Export Intensity and Productivity*

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Abstract

We study, both theoretically and empirically, how export intensity (the ratio of exports to sales) is related to firm productivity. Using a representative sample of Italian manufacturing firms, we find that Total Factor Productivity (TFP) is strongly negatively correlated with export intensity to low-income destinations and uncorrelated with export intensity to high-income destinations, conditional on exporting. To account for these facts, which are not easily predicted by existing heterogeneous-firms models, we extend the Melitz's (2003) model by allowing for endogenous product quality and for non-iceberg trade costs. Under plausible assumptions, our model predicts that the elasticity of export intensity to productivity is increasing in per capita income of the foreign destinations and decreasing in their distance. We find that these two variables can jointly explain the sign, size and ranking of the TFP elasticities of export intensity across individual foreign destinations.

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1 Introduction

A recent literature has extensively analyzed the differences between exporting and non-exporting firms, showing, in particular, that the former are more productive than the latter.[1] These findings have pushed toward a new paradigm, initiated by Melitz (2003), which points at the self-selection of more efficient firms into foreign markets as the likely explanation for the observed correlations. The basic idea is that, due to fixed and variable costs of exporting, only the most productive firms are profitable enough to afford paying the additional costs needed to break into foreign markets.

Notwithstanding the surge of works studying firm export behavior, the determinants and patterns of firm export intensity (the ratio of exports to sales) have remained relatively unexplored. This is somewhat surprising, because the latter is a most important indicator of the degree of firm involvement in foreign trade. To help fill this gap, in this paper we study, both theoretically and empirically, how export intensity is related to firm productivity. Although our object of inquiry is closely related to the previous literature, both theory and evidence suggest that the relationship between productivity and export intensity can be fundamentally different from that between productivity and export status (the dichotomy exporters/non-exporters). For instance, in the simplest version of Melitz's (2003) heterogeneous-firms model, exporters are more productive than non-exporters, yet export intensity is unrelated to productivity, conditional on exporting, because more productive firms sell proportionately more in both the domestic and the foreign market. We find indeed, using a representative sample of Italian manufacturing firms, that export intensity and productivity are uncorrelated, conditional on exporting. However, when disaggregating exports by destination market, we find that productivity is strongly negatively correlated with export intensity to low-income destinations and uncorrelated with export intensity to high-income destinations.[2]

To reconcile these facts with theory, in Section 2 we extend the basic heterogenous-firms model to take account of recent findings on the role of product quality and quality consumption in international trade. In particular, quality consumption seems to be strongly positively

[1] See, in particular, Bernard and Jensen (1995, 1999), and Eaton, Kortum and Kramarz (2004, 2008). See also Tybout (2003), Bernard et al. (2007), Greenaway and Kneller (2007), Mayer and Ottaviano (2007) and Wagner (2007) for comprehensive surveys of the empirical literature.

[2] Bernard, Redding and Schott (2007) have recently extended the Melitz's model to allow for endowment-based comparative advantage. Their model also implies that export intensity is unrelated to firm productivity, conditional on exporting. Our stylized fact cannot be easily explained either by the models in Bernard et al. (2003) and Melitz and Ottaviano (2008).

correlated with per capita income.[3] Moreover, product quality seems to vary substantially within any narrowly defined industry, and to be crucial to explain international export specialization.[4]

We bring these findings into our framework by allowing consumers to choose quality consumption based on their per capita income and firms product quality based on their productivity. The model delivers our stylized fact as a special case of a more general result, namely, that the elasticity of export intensity to productivity is increasing in per capita income of the foreign destinations. The reason is that more productive firms produce higher-quality products, for which *relative* demand is higher in high-income destinations. The model also shows, however, that the elasticity of export intensity to productivity crucially depends on the nature of trade costs. In particular, it suggests that this elasticity can be negative in the presence of relevant per unit trade costs (Hummels and Skiba, 2004), as these costs have a stronger negative impact on the foreign sales of more efficient firms.

In Section 3, we provide extensive evidence on the pattern of correlations between productivity and export intensity. We use Total Factor Productivity (TFP) estimates to proxy for firm productivity. Following a recent literature, and in particular De Loecker (2007, 2008), Amiti and Konings (2007) and Van Biesebroeck (2007), we take account of possible biases contaminating TFP estimates by allowing for different specifications of the underlying production function (Cobb-Douglas versus translog), for different estimators of its parameters (parametric versus semiparametric estimators), for different proxies of some productive inputs, and for a rich set of controls. This produces a battery of different TFP estimates. In the spirit of Van Biesebroeck (2008), in our empirical analysis we check the robustness of our results with respect to all of them, so as to ensure that the main findings do not simply reflect methodological choice.

We start by showing our main stylized fact by regressing export intensity to two broad groups of high-income and low-income destinations on our TFP estimates. We find that, independent of the TFP estimate we use, of the specification of the regression equation and of the number and types of controls, the TFP elasticity of export intensity to low-income destinations is invariably negative, large and very precisely estimated: conditional on exporting, a doubling of productivity is associated with about a 60% fall of export intensity. In

[3] See, in particular, Bils and Klenow (2001), Hummels and Skiba (2004), Brooks (2006), Hallak (2006, 2008), Verhoogen (2008), and Choi, Hummels and Xiang (2009).

[4] See Schott (2004), Hummels and Klenow (2005), Hallak and Schott (2008).

contrast, the TFP elasticity of export intensity to high-income destinations is statistically and economically close to zero.

Next, we try to explain these facts in the light of our theory. As a first step, we test whether these correlations are consistent with a positive firm-level relationship between productivity and product quality. While proxying for product quality is no easier than proxying for productivity, a unique feature of our dataset is that it allows to construct a large number of firm-level variables that are likely to be correlated with product quality according to both the classic and the more recent empirical literature on quality differentiation:[5] R&D and marketing expenditures, revenue from sales of innovative products, propensity to make process innovations, share of managers in total employment, and investment. We first show that, as required by our theory, TFP is positively correlated with these variables. Then, we construct a synthetic proxy for product quality by extracting the principal component of these variables through factor analysis, and regress export intensities on it: strikingly, we find that the correlations between export intensities and our proxy for product quality closely resemble those with TFP, suggesting that product quality may be an important determinant of the observed pattern of export intensities across destination markets.

Finally, we try to disentangle the role played by trade costs and per capita income of the foreign destinations in explaining the different geographic patterns of correlations between export intensity and productivity. To this purpose, we construct a panel of firm export intensities to all of the destinations for which we have data. We find that an interaction term between TFP and per capita income of the foreign destinations is strongly positively correlated with export intensity. Moreover, using distance to proxy for per unit trade costs (Hummels and Skiba, 2004), we find that its interaction with TFP is strongly negatively correlated with export intensity. More importantly, these two variables can jointly explain the sign, size and ranking of the TFP elasticities of export intensity across all individual foreign destinations.

As mentioned earlier, our paper is related to a vast literature that analyzes export behavior. Our main contribution to this literature is to study export intensity rather than export status. We are not, however, the first to introduce product quality in a heterogeneous-firms framework. In particular, we borrow from Verhoogen (2008) two basic ingredients of our explanation, namely, that the willingness to pay for quality varies with per capita income and that there is a positive association, at the firm-level, between productivity and product quality.

[5] See, e.g., Sutton (1998) and Kugler and Verhoogen (2008) on this point.

In his framework, the two assumptions are embedded in a model featuring a multinomial-logit specification on the demand side, and a complementarity between firm productivity and labor quality in producing output quality on the supply side. The model is then used to explain the observed skill upgrading in Mexico subsequent to Peso devaluations. Although our results are consistent with Verhoogen's, we use a different model, which we borrow instead from an established line of research, initiated by Sutton (1991) and recently applied to international trade by Hallak and Sivadasan (2008) and Johnson (2007), in which product quality is a choice variable, consumers have a preference for quality, and quality upgrading involves higher fixed costs.[6] We nest in this setting the assumption of non-homothetic preferences to show how firm heterogeneity interacts with the heterogeneity of export markets in determining the degree of firm involvement in foreign trade.

Our results also aim to provide a bridge between the recent literature on the characteristics of exporters and an earlier literature, inspired by the work of Linder (1961), on the role of product quality and quality consumption for the pattern of bilateral trade.[7] In particular, they are complementary to recent findings by Hallak (2006, 2008), who provides support for the Linder hypothesis that richer countries tend to import more from countries that produce high-quality goods using industry-level data.

Finally, our paper is related to a growing number of contributions studying the link between productivity, exports and other firm characteristics in Italy's manufacturing sector. In particular, Castellani and Zanfei (2007) find that exporters are generally more productive than non-exporters, while Castellani (2002), using older releases of our dataset, finds evidence of productivity increases after exporting (learning-by-exporting). Parisi, Schiantarelli and Sembenelli (2006) use instead the same dataset as ours to investigate the impact of firm innovative strategies on the growth of TFP. The stylized facts illustrated in this paper were however unnoticed by previous micro-level studies for Italy.

2 Theory

In this section, we formulate a one-sector, partial equilibrium model of a country open to international trade. We start with a minimalist version of the model to highlight the key

[6] See also Baldwin and Harrigan (2007), Alcalà (2007), and Kugler and Verhoogen (2008) for other interesting related works allowing for product quality in a heterogeneous-firms framework.

[7] See, in particular, Falvey and Kierzkowski (1987), Flam and Helpman (1987), Stokey (1991) and Murphy and Shleifer (1997).

ingredients needed to account for the stylized fact mentioned in the introduction and detailed in the empirical section. Then, we show how the results are affected when relaxing some of the most restrictive assumptions.

Consider a representative consumer characterized by the following preferences (see Manasse and Turrini, 2001):[8]

$$U = \left[\int_{v \in V} q(v)^{1-\rho} c(v)^{\rho} dv \right]^{\frac{1}{\rho}}, \quad 0 < \rho < 1, \tag{1}$$

where V is a continuous set of varieties available for consumption, indexed by v, $c(v)$ is consumption and $q(v)$ is quality of variety v, as perceived by the representative consumer. Each variety is therefore a Cobb-Douglas bundle of physical quantity and perceived quality. Consumers maximize (1) subject to the budget constraint:

$$y = \int_{v \in V} p(v) c(v) dv,$$

where y is the exogenously given per capita income. Solving this problem yields the following demand for variety v:

$$c(v) = q(v) \frac{p(v)^{-\sigma} R}{P^{1-\sigma}}, \tag{2}$$

where R is total income, $p(v)$ is the price of variety v, $\sigma = (1-\rho)^{-1} > 1$ is the constant elasticity of substitution among varieties and P is the ideal price index associated to (1):

$$P = \left[\int_{v \in V} q(v) p(v)^{1-\sigma} dv \right]^{\frac{1}{1-\sigma}}. \tag{3}$$

Although P is endogenous to the industry, firms treat it as exogenous, because their size is negligible relative to the size of the industry.[9] Our first crucial assumption is that the preference for quality by the representative consumer is non-homothetic with respect to per capita income, y. In particular, we assume that $q(v)$ takes the following form:

$$q(v) = \lambda(v)^{\alpha(y)}, \quad \alpha(y) > 0, \quad \alpha^{'}(y) > 0, \ \alpha^{''}(y) < 0, \tag{4}$$

[8] A similar formulation is used in Johnson (2007), Hallak and Sivadasan (2008), and Kugler and Verhoogen (2008).

[9] See Helpman (2006) for an illustration of the heterogeneous-firms model in partial equilibrium.

where $\lambda(v) \geq 1$ denotes "true" product quality[10] and $\alpha(y)$ is a concave function capturing how income affects the intensity of preference for quality.[11] To see the implications of this assumption, consider two firms, v_1 and v_2, with $\lambda(v_1) > \lambda(v_2)$. Using (4) into (2), the demand for variety v_1 relative to variety v_2 is:

$$\frac{c(v_1)}{c(v_2)} = \left(\frac{\lambda(v_1)}{\lambda(v_2)}\right)^{\alpha(y)} \left(\frac{p(v_1)}{p(v_2)}\right)^{-\sigma}.$$

Note that, for given relative price, the relative demand for higher-quality products is increasing in per capita income.

Consider now the production side of the model. Firms produce differentiated products under monopolistic competition. Technology is summarized by the following total cost function:

$$TC(\theta) = F(\lambda(\theta)) + MC(\theta)x(\theta),$$

where F is a fixed cost, MC is marginal cost, x is output and $\theta \geq 1$ is firm productivity (henceforth, θ will also index domestic firms). As in Melitz (2003), firms are heterogeneous in terms of productivity and marginal costs. We also assume, and this is our second key assumption, that higher-quality products require higher fixed costs. This captures the idea that quality upgrading involves more intensive R&D and marketing activities, which are mainly fixed costs in nature.[12] In particular, we assume the following functional forms:

$$F(\lambda(\theta)) = \phi\lambda(\theta)^{\gamma} + \phi; \quad MC(\theta) = \frac{1}{\theta}, \tag{5}$$

where ϕ and $\lambda(\theta)^{\gamma}$ represent, respectively, the exogenous and endogenous components of the fixed cost, and $\gamma > 0$ is the elasticity of the fixed cost to product quality. Note that, as in Melitz (2003), marginal cost is inversely related to firm productivity and is independent of product quality. This latter assumption is relaxed in the Appendix, where we consider the

[10] See Hallak (2006) for a similar formulation. We assume that λ is defined over the range $[1, \infty)$ or otherwise a rise in the intensity of preference for quality, $\alpha(y)$, would have ambiguous effects on the demand for quality.

[11] Note that the elasticity of aggregate demand to product quality of a poor country may look like that of a rich country if income distribution is very unequal. However, if $\alpha(\cdot)$ is sufficiently concave, income distribution effects are unlikely to overturn the ranking of countries' $\alpha(\cdot)$s based on per capita income. In our empirical analysis we use data on exports to broad destinations including more than one country, and therefore the possible presence of some poor (and presumably small) countries with a high $\alpha(\cdot)$ is unlikely to affect the main results.

[12] See, e.g., Sutton (1991, 1998), and more recent applications to a heterogeneous-firms framework by Johnson (2007) and Hallak and Sivadasan (2008).

case in which producing higher-quality goods requires (also) a higher marginal cost.

