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Sheffield Economic Research Paper Series.

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ISSN 1749-8368

SERPS no. 2013014
Originally Published: October 2013
Updated: March 2015

www.sheffield.ac.uk/economics

Intermediate inputs and the export gravity equation *†

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March 24, 2015

Abstract

This paper proposes a theoretical micro-foundation for the export gravity equation at the firm-level in the presence of imports in intermediates. By increasing a firm's productivity, importing intermediate inputs influences export decisions, both at the extensive and the intensive margins. In the model, market size and distance shape the effects that imports have on a firm's productivity. It follows that an increase in foreign market size or a decline in transportation costs exert, besides the standard direct impact, an indirect positive effect on export profitability through a firm's efficiency increase induced by the imports of intermediate inputs. Exploiting data on product-destination level transactions of a large panel of Italian firms, the paper provides empirical evidence in support of the predictions of the model.

JEL codes: F12, F14

Keywords: Imports, Exports, Firm heterogeneity, Gravity equation.

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† The present work has been possible thanks to a research agreement between the Italian Statistical Office (ISTAT) and the Scuola Superiore Sant'Anna. We thank the participants of the ISGEP 2012, the European Trade Study Group (ETSG 2013), the European Economic Association Meeting (EEA) (2014) and the seminars of the University of Gottingen, Siena and Barcelona for their numerous comments and stimulating suggestions. Francesco Serti gratefully acknowledges financial support from from the Spanish Ministries of Education and Science and Economics and Competitiveness (ECO2012-34928).

1 Introduction

A growing empirical and theoretical literature has emphasised the importance of firm heterogeneity in trade. The burgeoning studies on international trade have mostly focused on exports, while imports have been relatively neglected. Even less attention has been given to firms engaged in a combination of both imports and exports. This is quite surprising given the increasing international fragmentation of production, implying that more and more firms are active in both imports and exports of intermediates and final goods (Hummels et al.; 2001). Only very recently new research has started combining information on both the import and export sides. The available studies show that the majority of exporters are also importers and vice versa. These firms, which have been labeled as two-way traders, account for the bulk of a country's total trade (Bernard et al.; 2007; Mayer and Ottaviano; 2008; Muuls and Pisu; 2009; Castellani et al.; 2010).

We contribute to this new strand of literature by investigating previously unexplored effects of the connection between an individual firm's import and export outcomes. The paper studies the influence that the complementarity between the two trade activities has on the export gravity equation, at the firm level. The basic form of the gravity equation relates exports to the economic size and the geographical distance of the destination market, with the latter used as a proxy for transportation costs. The recent trade models with heterogeneous firms show that the gravity forces affect exports via both the extensive and intensive margins of trade (Melitz; 2003; Chaney; 2008; Helpman et al.; 2008). Accordingly, higher market size or lower distance increase the probability that a firm exports to a particular destination as well as its export value to that market.[1] However, whether a firm is importing or not may be relevant to evaluate the overall impact that market size and distance have on its export patterns.

This paper derives and estimates the export gravity equation for both the extensive and intensive margins of trade among asymmetric countries in the presence of imports in intermediate inputs. Our theoretical framework follows Chaney (2008) which derives the export gravity equation for final goods in a model of trade with firm heterogeneity. As in Chaney (2008) countries are asymmetric and differ in terms of size, labour costs, trade and institutional barriers. In addition, our model introduces an intermediate input sector. To produce, firms in the final good sectors use labor and a continuum of intermediate inputs from different locations. The technology is similar to early endogenous growth models (Romer; 1990; Rivera-Batiz and Romer; 1991), which use a Cobb Douglas specification in which there is love of variety in intermediate inputs.

Relevant implications emerge from our setting. In line with previous theoretical frameworks and empirical analyses, the model predicts that importing increases a firm's productivity, through a better reallocation of resources across new intermediate inputs.[2] The model shows that the relatively more productive firms self select into importing and that only a subset of the most productive firms undertake both trade activities.[3]

More importantly, our theoretical framework emphasizes that the positive effect of importing on

[1] As suggested in Crozet and Koenig (2010), the definition employed in this paper for the intensive margin of export reflects that used in Chaney (2008), that is the value shipped by the marginal exporter, which differs from the average shipment per exporter, used in most empirical analyses (Eaton et al.; 2004; Bernard et al.; 2007; Mayer and Ottaviano; 2008).

[2] For a theoretical background of the productivity gains induced by intermediate inputs see Markusen (1989); Grossman and Helpman (1991); Acharya and Keller (2009) among others. Micro-level empirical studies providing evidence on the positive relationship between import and a firm's productivity include Kasahara and Rodrigue (2008) for Chile, Halpern et al. (2011) for Hungary, Amiti and Konings (2007) for Indonesia. Similarly, Goldberg et al. (2010) find that an increase in imported input varieties contribute to the expansion in domestic firms' product scope.

[3] As stressed by Kasahara and Lapham (2013) the evidence points as the presence of fixed costs not only of exporting but also of importing, and to a process of self-selection in both export and import markets.

a firm's productivity depends on both the mass of imported intermediate inputs available, as well as the price of each intermediate. Bigger markets provide a larger variety of inputs, while closer countries charge lower prices because of lower transportation costs. This implies that importing from closer and larger markets has a stronger effect on a firm's productivity and thereby it rises a firm's probability of exporting, as well as its export value. Therefore, the standard gravity forces governing a firm's decision to export also determine the heterogeneous productivity gains across import-source countries.

In addition to the standard direct effect found in the gravity model, a decline in transportation costs (i.e., distance) has an indirect effect on a firm's export decision due to the reduction in the cost of imported inputs which allows a firm to offer its exports at lower prices and to increase its revenues in the exporting markets.[4] Following a similar reasoning, foreign market size exerts a positive effect on exports directly but also indirectly through an efficiency increase induced by imports of intermediate inputs. The intuition is that the bigger the foreign country, the larger the mass of imported inputs and the lower the marginal cost of production. Therefore, an increase in the size of foreign market determines larger efficiency gains and thereby increases a firm's export performance.

We test the main predictions of our model by exploiting an original Italian database obtained by merging a firm-level dataset, including standard balance sheet information, with a transaction-level dataset, recording custom information on exports and imports for each product and destination. The key advantage of our data is that we know, for each firm in the panel, whether a firm exports or imports, how much it trades, and where it exports to or imports from. Moreover, by exploiting the product information we can distinguish whether a firm's imports are intermediate inputs. Firm-level trade data are complemented by country characteristics including proxies for market size, distance, variable and fixed trade costs.

First, we estimate a production function taking into account the role of imports of intermediate inputs and derive the contribution of import to a firm's total factor productivity. Second, we estimate the equations for a firm's export participation and export sales in a destination market and show the positive influence that the component of productivity related to importing has on both margins of trade. Finally, we quantify the indirect effects of the two gravity forces on a firm's exports. All the empirical results support the theoretical predictions of the model.

Within the vast empirical literature on firm heterogeneity in international trade, this article directly relates to the emerging literature on the interdependence between importing and exporting activities. A leading recent theory is provided by Kasahara and Lapham (2013) who develop a symmetric country model on the import-productivity-export nexus. In their theoretical framework the use of foreign intermediates increases a firm's productivity but, because of the existence of fixed costs of importing, only the most productive firms are able to source from abroad. In turn, productivity gains from importing allows some importers to start exporting. In a similar framework, Nocco (2012) studies the consequences for average productivity and welfare of trade liberalisation in a model of trade with vertical linkages, obtaining that the results clearly depend on the share of intermediate inputs in the total production of the final good. Unlike these papers, we extend the Melitz (2003) model to incorporate trade in intermediates in an asymmetric country environment. The latter allows us to derive the gravity equation and to include cross country determinants of

[4]The idea that allowing trade in intermediates changes the aggregate trade elasticity of trade flows to trade barriers is not entirely new. Indeed, the seminal paper of Yi (2003) proposes a model in which vertical specialisation can magnify the effect that tariff reductions has on trade flows. Recent contributions allowing for sector heterogeneity in both imports and exports in an Eaton and Kortum's framework are Caliendo and Parro (2015) and Aichele et al. (2014). Our model takes into account firm heterogeneity, within country self-selection into both export and import markets based on productivity, and productivity gains associated with importing from larger/richer countries.

export and import activities across firms, which is the focus of the paper. The causal link from intermediate inputs to final good exports is also tested in Bas and Strauss-Kahn (2014). Using French firm-level data the study shows that a larger variety of imported inputs, increases a firm's productivity and firms with high productivity levels export more varieties. The importance of imported intermediates for exports is also implied by Feng et al. (2012), who find that Chinese firms that increased the expenditure and the varieties of imported inputs enlarged the value and the scope of their exports. In related work, Amiti and Khandelwal (2013) show that import tariffs have a significant impact on export quality upgrading. Unlike these papers, we explore the effect of importing on exporting in a multi-country environment obtaining that the standard gravity forces are shaping the effect that intermediate input imports have on a firms' productivity and consequently export performance.

Our paper is also strongly connected to the literature on the gravity equation. Applied for the first time by Tinbergen (1962), the equation shows that trade between two countries is proportional to their respective sizes, measured by their GDP, and inversely proportional to the geographic distance between them. The heterogeneous-firm model brings to the gravity model a need to consider the effects of trade barriers both on the value of exports by current exporters and on the entry of exporters. In his model Chaney (2008) extends the work of Melitz (2003) to show that there is both an intensive and an extensive margin of adjustment of trade flows to trade barriers. In a similar manner, Helpman et al. (2008) derive a gravity equation and develop an estimation procedure to obtain the effects of trade barriers and policies on the two margins. Empirical analyses that use firm-country level data confirm several of the theoretical predictions. Eaton et al. (2011, 2004) for France and Bernard et al. (2007) for the US find that the number of exporting firms is sharply decreasing in the distance to the destination country and increasing in importers' income. Crozet and Koenig (2010) use French data to estimate the structural parameters of Chaney's model and show by how much the foreign sales of a given set of firms and by how much the number of firms respond to changes in trade costs. By estimating an export firm-level gravity equation, other empirical studies offer evidence that both firm-level productivity and market-specific trade costs affect individual export decision and export sales to a particular destination (Lawless and Whelan; 2008; Smeets et al.; 2010). None of the cited studies, however, consider the role played by imports in the export firm-level gravity equation. Indeed, while it has been already established that market size and distance are crucial in shaping exports patterns, it is an open question whether and how importing plays a role in the gravity mechanisms. This paper provides a micro-foundation for the export gravity equation with imports in intermediate inputs.

The remained of the paper is organized as follows. Section 2 presents a trade model with heterogeneous firms, featuring imports in intermediate inputs to derive the export gravity equation, both at firm and industry level. Section 3 describes the data for the empirical study. Section 4 presents the estimation results and Section 5 concludes.

2 The model

2.1 Preferences

Consider N potential asymmetric countries, indexed by n, each of them populated by a continuum of individuals of measure L_n who derive utility from the consumption of the $H+1$ final goods existing in the economy according to the following functional form

$$U = \prod_{h=0}^{H} (Q_{hn})^{\mu_h}, \qquad \sum_{h=0}^{H} \mu_h = 1,$$

where Q_{hn} represents consumption of final good h in the generic country n. Sector 0 produces an homogeneous good. Each of the rest H different sectors produces a continuum of varieties ω in the set Ω_h. Preferences across different varieties of the same final good are described by the CES utility function

$$Q_{hn} = \left(\int_{\omega \epsilon \Omega_h} (q_{hn}(\omega))^{\frac{\sigma_h - 1}{\sigma_h}} \, d\omega \right)^{\frac{\sigma_h}{\sigma_h - 1}}, \quad \sigma_h > 1$$

where the parameter σ_h controls for the elasticity of substitution across varieties within the sector h. Solving for the consumer's maximization problem we obtain the demand function for each variety within each sector

$$q_{hn}(\omega) = \frac{\mu_h R_n}{P_{hn}} \left(\frac{p_{hn}(\omega)}{P_{hn}} \right)^{-\sigma_h}$$

where R_n, P_{hn} represent respectively income and the standard CES aggregate price index for country n.[5]

2.2 Production

Production of the homogeneous good uses labor as an input. The technology is linear, described by the following functional form

$$q_{0n} = \varepsilon_n l_{0n}.$$

Assuming that this good is produced under perfect competition and taking this good as the numeraire, profit maximization will imply that $w_n = \varepsilon_n$.

In the other final good sectors each firm produces a unique differentiated variety. To produce, each firm f in sector h needs to incur in per period fixed costs of operation F_h (in units of the numeraire). In contrast to Chaney (2008) we assume that firms use intermediate inputs and labor to produce. Each firm produces using the following Cobb-Douglas technology

$$q^f_{hn} = \varphi^f_h \left(l^f_{hn} \right)^{1-\alpha_h} \left(m^f_{hn} \right)^{\alpha_h} \tag{1}$$

where l^f_{hn} denotes labor dedicated to production, $m^f_{hn} = \left(\int_{\nu \epsilon \Lambda} \left(m^f_{hn}(\nu) \right)^{\frac{\phi_{h-1}}{\phi_h}} \right)^{\frac{\phi_h}{\phi_h - 1}}$ is the intermediate composite input used in sector h where $m^f_{hn}(\nu)$ is a firm f's demand of the intermediate input variety ν produced in country n, and φ^f_h denotes a firm's productivity. The parameter $\phi_h > 1$ controls for the degree of substitutability across intermediate inputs within a sector. The parameter α_h measures the importance of intermediate inputs in the production of each final good. We

[5] $P_{hn} = \left(\int_{\omega \epsilon \Omega_h} (p_{hn}(\omega))^{1-\sigma_h} \, d\omega \right)^{\frac{1}{1-\sigma_h}}.$

assume that the elasticity of substitution across intermediate inputs is a technological parameter and therefore it is common across all countries though it may differ across sectors. Following Romer (1990) and Rivera-Batiz and Romer (1991), we have assumed that there is love of variety in the set of intermediates.

