PRODUCTIVITY AND FIRM SELECTION: QUANTIFYING THE “NEW” GAINS FROM TRADE.*

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Abstract

We discuss how standard computable equilibrium models of trade policy can be enriched with selection effects. This is achieved by estimating and simulating a partial equilibrium model that accounts for a number of real world effects of trade liberalisation: richer availability of product varieties; tougher competition and weaker market power of firms; better exploitation of economies of scale; and, of course, efficiency gains via firms selection. The model is estimated on EU data and then simulated in counterfactual scenarios. Gains from trade are much larger in the presence of selection effects with substantial variability across countries and sectors.

Keywords: European integration, firm-level data, firm selection, gains from trade, total factor productivity
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1 Introduction

In the aftermath of the financial crisis and the ensuing collapse of manufacturing, the temptation of protectionism looms on the path to recovery (Evenett, 2010; WTO, 2010). The welfare losses from protectionism are well understood and some have been known for a couple of centuries: protectionism breeds inefficiency. By doping the price mechanism, protectionism distorts the allocation of resources forcing consumers to buy from cost ineffective producers and countries to be active in industries in which they have no cost advantage. By focusing firms on their domestic markets, protectionism also prevents the exploitation of scale economies and reduces the variety of both final and intermediate products available to consumers and producers. Finally, by promoting the market power of local firms, protectionism fosters their rents and wasteful rent-shifting activities.

Though the principles are well understood, as protectionist pressure mounts it is becoming increasingly crucial to give a sense of the order of magnitude of the costs of protectionism and, symmetrically, of the benefits of free trade. Along the years, this has been the objective of a vast literature that has tried to put numbers on the predictions of theoretical models of trade policy (see, e.g., Piermartini and Teh, 2005, for a recent survey). Its main tools are computable partial and general equilibrium models based on two methodological pillars. On the one hand, the idea is that policy analysis cannot but benefit from the logical rigour and consistency of theoretical models. On the other hand, it is acknowledged that the issues analyzed, often involving a multiplicity of linkages among a plethora of economic players, are so complex that they cannot be solved by relying only on a model in the analyst's head or a simple diagram. Computer-based models are then used to track such complex interactions and, through simulation, answer 'what if' type of questions concerning the effects of trade policies.

Compared with the state of the art in international trade theory, the main limitation of that literature is its current neglect of firm heterogeneity, which implies that only scale economies drive endogenous changes in productivity within sectors.[1] In recent models with heterogeneous firms trade liberalization has, instead, an additional positive impact on sectoral productivity through the selection of the most efficient firms (Bernard *et al.*, 2003; Melitz, 2003). The reason is a combination of import competition and export market access. On the one hand, as lower trade costs allow foreign producers to target the domestic markets, the operating profits of domestic firms in those markets shrink whatever their productivities. On the other hand, some domestic firms gain access to foreign markets and get additional profits from their foreign ventures. These are the firms that are productive enough to cope with the additional costs of foreign activity (such as those due to transportation and remaining administrative duties or institutional and cultural barriers). The result is the partition of the initially active domestic firms in three groups. As they start making losses in their home markets without gaining access to foreign markets, the least productive firms are forced to exit. On the contrary, as they are able to compensate lost profits on home sales with new profits on foreign sales, the most productive firms survive and expand their market shares. Finally, firms with intermediate levels of productivity also survive but, not being productive enough to access foreign markets, are relegated to home sales only and their market shares fall. Since international trade integration eliminates the least productive firms, average productivity grows through the reallocation of productive resources from less to more efficient producers.

This mechanism found empirical support in early firm-level analyses that tried to identify the direction of causation hidden in the positive correlation between the export status of a firm and its productivity (called 'exceptional exporter performance' by Bernard and Jensen, 1999). This is a crucial issue for trade policy. Causation going from export status to firm performance would reveal the existence of 'learning by exporting' and, therefore, call for export promotion. However, apart from peculiar cases concerning developing countries, most of the evidence supports reverse causation in the form of 'selection into export status': firms that already perform better have a stronger propensity to export than other firms (Tybout,

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[1] See, e.g., Smith and Venables (1988), Haaland and Norman (1992). As argued by Tybout and Westbrook (1996), the neglect of firm heterogeneity implies that scale effects may be overstated. On the one hand, exporting plants are typically the largest in their industry, so they are not likely to exhibit much potential for further scale economies exploitation. On the other hand, large plants also account for most of the production in any industry, so foregone economies of scale due to downscaling in import-competing sectors are also likely to be minor.

2003). Selection comes with two additional effects that are consistent with the theoretical argument discussed above. First, exposure to trade forces the least productive firms to shut down (Clerides *et al.*, 1998; Bernard and Jensen, 1999; Aw *et al.*, 2000). Second, trade liberalization leads to market share reallocations towards the most productive firms (Pavcnik, 2002; Bernard *et al.*, 2006). On both counts, aggregate average productivity improves. In the last few years a burgeoning empirical literature has confirmed those early results.[2]

The empirical relevance of the selection effect motivates additional efforts towards quantifying the corresponding gains from trade as a preliminary step towards their integration in the large-scale computable general equilibrium models used for policy analysis. This line of research has been heralded by Tybout (2003) and pursued by Bernard *et al.* (2003). These authors calibrate and simulate an oligopolistic model with heterogenous firms obtained by introducing Bertrand competition in the probabilistic Ricardian framework developed by Eaton and Kortum (2002).[3] Aggregate U.S. production data and trade data on the 47 leading U.S. export destinations (including the U.S. itself) are used to calibrate the model's parameters governing geographic barriers, aggregate technology differences, and differences in input costs. U.S. plant level data are used, instead, to calibrate the parameters that relate to the heterogeneity of goods in production and consumption. The calibrated model is then used to assess the impacts of various counterfactual scenarios.

The counterfactual analysis by Bernard *et al.* (2003) has the merit of showing for the first time how to provide a quantitative assessment of the selection effect of trade liberalization in the spirit of computable equilibrium models. It neglects, however, a few important dimensions of the effects of trade policy highlighted by both theoretical and empirical research. First, in the model of Bernard *et al.* (2003) the equilibrium distribution of firm markups is invariant to country characteristics and to geographic barriers. This removes an important source of cross-country variation in the selection effects and is not consistent with empirical evidence showing that markups do vary across firms and markets (Tybout, 2003).[4] Second, Bernard *et al.* (2003) assume that firms' entry does not respond to market profitability. This removes an important channel through which industry equilibrium is eventually restored and gives the model a strong short-run flavor.[5]

The aim of the present paper is to supplement the analysis by Bernard *et al.* (2003) suggesting how standard computable equilibrium models of trade policy can be enriched with selection effects without missing other important channels of adjustment. This is achieved by estimating and simulating a partial equilibrium model derived from Melitz and Ottaviano (2008). This model accounts for a number of real world effects of trade liberalisation: richer availability of product varieties; tougher competition and weaker market power of firms; better exploitation of economies of scale; and, of course, efficiency gains via the selection of the most efficient firms.[6] The model is estimated on E.U. data and simulated in counterfactual scenarios that target several dimensions of European integration. Simulations show that the gains from trade are much larger in the presence of selection effects.[7] The gains from freer

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[2] Recent evidence on the existence of causation from trade to aggregate income and productivity is provided by Frankel and Rose (2002), who find per capita income to be positively affected by the formation of currency unions, thanks to their positive impact on trade, and by Alcalà and Ciccone (2004), who report strong support for a positive causal effect of trade on labor productivity. With respect to our analysis, Alcalà and Ciccone (2004) provide the interesting insight that, at the aggregate level, such a positive causation mainly acts through total factor productivity.

[3] See also Finicelli *et al.* (2009) for a calibration and simulation of the perfectly competitive model by Eaton and Kortum (2002) as well as Waugh (2009) for a variant of the same model with traded intermediates and non-traded final goods.

[4] More precisely, Bernard *et al.* (2003) do generate markups that are variable at the firm level differing (in a statistical sense) between exporters and non exporters. It is the overall distribution of markups that is unchanged. However, the overall distribution of markups is seldom observed as one would need to include non-traded sectors in particular. In this respect, it could be argued that the findings in Tybout (2003) do not necessarily contradict their prediction.

[5] Markups are constant also in the CES models by Melitz (2003) and Chaney (2008).

[6] Chen, Imbs and Scott (2009) test the implications of the model by Melitz and Ottaviano (2008) for the dynamics of prices, productivity and markups as functions of openness to trade at a sectoral level. Using disaggregated data for EU manufacturing over the period 1989-1999, they find evidence that trade openness exerts a competitive effect, with prices and markups falling and productivity rising.

[7] As we will discuss, there is no obvious way to estimate the preference parameters. Hence, we are not able to assess the quantitative impact of counterfactual scenarios on the number of firms and, therefore, on overall welfare. Nevertheless, in the theoretical model indirect utility turns out to be positively correlated with average productivity irrespective of the

trade are, however, unevenly distributed between and within countries. Small, competitive and centrally located countries are those who benefit the most. Within countries, the main beneficiaries are the border regions located closer to the core of the European market. In other words, geography plays a key role in determining the distribution of gains across European regions.

How should our results be read? First of all, simulations of computable equilibrium models are not forecasts. As pointed out by Piermartini and Teh (2005), a forecast involves predicting the future values of the endogenous variables in the model making assumptions on the likely evolution of all its exogenous variables. Simulations concern, instead, hypothetical counterfactual scenarios whose investigation is not necessarily wedded to a particular view about the likelihood of the exogenous variables changing in a certain way. However, their usefulness in understanding complex and sometimes unexpected interactions in an economy should not be underestimated. As shown by Ottaviano *et al.* (2009) in their investigation of the selection effects of the euro based on the methodology developed in the present paper, the simulation of computable equilibrium models is often the only way to give a sense of the order of magnitude of policies when data unavailability prevents econometric investigation.

Second, we use a computable *partial* equilibrium model. As such it focuses only on a part of the economy (manufacturing) abstracting from the impact of that part on the rest of the economy and vice versa. Because it does not take into account the link between factor incomes and expenditures, our partial equilibrium model cannot be used to determine income, whereas general equilibrium models can. In this respect, our model should be seen as an additional ”application” for existing general equilibrium models that currently neglect neglect firm heterogeneity.

Third, in our simulations we adopt a comparative statics approach that examines how a change in policy changes the endogenous variables. Accordingly, we are concerned with discerning the difference between the initial and final equilibrium of the economy and not with the transition required to move from the former to the latter. An obvious limitation of this approach is that it may fail to capture some of the costs and benefits associated with the transition and so misstate the costs and benefits of a policy change. Dynamic models of international trade are, however, an exception both in theoretical and applied research.[8]

Fourth and last, we estimate our model on the European Union. This is mainly due to the fact that comparable firm-level panel data across a large set of countries is available only for Europe. While computable equilibrium models are not forecasts, they are clearly more valuable the more accurate their calibration and simulation are. An important methodological contribution of the present paper is to shows how to structurally estimate several parameters of the model combining macro and micro data. In addition, the focus on a set of sufficiently integrated countries, which are relatively homogeneous in terms of economic development and institutions, allows us to control for several confounding factors that may blur the working of selection effects in more heterogenous data sets.

The rest of the paper is organized in five additional Sections. Section 2 presents the model. Section 3 describes its estimation. Section 4 simulates alternative scenarios. Section 5 discusses the robustness of the simulated results. Section 6 concludes. Additional details on data and the estimation procedure are provided in two separate Appendices.

2 Theoretical framework

The model is based on the one proposed by Melitz and Ottaviano (2008) that we apply to a partial equilibrium framework and extend to allow for international differences in factor prices and entry costs.

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number of firms.

[8] See Costantini and Melitz (2008) and Arkolakis (2009) for two recent exceptions.

2.1 An industry model

Consider an industry that is active in M countries, indexed $l = 1, ..., M$. Country l is endowed with given amounts of labor L^l and capital K^l.[9] Both labor and capital are geographically immobile. The output of the industry is horizontally differentiated in a large set of varieties and we call N^l the measure ('number') of varieties sold in country l. Following Ottaviano *et al.* (2002), the inverse demand of a generic variety i in country l is linear and given by:

$$p^l(i) = \alpha - \frac{\upsilon q^l(i) + \eta Q^l}{L^l} \tag{1}$$

where $p^l(i)$ and $q^l(i)$ are the price and the quantity of variety i while $Q^l \equiv \int_0^{N^l} q^l(i)di$ is the total quantity of the differentiated good. Parameters α and η are positive and measure the intensity of the preference for the differentiated good: the larger α and the smaller η, the higher the vertical intercept of the linear demand. The parameter υ is also positive and measures the degree of product differentiation among the varieties of the differentiated good: the larger υ, the flatter the linear demand.

We define average price and average quantity of varieties sold in country l as $\overline{q}^l \equiv Q^l/N^l$ and $\bar{p}^l \equiv \left(1/N^l\right) \int_0^{N^l} p^l(i)di$ respectively. Then (1) implies the simple average relation $\overline{q}^l = (\alpha - \bar{p}^l)/(\upsilon + \eta N^l)$. This can be used to substitute for $Q^l = N^l \overline{q}^l$ in (1) to show that variety i is demanded (i.e. $q^l(i) > 0$) provided that its price is low enough

$$p^l(i) \leq \frac{1}{\eta N^l + \upsilon} \left(\upsilon\alpha + \eta N^l \bar{p}^l\right) \equiv p^l. \tag{2}$$

For given $p^l(i)$, this condition holds if consumers like the differentiated good a lot (large α and small η), varieties are very differentiated (large υ), the average price $\bar{p}^l$ is high, and the number of competing varieties N^l is small. In all these circumstances the price elasticity of demand $\varepsilon^l(i) \equiv \left\{\left[p^l/p^l(i)\right] - 1\right\}^{-1}$ is low.