The profit maximizing price is a constant markup $\left(\frac{\sigma}{\sigma-1}=\frac{1}{\rho}\right)$ over marginal cost:

$$p(\theta)=\frac{1}{\rho\theta}. \tag{6}$$

Using (2), (4) and (6), we can write the revenue of domestic firms in the domestic market, $r(\theta,\lambda(\theta))$, as a function of productivity and product quality:

$$r(\theta,\lambda(\theta))=R\left(\rho\theta P\right)^{\sigma-1}\lambda(\theta)^{\alpha(y)}. \tag{7}$$

What is the relationship between productivity θ and product quality λ? Following a recent literature, we assume that product quality is endogenous.[13] In particular, firms choose product quality to maximize profits. For simplicity, we assume that firms target product quality to domestic market conditions only (i.e., to maximize domestic profits). In the Appendix, we show that our qualitative results are unaffected in the more general case in which firms choose product quality to maximize overall profits. Firms therefore solve the following problem:

$$\max_{\lambda}\left\{\frac{1}{\sigma}R\left(\rho\theta P\right)^{\sigma-1}\lambda^{\alpha(y)}-\phi\lambda^{\gamma}-\phi\right\}, \tag{8}$$

where the first term in brackets represents operating profits, which are a constant share, σ^{-1}, of firm revenue. We assume that $\alpha(y)<\gamma$, namely, that the elasticity of revenue with respect to product quality is less than the elasticity of fixed costs, to ensure that the second-order conditions for a maximum are satisfied. Solving this simple problem yields the optimal value of λ:

$$\lambda(\theta)=\left(\overline{\lambda}\theta\right)^{\epsilon}, \tag{9}$$

where $\overline{\lambda}=\left(\frac{\alpha(y)(\rho P)^{\sigma-1}R}{\gamma\phi\sigma}\right)^{\frac{1}{\sigma-1}}$, and $\epsilon=\frac{\sigma-1}{\gamma-\alpha(y)}>0$ is the elasticity of product quality to productivity.[14] Hence, more productive firms choose a higher product quality. The intuition for this result is the same as for why only more productive firms export in the basic heterogeneous-firms model: given that quality upgrading involves higher fixed costs, only more productive firms are profitable enough to afford paying these additional costs. Optimal product quality is also higher the higher the preference for quality, $\alpha(y)$, and the larger the

[13] See, in particular, Johnson (2007) and Hallak and Sivadasan (2008).

[14] We assume that $\overline{\lambda}>1$ to ensure that there is quality upgrading in equilibrium. This condition is always satisfied for sufficiently low ϕ.

size of the domestic market (as captured by the term $P^{\sigma-1}R$). Using (9) into (7) gives:

$$r(\theta) = R\left(\rho P\right)^{\sigma-1}\overline{\lambda}^{\alpha(y)\epsilon}\theta^{\gamma\epsilon}. \tag{10}$$

Consider now exports to a foreign destination f (henceforth, variables related to the foreign market will be denoted by a subscript f). We initially assume that exporting involves only a variable trade cost $\tau > 1$ of the iceberg type. In later sections we will also consider a fixed cost of exporting and non-iceberg trade costs. Markup pricing and iceberg trade costs imply that the price of a domestic variety in the foreign market is $p_f(\theta) = \frac{\tau}{\rho\theta}$. Export revenue of domestic firms, $r_f(\theta)$, can be written as:

$$r_f(\theta) = R_f\left(\frac{P_f}{\tau}\rho\theta\right)^{\sigma-1}\lambda(\theta)^{\alpha(y_f)}. \tag{11}$$

Using equation (9) into equation (11) gives:

$$r_f(\theta) = R_f\left(\frac{P_f}{\tau}\rho\right)^{\sigma-1}\overline{\lambda}^{\alpha(y_f)\epsilon}\theta^{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]}. \tag{12}$$

Note that the elasticity of export revenue with respect to productivity is positive, as in the standard model, and increasing in per capita income of the foreign destination, as a higher foreign income implies a stronger preference for higher-quality products. Finally, taking the ratio of exports to domestic sales, $r_f(\theta)/r(\theta)$, we obtain an expression for the export intensity of domestic firms to destination f:

$$EXP_f(\theta) = \frac{R_f}{R}\left(\frac{P_f}{\tau P}\right)^{\sigma-1}\left(\overline{\lambda}\theta\right)^{-\epsilon\left[\alpha(y)-\alpha(y_f)\right]}. \tag{13}$$

Equation (13) shows that, for given firm productivity, export intensity is higher the lower the trade costs, τ, and the larger the relative size of the foreign market, as captured by the term $R_f P_f^{\sigma-1}/RP^{\sigma-1}$. Note also that $\overline{\lambda}$, which is increasing in $\alpha(y)$, enters with a negative exponent for $\alpha(y)-\alpha(y_f) > 0$. This term captures the trade-reducing effect of non-homothetic preferences: for given θ, export intensity to a lower-income destination is lower the higher the relative domestic income.[15] More importantly, equation (13) implies that the elasticity of

[15] This is a robust implication of trade models embedding non-homothetic preferences. For an analysis of the implications of non-homothetic preferences for international trade see, among others, Markusen (1986), Hunter (1991) and Matsuyama (2000).

export intensity to productivity is:

$$e_{\theta}^{EXP} \equiv \frac{d\ln EXP_f}{d\ln\theta} = -\epsilon\left[\alpha(y) - \alpha(y_f)\right]. \tag{14}$$

Note that $e_{\theta}^{EXP} < 0$ if f is a lower-income destination (i.e., if $y > y_f$). The intuition is that high-productivity firms produce higher-quality goods, for which *relative* demand is lower in low-income destinations. By the same reasoning, $e_{\theta}^{EXP} > 0$ if f is a higher-income destination. Finally, for $y = y_f$ or $\epsilon = 0$ the model boils down to the Melitz's (2003) model, in which export intensity and productivity are unrelated, conditional on exporting.

2.1 Fixed Costs of Exporting

We now allow for an exogenous fixed cost of exporting, ϕ_f, to show how it affects the selection of domestic firms into foreign markets and the relationship between export intensity and productivity. Consider first the productivity cutoff for domestic producers, namely, the productivity level at which a firm makes zero profits in the domestic market. Using (9) and (8), domestic profits, π_d, can be written as:

$$\pi_d(\theta) = \phi\left(\frac{\gamma - \alpha(y)}{\alpha(y)}\right)\left(\overline{\lambda}\theta\right)^{\gamma\epsilon} - \phi. \tag{15}$$

Imposing $\pi_d = 0$ gives the productivity cutoff for domestic producers, θ_d:

$$\theta_d = \left(\frac{\alpha(y)}{\gamma - \alpha(y)}\right)^{\frac{1}{\gamma\epsilon}}\frac{1}{\overline{\lambda}}. \tag{16}$$

Consider now profits in the foreign market, π_f. Using (12) and recalling that operating profits are proportional to revenue, we obtain:

$$\pi_f(\theta) = \frac{1}{\sigma}R_f\left(\frac{P_f}{\tau}\rho\right)^{\sigma-1}\overline{\lambda}^{\epsilon\alpha(y_f)}\theta^{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]} - \phi_f. \tag{17}$$

Imposing $\pi_f = 0$ gives the productivity cutoff θ_f for exporters, namely, the productivity level at which a firm is indifferent between exporting and serving only the domestic market:

$$\theta_f = \left[\frac{\sigma\phi_f\rho^{1-\sigma}}{\overline{\lambda}^{\epsilon\alpha(y_f)}R_f\left(P_f/\tau\right)^{\sigma-1}}\right]^{\frac{1}{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]}}. \tag{18}$$

As in the standard heterogeneous-firms model, θ_f can be greater or smaller than θ_d. In particular, θ_f is decreasing in $\alpha(y_f)$, implying that (for given total income, R_f) a lower foreign per capita income increases the export productivity cutoff.[16] The reason is that a lower income reduces the elasticity of export revenue to productivity and therefore requires, ceteris paribus, a higher productivity to offset the fixed cost of exporting.

By comparing π_d and π_f note that, in trade with a similar country, the elasticities of π_f and π_d with respect to θ are identical. In contrast, in trade with a lower-income destination, the elasticity of π_f with respect to θ is less than that of π_d, as illustrated in Figure 1. The different elasticities of domestic and export profits (and revenues) with respect to productivity imply that, whatever the position of the export productivity cutoff, conditional on exporting the ratio of exports to domestic sales is decreasing in productivity, the more so the lower the foreign income. By the same reasoning, in trade with a higher-income destination, the elasticity of π_f with respect to θ is greater than that of π_d, and export intensity is therefore increasing in productivity, conditional on exporting.

We summarize the main results in the following proposition:

Proposition 1 *Conditional on exporting, the elasticity of firm export intensity to productivity is increasing in per capita income of the foreign destinations.*

Our baseline model can nicely explain the stylized fact that motivated our theoretical analysis, as it implies that export intensity and productivity are negatively correlated in exports to lower income destinations and uncorrelated in exports to destinations with similar per capita income. As shown below, however, these specific implications are sensitive to the assumptions concerning the nature of fixed and variable trade costs.

2.2 Non-Iceberg Transport Costs

So far, we have assumed that variable trade costs are of the iceberg type, in this following a vast theoretical literature. However, Hummels and Skiba (2004) have provided strong evidence against this assumption. After estimating a transport cost function, they found that transport costs more closely resemble per unit costs rather than per value costs. We now show that allowing for a per unit component of trade costs brings about new and interesting implications

[16] Provided that $\theta_f > 1$, namely, that the export productivity cutoff is in the relevant range (recall that we assumed $\overline{\lambda} > 1$, $\theta \geq 1$).

about the link between export intensity and productivity. To see why assume, as in Hummels and Skiba (2004), that variable trade costs involve a per unit component $t > 0$ in addition to a per value component $\tau > 1$ proportional to marginal cost. The profit maximizing price of a firm selling to destination f is therefore given by:

$$p_f = \frac{1}{\rho}\left(\frac{\tau}{\theta} + t\right),$$

Export revenue is:

$$r_f(\theta) = (\tau + \theta t)^{1-\sigma} R_f (\rho \theta P_f)^{\sigma-1} \lambda(\theta)^{\alpha(y_f)}, \tag{19}$$

Substituting (9) into (19) and using (10), we obtain the following expression for export intensity:

$$EXP_f(\theta) = (\tau + \theta t)^{1-\sigma} \frac{R_f}{R} \left(\frac{P_f}{P}\right)^{\sigma-1} \left(\overline{\lambda}\theta\right)^{-\epsilon\left[\alpha(y)-\alpha(y_f)\right]}. \tag{20}$$

According to equation (20), the elasticity of export intensity to productivity is now:

$$e_\theta^{EXP} = -(\sigma - 1)\frac{t\theta}{\tau + \theta t} - \epsilon\left[\alpha(y) - \alpha(y_f)\right]. \tag{21}$$

Equation (21) shows that, in the presence of per unit trade costs (i.e., for $t > 0$), export intensity and productivity are inversely related *also* in exports to similar destinations. The reason is that per unit trade costs represent a higher share of marginal cost for high-productivity firms, and hence have a stronger negative impact on their export intensity. By the same reasoning, per unit trade costs strengthen (weaken) the negative (positive) correlation between productivity and export intensity to lower-income (higher-income) destinations.

We summarize this result in the following proposition:

Proposition 2 *In the presence of per unit trade costs, the elasticity of export intensity to productivity is ceteris paribus negative, conditional on exporting.*

Our model therefore suggests that, when per unit trade costs are relevant, productivity may affect export intensity directly, not only through its correlation with product quality.

2.3 A Continuum of Foreign Countries

In our data, we observe exports only to broad areas generally including more than one country. It is therefore important to study the model's implications when export intensity is computed over an aggregate of possibly many countries. Note first that, insofar as exporting involves a fixed cost that is independent of the number of countries served by an exporter, as assumed so far, our previous results hold unchanged. However, the empirical evidence suggests that fixed costs of exporting are mainly country-specific, thereby preventing most exporters from selling to every foreign country.[17]

To see how the results are affected in this case, consider a foreign destination f consisting of a continuum of countries, indexed by $z \in [0, 1]$, homogeneous in terms of per capita income y_f but heterogeneous in terms of size. Moreover, assume that exporting to each of these countries involves a fixed cost ϕ_f. Denoting by S_B the size of the biggest of these countries, the market size of country z can be written as $S_z = R_z (P_z/\tau_z)^{\sigma-1} = zS_B$, where z also denotes its relative size.[18]

Using equation (18), the productivity cutoff for exporting to country z is given by:

$$\theta_z = \theta_B z^{-\frac{1}{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]}}, \quad \theta_B = \left[\frac{\sigma\phi_f\rho^{1-\sigma}}{\overline{\lambda}^{\epsilon\alpha(y_f)}S_B}\right]^{\frac{1}{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]}}, \tag{22}$$

where θ_B is the productivity cutoff for exporting to the biggest country within destination f. Note that θ_z is inversely related to z, as shown in Figure 2, and that all firms with productivity $\theta > \theta_B$ can break into a positive measure of countries. For instance, a firm with productivity θ_z can export to those countries whose size is in the range $[z, 1]$. Using (12) and aggregating across countries within destination f, the overall export revenue of a firm with productivity θ_z is given by:

$$r_f(\theta_z) = \left[S_B \int_z^1 Zg(Z)dZ\right]\rho^{\sigma-1}\overline{\lambda}^{\epsilon\alpha(y_f)}\theta_z^{\epsilon\left[\gamma-\alpha(y)+\alpha(y_f)\right]}, \tag{23}$$

where $g(\cdot)$ is the density function of relative country size within destination f. Assuming, for

[17] See, in particular, Eaton, Kortum and Kramarz (2004, 2008) and Lawless (2009) on this point.

[18] For simplicity, we consider the case of iceberg trade costs, as with per unit trade costs there is no closed-form solution for export productivity cutoffs. Qualitative results would however be unchanged in this latter case.

simplicity, that g is uniform in $[0, 1]$, we have:

$$\int_z^1 Zg(Z)dZ = \frac{1}{2}\left(1 - z^2\right) = \frac{1}{2}\left(1 - (\theta_z/\theta_B)^{-2\epsilon\left[\gamma - \alpha(y) + \alpha(y_f)\right]}\right), \tag{24}$$

where we have used equation (22) to derive the latter equality. Equation (24) gives the proportion of total market size of destination f reached by a firm with productivity θ_z. This term is increasing and concave in θ_z and captures the extensive margin of export revenue. To gain intuition, note that it is proportional to the product of the terms $(1 - z)$ and $(1 + z)$. The former represents the measure of countries within destination f reached by a firm with productivity θ_z: it is increasing in productivity because more productive firms can break into a larger number of countries. The latter term captures instead what a single country adds to export revenue: it is decreasing in θ_z because, although more productive firms can sell to more countries, these additional countries are smaller and hence add less and less to export revenue.

Substituting (24) back into (23) and using (10), we obtain the overall export intensity to destination f of a firm with productivity θ_z:

$$EXP_f(\theta_z) = \frac{1}{2}\frac{S_B}{S}\left(1 - (\theta_z/\theta_B)^{-2\epsilon\left[\gamma - \alpha(y) + \alpha(y_f)\right]}\right)\left(\overline{\lambda}\theta_z\right)^{-\epsilon\left[\alpha(y) - \alpha(y_f)\right]}, \tag{25}$$

where $S = RP^{\sigma-1}$ denotes the domestic market size. Equation (25) implies that the elasticity of export intensity to productivity is:

$$e_\theta^{EXP} = \epsilon\left[\frac{(\theta_z/\theta_B)^{-2\epsilon\left[\gamma - \alpha(y) + \alpha(y_f)\right]}}{1 - (\theta_z/\theta_B)^{-2\epsilon\left[\gamma - \alpha(y) + \alpha(y_f)\right]}}\left[\gamma - (\alpha(y) - \alpha(y_f))\right] - \left[\alpha(y) - \alpha(y_f)\right]\right]. \tag{26}$$

By comparing (26) with (14), note that the novelty is represented by the first term in square brackets. This term is positive and captures the extensive margin of export revenue, which increases the export intensity of more productive firms. The sign of e_θ^{EXP} therefore depends on the difference between the two terms in square brackets. In particular, $e_\theta^{EXP} > 0$ in trade with similar or higher-income destinations. In trade with lower-income destinations, the sign of e_θ^{EXP} is instead ambiguous. Note, however, that the greater is domestic income relative to foreign's, the greater is the second term and the smaller the first. Hence, with large enough income differences, the elasticity of export intensity to productivity is still negative.[19]

We summarize the main results in the following proposition:

Proposition 3 *When the foreign destination is an aggregate of many countries, homogeneous in terms of per capita income but heterogeneous in terms of size, and each requiring a fixed cost of exporting, the elasticity of export intensity to productivity is ceteris paribus positive, conditional on exporting to one of these countries.*

To conclude, Propositions 1-3 highlight the main determinants of the sign and size of the elasticity of export intensity to productivity according to our theory. Depending on the characteristics of the foreign destinations, they may reinforce or offset each other. In the next section, we will test their empirical relevance in our data.[20]

3 Empirical Evidence

In this section, we provide extensive evidence on the pattern of correlations between export intensity and productivity across foreign destinations and on their main determinants. We use Total Factor Productivity (TFP) estimates to proxy for firm productivity, θ. We start by illustrating the dataset and our strategy for TFP estimation. Then, we show the stylized fact that motivated our theoretical analysis. Finally, we test our model's implications.