As it is common in this literature, we assume that firms in the H final good sectors differ in productivity. Firms' productivity level φ_h^f follows a Pareto distribution with cumulative distribution function given by

$$\Pr(\varphi_h^f \leq \varphi) = 1 - \varphi^{-\gamma_h}$$

with γ_h controlling for the productivity dispersion within sectors. Following the broad literature on trade and firm heterogeneity we assume $\gamma_h > \sigma_h - 1$ and $\gamma_h > 2$. At the moment of entry each firm takes a draw from this common productivity distribution. This determines the productivity of the firm that for simplicity is assumed to be constant over time.

In the intermediate input sector, each firm within each country is producing a unique variety. To produce it, a firm uses a linear technology where labor is the unique production factor

$$m(\nu) = l_m. \tag{2}$$

As in Chaney (2008), we assume that the mass of entrants is proportional to the income of the economy (i.e. $w_n L_n$). In this setup, however, we need to make an extra assumption about how the prospective entrants are distributed among the $H+1$ final goods sectors. We posit that an exogenous percentage of those entrants β_{hn} enters in the final good sector h and a proportion $\beta_{mn} = (1 - \sum_{h=1}^{H} \beta_{hn})$ enters in the intermediate sector. Therefore, our modeling strategy allows two different stages of production characterized by two different sets of tradable goods, final goods and intermediate inputs. However, for the sake of simplicity, the country level determinants of the allocation of resources across the two production stages are left unmodeled.

In this model entry is exogenous and firms earn positive profits. To complete the definition of the model, as it is common in the literature, we assume that all existing firms in the world belong to a mutual fund and each individual in each country owns w_n shares of this mutual fund.

2.3 Trade

In our world there exists trade in both final goods and intermediate inputs. Moreover, both activities bear fixed and variable costs. A firm in country k which wants to export to country j must pay a fixed cost F_{hxkj} in units of the numeraire and variable costs of the iceberg type τ_{hxkj}. We follow Anderson and van Wincoop (2004) in assuming that τ_{hxkj} is a log-linear function of D_{kj}, the distance between countries, and Δ_{hxkj}, other variable costs which are not related to distance (i.e. export tariffs). Variable export barriers are given by the following functional form

$$\tau_{hxkj} = \Delta_{hxkj} (D_{kj})^{\delta_h}, \tag{3}$$

where $\Delta_{hxkj} > 1$ if $k \neq j$.

Firms have also the option to import intermediates from abroad by incurring a fixed cost F_{hik} in units of the numeraire.[6] In order to keep tractability in the model, we assume that once a firm pays F_{hik}, it has access to all the intermediate inputs varieties available in the world. Different from exporting, the decision to import from a particular destination depends on the decision of

[6]Note that the fixed costs on the export side are indicated with x while those on the import side with i.

importing from other countries. Although it is possible to derive conditions that allow to establish a hierarchy of countries across importing strategies,[7] in practice this hierarchy depends on several country characteristics. This would not only complicate the calculations but also it would force to study specific cases. Moreover, in section 2.5 we show that the effects of importing intermediates on exporting at the firm level can be summarized with one statistic independently of this assumption.

To serve a foreign country, an intermediate input producer bears variable trade costs. Indeed, exporting from country j to country k implies paying an iceberg trade cost of τ_{hmjk}. We assume that variable costs related to distance are the same for final good exporters and intermediate producers that export, but we allow for differences in other variable costs

$$\tau_{hmjk} = \Delta_{hmjk} \left(D_{kj}\right)^{\delta_h} . \tag{4}$$

The inclusion of fixed costs in both activities implies that not all firms are going to find profitable either to export final goods or to import intermediates. Therefore, this model predicts a self-selection effect in both exporting and importing activities based on productivity levels.

2.4 The firm-level export gravity equation

This section derives a firm-level export gravity equation for the final good sector. To do that we first define the productivity thresholds required to export, to import and to survive in the domestic market. Second, we derive the aggregate price index and, finally, we provide an expression for a firm's intensive and extensive margins of exports which depends on gravity forces.

Since the model is deterministic, depending on the parameters' configuration we can have different types of equilibria. In this paper, we focus on equilibria where the firms engaged in international trade are either both exporters of final goods and importers of intermediate products or just only importers.[8]

Each intermediate input producer is a monopolist of its own variety. This producer charges the price $p_{hmjk} = \rho_{hm}\tau_{hmjk}w_j$, where $\tau_{hmjj} = 1$ and $\rho_{hm} = \frac{\phi_h}{\phi_h - 1}$ is the mark-up. The intermediate input producer charges a higher price to the foreign market because it is more costly to serve the foreign market.

In the final good sectors, the firm profit maximization problem can be described in two steps. In the first step, the cost minimization problem, firms choose the optimal combination of inputs for a given production quantity, while in the second step they choose the price (and therefore indirectly the quantity sold) they charge to consumers for their differentiated product. Solving the first step we obtain that the variable cost of production associated with a firm in country k is given by the following expression [9]

$$c^f_{hk}\left(\varphi^f\right) = \frac{\left(w_k\right)^{1-\alpha_h}\left(P_{hmk}\right)^{\alpha_h}}{\Gamma_h}\frac{q^f_{hk}}{\varphi^f} = \frac{\left(\rho_{hm}\right)^{\alpha_h} w_k}{\Gamma_h\left(\chi_{hk}\right)^d\left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h-1}}}\frac{q^f_{hk}}{\varphi^f} \tag{5}$$

[7] This condition depends on the elasticity of substitution of both final goods and intermediate input varieties and the importance of intermediate inputs in the production of the final goods. More precisely, if $\frac{\alpha_h(\sigma_h-1)}{\phi_h-1} > 1$ the gains from importing from a specific country are increasing with the number of countries from which a firm is already importing. Under this assumption, it is possible to establish a hierarchy of countries across sourcing strategies based on country characteristics, which becomes relevant for deriving the aggregate price index in the export gravity equation. This derivation is available upon request.

[8] A sufficient and necessary condition for the existence of this equilibria is $(\tau_{hxkj})^{\sigma_h-1}\left(\frac{Y_k}{Y_j}\right)^{\frac{\sigma_h-1}{\gamma_h}}\left(\frac{\theta'_{hk}}{\theta'_{hj}}\right)^{\sigma_h-1}\frac{(\chi_{hk})^{\sigma_h-1}-1}{(\chi_{hk})^{\sigma_h-1}}F_{hxkj} \geq F_{hik} \geq \left((\chi_{hk})^{\sigma_h-1}-1\right)F_h \quad \forall \quad j.$

[9] Details about how to derive this analytical result can be found in the Appendix A1.

which is a linear function of the quantity $\chi_{hk} = \left[\sum_{j=1}^{N} \left(\left(\frac{w_j}{w_k} \right) \tau_{hmjk} \right)^{1-\phi_h} \frac{\tilde{L}_j}{\tilde{L}_k} \right]^{\frac{\alpha_h}{\phi_h - 1}}$, d is an indicator function taking the value 1 if a firm imports intermediates and zero otherwise, Γ_h is a technological constant and $\tilde{L}_k = \beta_{mk} w_k L_k$. Notice that for an importing firm $\chi_{hk} > 1$. It follows that an importer enjoys lower marginal costs of production.[10]

In the second step of the profit maximization problem, as usual in the Dixit Stiglitz monopolistic competition framework, the price set by a firm is a constant mark-up over marginal costs. Therefore, the price on market j of a final good produced in country k by a firm with productivity φ^f is

$$p^f_{hxkj}\left(\varphi^f\right) = \frac{\sigma_h}{\sigma_h - 1} \frac{(\rho_{hm})^{\alpha_h}}{\Gamma_h \chi_{hk} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}}} \frac{\tau_{hxkj} w_k}{\varphi^f}.$$

Substituting the price expression in the demand function we obtain the quantity sold in country j by a final good producer of country k, which is

$$q^f_{hxkj}\left(\varphi^f\right) = \frac{\mu_h R_j}{(P_{hj})^{1-\sigma_h}} \left(\frac{\tau_{hxkj} \rho_h (\rho_{hm})^{\alpha_h} w_k}{\Gamma_h \chi_{hk} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}} \varphi^f} \right)^{-\sigma_h},$$

where $\rho_h = \frac{\sigma_h}{\sigma_h - 1}$ is the mark-up of final goods producers belonging to sector h. For a firm belonging to sector h of country k, the operating profits from selling to country j are given by

$$r^f_{hxkj}\left(\varphi^f\right) = (\tau_{hxkj})^{1-\sigma_h} \frac{\mu_h R_j}{\sigma_h (P_{hj})^{1-\sigma_h}} \left(\frac{\rho_h (\rho_{hm})^{\alpha} w_k}{\Gamma_h \chi_{hk} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}} \varphi^f} \right)^{1-\sigma_h}.$$

A firm of country k will export to country j when $r_{hxkj}(\varphi^f) \geq F_{hxkj}$. Hence, the productivity of the marginal firm which is indifferent between exporting and not exporting to country j is given by the following cutoff

$$\varphi^*_{hxkj} = \tau_{hxkj} \left(\frac{\sigma_h}{\mu_h} \right)^{\frac{1}{\sigma_h - 1}} \left(\frac{1}{R_j} \right)^{\frac{1}{\sigma_h - 1}} \rho_h (w_k) (P_{hj})^{-1} (F_{hxkj})^{\frac{1}{\sigma_h - 1}} \underbrace{\frac{(\rho_{hm})^{\alpha} \left(\tilde{L}_k\right)^{\frac{\alpha}{1-\phi_h}}}{\chi_{hk} \Gamma_h}}_{Interm.Inputs}. \tag{6}$$

To obtain the productivity cutoff associated with importing we first consider the operating profits that an importing firm has in the domestic market, which are given by

$$r^f_{hik}(\varphi^f) = \frac{\mu_h R_k}{\sigma_h (P_{hk})^{1-\sigma_h}} \left(\frac{\psi_h w_k}{\chi_{hk} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}} \varphi^f} \right)^{1-\sigma_h}$$

where $\psi_h = \frac{\rho_h (\rho_{hm})^{\alpha_h}}{\Gamma_h}$. A firm in k is willing to import if the gains in operating profits from importing intermediates overcome the fixed cost of importing F_{hik}.

[10] In section 2.5 we will show that the variable χ_{hk} captures the contribution that importing intermediates has on a firm's total factor productivity.

The domestic operating profits of a non importer are instead given by

$$r^f_{hk}\left(\varphi^f\right) = \frac{\mu_h R_k}{\sigma_h \left(P_{hk}\right)^{1-\sigma_h}} \left(\frac{\psi_h w_k}{\left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}} \varphi^f}\right)^{1-\sigma_h}.$$

Note that $r^f_{hik}(\varphi^f) = (\chi_{hk})^{\sigma_h - 1} r^f_{hk}\left(\varphi^f\right)$. Therefore, a firm in k will be importing intermediates if $r^f_{hik}(\varphi^f) - r^f_{hk}(\varphi^f) \geq F_{hik}$. The marginal firm, the one that is indifferent between importing and relying on domestic inputs only, satisfies the following condition

$$\left((\chi_{hk})^{\sigma_h - 1} - 1\right) \frac{\mu_h R_k}{\sigma_h \left(P_{hk}\right)^{1-\sigma_h}} \left(\frac{\psi_h \left(w_k\right)}{\left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}}}\right)^{1-\sigma_h} \left(\varphi^*_{hik}\right)^{\sigma_h - 1} = F_{hik}.$$

The productivity threshold of the marginal importing firm is given by

$$\begin{aligned} \varphi^*_{hik} = {} & \frac{1}{\left((\chi_{hk})^{\sigma_h - 1} - 1\right)^{\frac{1}{\sigma_h - 1}}} \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{1}{\sigma_h - 1}} \left(\frac{1}{R_k}\right)^{\frac{1}{\sigma_h - 1}} \psi_h w_k \left(P_{hk}\right)^{-1} \\ & \cdot \left(F_{hik}\right)^{\frac{1}{\sigma_h - 1}} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{1-\phi_h}}. \end{aligned} \tag{7}$$

This expression indicates that the larger the gains from importing, i.e. the larger χ_{hk}, the lower the import productivity threshold. Moreover, the larger the home market, R_k, the lower the productivity threshold and, therefore, the larger the mass of importing firms.[11]

Finally, the survival productivity threshold is described by the following equation

$$\varphi^*_{hk} = \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{1}{\sigma_h - 1}} \left(\frac{1}{R_k}\right)^{\frac{1}{\sigma_h - 1}} \left(\psi_h w_k\right) \left(P_{hk}\right)^{-1} \left(F_h\right)^{\frac{1}{\sigma_h - 1}} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{1-\phi_h}}. \tag{8}$$

Given the basic ingredients of the model (preferences, technologies and the optimal strategies of firms), we can derive the equilibrium aggregate price index for each economy, P_{hj}[12], as

$$P_{hj} = \lambda^{'}_{2h} \left(Y_j\right)^{\frac{1}{\gamma_h} - \frac{1}{\sigma_h - 1}} \theta^{'}_{hj} \tag{9}$$

where $\theta^{'}_{hj}$ is the multilateral resistance term, which takes also into account the fact that some firms are importing intermediate inputs and, consequently, they are charging different prices; $\lambda^{'}_{2h}$ is a constant term. In what follows we assume that our country is a small open economy. This implies that any change in the domestic market does not have any relevant impact on the measure θ'_{hj}. This simplifies significantly the calculations. With the definition of the price index in hand, we are able to derive the general equilibrium value of the export productivity cutoffs and of firm-level exports.