Market structure is monopolistically competitive and each variety is supplied by one and only one firm. In particular, the demand function (1) implies that firms do not interact directly. However, they do interact indirectly through an aggregate demand effect as shown by the presence of Q^l. Thus, though each firm is negligible to the market, when choosing its output level it must figure out what the total output of the industry will be. In other words, a firm accurately neglects its impact on the market but must explicitly account for the impact of the market on its profit.

All firms use the same technology employing labor and capital as their inputs but are heterogeneous in terms of efficiency in their usage. Different efficiency stems from different 'total factor productivity' (TFP). Specifically, the technology of a generic firm based in country l is described by the following Cobb-Douglas production function with constant returns to scale:

$$q^l(c) = c^{-1}x^l(c) \tag{3}$$

where c is the firm's inverse TFP, which we call 'unit input requirement' (UIR), while $x^l(c) = k^l(c)^{\beta_K} l^l(c)^{\beta_L}$ is the Cobb-Douglas composite input of capital $k^l(c)$ and labor employment $l^l(c)$ with factor shares $\beta_K + \beta_L = 1$ respectively. As in traditional Heckscher-Ohlin models, we assume that factor shares are the same across countries.

It will turn out to be convenient to index each firm by its UIR. Accordingly, technology (3) implies that firm c producing in country l faces marginal cost

$$m^l(c) = B\omega^l c \tag{4}$$

where $B \equiv (\beta_L)^{-\beta_L}(\beta_K)^{-\beta_K}$ is a positive constant and $\omega^l \equiv \left(z^l\right)^{\beta_K} \left(w^l\right)^{\beta_L}$ is the exact price index of the composite input $x^l(c)$ with w and z denoting the wage and the rental price of capital respectively.

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[9] In Melitz and Ottaviano (2008) labor is the only factor of production. Even though we will take factor prices are exogenous, we introduce two factors for consistency with the procedure we will follow to estimate productivity.

Firm heterogeneity is modelled as the outcome of a research and development process with uncertain outcome. In particular, in order to enter the market, each firm has to make an irreversible ('sunk') investment in terms of labor and capital to invent its own variety. The investment is equal to $F^l = \omega^l f^l$ as we assume that it entails the same factor proportions as subsequent production. A prospective entrant knows for certain that it will invent a new variety and use a Cobb-Douglas technology like (3). It does not know, however, its efficiency, as this is randomly assigned only after the sunk cost has been payed. In particular, upon entry each firm draws its c from a common and known distribution $G^l(c)$, with support $[0, c_A^l]$, which varies across countries. The upper bound of the support c_A^l determines the upper bound of the marginal cost $m_A^l \equiv m^l(c_A^l) = B\omega^l c_A^l$. If $\left(m_{A,s}^l / m_{A,r}^l\right) < \left(m_{A,s}^h / m_{A,r}^h\right)$, relative to entrants in l, entrants in h are more likely to get lower marginal cost draws in sector r than in sector s. In this sense, countries h and l can be said to have a (probabilistic) comparative advantage in sectors s and r respectively.

National markets are segmented. Nevertheless, firms can produce in one country and sell in another by incurring a per-unit trade cost. We interpret such cost in a wide sense as resulting from all impediments to trade. Specifically, the delivery of a unit of any variety from country l to country h requires the shipment of $\tau^{lh} > 1$ units, where $(\tau^{lh} - 1)$ is the frictional trade cost. We also allow for costly trade within a country with $\tau^{lh} > \tau^{ll} \geq 1$.

Since the entry cost F^l is sunk, only entrants that can cover their production and trade costs survive and produce. All other entrants exit without even starting production. Survivors maximize their profits facing the demand function (1) taking the average price $\bar{p}^l$ and number of competitors N^l as given. Since we assume that national markets are segmented and production faces constant returns to scale, firms independently maximize the profits in each country they sell to. Let $\pi^{lh}(c)$ denote the maximized value of the profits that sales to country h generate for firm c located in country l. Let $p^{lh}(c)$ and $q^{lh}(c)$ denote the corresponding profit-maximizing price and quantity. Then, they must satisfy $\pi^{lh}(c) = \left[p^{lh}(c) - \tau^{lh} m^l(c)\right] q^{lh}(c)$ and $q^{lh}(c) = \left(L^h/\upsilon\right)\left[p^{lh}(c) - \tau^{lh} m^l(c)\right]$.

Only firms earning non-negative profits in a market will choose to serve that market. This implies that the decision whether to serve a market or not obeys a cutoff rule. For example, firm c producing in country l will not serve country h if the cost of producing and delivering a unit of its variety is larger than the maximum price consumers in h are willing to pay. Given (2), that is the case if $\tau^{lh} m^l(c) > p^h$. Hence, only firms in country l that are efficient enough (i.e. have a low enough c) will serve country h. Let m^h denote the marginal cost inclusive of trade frictions faced by a producer in country h that is just indifferent between serving its local market or not. Then, by definition, we have $m^h = p^h$. Since firm c producing in country l serves country h when $\tau^{lh} m^l(c) < m^h$, does not serve it when $\tau^{lh} m^l(c) > m^h$, and is indifferent when $\tau^{lh} m^l(c) = m^h$, we call m^h the 'cutoff cost' in country h.

A useful property of our setup is that all performance measures of firm c in a certain market can be written as simple functions of the cutoff cost. In particular, independently of any specific assumption on the distribution $G^l(c)$, profit maximizing price and quantity evaluate to:

$$p^{lh}(c) = \frac{1}{2}\left[m^h + \tau^{lh} m^l(c)\right] \tag{5}$$

$$q^{lh}(c) = \frac{L^h}{2\upsilon}\left[m^h - \tau^{lh} m^l(c)\right] \tag{6}$$

with corresponding markup and profit

$$\mu^{lh}(c) = \frac{1}{2}\left[m^h - \tau^{lh} m^l(c)\right] \tag{7}$$

$$\pi^{lh}(c) = \frac{L^h}{4\upsilon}\left[m^h - \tau^{lh} m^l(c)\right]^2 . \tag{8}$$

Moreover, if one is ready to make specific assumptions on $G^l(c)$, also industry-level performance measures can be simply linked to the cutoff cost. While Combes *et al.* (2008) have shown that the model is theoretically tractable for any $G^l(c)$, our empirical implementation requires us to impose a specific parametrization, whose empirical relevance will then be tested. In particular, we assume that firms draw their efficiency from a Pareto distribution implying

$$G^l(c) = \left(\frac{c}{c_A^l}\right)^\gamma = \left[\frac{m^l(c)}{m_A^l}\right]^\gamma \qquad \text{with} \quad c \in [0, c_A^l]. \tag{9}$$

The shape parameter γ is the same in all countries and indexes the dispersion of draws. When $\gamma = 1$, the distribution is uniform on $[0, c_A^l]$. As γ increases, density is increasingly concentrated close to the upper bound c_A^l. As γ goes to infinity, the distribution becomes degenerate at c_A^l. The theoretical appeal of (9) comes from the fact that any truncation of $G^l(c)$ from above maintains its distributional properties. For instance, the distribution of firms producing in l and selling to h is given by $G^{lh}(c) = \left(c/c^{lh}\right)^\gamma$, with $c \in \left[0, c^{lh}\right]$, where $c^{lh} \equiv m^h/(B\omega^l\tau^{lh})$ is the UIR of the producer in country l that is just indifferent between serving country h or not.

2.2 Industry equilibrium

Firms choose a production site l prior to entry and sink the corresponding entry cost $F^l = \omega^l f^l$. Free entry then implies zero expected profits in equilibrium:

$$\sum_{h=1}^{M} \left[\int_0^{c^{lh}} \pi^{lh}(c) dG^l(c)\right] = F^l \tag{10}$$

One can, therefore, derive the equilibrium cutoff costs for the M countries by substituting (8) into (10) and solving the resulting system of M equations for $l = 1, ..., M$. This yields:

$$m^h = \Phi \left(\frac{r^h}{L^h}\right)^{\frac{1}{\gamma+2}} \tag{11}$$

where $\Phi \equiv [2\upsilon(\gamma+1)(\gamma+2)]^{\frac{1}{\gamma+2}}$ is a positive bundling parameter, while

$$r^h\left(P, \psi^1, ..., \psi^M\right) \equiv \frac{\sum_{l=1}^{M} \left|C^{lh}\right| \psi^l}{|P|} \tag{12}$$

measures the 'remoteness' of country h.

To see why r^h is a measure of remoteness, consider its various components. First, $|P|$ is the determinant of a matrix P whose element in row l and column h is $\rho^{lh} \equiv \left(\tau^{lh}\right)^{-\gamma} \in (0, 1]$ with corresponding cofactor $\left|C^{lh}\right|$. Being inversely related to the trade cost parameter τ^{lh}, ρ^{lh} measures the 'freeness of trade' from country l to country h. Henceforth, we will refer to P as the 'trade freeness matrix'. Second, the bundling parameter $\psi^l \equiv f^l\omega^l\left(m_A^l\right)^\gamma$ captures various exogenous determinants of country l's ability to generate low cost firms: low factor prices ω^l, low entry cost f^l and low probability of inefficient draws by entrants (low m_A^l) all foster the creation of low cost firms. Hence, for given ψ^l's, r^h is large when high trade barriers separate country l from its trading partners. Viceversa, for given trade barriers, r^h is large when the trading partners of country l tend to generate high cost firms.

The information provided by ψ^h has to be compared with that conveyed by the cutoff cost m^h. In particular, ψ^h captures the exogenous ability of country h to generate low cost firms abstracting from the size of its domestic market L^h and its remoteness r^h. The cutoff cost m^h determines, instead, the endogenous cost of producers in country h that survive a selection process in which market size and remoteness play key roles. For this reason, we will refer to ψ^h and m^h as inverse measures of, respectively, the 'exogenous' and the 'endogenous' competitiveness of country h. Section 3.3 will show that the endogenous competitiveness and the exogenous competitiveness of a country can be pretty different.

According to (11), a larger local market and closer proximity to countries with high exogenous competitiveness reduce m^h, thus decreasing the average cost of producers in country h. To see this, note that, under the distributional assumption (9), the average marginal cost of firms selling in country h (inclusive of trade frictions) equals

$$\overline{m}^h = \frac{\gamma}{\gamma+1} m^h \tag{13}$$

Hence, a percentage change in the cutoff cost causes an equal percentage change in the average marginal cost. Result (13) follows from the fact that the average cost of firms selling to country h from any country l is the same whatever the country of origin: $\overline{m}^h \equiv \left[1/G^l(c^{lh})\right] \int_0^{c^{lh}} \tau^{lh} m^l(c) dG^l(c)$ for any l (h included). This property holds for all other average performance measures of firms selling in country h, which can therefore be expressed as simple functions of m^h. In particular, average markups, prices, quantities and operating profits evaluate to:

$$\begin{aligned} \overline{\mu}^h &= \tfrac{1}{2(\gamma+1)} m^h, & \bar{p}^h &= \frac{2\gamma+1}{2\left(\gamma+1\right)} m^h \\ \overline{q}^h &= \tfrac{L^h}{2\upsilon(\gamma+1)} m^h, & \overline{\pi}^h &= \frac{L^h}{2\upsilon(\gamma+1)(\gamma+2)} (m^h)^2 \end{aligned} \tag{14}$$

where the average of a performance variable $z^{lh}(c)$ is defined as $\overline{z}^h \equiv \left[1/G^l(c^{lh})\right] \int_0^{c^{lh}} z^{lh}(c) dG^l(c)$. Thus, a smaller cutoff cost generates smaller average costs, smaller average markups and lower average prices for varieties sold in h. As the average cost and the average markup are both multiples of m^h, a percentage change in the cutoff has the same percentage impact on both the average markup $\overline{\mu}^h$ ('pro-competitive effect') and the average delivered cost $\overline{m}^h$ ('selection effect'). Through these channels, a given percentage change in the domestic cutoff translates into an identical percentage change in the average price. Finally, average quantities and profits are multiples of m^h and $(m^h)^2$ respectively: a percentage change in m^h causes the same percentage change in average quantity and a percentage change in profit in the same direction but larger in size.

Also the number of varieties sold in country h can be expressed as a simple function of the local cutoff cost. This can be shown by solving (2) for N^h after substituting $p^h = m^h$ and $\bar{p}^h$ from (14) in order to get:

$$N^h = \frac{2\upsilon(\gamma+1)}{\eta} \frac{\alpha - m^h}{m^h} \tag{15}$$

which points out that a reduction in the cutoff cost leads to an increase in the number of varieties sold.

Finally, given the demand function (1), the surplus of a consumer in country h can also be written as a simple function of the cutoff cost:

$$U^l = \frac{1}{2\eta} \left(\alpha - m^h\right) \left(\alpha - \frac{\gamma+1}{\gamma+2} m^h\right) \tag{16}$$

Note that, due to the law of large numbers, profits exactly match the entry cost not only ex ante in expected values, as implied by the free entry condition (10), but also ex post in average values. Specifically, we can write $\sum_{h=1}^{M} G^l(c^{lh}) \overline{\pi}^h = F^l$ as $G^l(c^{lh})$ is not only the ex ante probability of successfully selling from country l to country h but also the ex post fraction of entrants in l that serve h. This allows us to take consumer surplus (16) as a measure of welfare generated by the industry. Then (16) implies that welfare is a decreasing function of the cutoff cost due to the three concurrent effects: a lower cutoff entails a larger number of varieties, a lower average price (thanks to both lower average cost and lower average markup), and a higher average quantity.