3.1 Data

Our data comes from the 9th survey "Indagine sulle Imprese Manifatturiere", administered by the Italian Commercial Bank *Unicredit*. The survey is based on a questionnaire sent to a sample of 4,289 manufacturing firms and contains information for the period 2001-2003. Answers to the survey questions are complemented by balance sheet data. The sample is stratified by size class, geographic area and industry to be representative of the population of Italian manufacturing firms with more than 10 employees.[21] We drop roughly 100 firms

[19] Moreover, the first term is decreasing in θ_z and vanishes when θ_z grows very large.

[20] Although the focus of our theory and empirics is on conditional correlations (because the results are more interesting and our data are not well suited to study unconditional correlations), some of our findings can be easily generalized. In particular, our result that the elasticity of export intensity to productivity is increasing in per capita income of the foreign destinations holds also unconditionally when export productivity cutoffs are similar across destinations. Moreover, per unit trade costs tend to weaken the positive unconditional correlation between export intensity and productivity (for given relative income), whereas country-specific fixed trade costs tend to strengthen it.

[21] The strata are defined according to five size classes, four industry groups based on the Pavitt's (1984) classification, and two geographic areas (Northern and Central-Southern Italy).

reporting negative values for sales, capital stock or material purchases, or for which the various categories of employees (by educational level or occupation) do not sum up to the reported total employment.

A distinguishing feature of our dataset is that it contains information on firm exports in the year 2003 to the following destinations: EU15, New EU Members, Other European countries, North America, Latin America, China, Other Asian countries, Africa, and Oceania. To show our main stylized fact, we start by reaggregating them into two groups of high-income and low-income destinations. In particular, the former group includes EU15, North-America, and Oceania, whereas the latter includes Africa, China, Latin America and New EU Members. We exclude Other Europe and Other Asia from the two groups, because they include countries that are very heterogeneous in terms of per capita income.[22] Based on data from the World Development Indicators, average PPP per capita income in 2003 equals 27,000 US$ in the group of high-income destinations, 4,500 US$ in the group of low-income destinations, and 26,000 US$ in Italy.

With regard to input and output data, as is the case with most other micro datasets, we do not observe firm-level prices, and therefore rely on a revenue-based measure of output, defined as the sum of sales, capitalized costs and change in final goods inventories (see, e.g., Parisi, Schiantarelli and Sembenelli, 2006). Material inputs are computed as the difference between purchases and change in inventories of intermediate goods. Capital stock is the book value reported in the balance sheets. Finally, as for the labor inputs, we use two standard measures of skill. The first is based on the educational attainment of the workforce, available for the year 2003: we define as high-skill workers those with at least a high-school degree and as low-skill workers all the others.[23] The second measure is based instead on occupational data, available for the whole period 2001-2003: we proxy for high-skill workers with non-production workers (the sum of entrepreneurs, managers, technical and administrative employees) and for low-skill workers with manual workers.

Table 1 reports descriptive statistics for the year 2003. The median firm in the sample produces about 1 million Euros worth of output and employes 50 workers, 30% of which are

[22] Both areas include the richest and poorest countries in the world. For instance, Other Asia comprises Japan and Afghanistan, whereas Other Europe comprises Switzerland and Norway, as well as Russia and the Balkans. Our main results are however robust to including these areas among both the low-income and the high-income destinations.

[23] The survey reports three different levels of educational attainment: college degree, high-school degree, less than high-school degree.

non-production workers (37% are high-school or college graduates), and whose productivity (value added per worker) equals 90 thousand Euros. As for export behavior, three-fourths of the firms in our sample sell abroad.[24] Moreover, borrowing terminology from Eaton, Kortum and Kramarz (2008), high-income countries are more popular destinations than low-income countries for Italian exporters: almost all of them (91%) sell to the former and only a subset (49%) to the latter. Similarly, export intensity to high-income destinations is higher than export intensity to low-income destinations (30% versus 10% on average).[25]

3.2 TFP Estimation

In this section, we illustrate our empirical strategy to estimate the TFP. Methodological details and estimation results are reported in the Appendix. As is well known, estimating TFP is a hard task.[26] The issues involved in TFP estimation range from the choice of specification and sectorial aggregation of the underlying production function, to the choice of appropriate estimators of its parameters to address attenuation and simultaneity biases. Given that there is no simple and unique solution to these issues, our strategy consists in estimating a set of different TFP measures, rather than relying on just one of them: if we can show that our main findings are robust across TFP estimates, we can be confident that they reflect genuine economic phenomena rather than methodological choice.

As for the choice of functional form, following among others Hellerstein, Neumark and Troske (1999), Hellerstein and Neumark (2004) and Amiti and Konings (2007), we use both a Cobb-Douglas and a translog specification. The former is appealing due to its simple log-linear form, but imposes strong restrictions on the substitutability among inputs. The latter is more general, but is also more demanding in terms of identifying variance and may exacerbate bias due to measurement error.[27] We therefore use both specifications. In particular, we estimate our production functions using a revenue-based measure of output and four inputs: high-skill labor, low-skill labor, material inputs and physical capital.

[24] This figure is very close to that reported in other studies based on micro-level data collected by the Italian Statistical Office, e.g., Castellani, Serti and Tomasi (2008).

[25] When computed for the whole sample (i.e., considering also non-exporting firms), average export intensity equals 26%, a value close to the manufacturing-wide figure reported by the Italian Statistical Office (30%).

[26] See Bartelsman and Doms (2000) and Ackerberg et al. (2007), for recent surveys of the literature on TFP estimation.

[27] The Cobb-Douglas specification restricts the elasticity of substitution between any pair of inputs to be constant and equal to one, whereas the translog specification imposes no restrictions on the substitutability among inputs and provides a second-order local approximation to any twice-continuously differentiable production function (Diewert and Wales, 1987).

With regard to the choice of estimation method, we start by estimating the two production functions' parameters by OLS using cross-sectional variation in the year 2003. OLS estimates may be biased due to measurement error (attenuation bias) and potential correlation between inputs and unobserved productivity (simultaneity bias).[28] To address these issues, we follow three complementary approaches. First, we estimate the two production functions with (and without) a large set of controls, and using two different proxies for skill. Second, we estimate them by Two-Stage Least Squares (2SLS), using inputs in the years 2001 and 2002 to instrument for their levels in 2003, as in Hellerstein, Neumark and Troske (1999). Third, following among others De Loecker (2007), we estimate the Cobb-Douglas specification using the semiparametric estimators proposed by Olley and Pakes (OP, 1996) and Levinsohn and Petrin (LP, 2003), which deal with the simultaneity bias in a more structural way than does the 2SLS estimator, perform reasonably well in the presence of measurement error (Van Biesebroeck, 2007), and fully exploit the panel dimension of our three-year dataset. Despite many similarities, the OP and LP estimators have some important differences that may affect their relative performance.[29] We thus rely on both approaches for robustness. Moreover, following De Loecker (2008), we also use an augmented OP estimator in order to address the potential *omitted price variable bias* arising from using industry-level price indexes to deflate firm revenue (Klette and Griliches, 1996).

Finally, we relax the assumption of an equal technology across manufacturing industries by estimating, as in Bernard and Jensen (1999) and Kugler and Verhoogen (2009), cross-sectional OLS Cobb-Douglas production functions at the (2-digit) industry level.

Overall, our strategy yields twelve different estimates of the output elasticity of each production factor. They are presented and discussed in the Appendix. We use these estimates to compute twelve different TFP measures, in which (the log of) TFP is defined as: $\ln TFP_j = (\ln Y_j - \sum_r \xi_r \cdot \ln r_j)$, where j indexes firms, Y is output, r is one of the four inputs used in our analysis, and ξ_r is one of the twelve estimates of the output elasticity of factor r. The simple correlation among our TFP estimates is reassuringly high, as it equals 0.84 on average and ranges from a minimum of 0.40 to a maximum of 0.99. Although these estimates are

[28] The two biases may point in opposite directions. See De Loecker (2008) and Van Biesebroeck (2008) on the practical relevance of this point in TFP estimation.

[29] In particular, the OP estimator requires discarding observations with zero investment flows (about 25% in our data set), and this may bias parameter estimates and imply an efficiency loss relative to the LP estimator. The latter is however subject to more serious collinearity problems, which implies that identification of the labor coefficients is sensitive to the assumptions concerning the data generating process (Ackerberg, Caves and Frazer, 2006).

not all equally plausible, each has pros and cons, and therefore, following Van Biesebroeck (2008), in the next sections we will use all of them to ensure that methodological choice and specification details are not crucial for the main pattern of results.

3.3 Stylized Fact

Armed with a battery of TFP estimates, we can now study their correlation with export intensity. We run cross-sectional OLS regressions of the following form:

$$\ln EXP_j^i = \alpha_0 + \alpha_1 \ln TFP_j + \eta_i + u_j, \tag{27}$$

where j and i index firms and 3-digit industries, respectively,[30] EXP is a measure of export intensity,[31] TFP is one of the productivity measures estimated in the previous section, η_i are industry fixed-effects and u is an error term. Our coefficient of interest, α_1, proxies for the elasticity of export intensity to productivity, e_θ^{EXP}.[32] Table 2a reports our baseline results. Each panel of the table refers to a different export intensity measure, and each column to a different TFP estimate. In particular, as detailed in the Appendix, columns (1)-(4) refer to cross-sectional Cobb-Douglas estimates, columns (5)-(8) to cross-sectional translog estimates, columns (9)-(11) to semiparametric Cobb-Douglas panel estimates, and column (12) to cross-sectional OLS Cobb-Douglas estimates at the 2-digit industry level. Given that our main regressor is estimated, the table reports bootstrapped standard errors based on 100 replications (in square brackets), as well as, for comparison, heteroskedasticity-robust analytical standard errors (in round brackets).

In panel a1), we regress overall export intensity (the ratio of total exports to sales) on our TFP estimates: α_1 is positive in half of the specifications and is always small and insignificantly different from zero. Hence, as in the simplest Melitz's model, in our data export intensity and productivity seem to be uncorrelated, conditional on exporting. In panel a2), we use export intensity to high-income destinations as the dependent variable. Our coefficient

[30] Industries are classified according to the ATECO system, the standard industrial classification in Italy, equivalent to NACE.

[31] Unlike in the previous section, in our empirical analysis we normalize exports by total sales rather than by domestic sales. The former measure is a monotonic transformation of the latter and is the standard definition of export intensity. The ratio of exports to domestic sales is slightly less well suited in our regression framework, as it gives an overwhelming weight to firms selling a tiny share of their output in the domestic market, while dropping at the same time firms selling all their output abroad. In any case, we have experimented with both measures and found essentially the same results.

[32] Note that the log transformation conditions the analysis on exporting.

of interest is now always positive (except in one specification), but is imprecisely estimated. Finally, in panel a3) we use export intensity to low-income destinations as the dependent variable, and find that the picture is completely different: α_1 is now always negative and significantly different from zero beyond the 1% level using either type of standard errors. The estimated elasticity is also large in absolute value, implying that a doubling of TFP is associated with about a 60% fall of the export intensity to low-income destinations. In Table 2b, we augment our baseline specification (27) by adding the same battery of controls used in Tables A1-A2 to estimate the production functions' parameters.[33] The p-value of the F-statistic suggests that these controls are generally relevant, but the previous findings are unchanged.

The rest of this section is devoted to further check the robustness of the above results. To save space, we focus on export intensity to high-income and low-income destinations, and report bootstrapped standard errors only.[34] To start with, we check whether our results are mediated by other forms of firm participation in foreign markets that may be correlated with both export intensity and productivity. In particular, our dataset allows us to construct the following variables: $IMPINT$, a proxy for material offshoring defined as the share of imported inputs in total input purchases in the year 2003 (Feenstra and Hanson, 2003);[35] $SERV$, a dummy for service offshoring equal to 1 if a firm purchased services from abroad in the year 2003; $INSH$, a proxy for inshoring defined as the share of sales arising from productions subcontracted by foreign firms in 2003 (Slaughter, 2006); FDI, a proxy for foreign direct investment defined as the ratio of outward FDI to sales over the period 2001-2003. As shown in Table 3, inshoring is positively correlated with both export intensities, service offshoring is positively correlated with export intensity to high-income destinations only, and the coefficients of the other proxies for firm internationalization are generally statistically insignificant. More importantly, these additional controls leave our previous results unaffected: TFP remains strongly negatively correlated with export intensity to low-income destinations and uncorrelated with export intensity to high-income destinations.

With a revenue-based output measure, price variations are embodied in TFP estimates.

[33] Our set of controls includes: the share of part-time workers in total employment, a dummy equal to one if a firm is quoted on the stock market, a full set of dummies for Italian administrative regions, and three dummy variables that control for ownership structure. These latter dummies take a value of one in the presence, respectively, of stand-alone firms, firms that belong to a group in the position of leader, and controlled firms (the omitted category being firms with an intermediate position in the group).

[34] Overall export intensity remains uncorrelated with TFP throughout all the specifications shown below.

[35] We compute this variable including both imported intermediate inputs that are further processed in Italy, and final goods that are sold under the brand-name of the firm. We have also experimented with a narrower measure including only the former type of goods, with no change in the results.

Insofar as these price variations reflect differences in demand or market power, rather than differences in efficiency, they may contaminate our TFP estimates.[36] So far, we have shown that our results are unchanged when using the augmented Olley and Pakes methodology, which explicitly addresses the omitted price variable bias arising when firm prices deviate from the industry-level deflators and these deviations are correlated with input choices. Moreover, by controlling for 3-digit industry dummies we have already taken account of price differences that are constant within 3-digit industries. We have also run two additional checks, unreported to save space. First, we have added to our baseline specification the domestic market share of each firm, so as to further control for price deviations within 3-digit industries due to differences in domestic market power. Second, we have controlled for the log of firm age to account for the fact that young businesses tend to charge lower prices than incumbents for given efficiency (see Foster, Haltiwanger and Syverson, 2008). In both cases, the results were unaffected.