[11]This is due to two different mechanisms. First, a larger home market, R_k, implies a larger demand of final goods and, as a consequence, a larger demand of intermediate inputs. Second, firms in larger markets have access to a larger set of intermediate inputs and, therefore, have a lower marginal cost. As the gains from importing intermediates are inversely proportional to the marginal cost of production, firms' profits from importing intermediates are larger in larger markets.

[12]Details about the computation of P_{hj} are provided in the Appendix A2.

Plugging (9) in (6) and using again the fact that $R_j = Y_j$, we obtain the equilibrium value of the productivity threshold for exports. Then the probability that a firm in country k exports to country j is given by

$$\Pr(\varphi \geq \varphi^*_{hxkj}) = \left(\varphi^*_{hxkj}\right)^{-\gamma_h} = \left(\lambda'_{4h}\right)^{-\gamma_h} \underbrace{\left(\frac{Y_j}{Y}\right)\left(\frac{w_k \tau_{hxkj}}{\theta'_{hj}}\right)^{-\gamma_h} \left(f_{hxkj}\right)^{\frac{-\gamma_h}{\sigma_h - 1}}}_{Chaney's} \underbrace{\left(\tilde{\chi}_{hk}\right)^{\gamma_h}}_{new\ elements} \tag{10}$$

where λ'_{4h} is a constant[13] and $\tilde{\chi}_{hk} = \chi_{hk}\left(\frac{\beta_{mk}Y_k}{Y}\right)^{\frac{\alpha_h}{\phi_h - 1}}$.

This is the gravity equation at the firm-level for the extensive margin of trade. It relates the standard elements found in a gravity equation to the probability that a firm in k exports to country j (and therefore the mass of firms in k exporting to country j). Foreign market size contributes positively to the mass of firms exporting to country j. Barriers to exports (both fixed and variable costs) reduce the probability of exporting. The multilateral resistance term affects positively the mass of firms exporting. Indeed, the larger the trade barriers of a trade partner with the rest of the world, the larger will be the mass of firms exporting to such destination. The novelty with respect to a model without intermediate inputs is related to the last element of equation (10) which captures the contribution of intermediate inputs to a firm's productivity. Changes in the trade costs of importing goods from a particular source country, or changes in the market size of that trade partner will have an impact on a firm's export status through this element, as we will discuss in greater detail in the next section.

We can finally derive the expression of a firm's export to country j, X^f_{hxkj}, as

$$\begin{aligned} X^f_{hxkj}(\varphi^f) &= \left(\frac{\varphi^f}{\varphi^*_{hxkj}}\right)^{\sigma_h - 1} \sigma_h r_{hxkj}(\varphi^*_{hxkj}) \\ &= \left(\lambda'_{3h}\right) \underbrace{\left(\frac{Y_j}{Y}\right)^{\frac{\sigma_h - 1}{\gamma_h}} \left(\frac{\theta'_{hj}}{w_k \tau_{hxkj}}\right)^{\sigma_h - 1}}_{Chaney's} \underbrace{\left(\tilde{\chi}_{hk}\right)^{\sigma_h - 1}}_{new\ element} \left(\varphi^f\right)^{\sigma_h - 1} \end{aligned} \tag{11}$$

where λ'_{3h} is a constant.[14] This is the gravity equation for the intensive margin of exports. The individual export value increases with destination market size and country $j's$ remoteness from the rest of the world and decreases with variable trade costs. As for the extensive margin this equation introduces a new element which reflects the positive productivity contribution of intermediate inputs to a firm's exports, as it will be discussed in details in the next section.

2.5 Imports, total factor productivity and country characteristics

In this section, we derive a set of testable predictions for firms using foreign intermediate goods. First, we derive the expression for the effect that importing has on a firm's productivity and show that this effect depends on the characteristics of the country of origin of imports. Second, we show how changes in transportation costs or market size affect export behavior at both the intensive and the extensive margins, via importing.

[13] $\lambda'_{4h} = \left(\frac{\gamma_h}{\gamma_h - (\sigma_h - 1)}\right)^{\frac{1}{\gamma_h}} \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{1}{\gamma_h}} (1+\pi)^{\frac{-1}{\gamma_h}} (\psi_h)^{-1} \left(\frac{1+\pi}{Y}\right)^{\frac{\alpha_h}{\phi_h - 1}}$.

[14] Following Chaney (2008) notation $\lambda'_{3h} = \sigma\left(\lambda'_{4h}\right)^{1-\sigma}$.

Proposition 1 *Importing intermediate inputs has a positive effect on a firm's productivity. This effect depends on the characteristics of the country of origin of imports.*

The technology used to produce the final good presents decreasing returns to scale in the use of each intermediate input and increasing returns to scale in the mass of varieties used. A firm importing intermediates is able to escape from the decreasing returns to scale associated with each of the intermediate inputs currently used by the firm by splitting its intermediate input requirements across more varieties. The ability of a firm to do so depends on the mass of imported intermediate inputs available, as well as on the price of each intermediate input.

To formalize the intuition behind these results, we can derive a firm's total factor productivity (TFP). The demand of a firm in country k for an intermediate input produced in country j can be expressed as

$$m_{hj}^{f}(\nu) = \left(\frac{p_{hmj}(\nu)}{p_{hmk}(\nu)}\right)^{-\phi} m_{hk}^{f}(\nu)$$

where $m_{hk}^{f}(\nu)$ is the demand for a domestic variety.

The total volume of intermediate inputs used by a firm, M_{tot}^{f}, can be expressed as

$$M_{tot}^{f} = \int_{\nu\epsilon\Lambda} \frac{p_{hmj}\left(\nu\right) m_{hj}^{f}\left(\nu\right) d\nu}{p_{hmk}\left(\nu\right)} = \left[\sum_{j=1}^{N} \left(\left(\frac{w_j}{w_k}\right)\tau_{hmjk}\right)^{1-\phi_h} \frac{\tilde{L}_j}{\tilde{L}_k}\right] \left(\tilde{L}_k\right) \bar{m}_{hk}^{f}$$

where $\bar{m}_{hk}^{f}$ is the amount consumed for each domestic variety in equilibrium. Notice that M_{tot}^{f} is the value of the intermediate inputs used by a firm deflated by the domestic intermediate input price. Rearranging terms in the equation above we obtain that the variable χ_{hk} can be expressed as

$$\chi_{hk} = \left(\frac{M_{tot}^{f}}{M_{k}^{f}}\right)^{\frac{\alpha_h}{\phi_h - 1}} \tag{12}$$

where M_{k}^{f} is a firm's total domestic intermediates inputs.

It can be easily shown that the CES intermediate aggregate can be expressed as the total volume of imports multiplied by a weighted average of country characteristics

$$\left(\int_{\nu\epsilon\Lambda} \left(m_{hj}^{f}\left(\nu\right)\right)^{\frac{\phi_h - 1}{\phi_h}} d\nu\right)^{\frac{\phi_h}{\phi_h - 1}} = M_{tot}^{f} \left[\sum_{j=1}^{N} \left(\left(\frac{w_j}{w_k}\right)\tau_{hmjk}\right)^{1-\phi_h} \frac{\tilde{L}_j}{\tilde{L}_k}\right]^{\frac{1}{\phi_h - 1}} \left(\tilde{L}_k\right)^{\frac{1}{\phi_h - 1}}$$

and by plugging this equation into the production function (equation (1)) we get

$$q_{hk}^{f} = \varphi_h^{f} \left(l_{hk}^{f}\right)^{1-\alpha_h} \left(M_{tot}^{f}\right)^{\alpha_h} \left[\sum_{j=1}^{N} \left(\left(\frac{w_j}{w_k}\right)\tau_{mjk}\right)^{1-\phi_h} \frac{\tilde{L}_j}{\tilde{L}_k}\right]^{\frac{\alpha_h}{\phi_h - 1}} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}} .$$

The last two terms reflect the gains from variety obtained from imported and domestic intermediate inputs, respectively. By expressing the mass of each country intermediate input varieties as a function of GDP

$$\tilde{L}_j = \beta_{mj} w_j L_j = \beta_{mj} \frac{Y_j}{(1+\pi)}$$

and rearranging terms we obtain

$$\frac{q_{hk}^{f}}{\left(l_{hk}^{f}\right)^{1-\alpha_h}\left(M_{tot}^{f}\right)^{\alpha_h}} = \varphi_h^f \underbrace{\underbrace{\left[\sum_{j=1}^{N}\left(\left(\frac{w_j}{w_k}\right)\tau_{mjk}\right)^{1-\phi_h}\left(\frac{\beta_{mj}}{\beta_{mk}}\right)\frac{Y_j}{Y_k}\right]^{\frac{\alpha_h}{\phi_h-1}}}_{\chi_{hk}}\left(\frac{\beta_{mk}Y_k}{Y}\right)^{\frac{\alpha_h}{\phi_h-1}}}_{\tilde{\chi}_{hk}}\left(\frac{(1+\pi)}{Y}\right)^{\frac{\alpha_h}{1-\phi_h}.} \tag{13}$$

where the left-hand side is the expression for the TFP of a firm f belonging to sector h, that we will bring directly to the data in Section 4.1. In the right-hand side of the equation, the first term represents a firm's innate productivity, the second term ($\tilde{\chi}_{hf}$) captures the contribution of intermediate inputs to a firm's TFP and the third term is just a constant common to all firms. The term $\tilde{\chi}_{hf}$ is a weighted sum of the varieties sourced from each country where the weights take into account the fact that varieties coming from different countries have different prices.[15] This term can be conveniently decomposed in an element, χ_{hk}, that reflects the gains from importing intermediates and a component that accounts for the effect of the number of domestic varieties. The gains from importing depend on transportation costs, which determine the price of the different varieties of intermediate inputs, and on the mass of varieties sourced from each location. As indicated in equation (12), the term capturing the effect of importing intermediates on a firm's TFP can be rewritten as $\left(\frac{M_{tot}^f}{M_k^f}\right)^{\frac{\alpha_h}{\sigma_h-1}}$.

Note that the result concerning the gain from importing is robust to an alternative richer environment in which a firm bears fixed costs of importing per market, which are source-country specific. When the fixed costs of importing are heterogeneous across countries, a firm's choice regarding the number of source markets will depend on the characteristics of these markets and on its innate productivity. This will influence the number of countries included in χ_{hk}. However, the statistic $\left(\frac{M_{tot}^f}{M_k^f}\right)^{\frac{\alpha_h}{\sigma_h-1}}$ still captures the positive contribution of importing on a firm's TFP. Therefore, the main conclusions of the model hold both in the simplified setting of a unique fixed cost of importing and in the more general case in which there are multiple fixed costs of importing and these are heterogeneous across countries.

Proposition 2 *The effect of distance on a firm's probability of exporting and its export value is magnified by the presence of trade in intermediate inputs.*

To the extent that export and import variable costs have common determinants, as assumed in the model, a decrease in transportation costs has a comparatively larger impact on exports than in the absence of intermediate imports. This is the consequence of the fact that a reduction in distance affects a firm's export patterns through a direct effect, standard in the literature, and an indirect effect, via importing. Taking logs and derivatives in equation (10) we obtain the effect that a decrease in D_{kj} has on a firm's export status

$$\frac{d\ln(\Pr(\varphi \geq \varphi_{hxkj}^{*}))}{d\ln(D_{kj})} = -\delta_h\gamma_h + \gamma_h\frac{d\ln\chi_{hk}}{d\ln D_{kj}} \tag{14}$$

[15] Indeed, if there were no transportation costs and wages were equal across countries this term will be reduced to $\sum_{j=1}^{N}\frac{\beta_{mj}Y_j}{Y}$.

and a similar expression is obtained for a firm's export value

$$\frac{d\ln X^f_{hxkj}(\varphi^f)}{d\ln D_{kj}} = -\delta_h\left(\sigma_h - 1\right) + \left(\sigma_h - 1\right)\frac{d\ln \chi_{hk}}{d\ln D_{kj}}. \tag{15}$$

The direct effect corresponds to the first element on the right hand side of equations (14) and (15). That is, a reduction in the transportation costs of exporting to country j allows a firm to charge lower prices, increasing both the probability that a firm becomes an exporter to that destination and its export sales to that country. The indirect effect is inherent to this framework and it is captured by the second element of both equations. The reduction in transportation costs between k and j decreases the cost of importing intermediates from country j. This allows a firm to better reallocate its intermediate input requirements across existing varieties and, as a consequence, to become more efficient, as indicated in equation (13). The increase in a firm's TFP allows to charge lower prices, increasing its probability of exporting and its export sales not only to country j but to all destinations.

Proposition 3 *The effect of market size on a firm's probability of exporting and on its export value is magnified by the presence of trade in intermediate inputs.*

Taking logs and derivatives in equation (10) we obtain the effect that a decrease in Y_j has on a firm's export status

$$\frac{d\ln(\Pr(\varphi \geq \varphi^*_{hxkj}))}{d\ln Y_j} = 1 + \gamma_h\frac{d\ln \chi_{hk}}{d\ln Y_j}. \tag{16}$$

and a similar expression is obtained for a firm's export value

$$\frac{d\ln X^f_{hxkj}(\varphi^f)}{d\ln Y_j} = \left(\frac{\sigma_h - 1}{\gamma_h}\right) + \left(\frac{\sigma_h - 1}{\gamma_h}\right)\frac{d\ln \chi_{hk}}{d\ln Y_j}. \tag{17}$$

An increase in foreign market size has a positive effect on exports due to both a direct and an indirect effect. First, the larger the income level of country j, the larger the expenditure on final goods and the market potential for exporters. This reduces the productivity level necessary to cover the fixed costs of exporting to that destination and it increases a firm's export sales to that country. Second, the positive effect of the country size is magnified by the fact that the foreign market is also a source of intermediate inputs. The larger the source country, the larger the mass of imported intermediate inputs. The access to a larger set of intermediate input varieties coming from that country has a positive effect on a firm's TFP and it allows a firm to charge lower prices. A firm's probability of becoming an exporter and its export value to country j as well as to all other destinations, consequently, increases.[16]

This theoretical model explores the potential effect of changes in trade costs or market sizes on a firm's export patterns in a simple and tractable manner. The main predictions of the model holds in a more complex but richer environment in which we allow for technological differences in the production of intermediates across countries and differences in quality across intermediate inputs. Appendix A3 discusses the robustness of our results under this alternative assumption.