3 Estimation

Our aim is to estimate and simulate our model industry by industry in order to investigate the effects of trade frictions in different thought experiments. As just shown, a key feature of our model is that the cutoff costs in the different countries are sufficient statistics for industry performance. This allows us to focus only on their percentage changes in the different experiments with respect to a benchmark estimation. Specifically, each thought experiment will propose a counterfactual scenario affecting the trade freeness matrix and hence countries' remoteness. If we call P_* the counterfactual trade freeness matrix and r_*^h the corresponding remoteness, then (11) implies the percentage cutoff change due to turning P into P_* equals

$$\frac{m_*^h - m^h}{m^h} = \frac{\left(r_*^h\right)^{\frac{1}{\gamma+2}} - \left(r^h\right)^{\frac{1}{\gamma+2}}}{\left(r^h\right)^{\frac{1}{\gamma+2}}} \tag{17}$$

which maps exogenous remoteness changes into endogenous competitiveness changes showing that the exact value of the industry-specific constant Φ is immaterial.

For our benchmark estimation we focus on 18 manufacturing industries across 29 countries in the year 2000. Our data set is detailed in Appendix B. We choose 2000 because of the quality of the data and the fact that no major economic change took place in that specific year. On the one hand, 2000 is prior to both the adoption of the paper euro and the large fluctuations of its US dollar exchange rate that could have biased our results. On the other hand, in 2000 the effects of the Single Market had been already felt after eight years since its creation in 1992.

The 18 industries are listed in Table 13. Each industry is modeled as in the previous Section and we do not consider any interaction among them. We include all EU-15 countries (except Luxembourg), and further consider Australia, Canada, Czech Republic, Estonia, Hungary, Japan, Korea, Lithuania, Latvia, Norway, Poland, Taiwan, Slovakia, Slovenia, and the US as the 'rest of the world' (henceforth RoW). In 2000 our 18 industries accounted for 19.4% of EU-15 GDP. In that year trade among EU-15 countries accounted for 59.2% of their imports and 58% of their exports while trade between the EU-15 and the RoW accounted for an additional 23% (22.4%) of EU-15 imports (exports). Data limitations prevent us from including some interesting countries such as some of the new accession countries that joined the EU after 2000 or China. However, in 2000 China represented only 3.2% of the imports and 1.6% of the exports of EU-15 countries.

By (11), the structural parameters needed to compute the benchmark country-and-industry specific cutoff cost m^h (up to the industry-specific constant Φ) are: the industry specific shape parameter γ, the country specific matrix of trade freeness P, and the country specific exogenous competitiveness parameters ψ^l. As we are interested in percentage cutoff changes, we do not need to estimate Φ and, therefore, υ. To recover all other parameters, we proceed industry by industry in three steps:

1. For P, we estimate gravity equations using data on trade flows and distance.

2. For γ, we use firm-level data to recover this parameter from a regression that exploits the features of the distributional assumption (9).

3. For ψ^l, we first derive the cost cutoff m^h in each country from data on price aggregates. We then use (11) to back out the country values of ψ^l consistent with the values of P, γ and m^h derived in the previous steps. Specifically, once inverting (11), we compute the set of exogenous competitiveness values that make the remoteness r^h of each country h satisfy:

$$\left(m^h\right)^{\gamma+2} L^h = \Phi^{\gamma+2} r^h \left(P, \psi^1, ..., \psi^M\right) \tag{18}$$

up to the constant $\Phi^{\gamma+2}$. Making use of bootstrap techniques applied to the first two steps, we finally provide confidence intervals for the estimated ψ^l.

3.1 Trade freeness matrix (P)

In the first step of the benchmark estimation procedure, the trade freeness matrix is estimated through standard gravity regressions. We start with showing that our theoretical framework indeed yields a gravity equation for aggregate bilateral trade flows. Calling N_E^l the number of entrants in country l, the number of exporters from l to h equals $N_E^l G^l(c^{lh})$. Each exporter c from l to h generates f.o.b. export sales equal to $p^{lh}(c)q^{lh}(c)$. Then, aggregating over all exporters yields the aggregate exports from l to h. These, by (5), (6) and (9), evaluate to:

$$T^{lh} = \frac{1}{2\upsilon\left(\gamma+2\right)}\rho^{lh}\left(m_A^l\right)^{-\gamma} N_E^l \left(m^h\right)^{\gamma+2} L^h \tag{19}$$

which is a gravity equation in so far as it determines bilateral exports as a (log-linear) function of bilateral trade barriers and country characteristics. In particular, (19) reflects the combined effects of market size, technology, and geography on both the number of exporters (the so called 'extensive margin' of trade) and the amount of exports per exporter (the so called 'intensive margin' of trade). It shows that a lower cutoff cost in the country of destination dampens exports by cutting both margins.[10]

In equation (19), the only term that depends on both l and h is ρ^{lh}. Following the abundant gravity literature, Head and Mayer (2004) assume, when estimating trade freeness between European countries, that $\rho^{lh} = (d^{lh})^{\delta}\exp(\theta_B + \theta_{LB}\ Lang^{lh} + \theta_{CB}\ Cont^{lh})$ if $l \neq h$ and $\rho^{lh} = (d^{lh})^{\delta}$ if $l = h$, where d^{lh} is the distance between l and h, θ_B is a coefficient capturing the fall in exports due to crossing the l-h border (the so called 'border effect'), $Lang^{lh}$ is a dummy variable that takes value one if l and h share a common language, and $Cont^{lh}$ is a dummy variable indicating contiguity between l and h. In other words, as is standard in the gravity literature, trade costs are a power function of distance, while crossing a border, not sharing the same language or not being contiguous impose additional frictions.

However, in our gravity regression we consider many countries outside Europe and one of our goals is precisely to measure the different degree of trade freeness between the EU-15 block and the RoW. Furthermore, as pointed out in Disdier and Head (2008), the elasticity of trade with respect to distance (δ) is usually different depending on whether the trading partners belong to the same continent or not. In order to be both parsimonious and obtain precise estimates, we introduce an additional distance component $(d^{lh})^{\delta^{SC} SC^{lh}}$, where SC^{lh} is a dummy that takes value one if both l and h belong to the same continent, and further assume that $\theta_B = \theta_B^W + \theta_B^{EU} EU^{lh}$, where EU^{lh} is a dummy that takes value one if both l and h belong to the EU-15. The two parameters θ_B^W and θ_B^{EU} broadly account for differences in impediments to internal and external EU-15 trade flows while δ^{SC} controls for the different rate of trade decay with distance within and across continents.

As for the other terms in equation (19), these depend either on the origin country only $[N_E^l(m_A^l)^{-\gamma}]$, or on the destination country only $[\left(m^h\right)^{\gamma+2} L^h]$, or are constant $[1/(2\upsilon\left(\gamma+2\right))]$. As in Hummels (1999) and in Head and Mayer (2004), we can isolate the effects of these country-specific terms using dummies for origin (ex^l) and destination (im^h) countries. This approach avoids the specification problems discussed by Anderson and van Wincoop (2003) and produces parameters that are very similar to those obtained using their multilateral resistance terms to control for remoteness. Thus, our estimating gravity equation is

$$T^{lh} = ex^l\ im^h\ (d^{lh})^{\delta}\ (d^{lh})^{\delta^{SC} SC^{lh}}\ \exp\left(\left[\theta_B^W + \theta_B^{EU} EU^{lh} + \theta_{LB}\ lang^{lh} + \theta_{CB}\ cont^{lh}\right] bord^{lh}\right)\ \epsilon^{lh} \tag{20}$$

where $bord^{lh}$ is a dummy variable that equals one whenever $l \neq h$. Our reference year is 2000 but, to get more precise parameter estimates, we consider data from 1997 to 2001 and add a full set of year dummies. The population of interest consists of the EU-15 countries plus the 15 countries representing the RoW.

A first issue to address in the estimation of (20) is how to deal with the selection bias due to presence of zero trade flows (Helpman *et al.*, 2008). In our case, that is not likely to be too problematic as less than 1% of trade flows are zero in our sample at the chosen level of industry disaggregation. A second issue is that, as stressed by Santos Silva and Tenreyro (2006), the standard practice of interpreting the parameters of log-linearized models estimated by ordinary least squares (OLS) as elasticities can be highly misleading in the presence of heteroskedasticity in ϵ^{lh}. To tackle this issue, we take as our benchmark

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[10] See Eaton and Kortum (2002), Helpman *et al.* (2008), and Chaney (2008) for similar results derived from different models.

their Poisson Pseudo Maximum Likelihood (PPML) estimator of the non-linear equation (20). In Section 5 we will argue that our results are robust with respect to the more common strategy of estimating the log-linearized model by OLS.

Table 1 reports the results of our PPML estimations. Overall, parameters have the expected sign and magnitude. In particular, the average elasticity δ of trade to distance across sectors is -0.92. This value compares with the -0.91 mean value observed by Disdier and Head (2008) in their meta-analysis of 1467 estimates referring to 103 papers. Also in line with Disdier and Head(2008), we find that the elasticity of trade to distance is higher when considering trade within the same continent. δ^{SC} is in fact negative and significant in 9 out of 18 cases with an average across sectors of -0.03. The most notable feature of Table 1 is the considerable heterogeneity in trade barriers across industries. Some industries, such as Textiles, and Wearing Apparel are characterized by small distance frictions (low absolute value of δ), but high border frictions (large absolute value of θ_B^W). The latter are, however, much lower for internal than external EU-15 trade (i.e. $\theta_B^W + \theta_B^{EU}$ has smaller absolute value than θ_B^W). In other industries, such as Machinery and Electric Machinery, border frictions are much smaller and it is not possible to distinguish between θ_B^W and $\theta_B^W + \theta_B^{EU}$. The industries most affected by trade frictions include Petroleum and Coal and Printing and Publishing, which exhibit both large distance friction and large border frictions. Unsurprisingly, sharing a common language is extremely important in the latter industry as revealed by its large positive θ_{LB}.

3.2 Shape parameter (γ)

In the second step of the benchmark estimation we obtain the shape parameter γ. Assumption (9) implies a log-linear relationship between the cumulative distribution $G^l(c)$ and c with γ being the slope parameter. As such, γ can be estimated as the coefficient of a log-log regression of $G^l(c)$ on c. If the R^2 of such regression is close to one, then (9) can be considered a fairly good approximation of the UIR distribution, which means that the OLS coefficient of $\ln(c)$ provides a consistent estimator of the shape parameter.[11]

To implement this regression, we need some observable distributions of UIR across countries. The most natural candidate for a firm UIR c is, given equation (3), the inverse of its estimated TFP, which can be readily obtained as the Solow residual from the estimation of the Cobb-Douglas production function (3) at the firm level. At least two issues have to be addressed at this stage.

First, it is well known that a simple OLS estimation of (3) yields biased results due to simultaneity and omitted variables. We address this issue by relying on semi-parametric methods, as suggested by Olley and Pakes (1996) (henceforth OP) and Levinsohn and Petrin (2003) (henceforth LP). In particular, we use the former in our benchmark analysis and present results based on the latter in our robustness checks. Since both OP and LP assume that labour is a fully variable input, which may not be the case, we implement the two estimations following the correction introduced by Ackerberg *et al.* (2006). More details on this are reported in Appendix A.

Second, as the model assumes monopolistic competition, we need to account for heterogeneity in prices across firms. In particular, the left hand side of (3) is the quantity sold by a firm. Theory-consistent firm productivity (and so UIR) estimation would thus require either direct information on the quantities a firm produces or, if only revenues or value added are available, information on quoted prices. Both types of information are very seldom present in firm-level data sets and unfortunately our data set is no exception.[12].

In the literature the typical solution to such data unavailability is to rely on revenues or value added rather than quantities to estimate a "revenue based" UIR. This is problematic when firms have market power as in our model. To see this, consider a firm selling in its domestic market l only. When only data on revenues $p^{ll}(c)q^{ll}(c)$ are available, the standard practice is to consider the revenue based measure $\tilde{c}^l(c) \equiv x^l(c)/\left[p^{ll}(c)q^{ll}(c)\right] = c/p^{ll}(c)$ as a proxy for c. As a matter of fact, this introduces a bias in the

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[11] See Norman *et al.* (1994).

[12] See, e.g., Jaumandreu and Mairesse (2005) and Foster *et al.* (2008) for two exceptions in which information on firm-level physical output is available.

estimate of c. Indeed, by (7), as c increases firms charge smaller markups and are, therefore, attributed a proportionally smaller $\tilde{c}^l(c)$. A by-product of such omitted price bias, which is of particular relevance in our analysis, is that c and $\tilde{c}^l(c)$ do not follow the same distribution. Therefore, we cannot directly apply our log-log regression procedure to the distribution of $\tilde{c}^l(c)$ in order to estimate γ.[13]

Luckily the structure imposed by our theoretical framework helps us by suggesting a simple correction to be applied to $\tilde{c}^l(c)$ in order to recover an unbiased estimate of c and ultimately of γ. The correction, detailed in Appendix A, consists of the following transformation:

$$\hat{c}^l(c) \equiv \frac{\tilde{c}^l(c)}{2\tilde{c}^l(c^{ll}) - \tilde{c}^l(c)} \tag{21}$$

where c^{ll} refers to the marginal firm in country l (i.e. the firm that is just able to serve its domestic market l). Appendix A shows that $\hat{c}^l(c) = c/c^{ll}$, entailing that this "corrected" measure of UIR is no longer affected by the omitted price bias. Equation (21) thus shows how to transform the observable revenue based UIR $\tilde{c}^l(c)$, with unknown distribution, into another observable variable $\hat{c}^l(c)$ that, being equal to c/c^{ll}, follows a distribution like (9) with the same shape γ and support $[0, 1]$. Hence, we can recover the shape parameter γ by estimating $\tilde{c}^l(c)$, transforming $\tilde{c}^l(c)$ into $\hat{c}^l(c)$, and finally using the distribution of $\hat{c}^l(c)$ to retrieve γ.