Yet, we have not fully addressed the potential bias due to price differences stemming from heterogeneity in demand shocks or price behavior across markets (Demidova, Looi Kee and Krishna, 2006; Looi Kee and Krishna, 2008). If, for instance, firms systematically charge lower prices to low-income destinations, their TFP may be underestimated and the negative correlation between measured TFP and export intensity to low-income destinations may be overstated. To address this issue, in Table 4a we start by adding to our baseline specification a full set of seven export market dummies taking a value of one for firms exporting to a given destination.[37] These dummies should help control for price differences across markets that are constant across firms. Note that the p-value for these dummies is highly significant, but otherwise our main results are unchanged. It is possible, however, that price differences across markets are industry-specific. To address this possibility, in Table 4b we add a full set of interaction terms between export market dummies and 3-digit industry dummies. This specification now includes roughly one thousand variables, with a dramatic loss of degrees of freedom. Strikingly, however, export intensity to low-income destinations is still strongly negatively correlated with productivity (all TFP coefficients are negative and significant at least at the 5% level), whereas export intensity to high-income destinations is uncorrelated

[36] For a discussion of this point, see, in particular, Klette and Griliches (1996), Levinsohn and Melitz (2002), Eslava et al. (2004), Syverson (2004), Mairesse and Jaumandreau (2005), Amiti and Konings (2007), De Loeker (2008), Foster, Haltiwanger and Syverson (2008), and Katayama, Lu and Tybout (2009).

[37] Recall that we observe exports to four low-income and three high-income destinations.

with productivity.[38]

We close this section with an important robustness check. So far, we have assumed that firms exporting to high-income and low-income destinations share the same production function, and that all heterogeneity is concentrated in the productivity term. It is possible, however, that firms exporting to different destinations use radically different technologies. Note that this possibility is not ruled out by allowing parameters of the production function to vary across 2-digit industries, because technology differences among exporters may cut through the standard classification of industries. We address this issue by splitting our sample in two groups of roughly equal size: one includes firms exporting to low-income destinations, and the other all the remaining firms. We then re-estimate all the TFP measures separately for each group, using the same specifications and methodology as for the whole sample. This approach should also help further address the above discussed issue of unobserved price differences across destinations. The main results are reported in Table 5. Note that export intensity to low-income destinations is strongly negatively correlated with all TFP measures and that the coefficients are precisely estimated and very similar in magnitude to those reported in Table 2. Export intensity to high-income destinations is instead uncorrelated with productivity.[39]

3.4 Testing the Model's Implications

Having shown that our stylized fact is surprisingly robust, we now test whether our theory can consistently explain it. We start by looking for evidence on the firm-level relationship between productivity and product quality, and between product quality and export intensity. Then, we try to disentangle the role played by each of the main determinants of the TFP elasticity of export intensity according to our theory. Finally, we test whether it can explain the different pattern of correlations between export intensity and productivity across individual foreign destinations.

[38] Recent work by Demidova, Looi Kee and Krishna (2006) suggests to account for market-specific demand shocks by augmenting the polynomial (non-parametric) approximation for TFP in the OP estimator with export shares to different destinations. Because we observe exports only in one year, implementing this approach would require assuming that export shares remained constant over the sample period, which would not guarantee the invertibility of the policy functions in the OP estimator (see Van Biesebroeck, 2005, for a discussion of the invertibility conditions in a similar setting). Yet, we have experimented with this approach under such an assumption and found no change in the results.

[39] We have performed other tests, unreported to save space. In particular, our results do not change when conditioning export intensity to either group of destinations on export intensity to the other group.

3.4.1 Evidence on Product Quality and Productivity

As shown by equation (14), per capita income of the foreign destinations does not affect the TFP elasticity of export intensity for $\epsilon = 0$, namely, in the absence of a positive correlation between productivity and product quality. In this section, we therefore look for evidence on the firm-level correlation between productivity and product quality, and between the latter and export intensity, to test whether product quality plays an important role in determining the pattern of export intensities shown in the previous section.

Although measuring product quality is no easier than measuring TFP, the empirical literature (e.g., Sutton, 1998) suggests that the scope for quality differentiation is generally associated with the intensity of R&D and other activities aimed at producing new products or processes, with marketing activities, with the managerial capability of a firm, and more generally with the intensity of investment activities.[40] In this respect, a unique advantage of our dataset is that it allows us to construct a number of firm-level variables to proxy for some of these characteristics, and in particular: R&D and marketing expenditures per employee, sales of innovative products per employee, a dummy variable taking a value of one if a firm invested in process innovation in the previous three years and its interaction with sales of innovative products per employee, the share of managers in total employment and, finally, the level of investment per employee.

In Table 6, we regress each of these variables on our TFP measures and on a full set of 3-digit industry dummies. Note that all variables are positively correlated with all TFP measures. The coefficients of TFP are also quite precisely estimated. Given that these variables are likely to be correlated with product quality but none is a perfect proxy for it, following a standard practice in the empirical literature we extract their principal component by factor analysis and use it as a proxy for product quality. The basic idea is that the principal component may capture the common link of these variables with product quality. As shown in the last panel of the table, the principal component is strongly positively correlated with all our TFP measures.[41]

With this new variable at hand, in Table 7 we rerun the same specifications as in Section

[40] See also Kugler and Verhoogen (2008) on this point.

[41] Results in Table 6 are also consistent with Verhoogen (2008) and Kugler and Verhoogen (2008), in which a positive correlation between productivity and product quality stems from complementary between productivity and input quality in producing output quality. Consistent with these works, we have found that average firm wages (a proxy for input quality) are positively correlated with TFP. Moreover, adding wages to our factor analysis makes the positive correlation between the principal component and TFP even stronger.

3.3 by replacing TFP with our proxy for product quality.[42] If, as suggested by our theory, the correlation between export intensity and TFP is partly driven by the correlation between productivity and product quality, we should observe a similar pattern when regressing export intensity on product quality instead of TFP. This is indeed what we find: strikingly, in all specifications, product quality is strongly negatively correlated with export intensity to low-income destinations and uncorrelated with export intensity to high-income destinations.

One possible concern is that our proxy may simply be acting as a proxy for TFP rather than as a proxy for product quality. To check this possibility, we rerun our baseline regressions for export intensities by including both TFP and product quality among the regressors: if our variable is indeed proxying for TFP rather than for product quality, it should lose its explanatory power once TFP is included among the regressors. The main results are reported in Table 8. Note that our proxy for product quality is still strongly negatively correlated with export intensity to low-income destinations (and uncorrelated with export intensity to high-income destinations), suggesting that it is indeed relevant. Note, also, that TFP remains negatively correlated with export intensity to low-income destinations, which suggests that productivity may affect export intensity directly, not only through product quality.[43] As shown below, this result is consistent with per unit trade costs also playing an important role.

3.4.2 Panel Evidence on the Determinants of the TFP Elasticity of Export Intensity

According to our theory, the elasticity of export intensity to productivity is affected by relative per capita income of the foreign destinations (Proposition 1), by per unit trade costs (Proposition 2), and by country-specific fixed costs of exporting (Proposition 3). To disentangle the possible impact of each of these variables on the TFP elasticity of export intensity, we now use information on the export intensity to each of the seven destinations for which we have data. This allows us to estimate a panel regression of the following form:

$$\begin{aligned} \ln EXP^{i}_{j,f} \quad &= \quad \beta_f + \beta_{f,i} + \beta_1 \ln TFP_j + \beta_2(\ln TFP_j \times y_f) + \\ &\quad +\beta_3(\ln TFP_j \times d_f) + \beta_4(\ln TFP_j \times n_f) + u_{j,f}, \end{aligned} \tag{28}$$

[42] The only difference in these specifications is that our proxy for product quality is in levels rather than in logs, as it is a standardized variable with mean equal to zero and standard deviation equal to one. By implication, the coefficients in the table cannot be interpreted as elasticities.

[43] In any case, our proxy for product quality may be too rough to wash out all of the negative correlation between productivity and export intensity to low-income destinations.

where i indexes 3-digit industries, $EXP_{j,f}$ denotes firm j 's export intensity to destination f, β_f are destination fixed-effects, $\beta_{f,i}$ are destination-industry fixed effects, and TFP is one of our productivity estimates. The term $\ln TFP_j \times y_f$ is the interaction between firm j's productivity and per capita income of destination f.[44] It captures the impact of foreign income on the TFP elasticity of export intensity. The expected sign of β_2 is therefore positive according to Proposition 1. The term $\ln TFP_j \times d_f$ is instead the interaction between firm j's productivity and the distance of destination f from Italy, computed as the number of kilometers between Rome and the capital city of Italy's main trading partner within any destination.[45] As shown by Hummels and Skiba (2004), per unit trade costs are strongly positively correlated with physical distance, with an elasticity of the former to the latter of 20%, thereby suggesting that per unit trade costs are more relevant in exports to distant destinations. Under this assumption, the expected sign of β_3 is negative according to Proposition 2. Finally, the term $\ln TFP_j \times n_f$ is the interaction between firm j's productivity and the number of countries within any destination.[46] This term captures the fact that, if fixed costs of exporting are country-specific, more productive firms should be able to sell to a larger number of countries within any destination. The expected sign of β_4 is therefore positive according to Proposition 3.

The main results are reported in Table 9, together with standard errors corrected for clustering at the firm-level. In Panel a), we start with a specification including only the interaction term between income and TFP. Note that the coefficient β_2 is always positive, as expected, large and significant beyond the 1% level. In panel b), we add the interaction term between TFP and distance, whose coefficient is always negative, large and precisely estimated. This result suggests that distance has a stronger negative impact on the export intensity of more productive firms, and is consistent with our theory under the assumption that per unit trade costs are increasing in physical distance. Note, also, that adding this term does not affect the size and significance of the coefficient β_2, whereas it reduces, as expected, the absolute value of β_1. Finally, in panel c) we add the interaction between TFP and the

[44] We measure y_f using data on per capita GDP in PPP for the year 2003 from the World Development Indicators, and normalize it by Italy's per capita income.

[45] We compute d_f with data on geographical distance from CEPII, and normalize it by the average distance across all destinations. For a given destination, the main trading partner is the country with the highest share in Italy's trade, retrieved from CEPII's data on bilateral trade flows for the year 2003. In particular, the main trading partners are: Germany (EU15), United States (North America), Australia (Oceania), Poland (New EU Members), Brazil (Latin America), Tunisia (Africa), and China.

[46] n_f is constructed using information from the World Bank, and normalized by the average number of countries across all destinations.

number of countries within each destination, whose coefficient is however always economically and statistically close to zero. This suggests that using more aggregated export intensity data does not seem to have a strong impact on the estimated correlations with TFP.

3.4.3 The TFP Elasticity of Export Intensity across Individual Destinations

Our final step is to test whether per capita income and distance can jointly explain the sign, size and ranking of the TFP elasticities of export intensity across individual destinations. To this purpose, we start by rerunning our baseline regression equation (27) for each of the seven destinations separately. The results are reported in Table 10. As for low-income destinations (Africa, China, Latin America and New EU Members), note that the TFP elasticity of export intensity is always negative, very large and quite precisely estimated notwithstanding the substantial loss of degrees of freedom (it is always significant at least at the 10% level). As for high-income destinations, the estimated elasticity is weakly positive in the case of EU15, weakly negative in the case of North America, and strongly negative in the case of Oceania, the most distant destination from Italy.[47]

Next, for each destination we compute the TFP elasticity of export intensity predicted only on the basis of its income and distance from Italy. In particular, using the panel estimates in Table 9b, we compute the elasticities as:

$$e_{\theta}^{EXP_f} = \beta_1 + \beta_2 y_f + \beta_3 d_f. \qquad (29)$$

In Table 11, we compare the elasticities estimated in Table 10 (first column) with those predicted according to equation (29) (second column). Both elasticities are based on the augmented Olley-Pakes TFP estimates. Note that the predicted elasticities always match the sign of the estimated elasticities. Moreover, predicted elasticities account on average for 96.5% of estimated elasticities, and range from a minimum of 72% to a maximum of 138% (see the third column). Finally, and apart from China, whose predicted elasticity is underestimated, the ranking of predicted elasticities matches that of estimated elasticities. Consistent with our theory, the distance and income of foreign destinations can therefore provide a surprisingly accurate account of the different geographic patterns of correlations between export intensity

[47] Note that these elasticities can be equivalently obtained as the coefficients $\beta_{f,TFP}$ from the following panel regression: $\ln EXP^i_{j,f} = \beta_f + \beta_{f,i} + \sum_f \beta_{f,TFP}(\ln TFP_j \times DEST_f) + u_{j,f}$, where the terms $\ln TFP_j \times DEST_f$ are interactions between firm j's productivity and the seven destination dummies.

and productivity.

4 Conclusion

In this paper, we have formulated and tested a simple theory of export intensity and productivity in which, building on the recent literature, two plausible assumptions play a crucial role: first, consumers' willingness to pay for quality increases with per capita income and, second, more productive firms endogenously choose higher-quality products. We have shown that the two assumptions jointly imply that, conditional on exporting, the elasticity of export intensity to productivity is increasing in per capita income of the foreign destinations. Moreover, we have shown that the relationship between export intensity and productivity crucially depends on the characteristics of trade costs, and that it is ceteris paribus negative when per unit trade costs are relevant. Hence, our theory suggests the correlation between export intensity and productivity to be negative in trade with lower-income and/or distant destinations.

Our model can help explain a striking stylized fact that emerges from a representative sample of Italian manufacturing firms, namely, a strongly negative correlation between productivity and export intensity to low-income destinations, conditional on exporting. Moreover, it provides a parsimonious and yet surprisingly accurate account of the different patterns of correlations between export intensity and productivity across individual foreign destinations, as their per capita income and distance from Italy help predict the sign, size and ranking of the elasticities of export intensities to productivity. Finally, we have shown that in our data productivity and product quality are strongly positively correlated at the firm-level, thereby providing empirical support for a key mechanism underlying the above correlations according to our theory.

Although in recent years we have dramatically improved our understanding of firm export behavior, there are still some unresolved issues. In particular, the determinants of the "popularity" of foreign destinations from the standpoint of domestic exporters are not yet fully understood (Eaton, Kortum and Kramarz, 2008). We hope that, by showing how export intensity depends on the interplay between firm and foreign market characteristics, our contribution can shed light on this important issue, thereby bettering our understanding of firm export behavior in the global economy. We still do not know, however, whether the empirical regularities documented in this paper, although strong and plausible, hold in general. Testing whether our results extend beyond the Italian manufacturing is therefore a promising avenue for future research.

