regression assumption for each variable.

3. Data

To extract our data we merge the IX and X Survey on manufacturing firms conducted by Unicredit bank (formerly Capitalia and Mediocredito Centrale) and covering the period 2001-06. The two surveys provide information on a representative sample of 4,289 and 5,137 Italian manufacturing firms respectively. Firms with more than 500 employees are fully represented, while firms employing between 11 and 500 employees are selected on the basis of region of location, employment size and sector of economic activity. The survey responses provide information on firms' innovative activities, labour force composition and internationalization modes, and the market relationships between firms, the banks, customers and competitors.

After merging the two datasets, we drop those firms with missing values in the variables of interest, or showing inconsistencies or negative values in value added, labor cost and capital. The final sample consists of a balanced panel of 851 firms[13]. Table 5 shows the structure of the sample with respect to employment size, macro-area of firm location and Pavitt's industry, compared to the original sample extracted from the IX Survey (2001-03). From Table 5 we note that, with respect to the original sample, the merge slightly increased the number of medium and large firms, located in the North-Centre of Italy and belonging to the scale intensive and specialized suppliers industries.

[TABLE 5 around here]

4. Estimation results

Table 6 reports the estimates of our productivity equation: the first-stage in our 'GIS-productivity-internationalization' model.

[TABLE 6 around here]

[13] Unfortunately we cannot apply panel data techniques because *INT* is not available on a yearly basis and because the way firms are asked to rank the objectives of their investment differs across the IX and X survey.

Column 1 reports the results emerging from a model that includes the controls and the *Log_environment* variable only. Column 2, instead, reports estimation results of a model where controls and the general variable of investments are only considered. In both Columns we register that TFP is positively affected group leadership and the foreign-owned status of the firm. Productivity is also improved by the share of skilled personnel and by the R&D investment, although after a critical mass of investment is achieved. From Column 2 we also observe that investing in new machinery and equipment increases TFP by an average 1.2%, whereas environment-oriented investments *per se* do not show any significant effect. As explained in Section 2.1, we use local CO_2 emissions and tax reliefs to test for the possible endogeneity in the relation between investments and TFP. The last rows in Columns 1 and 2 show that the estimated coefficients of the two instrument are highly significant, and the F statistics higher than the rule-of-thumb value of 10. Although the first-stage R^2 is not very high, we test for the weakness of our instruments by using the Stock and Yogo test, from which we observe that the reported minimum eigenvalues are higher than the critical value (16.4) for not rejecting the null hypothesis of weak instrument at the 10% level. Finally, and most importantly, the robustified Durbin-Watson-Hu test does not reject the null hypothesis of exogeneity of both *Log_environment* and *Log_investments*$_{2001\text{-}03}$, so that we can consider all our investment variables as exogenous.

Column 3 reports the results for the GIS, along with the other types of investment strategies. We note that only investments targeted at reducing the use of raw materials do significantly affect firm TFP, with an elasticity of 0.007. These results are confirmed when measuring TFP as an average over 2004-2006, as in Column 4.

As a further specification, we interact the environment-oriented investments with the other types of investment to investigate the impact of more detailed GIS. Results in Column 5 show now that TFP is positively affected by investment strategies aimed at reducing both the environmental impact of production *and* the use of raw materials, whereas the other interacted variables are never significant. Column 5 confirms the same results when we also include, among regressors, the variable *Log_environment_only*.

From these results we conclude that, when investments are targeted at reducing only the environmental impact of production (e.g. through adopting an end-of-pipe technology), no

improvement in firm productive efficiency occurs. This latter is stimulated when the firm invests in cleaner production technologies (Frondel et al., 2007), aimed at simultaneously reducing the environmental impact and the use of raw materials.

From the two specifications in Columns 3 and 5 we extract the predicted value of TFP, as labeled in the last row of Table 6 (TFP^{PRED1} and TFP^{PRED2}), and we use it as the main regressor in the internationalization equation. Table 7 shows the corresponding ordered logit results. Column 1 reports the results for regressors TFP^{PRED1} and *Log_environment*. We also add Column 2 to include results for TFP^{PRED2} and the interaction effect *Log_lessraw*env*.