The revenue based UIR $\tilde{c}^l(c)$ is estimated by applying (industry by industry) the corrected OP procedure to data on value added, capital, labor, and investments drawn from the Amadeus database provided by the Bureau Van Dijk. The Amadeus database has been extensively used in several recent empirical studies, such as Helpman *et al.* (2004) and Javorcik and Spatareanu (2008) among others. The dataset is an unbalanced panel of 137,284 observations covering 32,840 firms active in our 18 manufacturing industries and spanning over our group of European countries.[14] The resulting labour (β_L) and capital (β_K) shares, are reported in Table 2, together with the associated standard errors.[15]

Once obtained the distribution of $\hat{c}^l(c)$, we estimate the shape parameter γ for each industry through a log-log regression of $\hat{c}^l(c)$ on its empirical cumulative distribution. Two comments are in order about our procedure. First, being the revenue based UIR of the least productive firm, the quantity $\tilde{c}^l(c^{ll})$ can be mis-measured due to the presence of outliers. As known, three types of outliers are usually recognized. Vertical outliers have outlying values on the y-axis, good leverage points have outlying values on the x-axis but located close to the regression line. Bad leverage points are both outliers in the space of the explanatory variables and located far from the (true) regression line. As we are more concerned with the slope parameter than with the intercept, vertical outliers are less of a problem whereas it is the presence of bad leverage points that can severely bias the slope estimate. Unfortunately, robust regression methods conceived to deal with this issue (MM-estimators) do not provide us with the R^2, which is our measure of the goodness of the Pareto assumption. Hence, we use an M-estimator (implemented in Stata through the command 'rreg') that downweights the observations with large residuals, thus avoiding the occurrence of inflated R^2's caused by the presence of good leverage points.[16]

Second, equation (21) is valid for sales to a given market l and the corresponding inputs $x^l(c)$. However, exporters may sell to different markets at different prices and a breakdown of input usage by destination market is not available. Therefore, there might be a bias as long as export prices are

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[13] One could be tempted to conclude that these problems are specific to our linear demand structure while being not relevant for the more frequently used CES demand with constant markups (see, e.g. Melitz, 2003). In the CES case, however, the problem with using revenue based UIR is even worse. To see this, call σ the constant demand elasticity. Then, one obtains $\tilde{c}^l(c) = [(\sigma - 1)/\sigma]\,(\tau^{ll} B\omega^l)^{-1}$, which is completely uninformative about c. We thank Jonathan Eaton for bringing this point to our attention.

[14] We include data on Norway in the production function estimation in order to improve the quality of our results. Norwegian data in the Amadeus are indeed of high quality in terms of firm coverage. This is unfortunately not the case for other European countries in the dataset.

[15] Consistently with the theoretical framework, the estimated production function coefficients are obtained under the assumption that all the European firms in a given sector use the same technology. However, we include country dummies in the TFP estimating equation in order to allow for country-specific productivity shocks potentially correlated with labour and capital use as well as with firm-level productivity shocks unobservable to the econometrician.

[16] For more details on the 'rreg' command see Croux and Verardi (2009).

systematically lower or higher than domestic ones. This is likely to be not much of an issue as domestic sales typically represent most of exporters' revenues and exporters are themselves a tiny fraction of all European producers (see, e.g., Mayer and Ottaviano, 2007). Nonetheless, we provide further evidence of this being a small problem by comparing the benchmark estimates obtained for all European firms with those obtained for non-exporting French firms.[17]

For each industry, Table 2 reports in column 4 (6) the estimated shape parameter γ and the corresponding standard errors of the foregoing OLS regression for all European firms (French non-exporters). The high R^2's in column 5 (7) reveal that the Pareto assumption fits well the data: the average cross-industry R^2 is 0.94 (0.90) in the case of all European firms (French non-exporters). Concerning the γ's, these are very precisely estimated in all cases. A striking feature is that there is much less heterogeneity across industries in terms of γ's than in terms of trade costs. The two groups of estimates, obtained for all European firms and for French non-exporters only, are not identical but the means across industries are very close: 1.79 and 1.96 respectively. Estimates of γ based on $\tilde{c}^l(c)$ in column 8 are always larger than those based on $\hat{c}^l(c)$, which suggests that neglecting firm heterogeneity in prices leads to the underestimation of firm heterogeneity in productivity. This is consistent with the theoretical results in Del Gatto *et al.* (2008) and the empirical evidence in Foster *et al.* (2008), who report a smaller standard deviation in TFP based on value added with respect to those based on physical output. In Section 5, we will show that our results are robust to alternative estimates of the shape parameter.

3.3 Endogenous and Exogenous competitiveness

In the third and last step of the benchmark estimation, we start with deriving the endogenous competitiveness (i.e. the cost cutoff) m^h in each country from price aggregates. We then use (18) to back out the set of exogenous competitiveness values ψ^l consistent with the latter and the previously estimated values of P and γ.

Endogenous competitiveness ($1/m^h$). The cost cutoff can be readily obtained as a function of the average price by rearranging the corresponding expression in (14) to yield:

$$m^h = \frac{2(\gamma+1)}{2\gamma+1}\overline{p}^h \tag{22}$$

As evident from (17), the factor multiplying $\overline{p}^h$ in (22) plays no role in the evaluation of counterfactual percentage changes. Therefore, only data on average producer prices, comparable across countries at the industry level, are needed for subsequent simulation. These are provided by EU Klems database, described in Timmer *et al.* (2007), for 1997 at the level of Nace 2 digit classification. We convert these data from 1997 to 2000 using country-industry specific value added deflators and match our 18-industry classification by weighing Nace 2 digit prices by the total hours worked in 2000.[18] Results are listed in Table 3.

Exogenous competitiveness ($1/\psi^h$). We use (18) to derive the exogenous competitiveness values ψ^l, up to a multiplicative constant, using estimates of P and γ as well as m^h. We further bootstrap 200 times the residuals obtained from the estimation of P and γ to create alternative values for trade costs and the shape of the productivity distribution. We then use such values to solve 200 times for ψ^l in (18) and obtain the distribution of each exogenous competitiveness parameter. Dots in Figure 1 represent the computed (log) values of $1/\psi^l$ for the EU-15 with higher values corresponding to higher exogenous competitiveness. Triangles and squares depict, respectively, the 5th and 95th percentiles of the distribution obtained by bootstrapping. The Figure reveals both substantial heterogeneity across industries and, with the exception of few cases, tight confidence intervals.

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[17] The choice of French firms is dictated by the very precise information about their export status in the Amadeus database.

[18] See Appendix B for additional details.

To better understand the relation between endogenous competitiveness and exogenous competitiveness, Table 4 reports two country rankings obtained by aggregating $1/m^h$ and $1/\psi^h$ based on the corresponding industry production share. The fourth column shows the difference between the positions in the two rankings. These are quite dissimilar and (11) explains why in terms of market size and remoteness. Three countries with high exogenous competitiveness, namely Austria, Finland and Sweden, are too small and too peripheral to fully exploit their potential, thus ending with a much lower endogenous competitiveness rank. By contrast, centrally located countries, like Belgium and the Netherlands, benefit from their central geography ending up with a higher rank in terms of endogenous than exogenous competitiveness. Finally, some large countries like Germany and Italy owe part of their endogenous competitiveness to market size. Once discounted for population, their exogenous competitiveness is revised downwards.

3.4 Validation

Before turning to counterfactuals, it is important to assess the extent to which our model is able to reproduce patterns of the data that have not been directly used for its benchmark estimation. In so doing, we choose to focus on France because of extended data coverage and high quality in the Amadeus database. Moreover, we are able to complement the Amadeus data with detailed information on French manufacturing firms provided by the database EAE (Enquete Annuelle Entreprises).[19]

We first compare the predictions of our model with what is actually observed in the data; then we discuss its performance with respect to competing trade models with firm heterogeneity.

3.4.1 Comparison with the data

We focus on five key measures: revealed comparative advantage across sectors; the share of firms that export; the fraction of exporters' revenues from exports; the size advantage of exporters; and their productivity advantage. The choice of these measures is driven by data availability.[20]

Revealed comparative advantage. We start with checking whether our micro model with heterogeneous firms generates predictions that are consistent with the received wisdom based on the concept of comparative advantage, according to which countries tend to export goods in sectors where their production costs are relatively low with respect to other countries. Within our framework, this implies that countries should export goods in sectors where their cutoff costs are relatively low. To see whether this is indeed the case, we compute the correlation between the cutoffs and a standard index of 'revealed comparative advantage'. This index measures export specialization by industry as

$$RCA_s^h = \frac{\sum\limits_{l} T_s^{hl} / \sum\limits_{l,s} T_s^{hl}}{\sum\limits_{h} \sum\limits_{l} T_s^{hl} / \sum\limits_{h} \sum\limits_{l,s} T_s^{hl}}, \tag{23}$$

where the term T_s^{hl} stands for export flows from h to l in industry s.

Table 5 reports the correlation across industries of RCA_s^h and m_s^h for a given country, with the latter being deflated by the industry mean. Countries are expected to specialize in industries where they have relatively lower cutoffs with respect to cross-country industry averages, leading to a negative correlation between average producer price and revealed comparative advantage across industries. Table 5 confirms that this is indeed the case for 10 of our 14 European countries.

Share of firms that export. Our second check targets a key prediction of our model with firm heterogeneity, according to which exporters are only a fraction of all firms. In 2000 the share of exporters

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[19] See Appendix B for additional details. Figures on the size and productivity advantages of exporters do not include the Petroleum and Coal industry as this behave as an outlier.

[20] Further details on how the various measures are computed from the model are available upon request.

in the whole population of French manufacturing firms was equal to 22.26%.[21] This figure can be considered as fairly stable over time (see Eaton *et al.*, 2008). Our model predicts that 25.01% of French firms should be exporters.

Fraction of revenues from export. Our third check concerns 'export intensity', defined as the fraction of firm revenues coming from exports. Table 6 compares the predictions of our model on the ratio of export revenues to total revenues with the actual distribution across French exporters. The second column, taken from Eaton *et al.* (2008), shows the actual percentage of exporting French firms getting a given share of their revenues from exports while the third columns reports predicted percentages. Our model does not match the high share of exporters declaring small export volumes. It is, however, able to predict that quite a few firms have very high export intensity (90 to 100%). Matching the pattern for high export intensity can be regarded as more important than matching the pattern for low export intensity as data on small export declarations are typically more noisy.

Size advantage of exporters. Our models with firm heterogeneity not only predicts that exporters are a subgroup of the population of firms. It also predicts that they are a 'selected' subgroup exhibiting better performance that other firms. In this respect, an obvious measure of performance is firm size.

Hence, our fourth check computes the size advantage of exporters as the percentage difference ('premium') between exporters' and non-exporters' domestic sales. We observe that exporters in the EAE dataset have a 149.35% advantage compared to non-exporters (i.e. the ratio of average domestic sales of exporters and non-exporters in 2.49). The model predicts a 119.26% size advantage.

Productivity advantage of exporters. Our final check considers firm productivity as this is the performance measure that our model stresses as the underlying determinant of firm size. The productivity advantage is measured by the percentage difference ('premium') between exporters' and non-exporters' TFP. For this calculation we rely again on the OP estimates. We obtain that the productivity advantage of exporters over firms serving only the French market is equal to 7.92% in the EAE data. This is much lower than the 259.38% premium predicted by our model.

As our model seems to fail this last check, it is worthwhile trying to understand why. Let us distinguish between two related issues. The first is its (large) overprediction of the productivity advantage of exporters. The second concerns its simultaneous (small) underprediction of their size advantage. As we will discuss in Section 3.4.2, the first issue is common to models with firm heterogeneity and can be due to two concurrent reasons. On the one hand, models with firm heterogeneity predict that the least productive exporter is more productive than the most productive non-exporter. This 'strict sorting property' does not hold empirically and has been shown to account for the severe overprediction of the size advantage in US firm sales data (Armenter and Koren, 2009). On the other hand, the overprediction of the model with respect to the actual data may also be due to the fact that our French data are left-censored. Due to the Pareto assumption this does not matter for our TFP estimates, but it biases the observed size and productivity advantages downwards. In particular, the 24,461 firms in the EAE database represent about 10% of the 251,357 manufacturing firms active in France in the year 2000. The reason is that only firms with at least 20 employees or more are recorded in the EAE database with 73.16% of them being exporters. When we truncate our simulated firm distribution to get that 73.16% of firms export, we are able to predict that exporters are only 15.83% more productive than the average firm, which is much closer to what is observed in the data.

This brings us to the second issue concerning our simultaneous slight underprediction of the size advantage of exporters. Domestic sales and measured productivity are closely related both in the model and in the data. In the model both are convex decreasing functions of the underlying cost parameter c. However in the model productivity has an infinite support, while sales revenues have a finite support as marginal utility is bounded. For instance, a zero cost firm from country h would have infinite productivity but finite sales equal to $L(c^{hh})^2/4\eta$. Our model is, therefore, less likely to underpredict the productivity

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[21] We thank Benjamin Nefussi of CREST-INSEE for computing this figure for us.

advantage than the size advantage of exporters. While, of course, overpredicting the former and underpredicting the latter is by no means a necessary outcome, it is nevertheless an outcome consistent with our model.

3.4.2 Comparison with other models

In the previous sections we have shown that our model satisfactorily passes four validation checks out of five. We have also explained why it may find the fifth check more challenging. Before using our model as a tool to evaluate different trade policy scenarios, it is nonetheless important to evaluate its performance against alternative analytical frameworks also featuring firm heterogeneity.