[16]Novel to this framework, domestic market size also affects a firm's export behaviour. More populated and more productive economies provide a greater number of varieties of intermediate inputs which increases a firm's TFP (this is reflected in equation 13). The increase in TFP decreases the marginal cost of production which allows a firm to charge lower prices. The latter gives a competitive advantage to domestic firms in foreign markets. Unfortunately, we are not able to test this prediction since we have information only for one domestic market, that is Italy.

3 Data and Facts

Before turning to our empirical analysis, we describe the firm-level data and the country-level variables employed in the regressions.

3.1 Firm level data

The empirical analysis combines three sources of data collected by the Italian Statistical Office (ISTAT): the Italian Foreign Trade Statistics (COE), the Italian Register of Active Firms (ASIA) and a firm level accounting dataset (Micro 3).[17]

The COE dataset is the official source for the trade flows of Italy and it reports all cross-border transactions performed by Italian firms for the period 1998-2003. The database includes the value of the transactions, on a yearly basis, of a firm as disaggregated by countries of destination for exports and markets of origin for imports.[18] The total value of a firm-country transaction, recorded in euros, is broken down into five broad categories of goods, Main Industrial Groupings (MIGs), identified by EUROSTAT as energy, intermediate, capital, consumer durables and consumer non-durables.[19] This is a unique feature of our dataset which allows distinguishing imported intermediate inputs from other types of imports.[20]

Using the unique identification code of a firm, we are able to link the trade data to ISTAT's archive of active firms, ASIA. The ASIA register covers the population of Italian firms active in the same time span, irrespective of their trade status. It reports annual figures on number of employees, sector of main activity and information about the geographical location of the firms (municipality of principal activity of legal address). The ASIA-COE dataset obtained by merging the two sources is not a sample but rather includes all active firms.

Data on firm-level characteristics come from Micro.3, which is a dataset based on the census of Italian firms conducted yearly by ISTAT containing information on firms with more than 20 employees covering all sectors of the economy for the period 1989-2007.[21] Starting in 1998 the census of the whole population of firms only concerns companies with more than 100 employees, while in the range of employment 20-99, ISTAT directly monitors only a "rotating sample" which varies every five years. In order to complete the coverage of firms in that range, Micro.3 resorts, from 1998 onward, to data from the financial statement that limited liability firms have to disclose, in accordance to Italian law.[22] The database contains information on a number of variables appearing in a firm's balance sheet. For the purpose of this paper we use: number of employees, turnover, value added, capital, labour cost, intermediate inputs costs and capital assets. Capital is proxied by tangible fixed assets at book value (net of depreciation). Nominal variables are in million euros and are deflated using 2-digit industry-level production prices indices provided by ISTAT.

After merging these three databases, we work with an unbalanced panel of about 46,819 manufacturing firms over the sample period. Table 1 presents the number of firms active in the man-

[17]The database has been made available for work after careful screening to avoid disclosure of individual information. The data were accessed at the ISTAT facilities in Rome.

[18]ISTAT collects data on exports based on transactions. The European Union sets a common framework of rules but leaves some flexibility to member states. A detailed description of requirements for data collection on exports and imports in Italy is provided in Appendix A4.

[19]EUROSTAT's end-use categories (Main Industrial Groupings, MIGs), based on the Nace Rev. 2 classification, are defined by the Commission regulation (EC) n.656/2007 of 14 June 2007.

[20]Hereafter, when using the word "import" we refer to import of intermediate inputs unless otherwise specified.

[21]The database has been built as a result of collaboration between ISTAT and a group of LEM researchers from the Scuola Superiore Sant'Anna, Pisa. See Grazzi et al. (2013) for further details.

[22]Limited liability companies (societa' di capitali) have to provide a copy of their financial statement to the Register of Firms at the local Chamber of Commerce.

Table 1: Coverage of our dataset

Year	Active Firms	Traders	Exports (billion)	Intermediate Imports (billion)	Imports (billion)
	(1)	(2)	(3)	(4)	(5)
			Panel A - ASIA-COE		
1998	570,548	119,979	190.0	50.0	106.2
1999	564,366	118,588	189.7	49.6	110.1
2000	565,396	122,098	211.6	59.2	131.5
2001	560,657	121,651	221.6	57.5	132.4
2002	552,940	122,538	216.0	53.8	120.8
2003	541,835	123,610	211.3	53.3	120.5
			Panel B - Our dataset		
1998	30,570	25,745	159.5	41.5	90.1
1999	30,592	25,668	161.9	42.5	95.6
2000	30,402	25,495	177.6	50.4	113.3
2001	30,011	25,338	184.4	47.0	111.5
2002	29,882	25,256	178.5	44.8	100.7
2003	28,920	24,583	171.0	43.8	98.7

Note: The Table reports the number of manufacturing firms in ASIA-COE and after the merge with Micro3. Panel A - ASIA-COE, Panel B, Our dataset.

Table 2: Country-level variables

Variables	Proxies	Type of variable	Source
Y_{jt}	Gdp_{jt}	Continuous	World Bank
D_j	$Distance_j$	Continuous	CEPII
θ_{jt}	$Remoteness_{jt}$	Continuous	World Bank
F_j	$Market\ Costs_j$	Continuous	World Bank
Δ_j	$Trade\ Opening_{jt}$	Continuous	Fraser Institute

Note: The Table reports the country-level variables used in the empirical analyses.

ufacturing sector for the ASIA-COE dataset (Panel A) and for our database (Panel B), obtained after the merge with Micro 3. We cover only 5% of the population of active Italian manufacturing firms (column 1) and about 21% of all manufacturers engaged in international transactions, either by means of exports, imports, or a combination of the two (column 2). Yet, despite relatively few in terms of number, the firms in our dataset account for the great bulk of overall Italian exports and imports, as shown in columns 3-5 of Table 1. Since the paper focuses on the role of intermediate inputs on a firm's export margins, column 4 reports the total Italian imports in intermediate inputs defined according to the MIG classification. As a comparison, in column 5 we report also the imports of all products. Given that our interest is in the complementarity between export and import activities, we can consider the representativeness of our database with respect to the whole Italian trade flows to be quite satisfactory. Indeed, our database covers on average 82% of total Italian exports (column 3), 83% of total imports in intermediate inputs (column 4), and about 84% of imports in all goods (column 5).

3.2 Country-level data

In addition to firm-level data, we complement the analysis with information on country characteristics. We consider the two standard gravity-type variables, GDP_{jt} and $Distance_j$ to proxy for market size (Y_{jt}) and transportation costs (D_j), respectively. Data on GDP are taken from the World Bank's World Development Indicators database. Information on geographical distance comes from CEPII. Distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important city (in terms of population) or of the official capital (De Sousa et al.; 2012).

We augment the gravity model by including additional variables that might be expected to affect the costs of trading internationally. As predicted by equation (10) of our model, the probability of exporting depends on variable trade costs not related to distance (Δ_j), market specific fixed costs (F_j) and a multilateral resistance term (θ_{jt}). At the same time equation (11) suggests that a firm's export sales to a specific destination can be modelled in a parallel fashion to the model for export participation, though in this case market-specific fixed costs are not included.

For additional trade costs (Δ_j), we use a measure of average country-level import tariffs taken from the Fraser Institute ($Trade\ Opening_{jt}$).[23] The market specific fixed costs (F_j) can be related to the establishment of a foreign distribution network, difficulties in enforcing contractual agreements, or the uncertainty of dealing with foreign bureaucracies. Following Bernard et al. (2011), to generate a proxy for these costs we use information from three measures from the World Bank Doing Business dataset: number of documents for importing, cost of importing and time to import (Djankov et al.; 2010). Given the high level of correlation between these variables, we use the primary factor ($Market\ Costs_j$) derived from principal component analysis as that factor accounts for most of the variance contained in the original indicators. Finally, to proxy the multilateral resistance terms (θ_{jt}) we employ the variable $Remoteness_{jt}$ which captures the extent to which a country is separated from other potential trade partners.[24] The idea is that a remote country has high shipping costs, high import prices, and thus a high aggregate price index. As in Manova and Zhang (2012) the variable remoteness is computed for each country as the distance weighted sum of the market sizes of all trading partners.[25]

Table 2 lists the country level characteristics used to proxy the variables in our empirical models. After selecting the destinations for which we have the information needed to carry out our analysis, we end up with a dataset including 109 countries.[26]

[23] This variable is a simple average of three sub-components: revenue from trade taxes, the mean tariff rate and the standard deviation of tariffs. Each sub-component is a standardized measure ranging from 0 to 10 which is increasing in the freedom to trade internationally. For further details see J.Gwartney, R.Lawson and J.Hall, 2012, Economic Freedom of the World - 2012 Annual Report, Fraser Institute.

[24] We are aware of the fact that the remoteness proxy bears little resemblance to its theoretical counterpart and that a structural approach would be more adequate. However, in the empirical analyses our main interest lies in the elasticity of exports with respect to distance and market size. All the other country variables are simply included as controls.

[25] Precisely, $Remoteness_j = \sum_{n=1}^{N} GDP_n * distance_{nj}$, where GDP_n is the GDP of the origin country and $distance_{nj}$ is the distance between n and j, and the summation is over all countries in the world n. An alternative measure of remoteness used in Baldwin and Harrigan (2011) is given by $Remoteness_j = \sum_{n=1}^{N} (GDP_n/distance_{nj})^{-1}$. Our results are robust to the use of this other measure.

[26] The complete list of countries is reported in Table A1 in Appendix A5. Basic statistics for the different market characteristics are reported in Table A2 in Appendix A5.

Table 3: Production function estimates

	$\ln l$	$\ln k$	$\ln \frac{M_{tot}}{M_k}$	N.Obs
	(1)	(2)	(3)	(4)
Food, Beverages and Tobacco	0.77***	0.19***	0.83***	8,010
Textiles and Apparel	0.91***	0.09***	0.38***	15,388
Hide and Leather	0.86***	0.12***	1.21***	5,892
Wood and Cork	0.96***	0.14***	0.23***	3,028
Pulp and Paper	0.81***	0.21***	0.42***	2,737
Printing and Publishing	0.88***	0.07***	0.24***	3,978
Coke and Chemical products	1.01***	0.07***	0.18***	5,183
Rubber and Plastics	0.89***	0.11***	0.38***	7,702
Processing of non-metallic minerals	0.83***	0.19***	0.39***	6,854
Basic Metals	0.83***	0.09***	0.18***	3,563
Fabricated Metal Products	0.88***	0.09***	0.34***	18,539
Machinery and Equipment	0.96***	0.08***	0.06***	18,137
Electrical and Optical Equipment	0.92***	0.08***	0.15***	10,161
Motor Vehicles and Trailers	0.84***	0.14***	0.08***	2,423
Other Transport Equipment	0.90***	0.15***	0.56***	1,391
Other manufacturing industries	0.91***	0.10***	0.20***	8,172

Note: The Table reports regressions using data on 1998-2003. Column (1) reports the coefficient of labour (l), column (2) the coefficients of capital (k) and column (3) the coefficients of the ratio of intermediate inputs on domestic inputs (M_{tot}/M_k) of a production function estimation run sector by sector. All the regressions include a constant term. Bootstrapped standard errors (500 replications) are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

4 Results

This section presents the results of our empirical analysis testing the main predictions of our theoretical model derived in Section 2. We follow three steps. First, we provide evidence that importing has a positive effect on a firm's TFP. Second, we estimate the equation for a firm's export participation and for its export sales and show the influence that the component of TFP related to importing has on both the extensive and the intensive margin of exports. Third, we estimate the indirect impact that the two gravity forces have on a firm's exports due to the presence of imports in intermediates.

4.1 Imported intermediate inputs and firm productivity

Proposition 1 suggests that importing intermediate inputs increases a firm's productivity. Equation (13) derives an expression for a firm's TFP which depends on its initial productivity draw, (φ^f), the ratio of total over domestic intermediate inputs used, $\left(\frac{M^f_{tot}}{M^f_k}\right)$ and a set of variables which are constant at the firm-level.

As a first step of our empirical investigation, we estimate total factor productivity taking into account the ability of a firm to import intermediates. We obtain estimates of the production function by relying on the semi-parametric strategy proposed by Levinsohn and Petrin (2003) and refined by De Loecker (2013). The aim of this methodology is to solve the problem of simultaneity between the inputs choice and the productivity shocks, the latter being unobserved by the econometrician. This is done by proxing the productivity shocks with a function of materials and by retrieving the innovation in productivity (the component of productivity at time t which is not predictable by the firm at time $t-1$) based on a first order Markov process for productivity. The works of De Loecker (2007, 2013) point to the importance of allowing the demand of intermediate inputs and the productivity dynamics to depend on internationalization choices of the firm.

For each sector h, we consider the production function used in our theoretical model augmented with physical capital[27]

$$\ln y_t^f = \beta_0 + \beta_l \ln l_t^f + \beta_k \ln k_t^f + \frac{\alpha}{\phi-1} \ln \frac{M_{tot,t}^f}{M_{kt}^f} + \ln \varphi_t^f + \epsilon_t^f \tag{18}$$

where y_t^f is the value added of firm f at time t, l_t^f is labor, k_t^f stands for capital stock and $\frac{M_{tot,t}^f}{M_{kt}^f}$ corresponds to the ratio of intermediates imports. The error can be decomposed into a productivity shock φ_t^f, observable to firms but not to the econometrician, and an i.i.d. component ϵ_t^f. The constant, β_0, subsumes common industry-level factors such as Y_k in equation (13).