5 Appendix

5.1 Export Intensity and Productivity when Marginal Cost is Increasing in Product Quality

We now consider the more general case in which higher-quality products require not only a higher fixed cost (as in the baseline model), but also a higher marginal cost. This is the case if, for instance, manufacturing higher-quality products requires higher-quality inputs.[48] Consider, in particular, the following marginal cost function (see Johnson, 2007):

$$MC(\theta, \lambda(\theta)) = \frac{\lambda(\theta)^{\delta}}{\theta}, \tag{30}$$

where $\delta > 0$ is the elasticity of marginal cost to product quality. The profit maximizing price in the domestic and foreign market is:

$$p(\theta, \lambda(\theta)) = \frac{\lambda(\theta)^{\delta}}{\rho\theta}, \quad p_f(\theta, \lambda(\theta)) = \tau\frac{\lambda(\theta)^{\delta}}{\rho\theta}. \tag{31}$$

Revenue of domestic firms in the domestic and foreign market is:

$$r(\theta, \lambda(\theta)) = R\left(\rho\theta P\right)^{\sigma-1}\lambda(\theta)^{\alpha(y)-\delta(\sigma-1)}, \tag{32}$$

$$r_f(\theta, \lambda(\theta)) = \tau^{1-\sigma}R_f\left(\rho\theta P_f\right)^{\sigma-1}\lambda^{\alpha(y_f)-\delta(\sigma-1)}. \tag{33}$$

As in the baseline setting, firms choose product quality to maximize domestic profits, and therefore solve the following problem:

$$\max_{\lambda}\left\{\frac{1}{\sigma}R\left(\rho\theta P\right)^{\sigma-1}\lambda^{\alpha(y)-\delta(\sigma-1)} - \phi\lambda^{\gamma} - \phi\right\}.$$

Assuming that $0 < \alpha(y) - \delta(\sigma - 1) < \gamma$ to ensure that the second-order condition for a maximum is satisfied, we obtain the following expression for the optimal product quality:

$$\lambda(\theta) = \left(\overline{\lambda}_{\delta}\theta\right)^{\epsilon_{\delta}}, \tag{34}$$

[48] See Verhoogen (2008) and Kugler and Verhoogen (2008, 2009) on this point.

where $\overline{\lambda}_\delta = \left[\frac{[\alpha(y)-\delta(\sigma-1)](\rho P)^{\sigma-1}R}{\gamma\phi\sigma}\right]^{\frac{1}{\sigma-1}}$ and $\epsilon_\delta = \frac{\sigma-1}{\gamma-[\alpha(y)-\delta(\sigma-1)]} > 0$. Note that a higher δ implies a lower optimal product quality and a lower elasticity of product quality to productivity, as it reduces the profitability of quality upgrading. Otherwise, the main results are unchanged. Using (34) into (33) and (32), we obtain the following expression for export intensity:

$$EXP_f(\theta) = \tau^{1-\sigma}\frac{R_f}{R}\left(\frac{P_f}{P}\right)^{\sigma-1}\left(\overline{\lambda}_\delta\theta\right)^{-\epsilon_\delta\left[\alpha(y)-\alpha(y_f)\right]}. \tag{35}$$

Note that, as in Proposition 1, the elasticity of export intensity to productivity is increasing in per capita income of the foreign destination. By the same reasoning, it would be straightforward to show that Proposition 3 also holds when marginal cost is increasing in product quality.

Consider now the case of per unit trade costs $t > 0$. The price charged by a firm selling to destination f is:

$$p_f = \frac{1}{\rho}\left[MC(\theta,\lambda)\tau + t\right] = \frac{1}{\rho}\frac{\left(\overline{\lambda}_\delta\theta\right)^{\epsilon_\delta\delta}\tau + t\theta}{\theta},$$

where the latter equality follows from using equation (34) into equation (30). Revenue in the foreign and domestic market is therefore:

$$\begin{aligned} r_f(\theta) &= \left[\left(\overline{\lambda}_\delta\theta\right)^{\epsilon_\delta\delta}\tau + t\theta\right]^{1-\sigma} R_f\left(\rho\theta P_f\right)^{\sigma-1}\left(\overline{\lambda}_\delta\theta\right)^{\epsilon_\delta\,\alpha(y_f)}, \\ r(\theta) &= \left[\left(\overline{\lambda}_\delta\theta\right)^{\epsilon_\delta\delta}\right]^{1-\sigma} R\left(\rho\theta P\right)^{\sigma-1}\left(\overline{\lambda}_\delta\theta\right)^{\epsilon_\delta\,\alpha(y)}, \end{aligned}$$

which implies the following expression for export intensity:

$$EXP_f(\theta) = \left(\tau + t\overline{\lambda}_\delta^{-\epsilon_\delta\delta}\theta^{1-\epsilon_\delta\delta}\right)^{1-\sigma}\frac{R_f}{R}\left(\frac{P_f}{P}\right)^{\sigma-1}\left(\overline{\lambda}_\delta\theta\right)^{-\epsilon_\delta\left[\alpha(y)-\alpha(y_f)\right]},$$

and hence the following elasticity of export intensity to productivity:

$$e_\theta^{EXP} = (\sigma-1)\frac{(\epsilon_\delta\delta-1)t\left(\overline{\lambda}_\delta\theta\right)^{-\epsilon_\delta\delta}}{\tau + t\overline{\lambda}_\delta^{-\epsilon_\delta\delta}\theta^{1-\epsilon_\delta\delta}} - \epsilon_\delta\left[\alpha(y)-\alpha(y_f)\right].$$

Note that the sign of the first term depends on the sign of $\epsilon_\delta\delta - 1$, which represents the elasticity of marginal cost to productivity. Using the expression for ϵ_δ we have:

$$\epsilon_\delta\delta - 1 = -\frac{\gamma-\alpha(y)}{\gamma-\alpha(y)+\delta(\sigma-1)},$$

where $\gamma-\alpha(y)+\delta(\sigma-1) > 0$ by the second order condition for optimal product quality. Hence, for $\gamma - \alpha(y) > 0$, marginal cost is decreasing in productivity, as in the baseline model (as well as in Melitz, 2003). In this case, our qualitative results are unchanged, as per unit trade costs represent a higher share of marginal cost for more productive firms and hence imply, ceteris paribus and conditional on exporting, a negative correlation between export intensity and productivity. In contrast, for $-\delta(\sigma-1) < \gamma - \alpha(y) < 0$, the elasticity of marginal costs to productivity is positive. In this case, more productive firms face higher marginal costs in addition to higher fixed costs. By implication, per unit trade costs represent a lower share of marginal cost for more productive firms and therefore induce, ceteris paribus, a positive conditional correlation between export intensity and productivity. As shown in the main text, this somewhat extreme case does not seem to be empirically relevant in our data.

5.2 Choosing Product Quality in Open Economy

We now show that our qualitative results are unchanged in the more general case in which domestic firms choose product quality to maximize overall profits rather than domestic profits, as assumed for simplicity in the main text. Assume, in particular, that domestic firms sell their output in the domestic market and in a foreign destination f, whose per capita income equals $y_f \gtreqless y$. Optimal product quality is the solution of the following problem:

$$\max_{\lambda} \left\{ \frac{(\rho\theta)^{\sigma-1}}{\sigma} \left(\lambda^{\alpha(y)} R P^{\sigma-1} + \lambda^{\alpha(y_f)} \tau^{1-\sigma} R_f P_f^{\sigma-1} \right) - \phi\lambda^{\gamma} - \phi \right\}, \tag{36}$$

where $RP^{\sigma-1}$ and $\tau^{1-\sigma} R_f P_f^{\sigma-1}$ represent, respectively, the size of the domestic and foreign market.[49] Equation (36) is a generalization of equation (8) which takes into account that part of domestic firms' revenue is generated in the foreign market. The first order condition for a maximum can be written as:

$$\lambda^{\gamma} = \frac{(\rho\theta)^{\sigma-1} \left(RP^{\sigma-1} + \tau^{1-\sigma} R_f P_f^{\sigma-1} \right)}{\gamma\phi\sigma} \left[\alpha(y)\lambda^{\alpha(y)} s + \alpha(y_f)\lambda^{\alpha(y_f)}(1-s) \right], \tag{37}$$

where $s = \frac{RP^{\sigma-1}}{RP^{\sigma-1} + \tau^{1-\sigma} R_f P_f^{\sigma-1}}$ denotes the relative size of the domestic market. Using the implicit function theorem, we can compute the elasticity of product quality to productivity

[49] For simplicity, in this section we assume $\delta = 0$ and ignore per unit and fixed trade costs.

implied by (37):

$$\frac{d\ln\lambda}{d\ln\theta}=\frac{(\sigma-1)}{\gamma-\frac{\alpha(y)^2\lambda^{\alpha(y)}s+\alpha(y_f)^2\lambda^{\alpha(y_f)}(1-s)}{\alpha(y)\lambda^{\alpha(y)}s+\alpha(y_f)\lambda^{\alpha(y_f)}(1-s)}}>0, \tag{38}$$

where the inequality follows from the second order condition for a maximum, which requires the denominator of (38) to be greater than zero. In particular, the denominator takes values between $\gamma-\alpha(y)$ for $s\to 1$, and $\gamma-\alpha(y_f)$ for $s\to 0$. Hence, the second order condition for a maximum is always satisfied for $\gamma>\max\{\alpha(y_f),\alpha(y)\}$. The fact that the elasticity of product quality to productivity is positive implies that our qualitative results carry unchanged in this more general case. Note, also, that the elasticity derived in the main text, $\epsilon=\frac{(\sigma-1)}{\gamma-\alpha(y)}$, is a special case of equation (38) when $s\to 1$, i.e., when domestic firms sell their output in the domestic country (and/or in similar countries). Finally, note that the elasticity of product quality to productivity is increasing in λ and, for $y>y_f$, it is increasing in s, implying a stronger correlation between product quality and productivity for high-quality firms in high-income areas.

5.3 TFP Estimation

In this section, we detail our strategy for estimating the TFP and illustrate the main results. The production function of firm j is:

$$Y_j=f(R_j)\cdot\omega_j, \tag{39}$$

where Y is revenue-based output, $R=\{S,U,K,M\}$ is the vector of inputs (respectively, high-skill workers, low-skill workers, capital stock and materials), and ω is the TFP. The Cobb-Douglas specification of equation (39) is:

$$\ln Y_j=\beta_0+\beta_S\ln S_j+\beta_U\ln U_j+\beta_K\ln K_j+\beta_M\ln M_j+\ln\omega_j+\varepsilon_j, \tag{40}$$

where β_r ($r\in R$) is the elasticity of output with respect to input r and ε_j is a random disturbance. The translog specification is instead:

$$\ln Y_j=\beta_0+\sum_{r\in R}\beta_r\cdot\ln r_j+0.5\cdot\sum_{r\in R}\sum_{z\in R}\beta_{rz}\cdot\ln r_j\cdot\ln z_j+\ln\omega_j+\varepsilon_j, \tag{41}$$

where the elasticity of output with respect to input r, λ_r, now equals:

$$\lambda_{r,j} \equiv \frac{\partial \ln Y_j}{\partial \ln r_j} = \beta_r + \sum_{z \in R} \beta_{rz} \cdot \ln z_j. \tag{42}$$

The (log of) TFP is computed as $\ln TFP_j \equiv \ln \omega_j = (\ln Y_j - \sum_r \beta_r \cdot \ln r_j)$ from equation (40), and as $\ln TFP_j = (\ln Y_j - \sum_r \lambda_r \cdot \ln r_j)$ from equation (41).[50]

As mentioned in the main text, we start by estimating (40) and (41) by OLS, using only cross-sectional variation in the year 2003. Then, we use different strategies to address attenuation bias and simultaneity bias. In particular, we estimate (40) and (41) with and without a large set of controls, by using two different proxies for skill, and by using the Two-Stage Least Squares (2SLS) estimator.[51,52] Finally, we estimate equation (40) by using the semiparametric estimators proposed by Olley and Pakes (OP, 1996) and Levinsohn and Petrin (LP, 2003).

The semiparametric estimators assume that productivity is a state variable in the dynamic optimization problem of the firm and that it follows a first-order Markow process. Profit maximization yields an investment demand function (in OP) and a materials demand function (in LP) that depend on productivity and the other state variable, capital. Under certain conditions, these functions are monotonically increasing in productivity, and can thus be inverted non-parametrically to express the productivity term in equation (40) in terms of observables.[53] Then, OLS yield unbiased estimates of the variable input elasticicities (β_S and β_U in LP; β_S, β_U and β_M in OP). The remaining coefficients are estimated in a second stage by non-linear least squares. Standard errors are computed by bootstrap, using 100 replications in our case.[54]

[50] In the main text, we have used ξ_r to define the output elasticity of input r. Hence, $\xi_r = \beta_r$ for the Cobb-Douglas and $\xi_r = \lambda_r$ for the translog.

[51] Note that, in the presence of heteroskedasticity of an unknown form in the error term, 2SLS estimates are consistent but inefficient. Therefore, we have also estimated (40) and (41) by Generalized Method of Moments (GMM). GMM estimates are efficient, but the efficiency gain may be offset by poorer performance in small samples (Baum, Schaffer and Stillman, 2003). In practice, however, our GMM estimates (unreported to save space) are very similar to 2SLS estimates.

[52] Following Yasar and Morrison (2008), we have also estimated (41) by combining it with the expression for the output share of labor, and by applying Iterated Three-Stage Least Squares on the resulting system of equations. Joint estimation leads to efficiency gains relative to single equation estimation, as it allows to exploit the information contained in the firm optimization process and the resulting parametric restrictions. However, if the system is miss-specified, parameters may be biased and inference incorrect (McElroy, 1987). Our system estimation results, reported in a previous version of this paper, are very similar to the single equation 2SLS results.

[53] The `levpet` routine in Stata 10.1 (Petrin, Poi and Levinsohn, 2004), which we use to implement the LP estimator, employs a third-order polynomial in materials and capital as the non-parametric approximation. As for the OP estimator, we have programmed our own routine using a fourth-order polynomial in investment and capital (as in Amiti and Konings, 2007).

[54] The OP estimator can also correct for bias due to firm exit. Note, however, the all firms in our sample are

Lacking information on output prices at the firm-level, we implement the semiparametric estimators by deflating output with producer price indexes for each 3-digit industry.[55] As noted by Klette and Griliches (1996), this may lead to biased estimates of the production function parameters if the price of individual firms deviates from the industry average and the deviations are correlated with input choices (omitted price variable bias). Likely cases arise if firms produce differentiated products and have pricing power, or if they face idiosyncratic demand shocks. Following Klette and Griliches (1996), we correct this bias by augmenting the production function with the log of average output in the 3-digit industry to which a firm belongs (Q). For industry i, this variable is computed as the weighted sum of deflated revenues, with weights equal to the firms' market shares.[56] As in De Loecker (2008), we implement the correction within the OP framework, because very restrictive assumptions would be necessary in the LP case to preserve the invertibility of the materials demand function.[57] The coefficient of average industry output, β_q, is identified in the first estimation stage and then used to obtain corrected estimates of the production function parameters as $\gamma_r = [1/(1-\beta_q)]\cdot\, \beta_r$, $\forall r \in R$, whereas productivity is computed as $\ln TFP_j = (1/(1-\beta_q))\cdot(\ln Y_j - \sum_r \beta_r \cdot \ln r_j - \beta_q \cdot \ln Q_i)$, where we have omitted the time index to save on notation.[58]

Results Table A1 reports cross-sectional Cobb-Douglas estimates in columns (1)-(4), cross-sectional translog estimates in columns (5)-(8), and semiparametric Cobb-Douglas panel estimates in columns (9)-(11). The table shows estimates of β_r (see equation 40) in columns (1)-(4) and (9)-(10), of λ_r (see equation 42) in columns (5)-(8), and of γ_r in column (11). Estimates of λ_r are evaluated at the sample mean with standard errors computed by the delta method.

In column (1), we start with a baseline specification without controls. All output elasticities are positive and precisely estimated and the model fit is high: this simple production function accounts for 94% of the variance of firm output. In columns (2)-(4), we add to our baseline specification a large set of controls: the share of part-time workers in total em-

observed over the entire sample period.