In this respect, the first natural alternative is the model by Bernard *et al.* (2003). This model predicts that 51% of US firms export, compared with an observed 21%. In contrast our model predicts a 25.01% share of exporting firms to be compared to the observed 22.26% share. As for the size and productivity advantages of exporters, Bernard *et al.* (2003) use them to calibrate their model and, therefore, those premia cannot be used to validate its predictions. Lastly, their model does a better job in matching the fraction of revenues from export for low export intensity firms, but severely underpredicts productivity dispersion.[22]

A second alternative is the model by Melitz (2003) that, in the absence of fixed cost data, can be calibrated on the observed share of exporters. Let us first consider the implied size advantage of exporters. Calibrating the Melitz model on our data (with a price elasticity of demand between 5 and 10) generates an implausible high size premium in the $[343\%, 5177\%]$ range.[23] In contrast, our model yields a 119.26% premium which is much closer to the observed 149.35%. Second, the Melitz model fails to match the (revenue-based) TFP advantage. In particular, with its constant markups, the Melitz model predicts identical revenue-based productivity across all firms. This is clearly rejected by the data. In contrast, our model endogenizes markup differences across firms. Lastly, the Melitz model also overpredicts the productivity advantage of exporters as we do. As already argued, this may be partly due to the 'strict sorting' property of the two models. Armenter and Koren (2009) show that, due indeed to the strict sorting property, the Melitz model overpredicts the actual sales revenue advantage by a factor 21 in US data.[24]

In sum, our model picks up important qualitative features of data on export, productivity, and sales, with a quantitative fit that is comparable to that of the model by Bernard *et al.* (2003) and arguably better than a calibrated version of the model by Melitz (2003). In particular, our fit of the size advantage of exporters is actually remarkably good, compared to other available calibrations/estimations (Armenter and Koren, 2009).

4 Counterfactual Scenarios

Having estimated and validated our model, we can now use it to simulate the effects industry by industry of trade frictions in different counterfactual scenarios. This is achieved by recomputing for each country the remoteness associated with a counterfactual trade freeness matrix P_* while keeping the exogenous competitiveness and the shape parameters at the values computed in the benchmark scenario. The resulting remoteness $r_*^h\left(P_*, \psi^1, ..., \psi^M\right)$ is then substituted into (17) to obtain the percentage changes in the cutoff costs. These in turn map into percentage changes in average productivity, delivered costs, markups, prices, quantities sold and profits that we are able to quantify by (14), as well as into variations

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[22] In a robustness check we set the Pareto shape parameter $\gamma = 3.6$ as in Bernard *et al.* (2003). The model's fit is similar to the baseline specification, but our predicted productivity advantage fits the data better (a 47.17% premium). This suggests that their and our paper face a tradeoff between matching moments of the TFP distribution and matching productivity differences between exporters and non-exporters.

[23] Anderson and van Wincoop (2004) conclude that $[5, 10]$ is the most plausible range, after a survey of several studies that estimate price elasticities using different methods and different datasets.

[24] While heterogeneity across firms in trade costs, as in Armenter and Koren (2009) or Eaton *et al.* (2008), could help solving this problem, the resulting model would become much less tractable and more difficult to calibrate.

in the number of available varieties and welfare that we are able to sign by (15) and (16) respectively. In particular, (14) implies the following relation between average performance variables and cutoff cost changes:

$$\frac{\overline{m}_*^h - \overline{m}^h}{\overline{m}^h} = \frac{\overline{\mu}_*^h - \overline{\mu}^h}{\overline{\mu}^h} = \frac{\overline{q}_*^h - \overline{q}^h}{\overline{q}^h} = \frac{m_*^h - m^h}{m^h}, \quad \frac{\overline{\pi}_*^h - \overline{\pi}^h}{\overline{\pi}^h} = \frac{\left(\overline{m}_*^h\right)^2 - \left(\overline{m}^h\right)^2}{\left(\overline{m}^h\right)^2} \tag{24}$$

where the asterisk labels counterfactual values. Moreover, according to (15) and (16), the number of varieties sold in a country and the welfare of its residents change in the opposite direction of its cutoff cost.

We introduce four counterfactual experiments in which we compute changes in cutoff costs and performance variables. For all the counterfactual experiments, we report the percentage effects on both the endogenous competitiveness $1/\overline{m}^h$ and the average cutoff cost $\overline{m}^h$. However, since these variables are closely related to each other, for parsimony we restrict our comments to the former variable, emphasising productivity (TFP) changes as we keep factor costs unchanged.

Non-Europe. As already mentioned, in 2000 59.2% of the imports and 58% of the exports of EU-15 countries concerned other EU-15 countries. This high level of European trade integration was achieved not just by eliminating all tariff barriers within the EU, but also by introducing mutual recognition of EU products, legal harmonization and other non-tariff barriers liberalization measures. What would be the cost of undoing these measures? In Section 4.1 we consider the counterfactual situation where intra-EU trade barriers would be set as the same level as with the rest of the world (RoW). This counterfactual experiment captures what the European Commission's 1988 Cecchini Report (European Commission, 1998) referred to as the 'costs of non-Europe': the foregone benefits of not having a single European market.

Tariff 1: External Tariff. As mentioned in the Introduction, the temptation of protectionism in the aftermath of the crisis looms large. As this temptation rises for a large number of policy-makers, including European ones, a possibility is that countries will end up introducing new external tariffs or some other sort of trade barrier. In Section 4.2 we examine what would have happened, had the EU-15 and RoW countries introduced an external across-the-board tariff of 5% while leaving intra-EU trade barriers unchanged. In this scenario trade costs $\tau^{lh} \equiv \left(\rho^{lh}\right)^{-1/\gamma}$ are increased by 5% if $l \neq h$ and if either l or h are outside the EU-15.

Tariff 2: External and Internal Tariff. Of further interest is the study of further protectionism among EU member states. We next consider a combination of a 5% internal EU-15 tariff with a 5% common external tariff. In Section 4.3 we examine a counterfactual increase of all trade costs $\tau^{lh} \equiv \left(\rho^{lh}\right)^{-1/\gamma}$ by 5% whenever $l \neq h$.

Intra- vs Inter-national trade. Finally, in Section 4.4 we look at the effect of either a 5% international or intra-national trade costs decrease and compare the two sets of results. For data availability reasons, we focus on the case of a large European country (France) that is divided up into its 21 NUTS2 continental regions. The goal of such an exercise is to compare the relative importance of inter- and intra-national trade in terms of the productivity gains from trade. In a world where the media and policy makers seem to be mainly concerned with what happens at the global level, it might be useful to remind them of the importance of intra-national trade barriers.

4.1 Non-Europe

In this section we look at the impact on endogenous competitiveness of an increase in intra-EU-15 trade frictions at the same level of those between the EU-15 and the RoW. Specifically, we examine changes in θ_B^{EU} as defined in Equation (20). We counterfactually set the border-related parameter $\theta_B^{EU} = 0$ and change the trade freeness matrix accordingly. Other trade frictions related to distance or language barriers are unaffected. Our experiment can, therefore, be thought of as the undoing of tariff and non-tariff barriers liberalization within the EU-15, when other trade costs are kept constant.

Note that our estimates of θ_B^{EU} are positive and significant (at the 5% confidence level) in 13 out of the 18 industries considered. This result strongly indicates that intra-EU trade indeed benefits from lower trade frictions. In the other cases, θ_B^{EU} is not significantly different from zero or, for the Professional and Scientific Equipment industry, it is negative and significant suggesting that there might be something special about this sector. In what follows we consider changes in endogenous competitiveness, average costs, cutoffs, etc., in the 13 industries for which there is strong evidence of higher intra-EU trade integration only.

The second and third columns in Table 7 report the simulated percentage changes in EU-15 endogenous competitiveness $1/\overline{m}^h$ and average cutoff costs $\overline{m}^h$ with respect to the benchmark estimation. Changes are computed by country-sector and averaged at the country level using the value of production as a sector weight. Similarly the second and third columns of Table 8 report the simulated percentage changes in endogenous competitiveness and average cutoff costs by industry. Changes are computed by country-sector and averaged at the sectoral level using the value of production as a country weight.

We can draw two lessons from Table 7. First, undoing behind-the-border integration in the EU-15 has sizeable costs. The average EU-15 country incurs a 7.02% permanent loss to average TFP, and an equivalent increase in average prices, markups and output. Using each country's share of EU-15 manufacturing output as weights, this corresponds to an aggregate 3.18% productivity loss. As for profits, by aggregating across EU-15 countries, we get a 6.57% reduction.

Second, losses vary substantially by country and by industry. A cross-country comparison suggests that peripheral EU-15 countries, such as Ireland, Finland, Portugal and Spain lose the most. Among central countries, smaller countries such as Belgium, Austria, or Denmark lose more than larger countries such as Germany, Great Britain or France. The quantitative lesson is that productivity losses to small peripheral countries, such as Ireland, can be one order of magnitude above losses to large central countries such as Great Britain or Germany. Losses vary substantially across industries too. Quantitatively, differences amount to up to one order of magnitude, from a 0.47% loss in average productivity in the Printing and Publishing industry, to a 8.39% loss to the Leather Products and Footwear industry. Qualitatively, industries with lower trade costs (i.e. lower magnitude of δl) lose more than the others. Finally, Table 7 reveals that the RoW would be positively affected by the undoing of EU-15 integration. This is due to the fact that the EU-15 space would become less competitive with firms from other countries being able to break even more easily thanks to higher prices.

How do we interpret this border-related countefactual analysis in terms of changes in actual trade barriers? One can expect border effects to vary with country size and geography, as shown by Anderson and van Wincoop (2003), but do border effects reflect legal obstacles to trade? Evidence is mixed. On the one hand, Head and Mayer (2000) show that non-tariff barriers to trade do not explain border effects in Europe while Hillberry (1999) finds little evidence that tariffs, regulations, information and communication costs are related to border effects either. On the other hand, Chen (2004) shows that technical barriers to trade (TBTs) play a significant role in explaining the border effects, using data collected by the European Commission in 78 of the 246 manufacturing industries that compose the Nace rev.1 classification. Our counterfactual experiment may therefore be interpreted as a re-introduction of TBTs, as could for example result from abandoning the principle of mutual recognition of products.

4.2 Tariff 1: Higher tariffs between the EU-15 and the rest of the world

The fourth and fifth columns of Tables 7 and 8 report the losses from the introduction of a 5% external tariff by both the EU-15 (as a whole) and the RoW countries. The average EU-15 country experiences a 0.49% loss in productivity, and an equivalent increase in average prices, markups and output. Weighted by each country's share of production, this corresponds to an aggregate 0.26% loss in productivity. The corresponding aggregate figure for profits is a 0.52% reduction. As for the RoW, its aggregate loss is larger

(0.91%) reflecting the preferential nature of the tariff introduction that leaves trade frictions between EU-15 countries unaffected. Differences between EU-15 countries mostly follow the same pattern as the costs of non-Europe. An exception is Austria where productivity actually increases as a result of the 5% tariff. This is likely to come from beneficial trade diversion, in the sense that the counterfactual remoteness r_*^h now favors trade with the closer and relatively competitive Central European countries.

Likewise, average productivity losses vary substantially across industries, ranging from a 2.03% loss in the Other Manufacturing category to a -0.10% gain in the Transport Equipment industry. It is worth stressing that, although we work with a partial equilibrium model with exogenous factor costs, some sectors gain while other lose with differences being up to one order of magnitude. Trade policy changes have important distributional consequences, even when traditional theoretical channels for increases in inequality (like factor re-allocation across industries) are not considered.

4.3 Tariff 2: Higher tariffs between any pair of countries

The sixth and seventh columns of Tables 7 and 8 report the losses in average productivity due to a further 5% internal tariff among EU-15 partners. The average EU-15 country experiences a 2.17% loss in productivity, and an equivalent increase in average prices, markups and output. Weighted by each country's share of production, this maps into an aggregate 1.25% loss in productivity which is five times larger than in the previous case. The corresponding aggregate figure for profits is a 2.54% reduction. These results shed light on how the cost of protectionism could be much higher were EU-15 trade relationships also affected.

Once again, average productivity losses to individual countries vary by more than an order of magnitude, from a 0.32% decrease in average British productivity to a 5.67% decrease in Irish productivity. Interestingly, Austria now experiences a loss, not a gain, from the compounded effect of both internal and external tariffs. Losses tend to be greater for peripheral, small countries. Similarly, cross-industry heterogeneity is substantial, with losses ranging from 0.20% in the Printing and Publishing industry to 2.88% in the Other Manufacturing industry.

4.4 Inter- vs. Intra-national trade

This counterfactual requires that we adapt our procedure to two important data constraints. First, regional price indices are rarely available and France is no exception. We are, therefore, unable to estimate the cutoff cost in a region using its average producer price. For this reason we investigate the relative importance of inter- and intra-national trade in a thought experiment, in which each French region is initially attributed the national cutoff cost of France. This situation would arise if, for instance, factor rewards were proportional to local productivity in all regions.

Second, trade flows by industry are not available for French regions, so we cannot apply the gravity regression (20) to origin-destination pairs involving those regions. We circumvent this limitation by building on the results by Combes *et al.* (2005). Using data on trade across French regions for the whole manufacturing sector, Combes *et al.* (2005) provide several gravity specifications and overall find a distance elasticity in line with what is usually obtained in comparable estimations based on international data. We thus use our previously estimated coefficients for distance (as well as those for language, contiguity, and borders) to reconstruct the trade freeness between French regions and our group of countries using compatible distance measures.[25] As for trade freeness between French regions, we use our coefficients of the distance elasticity while borrowing from Combes *et al.* (2005) the values of the contiguity and border parameters associated to regional trade.[26]

Together with the shape parameters previously estimated from Amadeus data and the regional populations obtained from Eurostat, our initial endogenous competitiveness and the reconstructed trade freeness can be used as usual to recover the underlying exogenous competitiveness ψ^l and perform a counterfactual analysis. Table 9 displays the results. First, a 5% decrease in inter-national trade costs

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[25] See Corcos *et al.* (2007) for additional details.