The law of motion of φ_t^f is represented by the following (endogenous) first order Markov process

$$\ln \varphi_{t+1}^f = \underbrace{g\left(\ln \varphi_t^f, \ln \frac{M_{tot,t}^f}{M_{kt}^f}\right)}_{\text{expected productivity}} + \underbrace{\left(\xi_{t+1}^f\right)}_{\text{productivity shock}}.$$

The parameters of interest are identified relying on the following moment conditions

$$E\left\{\xi_{t+1}^f\left(\beta_l, \beta_k, \frac{\alpha}{\phi-1}\right)\begin{pmatrix} \ln\left(l_{t+1}^f\right) \\ \ln\left(k_{t+1}^f\right) \\ \ln\left(\frac{M_{tot,t}^f}{M_{kt}^f}\right)\end{pmatrix}\right\} = 0$$

where both capital (as standard) and labor (due to the strong Italian employment protection legislation) are considered as state variables. We expect current intermediate input sourcing choices to be correlated with shocks to productivity and, therefore, we rely on lagged choices.

The expression $\xi_{t+1}^f\left(\beta_l, \beta_k, \frac{\alpha}{\phi-1}\right)$ is derived by regressing $\ln \varphi_{t+1}^f$ on a third degree-polynomial of $\left(\ln \varphi_t^f, \ln \frac{M_{tot,t}^f}{M_{kt}^f}\right)$ and

$$\ln \varphi_{t+1}^f = \widehat{\ln y_t^f} - \left[\beta_0 + \beta_l \ln l_t^f + \beta_k \ln k_t^f + \frac{\alpha}{\phi-1} \ln \frac{M_{tot,t}^f}{M_{kt}^f}\right].$$

In the first stage $\widehat{\ln y_t^f}$ is obtained by regressing $\ln y_t^f$ on the inputs $\left(\ln l_t^f, \ln k_t^f, \ln \frac{M_{tot,t}^f}{M_{kt}^f}\right)$ and on the proxy variable $\left(M_{tot,t}^f\right)$.[28]

Table 3 presents the results of the production function estimates. Consistent with the model, only for three sectors we can reject the hypothesis of constant returns to scale.[29] The estimated

[27] For simplicity we omit the notation for h in the remaining part of the paper.

[28] We use a second-degree polynomial of the four variables. Also notice that the coefficients of the production function $\left(\beta_l, \beta_k, \frac{\alpha}{\phi-1}\right)$ are obtained in the second stage, taking into account the argument made by Ackerberg et al. (2006).

[29] These sectors are: Wood and Cork, Coke and Chemical products and Machinery and Equipment. Results are available upon request.

coefficients for the ratio of total over domestic intermediate inputs are always positive and statistically significant across different sectors, pointing to the importance of foreign intermediates in explaining productivity differences across plants within sectors. At one extreme, for the Hide and Leather sector, we find that a 100% in the ratio of intermediate inputs on domestic inputs would increase productivity by 121%. At the bottom of the sectoral distribution, this effect amounts to 8% for the Motor Vehicles and Trailers sector.

4.2 The extensive and intensive margins of exports

As shown in equations (10) and (11) of the model, the component of the TFP related to the use of imported intermediate inputs enters into the firm-level gravity equations for the extensive and intensive margin. These two equations describe how a firm's decision to export and its export value to a country are related to gravity forces both through a direct effect and an indirect effect due to the TFP contribution of trade in intermediates. Precisely, equation (10) predicts that the country-by-country export decision depends on a firm's innate productivity (φ), foreign market size (Y), the multilateral resistance term (θ), variable trade costs (D and Δ), fixed trade costs (F), the contribution to TFP of importing intermediate inputs χ and other variables which are constant across firms. Similarly, all these elements, except the fixed trade costs, enter in the individual export value decision, equation (11). The fixed costs, once paid, do not influence an exporter's foreign sales. These two equations form the underpinning of our estimations.

Therefore, a model for a firm's decision to export to a specific country can be specified as follows

$$ExportStatus_{jt}^{f} = b_0 + b_1 \ln \hat{\varphi}_t^f + b_2 \ln \hat{\chi}_t^f + b_3 \ln D_j + b_4 \ln Y_{jt} + b_5 \Delta_{jt} + b_6 F_j + b_7 \ln \theta_{jt} + d^f + d_i + \epsilon_{jt}^f \tag{19}$$

where the dependent variable, $ExportStatus_{jt}^{f}$, is a dummy variable that takes value one if a firm f exports to country j at time t and zero otherwise. The empirical specification includes our estimates for a firm's innate productivity, $\hat{\varphi}_t^f$, and for the TFP-enhancing effect of imported intermediate inputs $\ln \hat{\chi}_t^f = \widehat{\frac{\alpha}{\phi-1}} \ln \frac{M_{tot}^f}{M_k^f}$. In accordance with our model we expect both b_1 and b_2 to be positive. In addition, the equation includes all the country-level variables that appear in equation (10) (Y_{jt}, θ_{jt}, D_j, Δ_{jt}, F_j). The model predicts that the probability of serving the foreign market j should increase with the size of the country ($b_4 > 0$) and the level of remoteness ($b_7 > 0$) and decrease with the level of variable costs ($b_3 < 0$; $b_5 < 0$) and fixed costs ($b_6 < 0$). By exploiting the three-dimensional nature (firms, destinations, time) of our dataset we include firm fixed effects, d^f, to account for time-invariant firm-level unobserved heterogeneity. Moreover, we introduce year or year-geographical areas dummies (d_i) to account for all the time-variant shocks common to countries belonging to the same area.

Table 4 reports the estimation results of equation (19). Following Bernard and Jensen (2004) to estimate our binary choice framework with unobserved heterogeneity, we employ a linear probability model so that firm fixed effects are accounted for in the regressions. Although this estimation strategy suffers from the problem of predicted probabilities outside the 0-1 range, it allows us to control for any unobserved time constant firm characteristic that influences the decisions regarding entry into foreign markets .[30]

We start in column 1 of Table 4 by reporting the results of a model which controls for firm and year fixed effects. The results provide a clear picture. The productivity variables have the expected

[30] We report standard errors clustered at the firm level. The results are robust to alternative treatments of the error terms, such as clustering by country or firm and country.

Table 4: Firms' exports extensive margin by country

	$ExportStatus^f_{jt}$			
	(1)	(2)	(3)	(4)
$\ln \widehat{\varphi}^f_t$	0.014***	0.015***	0.013***	0.015***
	(0.002)	(0.002)	(0.003)	(0.003)
$\ln \widehat{\chi}^f_t$	0.019***	0.019***	0.016***	0.018***
	(0.006)	(0.006)	(0.006)	(0.006)
$\ln Gdp_{jt}$	0.041***	0.038***	0.037***	0.039***
	(0.000)	(0.000)	(0.000)	(0.000)
$\ln Distance_j$	-0.070***	-0.059***	-0.056***	-0.060***
	(0.000)	(0.000)	(0.000)	(0.000)
$Trade\ Opening_{jt}$	0.010***	0.007***	0.007***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)
$\ln Remoteness_{jt}$	0.041***	0.062***	0.053***	0.061***
	(0.001)	(0.001)	(0.001)	(0.001)
$Market\ Costs_j$	-0.005***	-0.008***	-0.009***	-0.009***
	(0.000)	(0.000)	(0.000)	(0.000)
$Import\ Status^f_{j,t-1}$			0.253***	
			(0.002)	
$Imported\ Inputs\ Share^f_{j,t-1}$				1.244***
				(0.032)
Year FE	Yes	No	No	No
Year*Area FE	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Ad. R^2	0.291	0.315	0.333	0.321
N.Observations	12,603,229	12,603,229	8,773,854	8,773,854

Note: The Table reports regressions using data on 1998-2003. The dependent variable used is reported at the top of the columns. All the regressions include a constant term. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

positive and significant sign: an increase in firm-level TFP raises the likelihood of exporting to a specific country j. Specifically, a 10 percent increase in $\widehat{\varphi}^f_t$ is associated with an increase of about 0.14 percentage points in the probability of exporting. The magnitude of this effect is sizeable (i.e., 1.4%) if compared with the probability of exporting observed in our sample, which is 0.10. The estimated effect of the contribution of imported intermediate inputs to TFP ($\widehat{\chi}^f_t$) has a very similar magnitude.

As for the two gravity variables, we find that the probability of exporting to a specific market increases with market size but decreases with distance. A 10 percent rise in the destination country's GDP is associated with an increase of 0.4 percentage points in the probability of exporting to that country. A 10 percent increase in distance decreases the likelihood of a positive export decision by approximately 0.7 percentage points. As above, to gauge the economic significance of these variables we compare the estimated effects with the observed probability of exporting. The coefficient for market size suggests that, holding all other independent variables constant, a 10% increase in the GDP of a country raises the probability of exporting to a specific market by about 4%. The *ceteris paribus* effect of a 10% increase in distance is a decrease in the probability of exporting of around 7%.

Concerning the other country properties, as expected the probability of exporting decreases with market costs. The negative and significant coefficient of *Market Costs* suggests the existence of country-specific fixed export costs: the lower these costs are, the higher the probability of reaching a market. Easy and accessible markets are likely to be served by a large number of firms, whereas less accessible countries with higher fixed export costs are more difficult to export to. The coefficients for *Remoteness* and *Trade Opening* have both the expected positive sign. Since remoteness makes a destination market less competitive, *ceteris paribus*, it is relatively easier for a firm to serve a trade partner that is geographically isolated from most other nations. The probability of exporting to a country should indeed increase with both the remoteness of the destination and its level of freedom to trade.

While in our initial specification we include firm and year fixed effects, it might be that there are time-varying effects common to countries belonging to the same geographical area. Thus, in column 2 of Table 4 we replicate the previous regressions by including year-area fixed effects. All the results confirm the evidence from the specification with only year fixed effects.

In the baseline specification the effect of importing intermediate inputs comes only through $\widehat{\chi}_t^f$. However, besides the TFP channel, there could be additional mechanisms through which importing intermediate inputs influences exporting. Indeed, one could imagine that importing from country j reduces the fixed cost or the iceberg transport cost of exporting to country j. To account for this possible effects we introduce in column 3 the (lagged) *Import Status* of a firm f from country j and in column 4 the (lagged) *Imported Inputs Share* of a firm f from country j, the latter defined as the ratio of a firm's imports from j over the total value of intermediate inputs.

Our findings indicate that both the *Import Status* and the *Imported Inputs Share* enter with a positive and significant coefficient, confirming the hypothesis that, after controlling for its TFP effect, importing from a specific market has an additional positive effect on the probability of exporting in that market. The coefficient for the *Import Status* variable implies that, conditional on $\widehat{\chi}_t^f$, importing from country j has an effect which is more than two times the observed probability of exporting. Similarly, an increase of 1 percentage point in the import intensity from country j is associated with an increase in the likelihood of a positive export decision of approximately 0.012 points. Though these evidence points to the quantitative importance of non-TFP related mechanisms through which importing enhances exporting, the inclusion of these terms does not change the sign or the magnitude of the other coefficients.[31]

Having established the determinants of a firm's export participation across countries, we next explore whether firm and country differences are relevant for determining how much a firm sells across different markets, that is the intensive margin of exports. The econometric model, which can be thought of as a micro-gravity equation, takes the following form

$$\ln Exports_{jt}^f = c_0 + c_1 \ln \hat{\varphi}_t^f + c_2 \ln \hat{\chi}_t^f + c_3 \ln D_j + c_4 \ln Y_{jt} + c_5 \Delta_{jt} + c_6 \ln \theta_{jt} + d^f + d_i + \epsilon_{jt}^f \quad (20)$$

where the dependent variable is the (log) total exports of firm f to country j at time t. As in the previous equation, we include firm innate productivity, the TFP component related to the use of imported inputs, country determinants, firm dummies and year (or year-area) dummies. Following equation (11), we exclude the trade fixed costs variable.

The results are reported in Table 5. As for the export decision equation, we run the regression controlling for year dummies (column 1) and then taking into account year-area fixed effects

[31] Using the contemporaneous values of *Import Status* and *Imported Inputs Share* do not alter the results. Our findings are robust also to controlling for the global import status (i.e., a dummy equal one if the firm imports from at least one country).

Table 5: Firms' exports intensive margin by country

	$\ln Export_{jt}^f$			
	(1)	(2)	(3)	(4)
$\ln \widehat{\varphi}_t^f$	0.277***	0.279***	0.233***	0.258***
	(0.029)	(0.029)	(0.035)	(0.036)
$\ln \widehat{\chi}_t{}^f$	0.395***	0.396***	0.279***	0.281**
	(0.086)	(0.086)	(0.107)	(0.106)
$\ln Gdp_{jt}$	0.483***	0.460***	0.427***	0.462***
	(0.003)	(0.003)	(0.003)	(0.004)
$\ln Distance_j$	-0.572***	-0.532***	-0.452***	-0.519***
	(0.006)	(0.008)	(0.008)	(0.008)
$Trade\ Opening_{jt}$	0.041***	0.076***	0.066***	0.079***
	(0.002)	(0.003)	(0.003)	(0.003)
$\ln Remoteness_{jt}$	0.750***	0.583***	0.361***	0.506***
	(0.021)	(0.030)	(0.033)	(0.033)
$Import\ Status_{j,t-1}^f$			0.827***	
			(0.011)	
$Imported\ Inputs\ Share_{j,t-1}^f$				4.408***
				(0.205)
Year FE	Yes	No	No	No
Year*Area FE	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Ad. R^2	0.316	0.331	0.343	0.333
N.Observations	1,420,896	1,420,896	1,035,846	1,035,846

Note: The Table reports regressions using data on 1998-2003. The dependent variable used is reported at the top of the columns. All the regressions include a constant term. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

(columns 2-4). Column 1 displays the results of our baseline specification. The estimated parameters display the expected signs. We confirm that more productive firms not only are more likely to enter foreign markets but they also export more to each country. The coefficient on (log) $\widehat{\varphi}_t^f$ suggests that a 10% increase in a firm's innate productivity increases its exports by approximatively 2.8%. Moreover, we find a positive indirect effect of imports on a firm's export value, as expressed by the coefficient of $\widehat{\chi}_t^f$. The estimated elasticities of exports to GDP and $Distance$ are 4.8% and -5.7%, respectively. These effects are very similar to those observed for the extensive margin. Finally, the estimated effects of $Remoteness$ and $Trade\ Opening$ show the expected positive signs and are statistically significant. The results in column 2 including the control for the year-area dummies are qualitatively similar of those reported in column 1.