[TABLE 7 around here]

Our estimates confirm that TFP positively affects firms' propensity to internationalize, first through exports and then through FDI/offshoring. Looking at marginal effects, we register that a 1% increase in induced efficiency is related to a 0.13-0.14% increase in the probability to export, and to a 0.09-0.10% increase in the probability to engage in production relocation though FDI or offshoring. Interestingly, R&D shows both an indirect effect, though the coefficient of TFP^{PRED}, and a direct effect on internationalization: on average, 1000 euros spent in R&D increase the probability to export and to FDI by 2-3%. In both the specifications, the positive and statistically significant coefficients of predicted TFP confirm the indirect relationship between GIS and internationalization. Instead, we do not find any evidence of a direct effect of GIS. This means that the net effect of GIS on the likelihood to internationalize passes through TFP. In addition, Wald test of equality of coefficients shows also that estimated coefficients of TFP^{PRED1} and TFP^{PRED2} are the same across specifications.

In addition, we look at the scale effects in the INT-TFP (predicted) relationship. Specifically, we ask if the positive and significant sign of the estimated coefficient of the two predicted TFP variables depends on firm size. We compute two size dummy variables, one related to small firms (11-49 employees) and one to medium-large ones (over 50 employees). Then we interact them with our TFP^{PRED1} and TFP^{PRED2} variables, and we include the two resulting variables in the ordered logit estimates. Results are shown in Table 7, Columns 3 and 4, where we note that the previous positive

effect of induced TFP on internationalization entry choice holds only for medium and large-sized firms.[14]

With all these results we conclude that the effect of GIS on the internationalization entry choice of firms is characterized as follows. First, it materializes only if capital assets are designed for reduce both the environmental impact of production and the use of raw materials. Second, it cannot be properly identified by estimating reduced-form models, but it requires a structural modeling approach, where the first stage represents the effect of GIS on productivity. Finally, from the international trade perspective, investments in cleaner production technologies can be considered as an additional source of firm heterogeneity, together with human capital and R&D, which allows firms to overcome the sunk costs of internationalization.

5. Conclusions

The paper empirically investigated whether the green investment strategies (i.e. investments in machinery and equipment aimed at reducing the environmental impact of production) can influence firms' international competitiveness.

Using the firm heterogeneity framework, we estimated a two-stage structural model on a sample of Italian manufacturing firms, where we assumed that green investment strategies indirectly impact firm internationalization entry choice, i.e. by first improving the level of productive efficiency (TFP). Our results show that investing in end-of-pipe technology does not have any productivity effect. On the contrary, an environmental investment strategy that integrates environmental protection with the reduction in the use of raw materials allows the firm to increase the level of TFP. Once achieved a higher productive efficiency, firm are able to enter foreign markets, first through exports, and then through FDI or offshoring strategies.

From the environmental policy point of view, we have provided additional empirical support to the Porter hypothesis in its strong version. Our evidence indeed shows that, when the mediating role of

[14] In a robustness check we employed an alternative version of our structural model, in which we estimated a modified version of Equation 2, using value added as dependent variable, and including lagged capital and labour as main inputs. The predicted value added is then used as a regressor in the internationalization choice equation. Results, which are not reported here for reasons of space but available upon request, do not change and support our previous findings.

technical change is properly accounted for, environmental protection may positively affect international competitiveness. In particular, our results may contribute to the development of "properly designed" policy actions, that represents a major point in the Porter hypothesis: the logic sequence is that supporting the adoption of cleaner production technologies, rather than simply end-of-pipe ones, can actually increase firm internal efficiency, and, as a consequence, its international competitiveness. This means that policies should not only be directed at avoiding, or reducing, negative environmental externalities, but they should stimulate a higher efficiency in the use of raw materials. This policy implication turns out to be particularly interesting for the specific country analyzed in the paper, e.g. Italy. A ‘green’ type of public intervention, as the one suggested above, may be considered as a potential additional support for triggering the low capability of Italian firms to engage in more advanced forms of internationalization, like FDI (Mariotti and Mutinelli, 2012).

From the international trade perspective, the paper has provided a ‘green innovation’-based explanation for the relationship between productivity and trade. In particular, we have found that, in addition to R&D and human capital, integrated environmental technologies can determine firm TFP-heterogeneity. We find that more internationalized firms are also more productive and efficient, and this efficiency comes also from investing in new capital equipment which integrates a lower environmental impact and a lower use of raw materials. However, the paper also shows that, in order to properly consider the effect of green investment strategies on firm internationalization entry choices, a structural modeling approach is better suited than a reduce-form one.