[26] We consider parameter values from column 1 of Table 6 in Combes *et al.* (2005).

across all countries have a stronger effect on French regional productivity than a 5% decrease in intra-national trade frictions. The average French region experiences a 6.64% productivity gain from lower inter-national trade costs and, averaging across regions using gross regional products (GRP) as weights, this translates into a 4.15% productivity gain for France as a whole. This compares to a 2.42% productivity gain for the average French region, and an aggregate gain of 1.41% for France, in the case of lower intra-national trade costs across these regions.[27]

Second, gains in both scenarios vary substantially across regions. Not surprisingly, central regions gain more from changes in intra-national trade costs: the 6.16% and 4.12% productivity gains of Limousin and Picardie contrast with the 1.01% and 0.68% gains of Nord-Pas de Calais and Rhône-Alpes, respectively. In turn, border regions gain more from decreased international trade costs with, for example, Alsace (17.25%) and Basse-Normandie (13.23%) enjoying higher benefits than Rhône-Alpes (1.97%) and Centre (4.84% gain). We also find that gains from reduced intra-national trade barriers are negatively correlated with per capita GRP, while the correlation is positive for gains from reduced inter-national frictions. Greater Paris (Ile de France) stands as an outlier, benefiting very little in both scenarios because of the large gap in size and exogenous competitiveness with other regions.

5 Robustness Checks

Our results are robust to alternative trade costs and productivity measures. Percentage changes in the endogenous competitiveness of European countries (as well as RoW) and French regions are shown in Tables 10 and 11 respectively. For each counterfactual scenario we compare the results obtained in the previous Section with those obtained in the various robustness checks.[28]

Trade Costs Estimations: OLS. The PPML estimator used to recover the trade costs from (20) has many advantages with respect to OLS implemented on the log-linearized model. However, while PPML is relatively new in the literature, it is well known that it delivers quite different results from OLS. In particular, the distance elasticity obtained by PPML is usually smaller than that obtained by OLS and one may wonder whether and how this would affect our findings. Results show that the magnitude of losses and gains is smaller under the OLS specification, the reason being that our theoretical model delivers larger changes when trade costs are small. Indeed, OLS provide higher magnitudes for the gravity parameters and a freeness matrix P pointing to higher levels of trade barriers.

Productivity Estimations: LP. One key drawback of the Olley and Pakes (1996) methodology and its refinements is that it restricts production function estimations to the sample of firms with positive investments. This reduces considerably the number of available firms while introducing a possible selection bias. In order to check the robustness of our results, we use the Levinsohn and Petrin (2003) methodology (LP) that requires intermediate inputs consumption to be positive thus imposing a much weaker selection constraint. Following the same procedure as in Section 3.2, we first apply this technique to estimate $\tilde{c}^l(c)$ and then recover the shape parameter γ from the distribution of $\hat{c}^l(c)$. Results are extremely close to those of the baseline specification thus suggesting that the productivity estimation technique does not play a major role in our analysis.

Measurement Error in Value Added: BEJK. An issue raised by Bernard *et al.* (2003) is that value added at the firm level is likely to be measured with error. Value added is the dependent variable in the estimation of productivity. Measurement error in the dependent variable is not an issue for the

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[27] Though this quantitative balance is in favor of inter-national trade, a more thoughtful comparison should also consider the various costs and political difficulties associated with the implementation of the two types of trade barriers reductions. It is beyond the scope of our analysis to provide a quantitative figure for those costs.

[28] Apart from the robustness checks discussed in this section, we have experimented also with different distance and common language indicators (see Appendix B). The corresponding results are available upon request and are virtually identical to the ones reported here.

consistency of the production function parameter estimates. It may be, instead, an issue for the estimation of $\widetilde{c}(c)$. Specifically, being measured as a residual, $\widetilde{c}(c)$ is likely to display a much higher variance due to measurement error. In our model the shape parameter γ is inversely related to the variance of the UIR distribution and might be, therefore, underestimated. In order to provide insights on the potential bias for our results, we experiment with a higher value of $\gamma = 3.6$ borrowed from Bernard *et al.* (2003).[29] Losses in the counterfactual scenario of Non-Europe are very close. However, the magnitude of losses and gains in all the 5% trade costs increase and decrease counterfactuals are larger. This is due the fact that, a given change in trade costs $\tau^{lh} \equiv \left(\rho^{lh}\right)^{-1/\gamma}$ maps into a different change in trade freeness ρ^{lh} depending on the value of γ. The higher value of $\gamma = 3.6$ magnifies the impact of changes in τ^{lh} so inducing larger productivity variations.

6 Conclusion

We have suggested how standard computable equilibrium models of trade policy could be enriched with selection effects. This has been achieved by carefully estimating and simulating a partial equilibrium model derived from Melitz and Ottaviano (2008). Applying the model to EU countries we have shown that changes in internal or external trade barriers have relevant welfare effects through their impacts on average productivity, markups, prices, firm scale and product variety.

We believe that our analysis provides enough ground to support the inclusion of firm heterogeneity and selection effects in the standard toolkit of trade policy evaluation. The next step would be to embed our partial equilibrium approach into existing computable general equilibrium (CGE) models.

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A Appendix: estimation of firm-level UIR

The two main issues we address in the estimation of firm-level UIR are: simultaneity and price dispersion.

Simultaneity The simultaneity problem stems from the fact that information on the actual level of c, although unknown to the econometrician, is to some extent included in the information set of the firm when the decision concerning the amount of inputs is made. If this is the case, the estimated production function parameters obtained by applying simple OLS to a logarithmic transformation of (3) are biased due to the correlation between the regressors and the error term. To tackle this problem, we estimate c using a semi-parametric approach, as suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003). As both OP and LP assume that labour is a fully variable input, we use the more realistic correction suggested by Ackerberg *et al.* (2006). For more details on the OP and LP routines, as well as on how to implement the ACF correction, the reader is redirected to Del Gatto *et al.* (2010). Our estimation strictly follows the description in their Section 5.2.1.

Omitted price bias Productivity estimation at the firm level would require detailed information on physical output. This is very seldom available in firm level datasets, so that the production function parameters are commonly estimated on the basis of firms' revenue or value added instead of produced quantities. Although common in the empirical literature, this introduces a bias in the estimates, as long as the reference market structure is not perfectly competitive.

To gain insights on this omitted price bias, it is worth abstracting from the simultaneity bias and write the estimating version of the log of equation (3) as follows (dropping firms' and countries' indexes to simplify notation):

$$va = \frac{1}{c} + \mathbf{x}\beta + e \tag{25}$$

where va denotes firm's revenues (which equals value added in our model), β is the vector of production function coefficients, $\mathbf{x}$ is the $(1 \times L)$ vector of inputs, and e is an iid stochastic disturbance capturing measurement errors and other idiosyncratic shocks. The OLS estimator of β is:

$$\tilde{\beta}^{OLS} = (\mathbf{x}'\mathbf{x})^{-1}\mathbf{x}'va$$

where, following the notation introduced in Section (3.2), $\tilde{\beta}^{OLS}$ is the OLS estimator of the "revenue based" coefficients $\tilde{\beta}$. Bearing in mind that $va = q + p$, the probability limit of $\tilde{\beta}^{OLS}$ can be written as:

$$plim_{N\to\infty}(\tilde{\beta}^{OLS}) \equiv \tilde{\beta} = \beta + plim_{N\to\infty}\left[(\mathbf{x}'\mathbf{x})^{-1}\mathbf{x}'p\right] \tag{26}$$

where N is the number of observations, p is the vector of individual prices and we have assumed orthogonality in the error. The second term on the right hand side is the *omitted price bias*. To make the direction of this bias more explicit, it is worth thinking of it as the OLS estimator of vector ξ in the auxiliary regressions

$$p = \mathbf{x}\xi + u \tag{27}$$

where u is an orthogonal error term. Accordingly, we can write:

$$plim_{N\to\infty}(\tilde{\beta}^{OLS}) = \beta + \xi \tag{28}$$

so that in the limit:

$$plim_{N\to\infty}(\frac{1}{\tilde{c}}) = va - \mathbf{x}\,plim_{N\to\infty}(\tilde{\beta}^{OLS}) = \frac{1}{c} - \mathbf{x}\xi$$

where $\tilde{c}$ is the "revenue based" estimated UIR and $\mathbf{x}\xi$ is the omitted price bias.

As long as the theoretical framework provides a negative relationship between prices and quantity of inputs in (27), the associated bias is a decreasing function of c. To see this in our model, use the production function (3) to replace for quantity in (1). This yields:

$$p^l(c) = \frac{\alpha - \eta Q^l}{L^l} - \frac{\upsilon}{L^l}\frac{1}{c}x^l(c) \tag{29}$$

Equation (29) clearly shows that the omitted price bias is, through the slope parameter $(\upsilon/L^l)(1/c)$, decreasing in c. The relationship vanishes when markets are perfectly competitive ($\upsilon = 0$).[30]. In other words, *disregarding price dispersion results in understating the productivity of the more productive firms, and this bias is the higher the less competitive the market is.*

The inconsistency of the estimator obtained from a production function regression like (25) has been highlighted by Klette and Griliches (1996), who show how using firms' (deflated) sales systematically leads to downward biased returns to scale. Klette and Griliches (1996) provide a remedy but in absence of simultaneity. Levinsohn and Melitz (2002) show that, in a CES context with constant markups, semi-parametric methods (i.e. OP and LP) can be enriched to control for price dispersion, as well as simultaneity. This approach, recently followed by Del Gatto *et al.* (2008) and De Loecker (2007) (see Del Gatto *et al.*, 2010 for a review), is however not appropriate in our framework, as we assume variable markups.

We now turn to the correction to apply in order to get a consistent estimator of γ. The idea consists of transforming $\tilde{c}^l(c)$ into an observable auxiliary statistics $[\hat{c}^l(c)]$ which is a simple monotone transformation of the true UIR and is no longer affected by the omitted price bias.

To illustrate the correction, use (4) and (5) to write $\tilde{c}^l(c)$ as

$$\tilde{c}^l(c) = \frac{2\left(\tau^{ll}B\omega^l\right)^{-1}c}{c^{ll} + c} \tag{30}$$

where $c^{ll} \equiv m^l/(\tau^{ll}B\omega^l)$ is the UIR of a firm based in h that is just able to serve the domestic market. By definition, this firm (i.e. the "marginal" firm) prices at marginal cost, so that $p^{ll}(c^{ll}) = m^l$. Thus, $\tilde{c}^l(c^{ll}) = c^{ll}/p^{ll}(c^{ll}) = \left(\tau^{ll}B\omega^l\right)^{-1}$, entailing that (30) can be written as

$$\tilde{c}^l(c) = \frac{2\tilde{c}^l(c^{ll})c}{c^{ll} + c} \tag{31}$$

Now, the following transformation of $\tilde{c}^l(c)$ can be used to obtain an auxiliary observable statistic, which is based on the estimated revenue based UIR but is no longer a function of the true UIR c:

$$\hat{c}^l(c) = \frac{\tilde{c}^l(c)}{2\tilde{c}^l(c^{ll}) - \tilde{c}^l(c)}. \tag{32}$$

Indeed, using (31) to substitute for $\tilde{c}^l(c)$ in (32) yields

$$\hat{c}^l(c) \equiv \frac{c}{c^{ll}} \tag{33}$$

which is simply the "true" UIR divided by the upper bound of the true UIR distribution.

B Appendix: Data sources

Gravity measures: Trade flows. Data on trade flows are drawn form the Trade and Production database (*http://www.cepii.fr/anglaisgraph/bdd/TradeProd.htm*), provided by the Centre d'Etude Prospectives et d'Informations Internationales (CEPII). The dataset, used in Mayer and Zignago (2005),

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[30] Similarly, in a CES context, the relation would be: $p^l(c) = \left(c/x^l(c)\right)^{1/\sigma}\left(E^l/Q^l\right)$, where σ denotes the elasticity of substitution and E is industry total expenditure.

comprises trade and production figures in an ISIC 3-digit classification, which is consistent across a large set of countries over the 1976-2001 period.

Gravity measures: Distance. The distance measures provided by CEPII are in km and can be divided into simple measures (*dist* and *distcap*) and weighted measures (*distw* and *distwces*). In all reported estimations we use *distw*. In unreported estimations, available upon request, we have tried the other 3 measures obtaining similar results.

Simple geodesic distances are calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population) for the dist variable and the geographic coordinates of the capital cities for the *distcap* variable. These two variables incorporate internal distances (d^{hh}) that (as trade costs) we allow to be non-zero. They are based on the area of a country as in Head and Mayer (2004). In particular, the formula used to convert area into distance is $d^{hh} = (2/3)\sqrt{area^h/\pi}$. This formula models the average distance between a producer and a consumer on a stylized geography where all producers are centrally located and the consumers uniformly distributed across a disk-shaped region (see Head and Mayer (2002) for more details).

By contrast, weighted distances use city-level data on distances and the geographic distribution of population (in 2004) inside each nation. The basic idea is to calculate the distance between two countries as the weighted average bilateral distance between their biggest cities with the corresponding weights determined by the shares of those cities in the overall national populations. This procedure can be used in a totally consistent way for both national and international distances. Specifically, the general formula developed by Head and Mayer (2002) to calculate the distance between country l and h is:

$$d^{lh} = \left(\sum_{p \in l} \sum_{r \in h} (S^p/S^l)(S^r/S^h)\ (d^{pr})^\delta \right)^{1/\delta} \tag{34}$$

where S^p (S^r) denotes the population of agglomeration p (r) belonging to country l (h). The parameter δ measures the sensitivity of trade flows to bilateral distance d^{pr}. For the *distw* variable, δ is set equal to 1. The *distwces* calculation sets it equal to -1, which corresponds to the usual coefficient estimated from gravity models.