To check the robustness of our findings to the existence of additional non TFP-related mechanisms by which importing affects exporting, in columns 3 and 4 we introduce the (lagged) $Import\ Status$ of a firm f from country j and the (lagged) $Imported\ Inputs\ Share$ of a firm f from country j, respectively. We find that, after controlling for the effect of importing through TFP, importing from country j increases the value of exports to country j by about 80% (column 3) and an increase of 1 percentage point in the import intensity raises the export value by 4%. Most importantly, however, the effect of importing through the TFP channel remains economically and

Table 6: Firms' exports margins by country: Poisson specification

	$Export^f_{jt}$			
	(1)	(2)	(3)	(4)
$\ln \widehat{\varphi}^f_t$	0.311***	0.311***	0.352***	0.391***
	(0.080)	(0.080)	(0.090)	(0.089)
$\ln \widehat{\chi}^f_t$	0.954***	0.954***	1.033***	1.037***
	(0.159)	(0.159)	(0.189)	(0.182)
$\ln Gdp_{jt}$	0.851***	0.828***	0.745***	0.818***
	(0.020)	(0.018)	(0.020)	(0.020)
$\ln Distance_j$	-1.081***	-1.058***	-0.905***	-1.029***
	(0.046)	(0.081)	(0.086)	(0.088)
$Trade\ Opening_{jt}$	0.099***	0.076***	0.051*	0.073***
	(0.015)	(0.020)	(0.027)	(0.027)
$\ln Remoteness_{jt}$	0.946***	1.436***	1.031***	1.307***
	(0.187)	(0.324)	(0.347)	(0.355)
$Market\ Costs_j$	0.017	-0.406***	-0.404***	-0.409***
	(0.051)	(0.086)	(0.095)	(0.095)
$Import\ Status^f_{j,t-1}$			0.754***	
			(0.046)	
$Imported\ Inputs\ Share^f_{j,t-1}$				4.634***
				(0.494)
Year FE	Yes	No	No	No
Year*Area FE	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N.Observations	10,687,872	10,687,872	7,483,306	7,483,306

Note: The Table reports the results of the Poisson Pseudo Maximum Likelihood estimator using data on 1998-2003. The dependent variable used is reported at the top of the columns. All the regressions include a constant term. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

statistically significant.[32]

As a first robustness check we estimate Equation (20) in its multiplicative form with a pseudo-maximum-likelihood technique. To take into account firm unobserved heterogeneity, we use a conditional (firm) fixed-effects Poisson model. The results of the Poisson regression, which take into account the extensive and the intensive margins at the same time, are reported in Table 6. The main message with respect to the previous tables does not change. The estimated elasticity of exports with respect to both the "innate" productivity and the TFP component related to importing is economically and statistically significant.

As a second robustness check, in order to properly account for country specific fixed costs and multilateral resistance terms, we use an alternative distance variable, which is firm-destination specific. This is computed by exploiting the information of each firm's location in Italy (i.e. the municipality). We use the distance from a firm's location to the relevant Alpine tunnel by resorting to the great circle formula.[33] We then calculate a weighted average of the distances between the tunnel and each region in the destination country, using as weights the regional GDP. We do not

[32] Using the contemporaneous values of imports or using the global import status do not change our results.

[33] As in the Italian Alps there are various tunnels, we choose the shortest path to a given destination country depending on the location of a firm.

Table 7: Import ratio elasticities

	$\ln(M^f_{jt}/M^f_{kt})$ (1)	M^f_{jt}/M^f_{kt} (2)
$\ln Gdp_{jt}$	0.165***	0.797***
	(0.010)	(0.020)
$\ln Distance$	-0.089***	-0.788***
	(0.018)	(0.046)
$Market\ Costs_j$		0.033
		(0.048)
Year*Area FE	Yes	Yes
Firm FE	Yes	Yes
N.Observations	335,703	11,747,191

Note: The Table reports the results of the OLS (column 1) and of the Poisson Pseudo Maximum Likelihood (column 2) estimators using data on 1998-2003. The dependent variables used are reported at the top of the columns. All the regressions include a constant term. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

have information for a firm's exports to a specific region but we expect that richer areas are those importing more.[34] Since the distance variable is now firm-specific, we are able to estimate the effect of distance and simultaneously control for country-year fixed effects. However, the effect of all the other country characteristics which vary only at the country-year level are absorbed by the fixed effects. We run all the previous specifications with this new firm-level distance and results confirm our conclusions. Table A3 of Appendix 5 reports the estimates of the specification including the *Imported Inputs Share* variables.[35]

4.3 The indirect effect of gravity forces

The aim of this section is to quantify the indirect impact of gravity forces on a firm's export behaviour through importing. As indicated by equations (14)-(17), to do that we first need to compute the elasticity of χ_{hk} with respect to the two gravity forces. Then, we have to multiply the elasticity of χ_{hk} with respect to either distance or market size by the elasticity of exports to χ_{hk}, obtained through the export gravity equations.

Let's start with the computation of the elasticity of χ_{hk} with respect to distance, ρ^D, which can be written as

$$\rho^D = \frac{d\ln\chi_{hk}}{d\ln D_{kj}} = \frac{\alpha_h}{\phi_h - 1} * \frac{M^f_j}{\sum_{n=1}^{N} M^f_n} * \frac{d\ln\left(\frac{M^f_j}{M^f_k}\right)}{d\ln D_{kj}}. \tag{21}$$

[34]We compute this firm-level distance only when exports are directed to European countries. This is because a firm's location within Italy is less relevant when exporting to more distant markets. Moreover, since this measure is only relevant for land transport, we exclude from the analysis firms located in the south of Italy for which maritime shipping is more important.

[35]All other specifications are available upon request.

Similarly, the elasticity of χ_{hk} with respect to market size, ρ^Y, is given by

$$\rho^Y = \frac{d \ln \chi_{hk}}{d \ln Y_j} = \frac{\alpha_h}{\phi_h - 1} * \frac{M_j^f}{\sum_{n=1}^{N} M_n^f} * \frac{d \ln \left(\frac{M_j^f}{M_k^f} \right)}{d \ln Y_j}. \tag{22}$$

The first term in both equations is the TFP elasticity to imports and can be retrieved by the estimates of the production function.[36] The second element, which is directly observable in our data, is the fraction of imports of firm f from country j over the total intermediates inputs used by the firm. The third term can be obtained by estimating the elasticity of the ratio of imports from j over domestic intermediates with respect to distance and GDP. According to our theoretical setting, the ratio of imports of intermediates from country j to domestic intermediates can be expressed by

$$\frac{M_j^f}{M_k^f} = \frac{\beta_{mj} Y_j}{\beta_{mk} Y_k} \left(\left(\frac{w_j}{w_k} \right) \tau_{mjk} \right)^{1-\phi} \quad .$$

Given that the above expression is log-linear in distance and market size, we first estimate by OLS the following equation

$$\ln \frac{M_{jt}^f}{M_{kt}^f} = a_0 + a_1 \ln Y_{jt} + a_2 \ln D_j + d^f + d_i + \epsilon_{jt}^f. \tag{23}$$

where, in addition to the two gravity forces Y and D, we add a set of dummies to control for firm-fixed effects d^f and for year-geographical areas, d_i. Then, to take into account the large proportion of zeros observed in the data, we estimate the elasticity of the ratio with respect to gravity forces by using a conditional (firm) fixed-effects Poisson regression. The estimates of the log-linear specification are reported in column 1 of Table 7. In column 2 we show the results of our preferred estimator, the Poisson regression, and we include as additional control the proxy for fixed costs *Market Costs*. We observe that the elasticity of the import ratio is slightly lower than unity for both *GDP* and *Distance*. Therefore, it is confirmed that firms' sourcing behaviour is influenced by the same standard gravity forces which are also active on the export side.[37]

With the three terms for the elasticity of χ_{hk} with respect to either distance or market size, we can now quantify the indirect effect of the two gravity forces on a firm's export behavior by multiplying ρ^D and ρ^Y by the elasticity of exports to χ_{hk}, obtained in the gravity equation before. We consider the indirect effect of a generalized change in market size or transportation costs common across all countries. This is done by computing the second element of equations (21) and (22) as the fraction of a firm's imports from all countries over its total intermediates inputs. The results in Table 8 show the indirect effect of this generalized change using the elasticity of exports to χ_{hk} of the Poisson specification (see in Table 6). This allows us to quantify the indirect impact, considering together the extensive and the intensive margins of exports.[38] Column 1 reports the indirect effect of GDP while column 2 the indirect effect of distance. The two columns report the average indirect impact by sector.

Our findings confirm that market size has a positive indirect effect on a firm's export behaviour while distance a negative indirect impact. The results for distance are quantitatively very similar

[36] Colum 3 of Table 3.

[37] In an unreported regression, where we use the firm-specific measure of distance together with year-country fixed effects, we estimate an even greater elasticity to distance (i.e., 1.61).

[38] In Table A4 of Appendix 5 we report the same calculations for the export extensive and intensive margins separately. In Table A5 we also report the robustness check using the firm-specific distance variable. The results are qualitatively similar.

Table 8: Indirect effects of gravity forces on export margins

	Export elasticity to GDP (1)	Export elasticity to Distance (2)
Food, Beverages and Tobacco	0.02	-0.02
Textiles and Apparel	0.04	-0.03
Hide and Leather	0.01	-0.01
Wood and Cork	0.05	-0.05
Pulp and Paper	0.11	-0.11
Printing and Publishing	0.03	-0.03
Coke and Chemical products	0.02	-0.02
Rubber and Plastics	0.06	-0.06
Processing of non-metallic minerals	0.04	-0.04
Basic Metals	0.04	-0.04
Fabricated Metal Products	0.04	-0.04
Machinery and Equipment	0.00	0.00
Electrical and Optical Equipment	0.02	-0.02
Motor Vehicles and Trailers	0.00	0.00
Other Transport Equipment	0.02	-0.02
Other manufacturing industries	0.01	-0.01

Note: The Table reports the indirect effects of the two gravity forces on a firm's exports. This is computed by multiplying the elasticity of χ_{hk} with respect to either distance or market size by the elasticity of exports to χ_{hk}, obtained through the export gravity equation estimated with the Poisson specification. All the estimated indirect effects are statistically significant at 1%. Standard errors, which are not reported, have been obtained by bootstrapping (500 replications).

to those obtained for GDP. This is mainly driven by the fact that the estimated elasticities of the import ratio with respect to the two gravity forces are almost identical. Note that the indirect effect through imports that we estimate for both market size and distance is of an order of magnitude lower than the direct impact obtained in the gravity equation and reported in Table 6. This is mostly due to the relatively low average import share detected in the data, reported in Table A6 of Appendix 5. Some heterogeneity is observed across sectors with the Pulp and Paper industry having the largest indirect impact for both distance and market size. Overall, our results confirm the predictions of our model according to which the effect of the two gravity forces on a firm's export behaviour is magnified when imports of intermediates are accounted for.

5 Conclusions

This paper introduces intermediate inputs into a standard Melitz (2003)/Chaney (2008) model of trade with firm heterogeneity and asymmetric countries to investigate how imports in intermediate inputs affect a firm's export patterns. The theoretical framework provides a micro-foundation for the export gravity equation in the presence of imported intermediate inputs.

The model shows that, in addition to the standard direct effect, the two gravity forces have an indirect effect on a firm's export patterns due to the imports of intermediate inputs. This is because importing has a positive effect on a firm's productivity which depends on both the mass of imported intermediate inputs available, as well as on the price of each intermediate. Therefore, an increase in foreign market size exerts a positive effect on exports directly but also indirectly through an efficiency increase induced by the imports of intermediate inputs. Similarly, a decline in transportation costs has an indirect effect on a firm's exports pattern due to the reduction in the cost of imported inputs which allows a firm to offer its exports at lower prices and to increase its revenues in the exporting markets.

The propositions of the model are tested using a large and unique panel data set of Italian manufacturing firms over the 1998-2003 period. Our empirical analysis confirm the predictions of the theoretical framework. First, by estimating a production function which takes into account the role of imported inputs, we show that imports contribute positively on a firm's total factor productivity. Second, we find that the component of productivity related to importing has a positive impact of on both margins of exports. Third, we quantify the indirect effects of the two gravity forces on a firm's exports and confirm that the impact of market size and distance on a firm's export behaviour is magnified when imports of intermediates are accounted for.

Appendix

Appendix A1: The profit maximization problem of the final good firms

As commented on Section 2, a firm's maximization problem is solved in two steps. First, a firm chooses the optimal allocation of production factors to minimize the costs of production for a given quantity produced. In a second step, a firm chooses the price charged for its final good variety in each market taking into account the optimal cost function derived in the previous step.