[55] Similarly, we deflate capital with a common price index for investment goods and materials with a common price deflator for intermediate inputs. All deflators are drawn from the Italian Statistical Office.

[56] This is motivated by the fact that the price index is a market share-weighted average of firm prices.

[57] See also Melitz (2001) on this point.

[58] Bias may also arise from the use of common deflators for materials. As argued by De Loecker (2008), however, our correction should partly take account of this, as long as input price deviations translate into output price deviations. See Kugler and Verhoogen (2008) for a rare exception of a study in which firm input prices are observed.

ployment, a dummy variable equal to one if a firm is quoted on the stock market, a full set of dummies for Italian administrative regions and for 3-digit industries, and a set of three dummy variables that control for ownership structure. By comparing columns (1) and (2), note that these controls raise the R-squared by just one percentage point and produce only minor changes in the output elasticities. In column (3), we use occupations instead of educational attainment to proxy for skill: most output elasticities are little affected, except that of high-skill labor which is now slightly higher. In column (4), we report 2SLS estimates using inputs in the years 2001 and 2002 to instrument for their levels in 2003. We also report the minimum and maximum value of the F-statistics of excluded instruments and the p-value of the Hansen J-statistic of overidentifying restrictions. The F-statistics are very high, suggesting that our instruments are relevant, and the Hansen J-statistic is insignificant, pointing against the endogeneity of our instruments. Compared to OLS estimates, the coefficient of high-skill labor is now higher, whereas the remaining coefficients are lower.

In columns (5), we estimate the baseline translog production function without controls. The fit improves by one percentage point relative to the Cobb-Douglas specification. Moreover, the coefficients of high-skill labor and capital are lower, whereas those of low-skill labor and materials are higher. The same is true when adding controls, as shown in column (6). When using occupations instead of educational attainment to proxy for skill, see column (7), we find a higher coefficient for high-skill labor, as in the Cobb-Douglas case. In column (8), we use 2SLS and again find that the estimated output elasticity is higher for high-skill labor and lower for the other inputs. Finally, in columns (9)-(11) we report semiparametric estimates. We use the same controls as before, plus a full set of time dummies. As in other studies (see, e.g., De Loecker, 2008), these estimators produce larger estimates of the capital coefficient. Note, also, that the augmented OP estimates are very close to the baseline OP estimates. For each specification, the table also reports estimated returns to scale.[59] Note that all estimates are close to constant returns to scale.

Finally, we relax the assumption of a common production function across manufacturing industries. We therefore estimate equation (40) separately for 2-digit industries by cross-sectional OLS, using the same specification as in column (2) of Table A1.[60] The results are in Table A2. Note that most elasticities are precisely estimated also at the 2-digit industry-level

[59] Returns to scale are computed as $RS \equiv \sum_r \beta_r$ for the Cobb-Douglas specifications, and as $RS \equiv \sum_r \lambda_r$ for the translog specifications.

[60] Due to data constraints, we aggregate the smallest contiguous industries.

and that the point estimates are generally close to those reported in Table A1.

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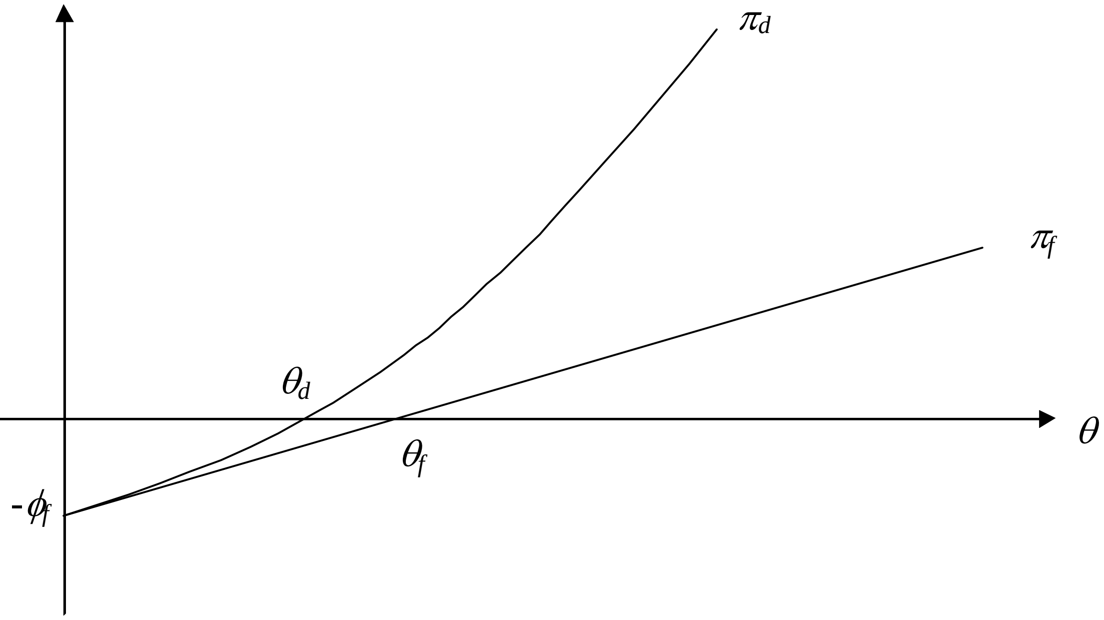

Figure 1. Productivity Cutoffs (Domestic vs. Lower-Income Foreign Destination)

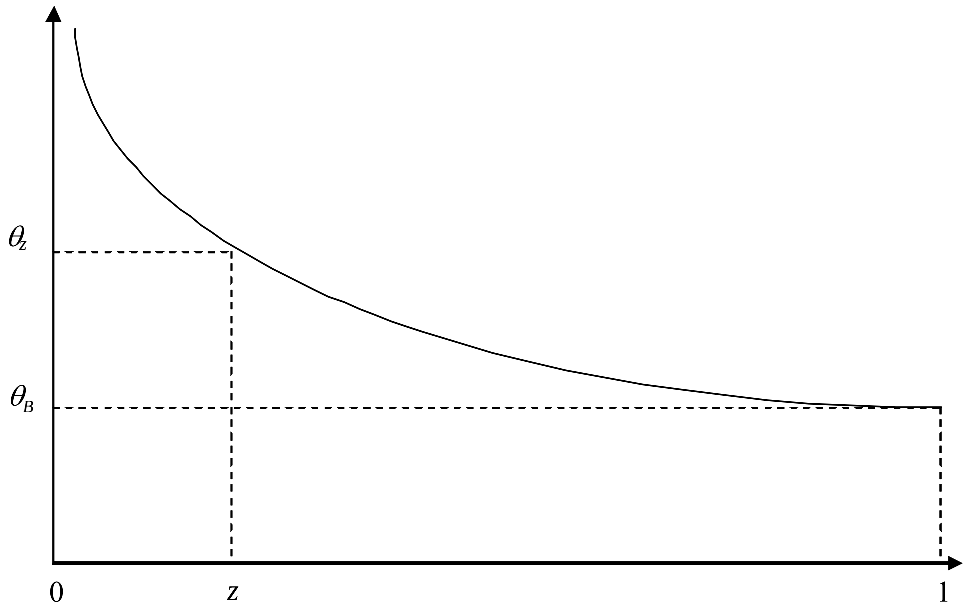

Figure 2. A Continuum of Export Productivity Cutoffs

Table 1 - Descriptive Statistics

	Technology			
	Mean	*Median*	*Std. Dev.*	*Observations*
Output (€, '000)	36205	9942	154463	3804
Labor Productivity (€, '000)	109	90	81	3748
Capital Stock per Worker (€, '000)	51	32	70	3798
Materials per Worker (€, '000)	140	87	215	3749
Number of Employees	144	49	414	4123
College + High-School Graduates (%)	44.1	36.7	26.7	3652
Non-Production Workers (%)	33.4	29.4	18.5	4084
	Export Intensity (%)			**Exporters**
	Mean	*Median*	*Std. Dev.*	*Number (%) of Firms*
All Destinations	40.2	36.0	28.4	3058 (75.6)
High-Income Destinations	30.1	25.0	24.0	2788 (68.9)
Low-Income Destinations	10.5	6.3	11.4	1484 (36.7)

Output equals sales plus capitalized costs and change in final goods inventories. *Labor productivity* is value added per worker. *Capital stock* is the book value of capital. *Materials* are the difference between purchases and change in inventories of intermediate goods. *Non-production workers* include entrepreneurs, managers, technical and administrative employees. *Export intensity* is the ratio of exports to sales. *High-income destinations* include North America, EU15 and Oceania. *Low-income destinations* include Africa, China, Latin America and New EU Members. All variables are computed for the year 2003. Source: *Capitalia.*

Table 2 - Export Intensity and TFP

Dependent Variables: Log of Export Intensities

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
							a) Baseline					
a1) Overall Export Intensity												
lnTFP	-0.019	-0.017	0.072	-0.077	0.001	-0.029	0.085	-0.083	0.133	0.075	0.086	-0.106
	[0.096]	[0.097]	[0.099]	[0.095]	[0.108]	[0.109]	[0.111]	[0.103]	[0.095]	[0.097]	[0.095]	[0.101]
	(0.105)	(0.105)	(0.097)	(0.103)	(0.114)	(0.115)	(0.104)	(0.110)	(0.095)	(0.095)	(0.094)	(0.109)
Obs.	2313	2313	2732	2313	2313	2313	2732	2313	2732	2732	2732	2313
R-squared	0.18	0.18	0.17	0.18	0.18	0.18	0.17	0.18	0.17	0.17	0.17	0.18
a2) Export Intensity to High-Income Destinations												
lnTFP	0.027	0.020	0.132	0.017	0.103	0.061	0.177	0.059	0.183	0.140	0.148	-0.041
	[0.131]	[0.130]	[0.113]	[0.129]	[0.131]	[0.132]	[0.116]	[0.128]	[0.113]	[0.113]	[0.111]	[0.127]
	(0.116)	(0.116)	(0.108)	(0.114)	(0.127)	(0.127)	(0.117)	(0.124)	(0.107)	(0.106)	(0.105)	(0.118)
Obs.	2189	2189	2515	2189	2189	2189	2515	2189	2515	2515	2515	2189
R-squared	0.13	0.13	0.12	0.13	0.13	0.13	0.12	0.13	0.12	0.12	0.12	0.13
a3) Export Intensity to Low-Income Destinations												
lnTFP	-0.650***	-0.650***	-0.598***	-0.672***	-0.671***	-0.690***	-0.570***	-0.684***	-0.590***	-0.575***	-0.565***	-0.645***
	[0.169]	[0.172]	[0.187]	[0.157]	[0.179]	[0.188]	[0.201]	[0.163]	[0.185]	[0.184]	[0.181]	[0.174]
	(0.172)	(0.173)	(0.165)	(0.165)	(0.183)	(0.185)	(0.180)	(0.173)	(0.164)	(0.164)	(0.161)	(0.179)
Obs.	1173	1173	1348	1173	1173	1173	1348	1173	1348	1348	1348	1173
R-squared	0.17	0.17	0.16	0.17	0.17	0.17	0.16	0.17	0.16	0.16	0.16	0.17
							b) Adding General Controls					
b1) Overall Export Intensity												
lnTFP	-0.060	-0.066	0.012	-0.097	-0.008	-0.048	0.073	-0.082	0.053	0.009	0.019	-0.155
	[0.113]	[0.113]	[0.094]	[0.107]	[0.120]	[0.119]	[0.105]	[0.113]	[0.093]	[0.093]	[0.091]	[0.118]
	(0.114)	(0.115)	(0.108)	(0.111)	(0.124)	(0.125)	(0.117)	(0.121)	(0.106)	(0.107)	(0.105)	(0.120)
P-value Controls	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	2066	2066	2369	2066	2066	2066	2369	2066	2369	2369	2369	2066
R-squared	0.21	0.21	0.20	0.21	0.21	0.21	0.20	0.21	0.20	0.20	0.20	0.21
b2) Export Intensity to High-Income Destinations												
lnTFP	-0.005	-0.021	0.086	0.005	0.102	0.048	0.180	0.069	0.121	0.086	0.094	-0.068
	[0.132]	[0.132]	[0.135]	[0.130]	[0.145]	[0.144]	[0.142]	[0.145]	[0.134]	[0.134]	[0.131]	[0.136]
	(0.128)	(0.128)	(0.120)	(0.125)	(0.139)	(0.139)	(0.130)	(0.137)	(0.119)	(0.119)	(0.116)	(0.132)
P-value Controls	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.002	0.002	0.001	0.000
Obs.	1955	1955	2234	1955	1955	1955	2234	1955	2234	2234	2234	1955
R-squared	0.16	0.16	0.14	0.16	0.16	0.16	0.14	0.16	0.14	0.14	0.14	0.16
b3) Export Intensity to Low-Income Destinations												
lnTFP	-0.701***	-0.705***	-0.653***	-0.702***	-0.705***	-0.736***	-0.597***	-0.708***	-0.639***	-0.626***	-0.615***	-0.734***
	[0.187]	[0.186]	[0.180]	[0.184]	[0.204]	[0.203]	[0.196]	[0.196]	[0.180]	[0.177]	[0.174]	[0.189]
	(0.183)	(0.184)	(0.179)	(0.174)	(0.194)	(0.195)	(0.196)	(0.186)	(0.178)	(0.177)	(0.174)	(0.193)
P-value Controls	0.491	0.491	0.020	0.481	0.546	0.524	0.025	0.531	0.023	0.023	0.022	0.465
Obs.	1057	1057	1204	1057	1057	1057	1204	1057	1204	1204	1204	1057
R-squared	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21

OLS regressions with robust standard errors in round brackets and bootstrapped standard errors based on 100 replications in square brackets. ***,** ,* = significant at 1, 5 and 10 percent level, respectively. Each column in the table refers to a different TFP estimate (see Tables A1-A2 for details). All specifications include a full set of industry dummies, defined at the 3-digit level of the ATECO classification. *General controls* include: a full set of dummies for Italian administrative regions, the share of part-time workers in total employment, a dummy for firms quoted on the stock market, and three dummies equal to one in the presence, respectively, of stand-alone firms, firms that belong to a group in the position of leader, firms that belong to a group and are controlled.