Finally, we should also recognize that the cross-sectional and survey nature of our data does not allow for a generalization of results. Therefore, we consider our estimated coefficients as slightly overestimated, as being particularly representative for the case of medium and large firms located in the North of Italy. Future research will be devoted to the analysis of more representative longitudinal data, which better allow for treatment of endogeneity.

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FIGURES AND TABLES

Figure 1 – The structural model between GIS, productivity and internationalization

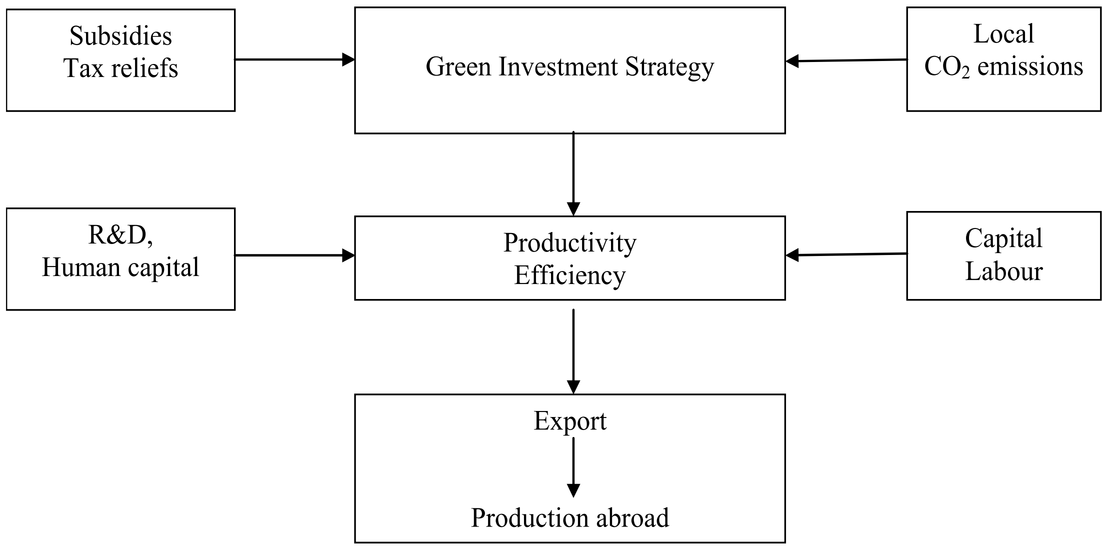

Table 1. Investment strategies: sample distribution

Object	%(*)	N. (total)	N. (only)	Only/Total
1. Product quality improvement	61.1	476	97	20.38
2. Increasing existing production	42.2	329	32	9.72
3. Introduction of new products	28.5	222	32	14.41
4. Lower environmental impact	21.2	165	16	9.70
5. Less raw materials	9.6	75	2	2.67
6. Less employment	16.7	130	11	8.46
7. Other	8.3	65	62	95.38

Note: (*) % is computed with respect to firms declaring to invest in new machinery and equipment.

Table 2a. Correlation among investment strategies: dummy variables

	1	2	3	4	5	6	7
1. Product quality improvement	1						
2. Increasing existing production	0.3207***	1					
3. Introduction of new products	0.1823***	0.1273***	1				
4. Lower environmental impact	0.2198***	0.1173***	0.0945***	1			
5. Lower use of raw materials	0.1674***	0.1788***	0.0891***	0.1935***	1		
6. Employment reduction	0.1203***	0.1794***	0.0676**	0.0479	0.2828***	1	
7. Other	-0.0656*	-0.0012	0.0206	0.0044	0.0667*	0.0255	1

Table 2b. Correlation among investment strategies: log values

	1	2	3	4	5	6	7
1. Log_prodimprov	1						
2. Log_incrprod	0.3666***	1					
3. Log_newprod	0.2218***	0.1545***	1				
4. Log_environment	0.2549***	0.1794***	0.1323***	1			
5. Log_lessraw	0.2105***	0.1955***	0.1173***	0.2185***	1		
6. Log_lessemp	0.1719***	0.2018***	0.1105***	0.0773**	0.2943***	1	
7. Log_other	0.2661***	0.3526***	0.5396***	0.2753***	0.3286***	0.0973***	1