A firm will choose the optimal combination of inputs by minimizing the cost of production. This exercise can be done in two steps as well. In the first step, a firm selects the optimal allocation of intermediate inputs for a given firm demand of the intermediate composite good m_{hk}^{f}. Then a firm chooses the optimal combination of labor and the intermediate composite good, for a given production quantity q_{hk}^{f}. Therefore, a firm firstly solves

$$Min \int_{\nu\epsilon\Lambda} p_{hmk}(\nu) m_{hk}^{f}(\nu)\, d\nu$$

$$s.t. \left(\int_{\nu\epsilon\Lambda} \left(m_{hk}^{f}(\nu) \right)^{\frac{\phi_h - 1}{\phi_h}} d\nu \right)^{\frac{\phi_h}{\phi_h - 1}} = m_{hk}^{f}$$

This leads to the standard demand function for each intermediate input

$$m_{hk}^{f}(\nu) = m_{hk}^{f} \left(\frac{p_{hmk}(\nu)}{P_{hmk}} \right)^{-\phi_h}$$

where the aggregate price index for the intermediate composite good is given by

$$P_{hmk} = \left(\int_{\nu\epsilon\Lambda} \left(p_{hmk}(\nu) \right)^{1-\phi_h} d\nu \right)^{\frac{1}{1-\phi_h}}.$$

We assume that the mass of varieties available is different across countries. Since each intermediate producer is a monopolist, then each firm will charge $p_{hmk}(\nu) = \frac{\phi_h \tau_{hmjk} w_j}{\phi_h - 1}$ where $\tau_{mhjj} = 1$.

Applying symmetry across all intermediate inputs belonging to the same country, we can express the aggregate price index for the intermediate composite good in country k and sector h as

$$P_{hmk} = \left(\sum_{j=1}^{N} \left(w_j \tau_{hmjk} \right)^{1-\phi_h} \tilde{L}_j \right)^{\frac{1}{1-\phi_h}} \frac{\phi_h}{\phi_h - 1}$$

where $\tilde{L}_j = \beta_{mj} w_j L_j$. Then a firm chooses the optimal combination of labor and the intermediate composite good

$$Min\ w_k l_{hk}^{f} + P_{hmk} m_{hk}^{f}$$

$$s.t. q_{hk}^{f} = \varphi^{f} \left(m_{hk}^{f} \right)^{\alpha_h} \left(l_{hk}^{f} \right)^{1-\alpha_h}$$

The conditional demand for each input of a firm with productivity φ^{f} is given by

$$l_{hk}^{f} = \frac{1}{\varphi^{f}} \left(\frac{P_{hmk}}{w_k} \frac{1-\alpha_h}{\alpha_h} \right)^{\alpha_h} q_{hk}^{f}$$

$$m_{hk}^{f} = \frac{1}{\varphi^{f}} \left(\frac{w_k}{P_{hmk}} \frac{\alpha_h}{1-\alpha_h} \right)^{1-\alpha_h} q_{hk}^{f}.$$

Substituting the last two equations in the objetive function we obtain the variable cost function for a firm with productivity φ^f in country k and sector h

$$c_{hk}^{f}\left(\varphi^{f}\right) = \frac{(w_k)^{1-\alpha_h} (P_{hmk})^{\alpha_h}}{\Gamma_h} \frac{q_{hk}^{f}}{\varphi^{f}} = \frac{(\rho_{hm})^{\alpha_h} w_k}{\Gamma_h (\chi_{hk})^{d} \left(\tilde{L}_k\right)^{\frac{\alpha_h}{\phi_h - 1}}} \frac{q_{hk}^{f}}{\varphi^{f}}$$

where $d = 1$ if a firm imports intermediates (and 0 otherwise) and $\Gamma_h = \alpha_h^{\alpha_h}(1-\alpha_h)^{1-\alpha_h}$. We denote with $\rho_{hm} = \frac{\phi_h}{\phi_h - 1}$ the mark-up of the intermediate producers.

Appendix A2: Computing P_{hj}

The economy j aggregate price index P_{hj} can be easily obtained considering that

$$P_{hj}^{1-\sigma_h} = \underbrace{\beta_{hj} w_j L_j \int_{\varphi_{hj}^*}^{\infty} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi}_{\text{Domestic firms}} + \underbrace{\sum_{n \neq j}^{N} \beta_{hn} w_n L_n \int_{\varphi_{hxnj}^*}^{\infty} (p_{hxnj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi}_{\text{foreign exporters}}.$$

In contrast to models in which firms are not allowed to import, we need to distinguish between domestic importers and non-importers, as they price differently

$$\int_{\varphi_{hj}^*}^{\infty} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi = \int_{\varphi_{hj}^*}^{\varphi_{hij}^*} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi + \int_{\varphi_{hij}^*}^{\infty} (p_{hij}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi.$$

In the following steps we compute each of these integrals. Substituting the expressions for $p_{hj}(\varphi), p_{hij}(\varphi)$ we have that

$$\int_{\varphi_{hj}^*}^{\infty} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi = \left(w_j \left(\tilde{L}_j\right)^{\frac{\alpha_h}{1-\phi_h}} \psi_j \right)^{1-\sigma_h}$$

$$\cdot \underbrace{\left(\int_{\varphi_{hj}^*}^{\varphi_{hij}^*} \varphi^{\sigma_h - 1} g(\varphi)\, d\varphi + (\chi_{hk})^{\sigma_h - 1} \int_{\varphi_{hij}^*}^{\infty} \varphi^{\sigma_h - 1} g(\varphi)\, d\varphi. \right)}_{A}.$$

Taking the derivative of the cumulative distribution function we obtain the density function $g(\varphi) = \gamma_h (\varphi)^{-(\gamma_h + 1)}$. Substituting in the latter expression and solving for the integrals we have that

$$A = \frac{\gamma_h}{\gamma_h - (\sigma_h - 1)} \left[\left(\varphi_{hj}^*\right)^{\sigma_h - \gamma_h - 1} + \left(\varphi_{hij}^*\right)^{\sigma_h - \gamma_h - 1} \left((\chi_{hk})^{\sigma_h - 1} - 1 \right) \right].$$

Using the fact that $\left(\frac{\varphi_{hij}^*}{\varphi_{hj}^*}\right) = \left(\frac{F_{hik}}{((\chi_{hk})^{\sigma_h - 1} - 1) F_h} \right)^{\frac{1}{\sigma_h - 1}}$ and rearranging terms yields

$$\int_{\varphi_{hj}^*}^{\infty} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi = \left(w_j \left(\tilde{L}_j\right)^{\frac{\alpha_h}{1-\phi_h}} \psi_j \right)^{1-\sigma_h} \frac{\gamma_h}{\gamma_h - (\sigma_h - 1)}$$

$$\cdot \left[\frac{(F_h)^{\frac{\sigma_h - \gamma_h - 1}{\sigma_h - 1}} + \left((\chi_{hk})^{\sigma_h - 1} - 1 \right)^{\frac{\gamma_h}{\sigma_h - 1}} (F_{hik})^{\frac{\sigma_h - \gamma_h - 1}{\sigma_h - 1}}}{(F_h)^{\frac{\sigma_h - \gamma_h - 1}{\sigma_h - 1}}} \right] \left(\varphi_{hj}^*\right)^{\sigma_h - \gamma_h - 1}.$$

Substituting the expression for φ_{hj}^* obtained from equation (8), and rearranging terms

$$\int_{\varphi_{hj}^*}^{\infty} (p_{hj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi = \left(w_j \left(\tilde{L}_j\right)^{\frac{\alpha_h}{1-\phi_h}} \psi_j \right)^{1-\sigma_h} \frac{\gamma_h}{\gamma_h - (\sigma_h - 1)}$$
$$\cdot \left[(F_h)^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} + \left((\chi_{hk})^{\sigma_h-1} - 1 \right)^{\frac{\gamma_h}{\sigma_h-1}} (F_{hik})^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} \right]$$
$$\cdot \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} \left(\frac{1}{R_k}\right)^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} \left(\psi_h w_j P_{hj}^{-1}\right)^{\sigma_h-\gamma_h-1} \left(\tilde{L}_k\right)^{\frac{\alpha_h(\sigma_h-\gamma_h-1)}{1-\phi_h}}$$

Now we compute the foreign exporters part. Substituting for the optimal prices and rearranging terms we have that

$$\sum_{n \neq j}^{N} \beta_{hn} w_n L_n \int_{\varphi_{hxnj}^*}^{\infty} (p_{hxnj}(\varphi))^{1-\sigma_h} g(\varphi)\, d\varphi = \sum_{n \neq j}^{N} \beta_{hn} w_n L_n \left(\frac{\psi_h \tau_{hxnj} w_n}{\left(\chi_{hn}\left(\tilde{L}_n\right)\right)^{\frac{\alpha_h}{\phi_h-1}}} \right)^{1-\sigma_h}$$
$$\cdot \int_{\varphi_{hxnj}^*}^{\infty} (\varphi)^{1-\sigma_h} g(\varphi)\, d\varphi.$$

Solving for the integral we have that

$$\sum_{n \neq j}^{N} \beta_{hn} w_n L_n \left(\frac{\psi_h \tau_{hxnj} w_n}{\left(\chi_{hn}\left(\tilde{L}_n\right)\right)^{\frac{\alpha_h}{\phi_h-1}}} \right)^{1-\sigma_h} \left(\frac{\gamma_h}{\gamma_h - (\sigma_h - 1)} \right) (\varphi_{hxnj}^*)^{\sigma_h-\gamma_h-1}$$

and substituting the expression for the productivity cutoff and rearranging terms yields

$$\sum_{n \neq j}^{N} \beta_{hn} w_n L_n \left(\frac{\psi_h \tau_{hxnj} w_n}{\left(\chi_{hn}\left(\tilde{L}_n\right)\right)^{\frac{\alpha_h}{\phi_h-1}}} \right)^{1-\sigma_h} \left(\frac{\gamma_h}{\gamma_h - (\sigma_h - 1)} \right) \tau_{hxnj} \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{1}{\sigma_h-1}} \left(\frac{1}{R_j}\right)^{\frac{1}{\sigma_h-1}}$$
$$\cdot \psi_h (w_n) (P_{hj})^{-1} (F_{hxnj})^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} \tilde{L}_n^{\frac{\alpha_h}{1-\phi_h}} \left((\chi_{hn})^{-1} \right)^{\sigma_h-\gamma_h-1}.$$

Putting both integrals together, and rearranging terms:

$$P_j^{-\gamma_h} = \left(\frac{\gamma_h}{\gamma_h - (\sigma_h - 1)} \right) \left(\frac{\sigma_h}{\mu_h}\right)^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}} \left(\frac{1}{R_j}\right)^{\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}}$$
$$\cdot \sum_{n=1}^{N} \beta_{hn} w_n L_n \left(\tilde{L}_n\right)^{\frac{\alpha_h \gamma_h}{\phi_h-1}} \psi_h^{-\gamma_h} (w_n \tau_{hxnj})^{-\gamma_h} \left(\chi_{hn}^{\gamma_h}\right)^{(1-\xi)} (\Phi_h)^{\xi} (F_{hxnj})^{\left(\frac{\sigma_h-\gamma_h-1}{\sigma_h}\right)(1-\xi)}$$

where $\Phi_h = (F_h)^{\left(\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}\right)} + \left((\chi_{hn})^{\sigma_h-1} - 1 \right)^{\frac{\gamma_h}{\sigma_h-1}} (F_{hin})^{\left(\frac{\sigma_h-\gamma_h-1}{\sigma_h-1}\right)}$ and ξ is an indicator function taking the value of 1 if $n = j$ and 0 otherwise. Defining $\lambda_{2h}^{\gamma_h} = \left(\frac{\gamma_h-(\sigma_h-1)}{\gamma_h}\right)\left(\frac{\sigma_h}{\mu_h}\right)^{\frac{\sigma_h-\gamma_h-1}{1-\sigma_h}} \left(\frac{1+\pi}{Y}\right)$ and taking into account that $R_j = w_j L_j (1+\pi) = Y_j$, and rearranging terms, P_{hj} can be expressed as

$$
\begin{aligned}
P_{hj} &= \lambda_{2h} \left(Y_j\right)^{\frac{1}{\gamma_h} - \frac{1}{\sigma_h - 1}} \theta_{hj} \\
\left(\theta_{hj}\right)^{-\gamma_h} &= \left[\sum_{n=1}^{N} \frac{Y_n}{Y} \left(w_n \tau_{hxnj}\right)^{-\gamma_h} \left(F_{hxnj}\right)^{\left(\frac{\sigma_h - \gamma_h - 1}{\sigma_h}\right)(1-\xi)} \beta_{hn} \left(\tilde{L}_n\right)^{\frac{\alpha_h \gamma_h}{\phi_h - 1}} \psi_h^{-\gamma_h} \left(\chi_{hn}^{\gamma_h}\right)^{(1-\xi)} \left(\Phi_h\right)^{\xi}\right].
\end{aligned}
$$

Appendix A3: Heterogeneity in quality and technology of intermediates

The goal of this appendix is to verify whether the predictions of our model change when considering a more complex and richer environment in which we allow for technological differences in the production of intermediates across countries and differences in quality across intermediate inputs.