Table 3 - Export Intensity and TFP (Controlling for Other Measures of Firm Internationalization)

Dependent Variables: Log of Export Intensities

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
a) Export Intensity to High-Income Destinations												
lnTFP	0.026	0.008	0.117	0.046	0.102	0.054	0.162	0.084	0.148	0.111	0.118	-0.042
	[0.108]	[0.108]	[0.108]	[0.109]	[0.118]	[0.116]	[0.104]	[0.119]	[0.106]	[0.106]	[0.104]	[0.120]
IMPINT	0.225	0.225	0.138	0.225	0.227	0.226	0.143	0.227	0.136	0.138	0.138	0.225
	[0.221]	[0.221]	[0.229]	[0.221]	[0.221]	[0.221]	[0.229]	[0.221]	[0.228]	[0.229]	[0.229]	[0.221]
SERV	0.303***	0.304***	0.326***	0.303***	0.303***	0.303***	0.327***	0.304***	0.325***	0.327***	0.326***	0.304***
	[0.059]	[0.059]	[0.056]	[0.059]	[0.059]	[0.059]	[0.056]	[0.059]	[0.056]	[0.056]	[0.056]	[0.059]
INSH	1.629***	1.629***	1.691***	1.629***	1.628***	1.628***	1.691***	1.629***	1.690***	1.690***	1.690***	1.629***
	[0.084]	[0.084]	[0.070]	[0.084]	[0.084]	[0.084]	[0.070]	[0.084]	[0.070]	[0.070]	[0.070]	[0.084]
FDI	-0.865	-0.881	-0.421	-0.848	-0.793	-0.841	-0.402	-0.823	-0.432	-0.435	-0.433	-0.924
	[4.009]	[4.010]	[3.878]	[4.005]	[4.002]	[4.007]	[3.870]	[3.998]	[3.878]	[3.880]	[3.879]	[4.030]
Obs.	2078	2078	2385	2078	2078	2078	2385	2078	2385	2385	2385	2078
R-squared	0.28	0.28	0.27	0.28	0.28	0.28	0.27	0.28	0.27	0.27	0.27	0.28
b) Export Intensity to Low-Income Destinations												
lnTFP	-0.650***	-0.649***	-0.583***	-0.663***	-0.603***	-0.621***	-0.529***	-0.638***	-0.586***	-0.568***	-0.559***	-0.653***
	[0.168]	[0.171]	[0.185]	[0.163]	[0.186]	[0.188]	[0.189]	[0.180]	[0.184]	[0.183]	[0.179]	[0.186]
IMPINT	-0.045	-0.041	-0.058	-0.060	-0.043	-0.045	-0.065	-0.048	-0.049	-0.054	-0.053	-0.029
	[0.285]	[0.285]	[0.282]	[0.284]	[0.285]	[0.286]	[0.286]	[0.284]	[0.282]	[0.282]	[0.282]	[0.285]
SERV	0.064	0.064	0.071	0.056	0.050	0.051	0.065	0.041	0.074	0.070	0.071	0.063
	[0.089]	[0.089]	[0.073]	[0.089]	[0.090]	[0.090]	[0.072]	[0.089]	[0.073]	[0.072]	[0.072]	[0.089]
INSH	1.067***	1.068***	0.967***	1.064***	1.062***	1.062***	0.970***	1.062***	0.970***	0.970***	0.970***	1.074***
	[0.113]	[0.113]	[0.128]	[0.113]	[0.113]	[0.113]	[0.128]	[0.112]	[0.128]	[0.128]	[0.128]	[0.113]
FDI	-1.609	-1.590	-0.534	-1.639	-1.717	-1.650	-0.518	-1.660	-0.438	-0.485	-0.471	-1.550
	[3.735]	[3.730]	[4.636]	[3.715]	[3.696]	[3.675]	[4.662]	[3.640]	[4.626]	[4.631]	[4.631]	[3.717]
Obs.	1124	1124	1288	1124	1124	1124	1288	1124	1288	1288	1288	1124
R-squared	0.24	0.24	0.22	0.25	0.24	0.24	0.22	0.24	0.22	0.22	0.22	0.24

IMPINT = share of imported inputs in total input purchases; *SERV* = dummy variable equal to 1 for importers of services; *INSH* = share of sales subcontracted from abroad; *FDI* = ratio of outward FDI to sales over the period 2001-2003. See also notes to previous tables.

Table 4 - Export Intensity and TFP (Controlling for Export Market Dummies)

Dependent Variables: Log of Export Intensities

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	a) Adding Export Market Dummies											
a1) Export Intensity to High-Income Destinations												
lnTFP	-0.076	-0.091	0.018	-0.062	-0.050	-0.092	0.027	-0.076	0.043	0.018	0.026	-0.135
	[0.122]	[0.122]	[0.105]	[0.118]	[0.120]	[0.122]	[0.110]	[0.115]	[0.106]	[0.105]	[0.103]	[0.122]
P-value Dummies	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	2189	2189	2515	2189	2189	2189	2515	2189	2515	2515	2515	2189
R-squared	0.25	0.25	0.23	0.25	0.25	0.25	0.23	0.25	0.23	0.23	0.23	0.25
a2) Export Intensity to Low-Income Destinations												
lnTFP	-0.665***	-0.675***	-0.577***	-0.649***	-0.660***	-0.693***	-0.541***	-0.665***	-0.590***	-0.547***	-0.542***	-0.676***
	[0.163]	[0.167]	[0.173]	[0.148]	[0.170]	[0.178]	[0.180]	[0.153]	[0.173]	[0.170]	[0.168]	[0.170]
P-value Dummies	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	1173	1173	1348	1173	1173	1173	1348	1173	1348	1348	1348	1173
R-squared	0.28	0.28	0.27	0.28	0.28	0.28	0.26	0.28	0.27	0.26	0.26	0.28
	b) Adding Export Market Dummies Interacted with 3-Digit Industry Dummies											
b1) Export Intensity to High-Income Destinations												
lnTFP	-0.015	-0.023	0.045	-0.032	0.014	-0.022	0.064	-0.043	0.074	0.044	0.052	-0.041
	[0.133]	[0.133]	[0.126]	[0.132]	[0.144]	[0.144]	[0.133]	[0.142]	[0.124]	[0.123]	[0.121]	[0.139]
P-value Dummies	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	2189	2189	2515	2189	2189	2189	2515	2189	2515	2515	2515	2189
R-squared	0.41	0.41	0.38	0.41	0.41	0.41	0.38	0.41	0.38	0.38	0.38	0.41
b2) Export Intensity to Low-Income Destinations												
lnTFP	-0.620**	-0.620**	-0.527**	-0.607***	-0.674***	-0.685**	-0.521**	-0.626***	-0.544**	-0.494**	-0.491**	-0.598**
	[0.244]	[0.249]	[0.217]	[0.224]	[0.258]	[0.266]	[0.234]	[0.235]	[0.217]	[0.215]	[0.212]	[0.252]
P-value Dummies	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	1173	1173	1348	1173	1173	1173	1348	1173	1348	1348	1348	1173
R-squared	0.57	0.57	0.53	0.57	0.57	0.57	0.53	0.57	0.53	0.53	0.53	0.57

Export market dummies are seven binary indicators taking a value of 1 for firms exporting to a given destination. See also notes to previous tables.

Table 5 - Export Intensity and TFP (Sample Split)

Dependent Variables: Log of Export Intensities

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
a) Export Intensity to High-Income Destinations												
lnTFP	-0.004	0.004	0.181	-0.026	0.048	0.018	0.180	-0.094	0.205	0.082	0.112	-0.011
	[0.146]	[0.144]	[0.136]	[0.155]	[0.164]	[0.160]	[0.152]	[0.163]	[0.133]	[0.137]	[0.132]	[0.160]
Obs.	1087	1087	1248	1087	1087	1087	1248	1087	1248	1248	1248	1087
R-squared	0.17	0.17	0.15	0.17	0.17	0.17	0.15	0.17	0.15	0.15	0.15	0.17
b) Export Intensity to Low-Income Destinations												
lnTFP	-0.739***	-0.727***	-0.664***	-0.696***	-0.706***	-0.709***	-0.614***	-0.641***	-0.350***	-0.629***	-0.628***	-0.549***
	[0.182]	[0.185]	[0.192]	[0.157]	[0.184]	[0.187]	[0.204]	[0.143]	[0.127]	[0.191]	[0.190]	[0.170]
Obs.	1173	1173	1348	1173	1173	1173	1348	1173	1348	1348	1348	1173
R-squared	0.18	0.18	0.16	0.18	0.17	0.17	0.16	0.17	0.16	0.16	0.16	0.17

TFP are estimated separately for firms exporting\non-exporting to low-income destinations. See also notes to previous tables.

Table 6 - Product Quality and TFP

Dependent Variables: Proxies for Product Quality

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
a) R&D and Marketing Expenditures per Employee												
lnTFP	0.053**	0.054**	0.062***	0.044	0.070**	0.070**	0.077***	0.060*	0.063***	0.057***	0.058***	0.210**
	[0.026]	[0.025]	[0.023]	[0.028]	[0.031]	[0.031]	[0.026]	[0.036]	[0.023]	[0.022]	[0.022]	[0.103]
Obs.	2240	2240	2509	2240	2240	2240	2509	2240	2509	2509	2509	2240
R-squared	0.06	0.06	0.07	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.06
b) Sales of Innovative Products per Employee												
lnTFP	0.031***	0.030***	0.027***	0.027***	0.024***	0.021***	0.015***	0.018***	0.026***	0.024***	0.025***	0.113***
	[0.008]	[0.008]	[0.007]	[0.007]	[0.006]	[0.006]	[0.005]	[0.006]	[0.007]	[0.007]	[0.007]	[0.028]
Obs.	2742	2742	3130	2742	2742	2742	3130	2742	3130	3130	3130	2742
R-squared	0.13	0.12	0.10	0.12	0.12	0.12	0.09	0.12	0.10	0.10	0.10	0.13
c) Dummy for Process Innovation												
lnTFP	0.038*	0.039*	0.030*	0.033*	0.043*	0.044**	0.036*	0.034	0.030*	0.030*	0.030*	0.135*
	[0.021]	[0.021]	[0.018]	[0.020]	[0.022]	[0.022]	[0.019]	[0.021]	[0.018]	[0.018]	[0.018]	[0.072]
Obs.	3089	3089	3570	3089	3089	3089	3570	3089	3570	3570	3570	3089
R-squared	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
d) Dummy for Process Innovation Interacted with Sales of Innovative Products per Employee												
lnTFP	0.060*	0.057*	0.050*	0.061*	0.067*	0.063*	0.051*	0.065*	0.048*	0.046*	0.047*	0.211*
	[0.035]	[0.033]	[0.029]	[0.035]	[0.039]	[0.037]	[0.030]	[0.037]	[0.027]	[0.026]	[0.027]	[0.120]
Obs.	2723	2723	3107	2723	2723	2723	3107	2723	3107	3107	3107	2723
R-squared	0.05	0.05	0.04	0.05	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.05
e) Share of Managers in Total Employment												
lnTFP	0.094***	0.096***	0.059***	0.071***	0.088***	0.088***	0.034*	0.055***	0.056***	0.046**	0.046**	0.368***
	[0.024]	[0.025]	[0.021]	[0.022]	[0.022]	[0.023]	[0.019]	[0.020]	[0.021]	[0.021]	[0.021]	[0.093]
Obs.	3104	3104	3664	3104	3104	3104	3664	3104	3664	3664	3664	3104
R-squared	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07
f) Investment per Employee												
lnTFP	0.057***	0.049***	0.068***	0.062***	0.075***	0.064***	0.056***	0.056***	0.060***	0.052**	0.054**	0.156**
	[0.019]	[0.018]	[0.023]	[0.019]	[0.020]	[0.020]	[0.019]	[0.020]	[0.023]	[0.021]	[0.022]	[0.070]
Obs.	2503	2503	2958	2503	2503	2503	2958	2503	2958	2958	2958	2503
R-squared	0.13	0.13	0.06	0.13	0.13	0.13	0.06	0.13	0.06	0.06	0.06	0.12
g) Principal Component												
lnTFP	0.092***	0.091***	0.091***	0.083**	0.112***	0.108***	0.105***	0.095**	0.089***	0.080***	0.082***	0.335**
	[0.033]	[0.033]	[0.028]	[0.037]	[0.039]	[0.038]	[0.031]	[0.044]	[0.028]	[0.028]	[0.028]	[0.135]
Obs.	1692	1692	1905	1692	1692	1692	1905	1692	1905	1905	1905	1692
R-squared	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Principal component is extracted from the above proxies for product quality using factor analysis. All regressions include a full set of 3-digit industry dummies. See also notes to previous tables.

Table 7 - Export Intensity and Product Quality

Dependent Variables: Log of Export Intensities

	Export Intensity to High-Income Destinations					Export Intensity to Low-Income Destinations				
	Baseline	Adding General Controls	Adding Trade Controls	Adding Export Market Dummies	Adding Export Market Dummies Interacted with 3-Digit Industry Dummies	Baseline	Adding General Controls	Adding Trade Controls	Adding Export Market Dummies	Adding Export Market Dummies Interacted with 3-Digit Industry Dummies
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Proxy for Product Quality	0.022	0.013	0.024	0.003	0.011	-0.068***	-0.066***	-0.070***	-0.062***	-0.038**
	[0.018]	[0.014]	[0.016]	[0.013]	[0.016]	[0.013]	[0.013]	[0.015]	[0.013]	[0.016]
P-value Controls	-	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000
Obs.	1550	1532	1409	1550	1550	854	846	778	854	854
R-squared	0.15	0.17	0.27	0.26	0.44	0.21	0.25	0.26	0.33	0.64

Proxy for product quality is the principal component used in Table 6. All regressions include a full set of 3-digit industry dummies. See also notes to previous tables.

Table 8 - Export Intensity and Product Quality (Controlling for TFP)

Dependent Variables: Log of Export Intensities

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
a) Export Intensity to High-Income Destinations												
Proxy for Product Quality	0.023	0.023	0.020	0.024	0.023	0.023	0.019	0.024	0.019	0.020	0.020	0.023
	[0.020]	[0.020]	[0.018]	[0.020]	[0.019]	[0.020]	[0.018]	[0.020]	[0.018]	[0.018]	[0.018]	[0.020]
lnTFP	-0.012	-0.013	0.028	-0.018	-0.004	-0.013	0.038	-0.016	0.040	0.027	0.030	-0.048
	[0.042]	[0.043]	[0.037]	[0.041]	[0.041]	[0.042]	[0.036]	[0.040]	[0.037]	[0.037]	[0.037]	[0.151]
Obs.	1254	1254	1413	1254	1254	1254	1413	1254	1413	1413	1413	1254
R-squared	0.17	0.17	0.15	0.17	0.17	0.17	0.15	0.17	0.15	0.15	0.15	0.17
b) Export Intensity to Low-Income Destinations												
Proxy for Product Quality	-0.063***	-0.063***	-0.061***	-0.063***	-0.063***	-0.063***	-0.062***	-0.063***	-0.062***	-0.062***	-0.062***	-0.064***
	[0.013]	[0.012]	[0.012]	[0.013]	[0.013]	[0.012]	[0.012]	[0.013]	[0.012]	[0.012]	[0.012]	[0.013]
lnTFP	-0.184***	-0.185***	-0.145***	-0.184***	-0.174***	-0.182***	-0.126**	-0.172***	-0.142***	-0.144***	-0.143***	-0.631***
	[0.058]	[0.059]	[0.054]	[0.054]	[0.053]	[0.054]	[0.051]	[0.050]	[0.054]	[0.054]	[0.054]	[0.216]
Obs.	702	702	787	702	702	702	787	702	787	787	787	702
R-squared	0.24	0.24	0.21	0.24	0.24	0.24	0.21	0.24	0.21	0.21	0.21	0.24

See notes to previous tables.