Gravity measures: Common Language Indicators. For each country, the CEPII provides 3 different common language indicators. The first one ($langoff$) considers that two countries share a language if the language is officially used by the public administrations of both countries. The second one ($lang9$) attributes a common language to a country pair if at least 9% of the population of both countries speaks the same language. Finally, $lang20$ attributes a common language to a country pair if at least 20% of the population of both countries speaks the same language. Our preferred measure is $langoff$ but unreported estimations, available upon request, show that the other two measures lead to similar results.

Firm-level data for productivity estimation. To estimate individual productivity we rely on the information on value added, capital, labor and investments provided by Bureau Van Dijk in the Amadeus database, which contains the most comprehensive and accurate information on European firms balance sheets data.

This data has been extensively used in recent empirical studies. See, e.g., Helpman *et al.* (2004) and Javorcik and Spatareanu (2008). The data we use refer to years 1998-2003 and cover 12 out of the 14 European countries group plus Norway. Value added for Greece and Ireland is in fact not available due to differences in accounting regulations that make balance sheets data not comparable to other European countries. This confirms the attention paid by Bureau Van Dijk in making data comparable across countries.

The resulting dataset is an unbalanced panel of 137,284 observations covering 32,840 firms spanning our 18 manufacturing industries. Details on the sectoral and country coverage are reported in Tables 13 and 12. Book capital value has been corrected using appropriate industry deflators.

Average producer prices for the domestic cutoff. Data on average producer prices, comparable across countries at the industry level, are provided by Timmer *et al.* (2007). The data represent an extension, in terms of both country coverage and accuracy, of the ICOP database provided by the Groningen GRoWth and Development Centre (*http://www.ggdc.net*). Data are originally available by Nace 2 digit industry and refer to the year 1997. To convert these data from 1997 to 2000 we use country-industry specific value added deflators. Finally, to match our 18-industry classification, we weight Nace 2 digit prices in each of our sectors by total hours worked in 2000. Both are drawn from the Groningen GRoWth and Development Centre "60-Industry Database", available on line. The computed m^h are listed in Table 3. We report them with two digits after the decimal point in order to save space.

The EAE database on French firms. The EAE (Enquete Annuelle Entreprises) database is provided by the SESSI (Service des Etudes et Statistiques Industrielles, French Ministry of Industry) and the SCEES (Service Central des Enquêtes et Etudes Statistiques, French Ministry of Agriculture and Fisheries). We use this dataset under the authorization of the French Conseil National de l'Information Statistique (CNIS). EAE provides detailed information on the balance sheets and location of all French manufacturing firms with more than 20 employees, as well as on a stratified sample of firms with less than 20 employees. It provides us with information about 24,519 manufacturing French firms, compared to 3,415 in the Amadeus database.

Table 1: *Gravity estimations.*

Industry	δ	δ^{SC}	θ_B^W	θ_B^{EU}	θ_{LB}	θ_{CB}
Food beverages and tobacco	-1.1305**	-0.1001**	-3.2100**	1.3480**	0.7650**	0.0906
	(0.0488)	(0.0112)	(0.0925)	(0.0526)	(0.0599)	(0.0673)
Textiles	-0.5407**	0.0526**	-2.4180**	0.6123**	0.6054**	0.5412**
	(0.0407)	(0.0100)	(0.0728)	(0.0613)	(0.0623)	(0.0535)
Wearing apparel except footwear	-0.6266**	0.0271	-2.9958**	0.8046**	0.5877**	0.6052**
	(0.0698)	(0.0152)	(0.1444)	(0.1125)	(0.1061)	(0.1052)
Leather products and footwear	-0.6997**	-0.0574**	-1.9472**	0.7099**	0.5977**	0.1675*
	(0.0560)	(0.0122)	(0.1362)	(0.0872)	(0.1051)	(0.0726)
Wood products except furniture	-1.4120**	-0.0299	-2.2878**	0.0397	0.3803**	0.6460**
	(0.0567)	(0.0181)	(0.1053)	(0.0655)	(0.0727)	(0.0811)
Paper products	-1.1430**	-0.0017	-1.8850**	0.5925**	0.5301**	0.3766**
	(0.0400)	(0.0087)	(0.0876)	(0.0543)	(0.0578)	(0.0487)
Printing and Publishing	-0.9902**	-0.0387**	-3.3415**	0.2205**	1.2079**	0.5433**
	(0.0518)	(0.0106)	(0.0880)	(0.0655)	(0.0675)	(0.0767)
Petroleum and Coal	-1.1866**	-0.0266	-2.6312**	0.2727*	0.8139**	0.3654**
	(0.0680)	(0.0162)	(0.1736)	(0.1171)	(0.1167)	(0.1168)
Chemicals	-0.8053**	-0.0353**	-1.4760**	0.4660**	0.5186**	0.0405
	(0.0584)	(0.0116)	(0.0916)	(0.0820)	(0.1005)	(0.0533)
Rubber and plastic	-0.9043**	-0.0013	-2.4284**	0.5355**	0.5859**	0.4954**
	(0.0330)	(0.0091)	(0.0615)	(0.0482)	(0.0493)	(0.0433)
Other non-metallic mineral products	-1.1747**	-0.1039**	-2.5351**	0.4734**	0.5118**	0.2972**
	(0.0384)	(0.0098)	(0.0786)	(0.0477)	(0.0474)	(0.0531)
Metallic products	-0.9130**	0.0075	-1.6281**	0.6305**	0.7832**	0.3076**
	(0.0495)	(0.0105)	(0.0776)	(0.0642)	(0.0825)	(0.0557)
Fabricated metal products	-1.0496**	-0.0337**	-2.1618**	0.0291	0.5388**	0.4793**
	(0.0689)	(0.0127)	(0.0787)	(0.0712)	(0.1046)	(0.0583)
Machinery except electrical	-0.9636**	-0.0782**	-0.8871**	0.1569	0.5798**	-0.0750
	(0.0800)	(0.0145)	(0.1106)	(0.0986)	(0.0756)	(0.0920)
Electric machinery	-0.7759**	-0.0279*	-0.9716**	0.1439*	0.4895**	0.2003**
	(0.0499)	(0.0121)	(0.1029)	(0.0713)	(0.0640)	(0.0621)
Professional and scientific equipment	-0.5745**	-0.0027	-1.0464**	-0.2977**	0.3238**	0.1447**
	(0.0503)	(0.0151)	(0.0865)	(0.0945)	(0.0672)	(0.0547)
Transport equipment	-1.0421**	-0.0358*	-0.9118**	0.2082*	0.4231**	0.2524**
	(0.0579)	(0.0162)	(0.0999)	(0.0971)	(0.0708)	(0.0634)
Other manufacturing	-0.6119**	-0.0247	-2.5569**	-0.1764	0.3362**	0.6320**
	(0.0630)	(0.0148)	(0.1401)	(0.1055)	(0.1002)	(0.0854)

Robust standard errors in parenthesis, with *, and ** denoting significantly different from zero at, respectively, the 5% and 1% confidence level.

Table 2: *Production function and γ estimations.*

	Production function estimations		γ estimations on $\hat{c}$: all firms		γ estimations on $\hat{c}$: French non-exporters		γ estimations on $\tilde{c}$: all firms	
Industry	β_L	β_K	γ	R^2	γ	R^2	γ	R^2
Food beverages and tobacco	0.5842**	0.2209**	1.7376**	0.9684	1.1337**	0.9268	2.2275**	0.9258
	(0.0337)	(0.0298)	(0.0055)		(0.0105)		(0.0111)	
Textiles	0.7496**	0.1655**	1.7865**	0.8833	1.3462**	0.8577	3.2974**	0.8576
	(0.0899)	(0.0534)	(0.0248)		(0.0650)		(0.0513)	
Wearing apparel except footwear	0.6213**	0.1248	1.4632**	0.9408	2.7282**	0.9185	2.0520**	0.9068
	(0.0874)	(0.0781)	(0.0181)		(0.1507)		(0.0324)	
Leather products and footwear	0.7157**	0.0888	2.3442**	0.9838	1.2975**	0.8167	2.9375**	0.8728
	(0.1109)	(0.0644)	(0.0180)		(0.1440)		(0.0672)	
Wood products except furniture	0.7385**	0.2433**	1.5930**	0.9264	1.8982**	0.9196	3.4348**	0.8701
	(0.1059)	(0.0845)	(0.0191)		(0.0294)		(0.0566)	
Paper products	0.5580**	0.1097*	1.4900**	0.9882	0.9910**	0.8079	2.0369**	0.9445
	(0.0800)	(0.0493)	(0.0069)		(0.0719)		(0.0210)	
Printing and Publishing	0.7797**	0.0394	1.3426**	0.9547	1.4829**	0.9146	2.2488**	0.9362
	(0.1081)	(0.0562)	(0.0108)		(0.0244)		(0.0218)	
Petroleum and Coal	0.3961**	0.3363**	1.0800**	0.9814	0.1606	0.9214	1.3689**	0.8684
	(0.1628)	(0.1337)	(0.0126)		(0.0176)		(0.0450)	
Chemicals	0.7138**	0.1523**	1.3746**	0.9152	0.8960**	0.9589	2.2774**	0.8733
	(0.0562)	(0.0329)	(0.0089)		(0.0173)		(0.0185)	
Rubber and plastic	0.6622**	0.1796**	1.7341**	0.9441	1.8917**	0.9589	3.0755**	0.8683
	(0.0619)	(0.0429)	(0.0125)		(0.0307)		(0.0355)	
Other non-metallic mineral products	0.5687**	0.2477**	1.6183**	0.9020	1.9121**	0.9430	2.6072**	0.8734
	(0.0508)	(0.0437)	(0.0162)		(0.0227)		(0.0302)	
Metallic products	0.5696**	0.2042**	1.7070**	0.9632	0.4059**	0.9677	2.3659**	0.9215
	(0.0783)	(0.0537)	(0.0118)		(0.0120)		(0.0244)	
Fabricated metal products	0.7260**	0.1084**	1.8104**	0.9608	2.1072**	0.9304	3.2698**	0.8707
	(0.0488)	(0.0280)	(0.0086)		(0.0176)		(0.0296)	
Machinery except electrical	0.7143**	0.1122**	1.6600**	0.9527	1.8306**	0.9489	2.8308**	0.8980
	(0.0418)	(0.0254)	(0.0086)		(0.0231)		(0.0221)	
Electric machinery	0.8021**	0.0986*	1.5496**	0.9185	1.3766**	0.9508	2.6098**	0.8502
	(0.0610)	(0.0386)	(0.0135)		(0.0212)		(0.0321)	
Professional and scientific equipment	0.6629**	0.1446*	1.2944**	0.8813	2.1236**	0.9762	2.3190**	0.7798
	(0.1023)	(0.0633)	(0.0219)		(0.0248)		(0.0567)	
Transport equipment	0.9003**	0.0459	1.4713**	0.9257	1.8080**	0.9856	2.8579**	0.8440
	(0.0480)	(0.0446)	(0.0126)		(0.0196)		(0.0370)	
Other manufacturing	0.8527**	0.0172	1.8500**	0.9710	1.8152**	0.9624	3.0416**	0.8992
	(0.0575)	(0.0603)	(0.0104)		(0.0208)		(0.0331)	

Robust standard errors in parenthesis, with *, and ** denoting significantly different from zero at, respectively, the 5% and 1% confidence level.

Table 3: *Industry-country producer prices.*

Industry	Country														
	AT	AU	BE	CA	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE
Food beverages and tobacco	1.15	1.02	0.99	1.07	0.62	0.98	1.04	0.95	0.89	1.11	1.19	1.34	1.12	0.58	1.14
Textiles	1.32	0.72	0.78	0.74	0.54	1.00	0.90	0.84	0.56	0.91	1.00	0.92	0.74	0.40	0.76
Wearing apparel except footwear	1.24	0.70	0.73	0.74	0.53	1.02	0.92	0.84	0.57	0.97	0.99	0.93	0.71	0.54	0.86
Leather products and footwear	1.28	0.70	0.74	0.74	0.54	1.01	0.90	0.84	0.57	1.08	1.08	1.05	0.72	0.52	0.65
Wood products except furniture	1.34	1.13	1.14	0.86	0.50	1.00	1.16	0.93	0.65	0.88	0.85	1.83	0.63	0.47	0.99
Paper products	1.28	1.18	1.06	1.16	0.63	1.08	1.24	0.98	0.85	1.04	1.18	1.44	0.96	0.67	1.06
Printing and Publishing	1.15	1.13	1.09	1.16	0.56	1.03	1.17	0.98	0.81	0.92	1.04	1.49	0.96	0.62	1.05
Petroleum and Coal	1.79	1.31	1.74	1.57	1.39	1.40	2.84	1.20	1.42	2.10	1.48	1.22	1.73	1.58	0.93
Chemicals	0.90	1.26	0.94	1.10	0.50	1.02	1.05	0.87	0.77	0.73	1.03	1.16	0.65	0.76	0.79
Rubber and plastic	0.90	1.51	0.70	1.40	0.47	1.01	1.36	0.93	0.65	1.09	0.83	0.92	1.31	0.53	0.91
Other non-metallic mineral products	1.15	1.03	0.97	1.26	0.43	0.99	1.36	0.78	0.66	1.21	1.16	1.31	0.67	0.53	1.17
Metallic products	1.42	1.19	1.00	1.00	0.61	1.04	1.22	0.78	0.75	0.93	1.15	1.23	0.73	0.64	1.01
Fabricated metal products	1.42	1.10	0.97	1.00	0.62	1.02	1.22	0.78	0.74	0.96	1.03	1.22	0.74	0.61	0.98
Machinery except electrical	1.37	1.04	1.02	0.83	0.61	1.03	1.20	1.10	0.74	1.09	0.98	0.96	0.70	0.32	1.16
Electric machinery	1.10	1.14	0.92	0.85	0.52	0.98	1.37	1.07	0.84	0.89	1.05	1.03	0.86	0.54	1.19
Professional and scientific equipment	1.11	1.13	0.98	0.85	0.55	1.03	1.44	1.07	0.86	1.35	0.79	0.99	0.84	0.57	1.20
Transport equipment	1.13	0.98	1.13	0.75	0.62	1.02	1.68	0.88	0.73	1.40	1.05	1.28	1.08	0.87	1.38
Other manufacturing	1.41	1.09	0.80	0.98	0.69	1.04	0.74	0.90	0.68	0.74	1.04	0.69	0.77	0.45	0.92