To produce a firm in the final good sector combines labour and intermediate input using a Cobb-Douglas technology as before. However, the expression for the intermediate input composite good is given by $m_{hn}^f = \left(\int\limits_{\nu\epsilon\Lambda} \left(z_{hn} m_{hn}^f(\nu) \right)^{\frac{\phi_{h-1}}{\phi_h}} \right)^{\frac{\phi_h}{\phi_h - 1}}$ where the parameter z_{hn} is a measure of the quality of the variety of intermediate input coming from country n. We assume that all intermediate input varieties coming from a specific location share the same quality. In addition we assume that in each country intermediate inputs are produced using the following technology

$$m(\nu) = \eta_n l_m.$$

In this case a firm's production function can be rewritten as

$$q_{hk}^f = \varphi_h^f \left(l_{hk}^f \right)^{1-\alpha_h} \left(M_{tot}^f \right)^{\alpha_h} \left[\sum_{j=1}^{N} \left(\left(\frac{w_j \eta_k}{w_k \eta j} \right) \tau_{mjk} \right)^{1-\phi_h} \left(\frac{z_{hj}}{z_{hk}} \right)^{\phi_h - 1} \frac{\tilde{L}_j}{\tilde{L}_k} \right]^{\frac{\alpha_h}{\phi_h - 1}} \left(\tilde{L}_k \right)^{\frac{\alpha_h}{\phi_h - 1}} \quad .$$

and that the new definition for χ_{hk} is given by

$$\chi_{hk} = \left[\sum_{j=1}^{N} \left(\left(\frac{w_j \eta_k}{w_k \eta_j} \right) \tau_{hmjk} \right)^{1-\phi_h} \left(\frac{z_{hj}}{z_{hk}} \right)^{\phi_h - 1} \frac{\tilde{L}_j}{\tilde{L}_k} \right]^{\frac{\alpha_h}{\phi_h - 1}} = \left[\frac{M_{tot}^f}{\left(\tilde{L}_k \right) \bar{m}_{hk}^f} \right]^{\frac{\alpha_h}{\phi_h - 1}} = \left(\frac{M_{tot}^f}{M_k^f} \right)^{\frac{\alpha_h}{\phi_h - 1}} .$$

The definition of the variable χ_{hk} now depends on elements that control for technological differences across source intermediate input countries together with differences in the quality of intermediate inputs. Yet, as shown in the main model, we can control for χ_{hk} by using the statistic $\left(\frac{M_{tot}^f}{M_k^f} \right)^{\frac{\alpha_h}{\sigma_h - 1}}$. Consequently, the effect of changes in trade costs or market size on exports through imports can be perfectly captured by this element even if we assume a more realistic environment in which countries differ on the way they produce intermediates. Identically, the effects that changes in trade costs or market size have on exports via imports can be computed as described before.

Appendix A4: Custom data

In compliance with the common framework defined by the European Union (EU), there are different requirements in order for a transaction to be recorded, depending on whether the importing country is an EU or NON-EU country, and on the value of the transaction.

As far as outside EU transactions are concerned, there is a good deal of homogeneity among member states as well as over time. In the Italian system the information is derived from the Single Administrative Document (SAD) which is compiled by operators for each individual transaction. Since the adoption of the Euro, Italy sets the threshold at 620 euro (or 1000 Kg), so that all transactions bigger than 620 euro (or 1000 Kg) are recorded. For all of these recorded extra-EU transactions, the COE data report complete information, that is, also information about the product quantity and value.

Transactions within the EU are collected according to a different systems (Intrastat), where the thresholds on the annual value of transactions qualifying for a complete record are less homogeneous across EU member states, with direct consequences on the type of information reported in the data. In 2003 (the last year covered in the analysis), there are two cut-offs. If a firm has more than 200,000 euro of exports (based on previous year report), then a firm must fill the Intrastat document monthly. This implies that complete information about product is also available. Instead, if previous year export value falls in between 40,000 and 200,000 euro, the quarterly Intrastat file has to be filled, implying that only the amount of export is recorded, while information on the product is not. Firms with previous year exports below 40,000 euro are not required to report any information on trade flows. According to ISTAT, about one-third of the operators submitted monthly declarations, though covering about 98% of trade flows (http://www.coeweb.istat.it/default.htm). Thus, firms which do not appear in COE are either of this type (i.e. marginal exporters) or do not export at all.

Appendix A5: Descriptive statistics and additional results

Table A1: List of countries

Country	Starters	Country	Starters	Country	Starters
Albania (ALB)	1195	Greece (GRC)	1428	Nigeria (NGA)	1001
Algeria (DZA)	1040	Guatemala (GTM)	546	Norway (NOR)	1597
Argentina (ARG)	800	Guyana (GUY)	81	Oman (OMN)	618
Australia (AUS)	1532	Haiti (HTI)	72	Pakistan (PAK)	787
Austria (AUT)	1452	Honduras (HND)	281	Panama (PAN)	593
Bahamas (BHS)	116	Hong Kong (HKG)	1721	Paraguay (PRY)	180
Bahrain (BHR)	838	Hungary (HUN)	2128	Peru (PER)	955
Bangladesh (BGD)	363	Iceland (ISL)	652	Philippines (PHL)	927
Belize (BLZ)	40	India (IND)	1660	Poland (POL)	2284
Benin (BEN)	182	Indonesia (IDN)	1248	Portugal (PRT)	1364
Bolivia (BOL)	238	Iran (IRN)	1293	Romania (ROM)	2593
Botswana (BWA)	33	Ireland (IRL)	437	Russia (RUS)	2399
Brazil (BRA)	1369	Israel (ISR)	1412	Rwanda (RWA)	40
Bulgaria (BGR)	1920	Jamaica (JAM)	154	Senegal (SEN)	482
Burundi (BDI)	54	Japan (JPN)	1826	Sierra Leone (SLE)	126
Cameroon (CMR)	384	Jordan (JOR)	1080	Singapore (SGP)	1593
Canada (CAN)	1874	Kenya (KEN)	497	Slovenia (SVN)	1903
Chad (TCD)	49	Kuwait (KWT)	1127	South Africa (ZAF)	1338
Chile (CHL)	1111	Latvia (LVA)	1290	Spain (ESP)	1588
China (CHN)	2307	Lithuania (LTU)	1658	Sri Lanka (LKA)	534
Colombia (COL)	1066	Luxembourg (LUX)	671	Sweden (SWE)	1347
Costa Rica (CRI)	719	Macedonia (MKD)	255	Switzerland (CHE)	1838
Croatia (HRV)	2090	Madagascar (MDG)	268	Syria (SYR)	937
Cyprus (CYP)	1273	Malawi (MWI)	49	Tanzania (TZA)	258
Denmark (DNK)	1240	Malaysia (MYS)	1316	Thailand (THA)	1408
Ecuador (ECU)	744	Mali (MLI)	139	Togo (TGO)	153
Egypt (EGY)	1197	Mauritius (MUS)	501	Tunisia (TNU)	1549
El Salvador (SLV)	415	Mexico (MEX)	1935	Turkey (TUR)	1641
Estonia (EST)	1126	Morocco (MAR)	1345	Uganda (UGA)	162
Fiji (FJI)	81	Mozambique (MOZ)	76	Ukraine (UKR)	1706
Finland (FIN)	1195	Namibia (NAM)	80	United Kingdom (GBR)	1516
France (FRA)	1268	Nepal (NPL)	73	United States (USA)	1957
Gabon (GAB)	225	Netherlands (NLD)	1409	Uruguay (URY)	558
Georgia (GEO)	156	New Zealand (NZL)	1126	Venezuela (VEN)	1151
Germania (DEU)	1235	Nicaragua (NIC)	159	Vietnam (VNM)	293
Ghana (GHA)	446	Niger (NER)	110	Zambia (ZMB)	80
				Zimbabwe (ZWE)	132
Total			101,064		

Note: The Table reports the list of 109 countries used in the empirical analysis. ISO codes for the names of countries are reported in parenthesis.

Table A2: Country variables: summary statistics

	Mean	SD	Min	25th Pct	75th Pct	Max
$\ln Distance_j$	8.29	0.92	6.19	7.58	9.07	9.83
$\ln GDP_{jt}$	24.11	2.05	20.40	22.51	25.54	29.98
$Trade\ Opening_{jt}$	7.19	1.67	2.26	6.08	8.48	9.94
$Market\ Costs_j$	-0.168	0.91	-1.57	-0.82	0.19	3.48
$\ln Remoteness_{jt}$	40.08	0.25	39.70	39.83	40.26	40.67

Note: The Table reports the summary statistics for the country variables used in the empirical analysis. Statistics are computed on 109 countries.

Table A3: Firm-specific distance

	$ExportStatus^f_{jt}$	$\ln Export^f_{jt}$	$Export^f_{jt}$
	(1)	(2)	(3)
$\ln \widehat{\varphi}^f_t$	0.030***	0.348***	0.473***
	(0.005)	(0.045)	(0.097)
$\ln \widehat{\chi}^f_t$	0.066***	0.501***	1.013***
	(0.016)	(0.137)	(0.182)
$\ln Distance^f_j$	-0.209***	-0.774***	-0.766***
	(0.004)	(0.035)	(0.114)
$Imported\ Inputs\ Share^f_{j,t-1}$	0.837***	4.071***	4.596***
	(0.029)	(0.213)	(0.546)
Year*Country FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Ad. R^2	0.463	0.402	
N.Observations	1,857,788	549,367	1,555,748

Note: The Table reports the results of the OLS (columns 1 and 2) and of the Poisson Pseudo Maximum Likelihood (column 3) estimators using data on 1998-2003. The dependent variable used is reported at the top of the columns. The distance variable, which is firm-destination specific, is computed by exploiting the information of each firm's location in Italy as described in the text. All the regressions include a constant term. Robust standard errors clustered at the firm level are reported in parenthesis below the coefficients. Asterisks denote significance levels (***:p<1%; **: p<5%; *: p<10%).

Table A4: Indirect effects of gravity forces on export margins: Extensive and Intensive Margins

	Export elasticity to Distance Extensive Margin (1)	Export elasticity to Distance Intensive Margin (2)	Export elasticity to GDP Extensive Margin (3)	Export elasticity to GDP Intensive Margin (4)
Food, Beverages and Tobacco	-0.0003	-0.0045	0.0003	0.0046
Textiles and Apparel	-0.0006	-0.0094	0.0006	0.0095
Hide and Leather	-0.0002	-0.0037	0.0002	0.0037
Wood and Cork	-0.0008	-0.0131	0.0009	0.0133
Pulp and Paper	-0.0019	-0.0299	0.0019	0.0303
Printing and Publishing	-0.0005	-0.0084	0.0005	0.0085
Coke and Chemical products	-0.0004	-0.0064	0.0004	0.0064
Rubber and Plastics	-0.0011	-0.0173	0.0011	0.0175
Processing of non-metallic minerals	-0.0006	-0.0098	0.0006	0.0099
Basic Metals	-0.0007	-0.0114	0.0007	0.0115
Fabricated Metal Products	-0.0006	-0.0098	0.0006	0.0100
Machinery and Equipment	0.0000	-0.0004	0.0000	0.0004
Electrical and Optical Equipment	-0.0004	-0.0065	0.0004	0.0065
Motor Vehicles and Trailers	-0.0001	-0.0009	0.0001	0.0009
Other Transport Equipment	-0.0004	-0.0055	0.0004	0.0056
Other manufacturing industries	-0.0002	-0.0030	0.0002	0.0030

Note: The Table reports the indirect effects of the two gravity forces on a firm's exports. This is computed by multiplying the elasticity of χ_{hk} with respect to either distance or market size by the elasticity of exports to χ_{hk}, obtained through the equations for the extensive and intensive margins, respectively. All the estimated parameters are statistically significant at 1%. Standard errors, which are not reported, have been obtained by bootstrapping (500 replications).

Table A5: Indirect effects of distance on export margins: firm specific distance

	Average import share (1)	Export elasticity to Distance Extensive Margin (2)	Export elasticity to Distance Intensive Margin (3)	Export elasticity to Distance Poisson (4)
Food, Beverages and Tobacco	0.0211	-0.0019	-0.0141	-0.0285
Textiles and Apparel	0.0699	-0.0028	-0.0214	-0.0433
Hide and Leather	0.0141	-0.0018	-0.0138	-0.0279
Wood and Cork	0.1832	-0.0045	-0.0340	-0.0687
Pulp and Paper	0.1879	-0.0084	-0.0636	-0.1287
Printing and Publishing	0.1644	-0.0042	-0.0318	-0.0643
Coke and Chemical products	0.1273	-0.0024	-0.0185	-0.0374
Rubber and Plastics	0.1868	-0.0075	-0.0572	-0.1157
Processing of non-metallic minerals	0.0743	-0.0031	-0.0234	-0.0472
Basic Metals	0.1766	-0.0034	-0.0256	-0.0518
Fabricated Metal Products	0.1071	-0.0039	-0.0294	-0.0594
Machinery and Equipment	0.0270	-0.0002	-0.0013	-0.0026
Electrical and Optical Equipment	0.1455	-0.0023	-0.0176	-0.0356
Motor Vehicles and Trailers	0.0400	-0.0003	-0.0026	-0.0052
Other Transport Equipment	0.0282	-0.0017	-0.0127	-0.0257
Other manufacturing industries	0.0591	-0.0013	-0.0095	-0.0193

Note: The Table reports the indirect effects of distance, using the firm-level distance variable. The indirect effect is computed by multiplying the elasticity of χ_{hk} with respect to either distance or market size by the elasticity of exports to χ_{hk}, obtained through the equations for the extensive, the intensive margin and the Poisson specification, respectively. Column 1 reports the average import share of intermediate inputs considering only imports from European countries and excluding those firms located in the South of Italy. All the estimated parameters are statistically significant at 1%. Standard errors, which are not reported, have been obtained by bootstrapping (500 replications).

Table A6: Average Import share

	Average Import Share
Food, Beverages and Tobacco	0.02
Textiles and Apparel	0.11
Hide and Leather	0.01
Wood and Cork	0.26
Pulp and Paper	0.32
Printing and Publishing	0.16
Coke and Chemical products	0.16
Rubber and Plastics	0.21
Processing of non-metallic minerals	0.11
Basic Metals	0.29
Fabricated Metal Products	0.13
Machinery and Equipment	0.03
Electrical and Optical Equipment	0.19
Motor Vehicles and Trailers	0.05
Other Transport Equipment	0.04
Other manufacturing industries	0.07

Note: The Table reports the import share, computed as the fraction of a firm's imports from all countries over its total intermediates inputs, averaged across firms belonging to the same sector.

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