Table 3. Investment strategies, log value added and Total Factor Productivity

Objects	N	$LogVA_{2004}$	$LogVA_{04-06}$	TFP_{2004}	$TFP_{2004-06}$
$Investments_{2001-03}$ (no)	72	14.80	14.79	-0.067	-0.092
$Investments_{2001-03}$ (yes)	779	15.28	15.27	0.016	-0.012
Product improvement	476	15.24	15.25	0.009	-0.009
Increasing production	329	15.24	15.24	0.014	-0.006
New product	222	15.34	15.34	0.010	-0.012
Lower environmental impact	165	15.44	15.43	0.050	0.025
Lower environmental impact (only)	22	15.54	15.56	0.028	0.037
Less raw materials	75	15.71	15.70	0.112	0.077
Less employment	130	15.25	15.22	-0.011	-0.047
Other	65	15.16	15.13	0.071	0.022
Average		15.21	15.21	0.005	-0.023

Table 4. Firm productivity and internationalization modes: sample statistics

	%	$LnVA_{2004}$	$LnVA_{2004-06}$	TFP_{2004}	$TFP_{2004-06}$
Domestic	24.2	14.87	14.85	-0.047	-0.067
Exporting (INT=1)	66.9	15.24	15.22	0.007	-0.024
Exports + FDI (INT=2)	8.9	15.85	15.80	0.126	0.105

Table 5. Descriptive statistics

Employment size	**2001-03**	**2001-06**
11-20	22.1	10.7
21-50	29.6	23.7
51-250	36.9	50.8
251-500	5.3	6.9
500+	6.1	7.9
Area		
North West	35.9	36.6
North East	30.2	32.7
Centre	17.6	18.3
South	16.3	12.5
Pavitt industry		
Supplier dominated	51.9	48.2
Scale intensive	16.8	18.2
Specialized supplier	26.7	31.4
Science based	4.6	2.5

Table 6. The impact of investment strategies on TFP

	(1) TFP_{2004}	(2) TFP_{2004}	(3) TFP_{2004}	(4) $TFP_{2004-06}$	(5) TFP_{2004}	(6) TFP_{2004}
$Log\_investments_{2001-03}$		0.012***				
		(0.003)				
Log_investments IV		*0.019*				
		(0.016)				
Log_environment	0.004		0.003	0.003		
	(0.004)		(0.003)	(0.002)		
Log_environment IV	*-0.007*					
	(0.017)					
Log_ prodimprov			-0.000	0.002		
			(0.002)	(0.002)		
Log_incrprod			0.000	-0.001		
			(0.002)	(0.002)		
Log_newprod			-0.002	-0.002		
			(0.002)	(0.002)		
Log_lessraw			0.006**	0.006**		
			(0.003)	(0.003)		
Log_lessemp			0.000	-0.001		
			(0.003)	(0.003)		
Log_other			0.003	0.002		
			(0.004)	(0.004)		
Log_environment_only						0.006
						(0.004)
Log_prodimprov*env					-0.003	-0.001
					(0.003)	(0.002)
Log_incrprod * env					0.001	0.002
					(0.003)	(0.003)
Log_newprod * env					-0.001	-0.001
					(0.003)	(0.003)
Log_lessraw*env					0.008**	0.007**
					(0.004)	(0.004)
Log_lessemp*env					0.006	0.006
					(0.004)	(0.004)
Log_other*env					0.011	0.008
					(0.008)	(0.008)
Group leader	0.367**	0.238***	0.257***	0.149*	0.264***	0.264***
	(0.145)	(0.082)	(0.084)	(0.083)	(0.083)	(0.083)
Group affiliate	-0.002	0.024	0.019	0.009	0.016	0.015
	(0.072)	(0.025)	(0.026)	(0.024)	(0.026)	(0.026)
MNE	0.054	0.101**	0.098**	0.143***	0.101**	0.101**
	(0.088)	(0.045)	(0.043)	(0.042)	(0.041)	(0.042)
HC	0.545	0.289***	0.253**	0.289**	0.264**	0.266**
	(0.354)	(0.108)	(0.115)	(0.131)	(0.123)	(0.120)
R&D	-0.100***	-0.075***	-0.076***	-0.059***	-0.076***	-0.076***
	(0.021)	(0.013)	(0.013)	(0.011)	(0.014)	(0.014)
$R\&D^2$	0.008***	0.006***	0.006***	0.005***	0.006***	0.006***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Area dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	851	851	851	851	851	851
R^2	0.194	0.173	0.162	0.122	0.164	0.164
Instrument #1: CO_2 emissions	*0.967****					
Instrument #2: Tax reliefs		*1.670****				
1st stage adj. R^2	0.194	0.122				
F	20.79	21.90				
DWH endogeneity test	0.333	0.005				
(p-value)	(0.568)	(0.945)				
Min. eigenvalue	39.35	24.30				
Predicted value			TFP^{PRED1}		TFP^{PRED2}	