Table 9 - Export Intensity and TFP (Panel Regressions)
Dependent Variable: Log of Export Intensity to Destination *f*

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	a) TFP Interacted with Income											
lnTFP	-1.156***	-1.176***	-1.074***	-1.065***	-1.213***	-1.267***	-1.019***	-1.123***	-1.154***	-1.003***	-1.006***	-1.207***
	[0.246]	[0.245]	[0.234]	[0.243]	[0.254]	[0.257]	[0.246]	[0.240]	[0.231]	[0.231]	[0.227]	[0.247]
lnTFP * Income	0.988***	1.000***	1.037***	0.907***	1.087***	1.105***	1.003***	0.977***	1.132***	0.981***	0.988***	0.979***
	[0.263]	[0.262]	[0.241]	[0.260]	[0.268]	[0.272]	[0.252]	[0.256]	[0.238]	[0.237]	[0.233]	[0.263]
Obs.	5406	5406	6217	5406	5406	5406	6217	5406	6217	6217	6217	5406
R-squared	0.39	0.39	0.38	0.39	0.39	0.39	0.38	0.39	0.38	0.38	0.38	0.39
	b) Adding TFP Interacted with Distance											
lnTFP	-0.954***	-0.969***	-0.901***	-0.878***	-1.028***	-1.075***	-0.865***	-0.912***	-0.946***	-0.825***	-0.826***	-0.961***
	[0.251]	[0.251]	[0.237]	[0.246]	[0.260]	[0.264]	[0.251]	[0.246]	[0.235]	[0.235]	[0.231]	[0.251]
lnTFP * Income	0.968***	0.977***	1.023***	0.892***	1.075***	1.090***	0.996***	0.965***	1.114***	0.965***	0.972***	0.942***
	[0.265]	[0.264]	[0.241]	[0.261]	[0.269]	[0.273]	[0.253]	[0.257]	[0.238]	[0.237]	[0.233]	[0.263]
lnTFP * Distance	-0.306**	-0.308**	-0.264**	-0.289**	-0.286**	-0.295**	-0.243*	-0.335***	-0.315***	-0.270**	-0.273**	-0.359***
	[0.119]	[0.120]	[0.118]	[0.119]	[0.132]	[0.132]	[0.127]	[0.129]	[0.117]	[0.115]	[0.114]	[0.127]
Obs.	5406	5406	6217	5406	5406	5406	6217	5406	6217	6217	6217	5406
R-squared	0.39	0.39	0.38	0.39	0.39	0.39	0.38	0.39	0.38	0.38	0.38	0.39
	c) Adding TFP Interacted with the Number of Countries within Each Destination											
lnTFP	-0.990***	-1.016***	-0.943**	-0.857**	-1.045***	-1.070***	-0.938**	-0.809**	-0.963***	-0.873**	-0.868**	-0.867**
	[0.383]	[0.382]	[0.368]	[0.378]	[0.400]	[0.403]	[0.400]	[0.387]	[0.366]	[0.363]	[0.357]	[0.392]
lnTFP * Income	0.990***	1.004***	1.048***	0.880***	1.085***	1.088***	1.039***	0.904***	1.124***	0.993***	0.997***	0.886***
	[0.315]	[0.313]	[0.296]	[0.316]	[0.327]	[0.329]	[0.318]	[0.319]	[0.293]	[0.290]	[0.286]	[0.318]
lnTFP * Distance	-0.298**	-0.298**	-0.255*	-0.293**	-0.282*	-0.296**	-0.227	-0.357**	-0.311**	-0.260**	-0.264**	-0.378***
	[0.135]	[0.136]	[0.135]	[0.134]	[0.148]	[0.149]	[0.144]	[0.145]	[0.134]	[0.132]	[0.130]	[0.144]
lnTFP * Number of Countries	0.019	0.024	0.022	-0.011	0.009	-0.003	0.037	-0.053	0.009	0.025	0.022	-0.050
	[0.162]	[0.162]	[0.147]	[0.158]	[0.167]	[0.170]	[0.155]	[0.156]	[0.146]	[0.145]	[0.142]	[0.165]
Obs.	5406	5406	6217	5406	5406	5406	6217	5406	6217	6217	6217	5406
R-squared	0.39	0.39	0.38	0.39	0.39	0.39	0.38	0.39	0.38	0.38	0.38	0.39

The panel is obtained by pooling data on export intensities to the following destinations: EU15, New EU Members, North America, China, Latin America, Africa and Oceania. *Income* is average PPP per capita GDP of each destination relative to Italy's. *Distance* is the number of kilometers between Rome and the capital city of the main trading partner in each destination, relative to the average distance. *Number of countries* is the number of countries within each destination, relative to the average number of countries per destination. All regressions include destination dummies, both linearly and interacted with 3-digit industry dummies. Standard errors are corrected for clustering at the firm-level. See also notes to previous tables.

Table 10 - Export Intensity and TFP (Cross-Sectional Regressions for Individual Destinations)
Dependent Variable: Log of Export Intensity to Each Destination

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions			CD+controls (2-digit ind.)
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
EU15												
lnTFP	0.022	0.014	0.110	0.026	0.086	0.045	0.140	0.071	0.160	0.121	0.128	-0.009
	[0.114]	[0.117]	[0.119]	[0.108]	[0.130]	[0.131]	[0.129]	[0.122]	[0.115]	[0.116]	[0.114]	[0.124]
Obs.	2130	2130	2441	2130	2130	2130	2441	2130	2441	2441	2441	2130
R-squared	0.12	0.12	0.10	0.12	0.12	0.12	0.10	0.12	0.10	0.10	0.10	0.12
North America												
lnTFP	-0.354	-0.345	-0.118	-0.381*	-0.310	-0.320	-0.084	-0.386	-0.147	-0.102	-0.103	-0.466*
	[0.232]	[0.234]	[0.224]	[0.229]	[0.234]	[0.238]	[0.227]	[0.236]	[0.225]	[0.215]	[0.212]	[0.245]
Obs.	976	976	1127	976	976	976	1127	976	1127	1127	1127	976
R-squared	0.14	0.14	0.13	0.14	0.14	0.14	0.13	0.14	0.13	0.13	0.13	0.14
Oceania												
lnTFP	-1.015***	-1.074***	-0.847**	-0.891**	-1.109***	-1.243***	-0.999**	-1.216***	-0.954**	-0.840**	-0.837**	-1.314***
	[0.370]	[0.373]	[0.378]	[0.365]	[0.428]	[0.428]	[0.390]	[0.419]	[0.371]	[0.372]	[0.365]	[0.428]
Obs.	307	307	358	307	307	307	358	307	358	358	358	307
R-squared	0.36	0.36	0.33	0.35	0.36	0.36	0.33	0.36	0.33	0.33	0.33	0.37
New EU Members												
lnTFP	-0.684***	-0.729***	-0.609***	-0.552***	-0.777***	-0.845***	-0.683***	-0.597***	-0.645***	-0.556***	-0.555***	-0.772***
	[0.216]	[0.218]	[0.213]	[0.208]	[0.235]	[0.235]	[0.231]	[0.224]	[0.215]	[0.212]	[0.208]	[0.233]
Obs.	771	771	884	771	771	771	884	771	884	884	884	771
R-squared	0.17	0.17	0.14	0.16	0.17	0.17	0.14	0.16	0.14	0.13	0.13	0.17
Africa												
lnTFP	-0.963***	-0.954***	-0.787***	-0.992***	-1.127***	-1.151***	-0.812***	-1.120***	-0.861***	-0.702**	-0.711**	-1.056***
	[0.355]	[0.360]	[0.305]	[0.329]	[0.360]	[0.369]	[0.312]	[0.315]	[0.295]	[0.297]	[0.291]	[0.351]
Obs.	499	499	579	499	499	499	579	499	579	579	579	499
R-squared	0.22	0.22	0.20	0.22	0.23	0.23	0.20	0.23	0.20	0.20	0.20	0.23
China												
lnTFP	-0.932**	-0.902**	-0.768*	-0.986**	-0.892**	-0.870*	-0.679	-0.980**	-0.784**	-0.737*	-0.732*	-0.766*
	[0.454]	[0.441]	[0.396]	[0.473]	[0.448]	[0.448]	[0.433]	[0.439]	[0.390]	[0.379]	[0.374]	[0.419]
Obs.	287	287	330	287	287	287	330	287	330	330	330	287
R-squared	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Latin America												
lnTFP	-1.052***	-1.084***	-1.130***	-0.864**	-0.787**	-0.890***	-0.766**	-0.712**	-1.214***	-1.091***	-1.089***	-1.137***
	[0.326]	[0.320]	[0.322]	[0.338]	[0.346]	[0.343]	[0.349]	[0.344]	[0.322]	[0.317]	[0.312]	[0.350]
Obs.	436	436	498	436	436	436	498	436	498	498	498	436
R-squared	0.26	0.26	0.24	0.25	0.25	0.25	0.22	0.25	0.24	0.24	0.24	0.26

See notes to previous tables.

Table 11 - TFP Elasticities of Export Intensity: Predicted vs. Estimated

TFP Elasticity of Export Intensity	Estimated	Predicted (based on *Income* and *Distance*)	Predicted / Estimated (%)
	(1)	(2)	(3)
EU15	0.128	0.104	81.3
North America	-0.103	-0.092	89.3
New EU Members	-0.555	-0.402	72.4
Africa	-0.711	-0.773	108.7
China	-0.732	-1.008	137.7
Oceania	-0.837	-0.805	96.2
Latin America	-1.089	-0.981	90.1

Elasticities are based on the augmented Olley and Pakes TFP estimates.

Table A1 - Production Function Estimates

Dependent Variable: Log of Real Output

	Cobb-Douglas Production Functions				Translog Production Functions				Panel Regressions		
	Baseline	Adding controls	Prod/non-prod	2SLS	Baseline	Adding controls	Prod/non-prod	2SLS	Lev./Pet.	Olley/Pakes	Olley/Pakes augmented
Output Elasticity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
High-Skill Labor	0.187***	0.162***	0.188***	0.250***	0.165***	0.147***	0.161***	0.219***	0.172***	0.187***	0.191***
	[0.011]	[0.015]	[0.016]	[0.017]	[0.008]	[0.009]	[0.012]	[0.019]	[0.008]	[0.007]	[0.008]
Low-Skill Labor	0.127***	0.126***	0.122***	0.093***	0.149***	0.146***	0.135***	0.091***	0.103***	0.094***	0.096***
	[0.008]	[0.011]	[0.012]	[0.015]	[0.007]	[0.008]	[0.010]	[0.013]	[0.007]	[0.006]	[0.007]
Capital	0.055***	0.064***	0.061***	0.039***	0.047***	0.053***	0.065***	0.055***	0.076	0.088***	0.088***
	[0.007]	[0.009]	[0.009]	[0.007]	[0.006]	[0.007]	[0.007]	[0.008]	[0.063]	[0.029]	[0.024]
Materials	0.603***	0.617***	0.612***	0.597***	0.628***	0.648***	0.637***	0.631***	0.615***	0.607***	0.619***
	[0.014]	[0.019]	[0.018]	[0.013]	[0.006]	[0.008]	[0.009]	[0.010]	[0.119]	[0.009]	[0.012]
Obs.	3132	2812	3219	2460	3132	2812	3219	2460	9759	7267	7267
R-squared	0.94	0.95	0.96	0.93	0.95	0.96	0.97	0.94	-	-	-
Returns to Scale	0.97	0.97	0.98	0.98	0.99	0.99	1.00	1.00	0.97	0.98	0.99
P-value Hansen *J*-stat.				0.351				0.168			
F-Stat. of exclud. instr. (min/max)				735/1689				233/1526			

Columns (2)-(4) and (6)-(11) include the following controls: the share of part-time workers in total employment, a dummy for firms quoted on the stock market, three dummies for ownership structure, and a full set of dummies for Italian administrative regions and for 3-digit industries; columns (9)-(11) also include time dummies. Skills are proxied by occupations in columns (3), (7), and (9)-(11), and by educational attainment otherwise. In 2SLS estimates, all inputs are instrumented with their first and second lags. Translog output elasticities are evaluated at the sample mean and standard errors are computed by the delta method. In columns (9)-(11), standard errors are based on 100 bootstrap replications. Output elasticities in column (11) are corrected using the estimated coefficient of average industry output as explained in the Appendix. ***,**,* = significant at 1, 5 and 10 percent level, respectively.

Table A2 - Production Function Estimates at the 2-Digit Industry Level
Dependent Variable: Log of Real Output

		High-Skill Labor	Low-Skill Labor	Capital	Materials	Obs.	R-squared
15	Food products and beverages	0.119***	0.064*	0.143***	0.650***	323	0.94
		[0.041]	[0.036]	[0.038]	[0.073]		
17	Textiles	0.282***	0.146***	0.042	0.483***	213	0.92
		[0.080]	[0.029]	[0.030]	[0.077]		
18	Wearing apparel, dressing and dyeing of fur	0.220***	0.109***	0.072	0.542***	81	0.95
		[0.050]	[0.040]	[0.044]	[0.073]		
19	Leather, luggage, handbags, saddlery, harness and footwear	0.094***	0.169***	0.048**	0.697***	130	0.97
		[0.021]	[0.049]	[0.020]	[0.054]		
20	Wood and products of wood and cork, except furniture	0.108***	0.149***	0.062**	0.662***	88	0.98
		[0.031]	[0.039]	[0.024]	[0.048]		
21	Pulp, paper and paper products	0.102***	0.175***	0.041*	0.684***	83	0.99
		[0.031]	[0.052]	[0.025]	[0.037]		
22	Publishing, printing and reproduction of recorded media	0.337***	0.203**	0.073	0.399***	65	0.94
		[0.095]	[0.092]	[0.049]	[0.114]		
23 - 24	Coke, refined petroleum products and nuclear fuel - Chemicals	0.180***	0.097***	0.018	0.708***	172	0.98
		[0.028]	[0.021]	[0.016]	[0.028]		
25	Rubber and plastic products	0.137***	0.155***	0.067***	0.646***	144	0.99
		[0.027]	[0.033]	[0.019]	[0.024]		
26	Other non-metallic mineral products	0.170***	0.176***	0.058**	0.611***	186	0.97
		[0.030]	[0.026]	[0.023]	[0.031]		
27	Basic metals	0.153***	0.209***	0.014	0.620***	99	0.99
		[0.029]	[0.037]	[0.028]	[0.042]		
28	Fabricated metal products, except machinery and equipment	0.155***	0.182***	0.102**	0.551***	387	0.93
		[0.044]	[0.045]	[0.045]	[0.060]		
29	Machinery and equipment n.e.c.	0.182***	0.114***	0.040***	0.613***	382	0.97
		[0.018]	[0.017]	[0.011]	[0.021]		
30 - 31	Office machinery and computers - Electrical machinery and apparatus n.e.c.	0.125***	0.101***	0.030*	0.686***	104	0.98
		[0.035]	[0.035]	[0.017]	[0.041]		
32 - 33	Radio, television and communication equipment and apparatus - Medical, precision and optical instruments, watches and clocks	0.141**	0.086**	0.017	0.688***	99	0.98
		[0.058]	[0.036]	[0.030]	[0.054]		
34 - 35	Transport equipment	0.158	0.054	0.046	0.693***	65	0.99
		[0.097]	[0.109]	[0.055]	[0.122]		
36	Manufacture of furniture; manufacturing n.e.c.	0.090***	0.134***	0.061**	0.673***	191	0.97
		[0.030]	[0.025]	[0.026]	[0.053]		

OLS regressions with robust standard errors in square brackets. The regressions include the same controls as in column (2) of Table A1. ***,**,* = significant at 1, 5 and 10 percent level, respectively.