Notes: cluster (industry-area) robust standard errors in parentheses. A constant term is also included. * Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Table 7. TFP heterogeneity, GIS and internationalization entry modes: ordered logit estimates

	(1)	(2)	(3)	(4)
TFP^{PRED1}	1.370**			
	(0.547)			
marg. eff. INT=1	*0.141***			
	(0.059)			
marg. eff. INT=2	*0.095***			
	(0.038)			
TFP^{PRED2}		1.364**		
		(0.663)		
marg. eff. INT=1		*0.140***		
		(0.071)		
marg. eff. INT=2		*0.095***		
		(0.051)		
Log_environment	0.000		0.001	
	(0.014)		(0.014)	
Log_lessraw*env		-0.007		-0.007
		(0.027)		(0.028)
R&D	0.029**	0.030**	0.026**	0.026**
	(0.012)	(0.014)	(0.013)	(0.013)
marg. eff. INT=1	*0.003***	*0.003***	*0.003***	*0.003***
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*
marg. eff. INT=2	*0.002***	*0.002***	*0.002***	*0.002***
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*
TFP^{PRED1} * SMALL			-0.292	
			(1.157)	
TFP^{PRED1} * MEDIUM-LARGE			1.822**	
			(0.788)	
marg. eff. INT=1			*0.188***	
			(0.085)	
marg. eff. INT=2			*0.125***	
			(0.053)	
TFP^{PRED2} * SMALL				-0.343
				(1.206)
TFP^{PRED2} * MEDIUM-LARGE				1.845***
				(0.687)
marg. eff. INT=1				*0.190***
				(0.075)
marg. eff. INT=2				*0.127****
				(0.048)
Industry dummies	Yes	Yes	Yes	Yes
Area dummies	Yes	Yes	Yes	Yes
N	851	851	851	851
Pseudo R^2	0.062	0.063	0.064	0.064
Brant test	18.08	19.08	18.24	18.86
(p-value)	(0.450)	(0.387)	(0.507)	(0.466)
Wald test: $TFP^{PRED1} = TFP^{PRED2}$	0.01 (0.93)			

Notes: bootstrapped (200 reps.) standard errors in parentheses. Estimates also include a constant term.
* Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Appendix

Table A1. Green investment strategies: sample statistics, in Euros

	Mean	Median	Min	Max	St. dev.
Log investments (total)	4,220,807	775,303	0	2.46e+08	1.40e+07
Log investments (>0)	4,880,308	1,018,888	1,755.03	2.46e+08	1.49e+07
Log_prodimprov	5,184,668	1,170,017	1,755.03	2.46e+08	1.75e+07
Log_incrprod	5,148,031	1,209,401	5850,08	1.24e+08	1.48e+07
Log_newprod	4,867,045	1,170,017	12,718.9	9.90e+07	1.11e+07
Log_environment	9,294,235	1,462,521	1755,03	2.46e+08	2.62e+07
Log_lessraw	8,908,155	1,209,736	40,241.5	2.46e+08	3.11e+07
Log_lessemp	3,618,975	1,006,528	40,241.5	1.00e+08	9,952,640
Log_other	323,537	0	0	9.90e+07	3,752,292
Log_environment_only	94,015.4	0	0	2.49e+07	1,226,167
Log_prodimprov*env	9,304,000	1,413,611	1755,03	2.46e+08	2.86e+07
Log_incrprod*env	1.03e+07	1,809,491	40241,5	1.05e+08	2,32e+07
Log_newprod*env	9,230,975	1,632,408	48,458.1	9.90e+07	1.76e+07
Log_lessraw*env	1.54e+07	1,407,939	40241.5	2.46e+08	4.58e+07
Log_lessemp*env	7,980,829	2,101,340	40,241.5	1.00e+08	1.87e+07
Log_other*env	185,465	0	0	9.90e+07	3,567,779