Industry	Country													
	IT	JP	KO	LT	LV	NL	NO	PL	PT	SE	SI	SK	TW	US
Food beverages and tobacco	1.01	3.23	1.60	0.89	0.98	0.93	1.19	0.68	1.04	1.17	0.99	0.58	1.19	1.20
Textiles	0.76	1.07	0.82	0.72	1.02	0.68	1.15	0.37	0.57	1.22	0.77	0.70	0.58	0.73
Wearing apparel except footwear	0.77	1.07	0.77	0.72	1.02	0.73	1.15	0.32	0.56	1.24	0.70	0.76	0.77	0.76
Leather products and footwear	0.78	1.10	0.83	0.67	1.02	0.72	1.15	0.43	0.60	1.24	0.76	0.74	0.55	0.75
Wood products except furniture	0.83	2.01	0.85	0.88	0.97	1.70	1.01	0.50	0.83	0.88	0.82	0.66	0.90	1.07
Paper products	1.02	1.82	1.37	1.04	0.99	1.34	1.10	0.69	0.98	1.04	0.91	0.89	1.08	1.29
Printing and Publishing	0.97	1.89	1.13	1.04	0.99	1.27	1.10	0.72	0.92	1.01	0.82	0.82	0.74	1.26
Petroleum and Coal	2.20	3.23	1.52	2.59	1.58	2.23	1.53	0.87	2.67	2.33	2.45	1.44	0.82	1.48
Chemicals	0.82	1.80	0.62	0.71	0.83	0.84	1.13	0.59	0.82	1.03	0.64	0.60	0.88	1.29
Rubber and plastic	0.62	2.29	0.97	0.70	0.99	0.95	1.27	0.34	0.54	1.25	0.75	0.71	1.00	1.48
Other non-metallic mineral products	0.74	2.18	0.81	0.66	0.85	1.06	1.31	0.48	0.75	1.63	0.54	0.50	0.83	1.53
Metallic products	0.64	1.43	1.02	0.77	0.74	0.94	1.25	0.73	0.66	1.04	0.70	0.82	0.92	1.09
Fabricated metal products	0.64	1.44	1.05	0.77	0.74	0.91	1.25	0.64	0.71	1.07	0.66	0.78	1.06	1.16
Machinery except electrical	0.71	1.35	0.85	0.80	1.44	1.26	1.14	0.77	1.00	1.13	0.79	0.85	0.82	1.13
Electric machinery	0.96	1.29	0.64	0.90	0.94	1.02	1.10	0.91	0.71	0.92	0.70	0.62	0.33	0.70
Professional and scientific equipment	1.01	1.37	0.81	0.90	0.94	1.01	1.10	0.98	0.91	1.06	0.66	0.64	0.47	1.02
Transport equipment	0.83	1.09	0.64	0.81	1.02	1.08	1.30	0.74	1.32	1.28	0.89	0.67	0.69	0.86
Other manufacturing	0.65	2.12	0.71	0.70	0.98	1.18	1.27	0.91	1.04	0.99	0.62	0.58	0.88	1.10

Country ISO2 codes: 'AT' = Austria; 'AU' = Australia; 'BE' = Belgium; 'CA' = Canada; 'CZ'=Czec Republic; 'DE' = Germany; 'DK' = Denmark; 'ES' = Spain; 'ES' = Estonia; 'FI' = Finland; 'FR' = France; 'GB' = Great Britain; 'GR' = Greece; 'HU' = Hungary; 'IE' = Ireland; 'IT'= Italy; 'JP' = Japan; 'KO' = Korea; 'LT' = Lithuania; 'LV' = Latvia; 'NL' = Netherlands; 'NO' = Norway; 'PL' = Poland; 'PT' = Portugal; 'SE' = Sweden; 'SI' = Slovenia; 'SK' = Slovakia; 'TW' = Taiwan; 'US' = United States.

Table 4: *Endogenous vs Exogenous competitiveness.*

Country	Endog. comp. ($1/m^l$) rank	Exog. comp. ($1/\psi^l$) rank	Difference
Austria	12	6	6
Belgium	5	11	-6
Germany	8	12	-4
Denmark	13	8	5
Spain	1	1	0
Finland	9	2	7
France	10	10	0
Great Britain	14	14	0
Greece	2	9	-7
Ireland	6	4	2
Italy	4	7	-3
Netherlands	7	13	-6
Portugal	3	3	0
Sweden	11	5	6

Table 5: *Correlation between prices and revealed comparative advantage.*

Country	Correlation
Austria	0.41
Belgium	-0.25
Denmark	-0.51
Finland	-0.29
France	0.42
Germany	-0.02
Great Britain	-0.48
Greece	0.09
Ireland	0.14
Italy	-0.26
Netherlands	-0.29
Portugal	-0.35
Spain	-0.55
Sweden	-0.60

Table 6: *Frequency of Export intensity.*

Export intensity of exporters in %	Observed France	Our Simulations
0 to 10	69.2	26.0
10 to 20	12.3	13.1
20 to 30	6.7	10.7
30 to 40	4.1	7.1
40 to 50	2.2	5.5
50 to 60	1.4	5.0
60 to 70	0.8	6.2
70 to 80	0.4	8.2
80 to 90	0.3	11.6
90 to 100	2.6	6.6

Table 7: *Non-Europe, Tariff 1, and Tariff 2 costs by country: EU-15 and RoW.*

	costs of Non-Europe		costs of Tariff 1		costs of Tariff 2	
Country	% decr. $1/\bar{m}$	% incr. $\bar{m}$	% decr. $1/\bar{m}$	% incr. $\bar{m}$	% decr. $1/\bar{m}$	% incr. $\bar{m}$
Austria	5.57	5.90	-0.13	-0.13	1.88	1.92
Belgium	7.74	8.39	0.14	0.14	2.58	2.65
Denmark	4.76	5.00	0.46	0.46	1.88	1.91
Finland	7.65	8.28	1.31	1.33	3.54	3.67
France	2.13	2.17	0.10	0.10	0.71	0.72
Germany	1.37	1.38	0.05	0.05	0.40	0.40
Great Britain	0.55	0.55	0.13	0.13	0.32	0.32
Greece	5.02	5.29	0.81	0.81	2.11	2.15
Ireland	12.59	14.41	1.20	1.22	5.67	6.01
Italy	3.64	3.78	0.40	0.40	1.75	1.78
Netherlands	4.58	4.80	0.10	0.10	1.10	1.11
Portugal	7.48	8.09	1.18	1.19	3.27	3.38
Spain	7.16	7.71	0.83	0.84	3.01	3.10
Sweden	5.30	5.60	0.32	0.32	2.20	2.25
EU-15	3.18	3.37	0.26	0.26	1.25	1.28
RoW	-0.61	-0.60	0.91	0.98	0.78	0.83

Table 8: *Non-Europe, Tariff 1, and Tariff 2 costs by industry: EU-15 only.*

	costs of Non-Europe		costs of Tariff 1		costs of Tariff 2	
Industry	% decr. $1/\bar{m}$	% incr. $\bar{m}$	% decr. $1/\bar{m}$	% incr. $\bar{m}$	% decr. $1/\bar{m}$	% incr. $\bar{m}$
Food beverages and tobacco	3.53	3.66	0.32	0.32	0.71	0.71
Textiles	7.17	7.72	0.08	0.08	1.65	1.68
Wearing apparel except footwear	6.36	6.80	0.07	0.07	0.99	1.00
Leather products and footwear	8.39	9.16	0.20	0.20	2.56	2.63
Wood products except furniture	—	—	0.09	0.09	1.06	1.07
Paper products	5.39	5.69	0.09	0.09	0.99	1.00
Printing and Publishing	0.47	0.47	0.05	0.05	0.20	0.20
Petroleum and Coal	1.20	1.21	0.05	0.05	0.32	0.32
Chemicals	6.56	7.02	0.57	0.57	1.81	1.84
Rubber and plastic	4.51	4.73	0.98	0.99	1.89	1.93
Other non-metallic mineral products	2.66	2.73	0.38	0.38	0.93	0.94
Metallic products	8.23	8.97	0.17	0.17	1.83	1.86
Fabricated metal products	—	—	0.21	0.22	0.97	0.98
Machinery except electrical	—	—	0.29	0.29	1.57	1.59
Electric machinery	2.49	2.55	-0.09	-0.09	1.27	1.28
Professional and scientific equipment	—	—	-0.07	-0.07	1.20	1.21
Transport equipment	3.76	3.91	-0.10	-0.10	1.30	1.32
Other manufacturing	—	—	2.03	2.07	2.88	2.97

Table 9: *The relative importance of inter- and intra-national trade for France.*

Code	French Region	Per capita GRP (France=100)	5% decr. inter-national frictions		5% decr. intra-national frictions	
			% incr. $1/\bar{m}$	% decr. $\bar{m}$	% incr. $1/\bar{m}$	% decr. $\bar{m}$
FR10	Ile de France	154.80	0.54	0.54	0.14	0.14
FR21	Champagne-Ardennes	93.55	9.96	9.06	4.56	4.36
FR22	Picardie	80.65	7.92	7.34	4.12	3.95
FR23	Haute-Normandie	90.86	6.46	6.06	2.44	2.38
FR24	Centre	88.46	4.84	4.61	2.77	2.69
FR25	Basse-Normandie	81.52	13.23	11.68	3.11	3.01
FR26	Bourgogne	87.46	8.56	7.88	3.57	3.45
FR31	Nord-Pas de Calais	77.09	3.17	3.08	1.01	1.00
FR41	Lorraine	81.48	8.09	7.48	1.74	1.71
FR42	Alsace	98.08	17.25	14.71	1.96	1.92
FR43	Franche-Comté	87.66	9.73	8.87	3.94	3.79
FR51	Pays de la Loire	89.30	3.80	3.66	1.31	1.29
FR52	Bretagne	85.22	6.40	6.02	1.46	1.44
FR53	Poitou-Charentes	81.58	6.33	5.95	2.77	2.69
FR61	Aquitaine	87.98	3.63	3.51	1.40	1.38
FR62	Midi-Pyrénées	86.38	3.78	3.65	1.55	1.52
FR63	Limousin	80.96	9.11	8.35	6.16	5.80
FR71	Rhône-Alpes	100.28	1.97	1.93	0.68	0.67
FR72	Auvergne	82.75	7.37	6.86	3.46	3.34
FR81	Languedoc-Roussillon	76.10	4.57	4.37	1.89	1.86
FR82	PACA	91.05	2.78	2.70	0.84	0.84
France		100.00	4.15	3.99	1.41	1.39

Table 10: *Robustness checks: Non-Europe, Tariff 1, and Tariff 2 costs by country: EU-15 and RoW.*

	costs of Non-Europe % decr. $1/\bar{m}$				costs of Tariff 1 % decr. $1/\bar{m}$				costs of Tariff 2 % decr. $1/\bar{m}$			
Country	Baseline	OLS	LP	BEJK	Baseline	OLS	LP	BEJK	Baseline	OLS	LP	BEJK
Austria	5.57	2.62	8.63	5.47	-0.13	-0.19	-0.16	0.78	1.88	0.77	1.88	3.20
Belgium	7.74	2.18	9.69	7.82	0.14	0.02	0.14	0.92	2.58	0.97	2.66	4.77
Denmark	7.65	2.22	6.61	4.28	1.31	0.05	0.45	2.04	3.54	0.79	1.88	3.59
Finland	1.37	2.90	9.92	8.21	0.05	0.27	1.32	5.53	0.40	1.37	3.61	8.28
France	0.55	1.48	2.57	1.79	0.13	0.05	0.10	0.58	0.32	0.74	0.74	1.67
Germany	4.76	1.03	1.85	1.67	0.46	0.00	0.04	0.43	1.88	0.39	0.41	1.19
Great Britain	5.02	0.25	0.71	0.47	0.81	0.02	0.14	0.56	2.11	0.18	0.33	0.90
Greece	12.59	0.79	5.47	5.81	1.20	0.12	0.87	4.29	5.67	0.49	2.25	6.68
Ireland	3.64	6.56	16.79	14.32	0.40	0.13	1.21	4.41	1.75	2.32	5.73	10.32
Italy	4.58	2.18	5.16	5.67	0.10	0.11	0.43	2.56	1.10	1.38	1.89	5.76
Netherlands	7.48	1.88	5.47	4.84	1.18	0.01	0.10	0.72	3.27	0.61	1.11	2.48
Portugal	7.16	2.13	9.35	9.41	0.83	0.27	1.25	5.04	3.01	1.24	3.43	8.58
Spain	2.13	5.20	8.97	10.46	0.10	0.31	0.87	4.66	0.71	2.19	3.21	9.73
Sweden	5.30	2.86	7.27	4.95	0.32	0.03	0.30	1.91	2.20	1.40	2.26	4.61
EU-15	3.18	1.80	3.19	2.92	0.26	0.06	0.27	1.48	1.25	0.84	1.31	3.36
RoW	-0.61	-0.19	-0.59	-0.68	0.91	0.73	0.96	2.24	0.78	0.65	0.82	2.03

Table 11: *Robustness checks: The relative importance of inter- and intra-national trade for France.*

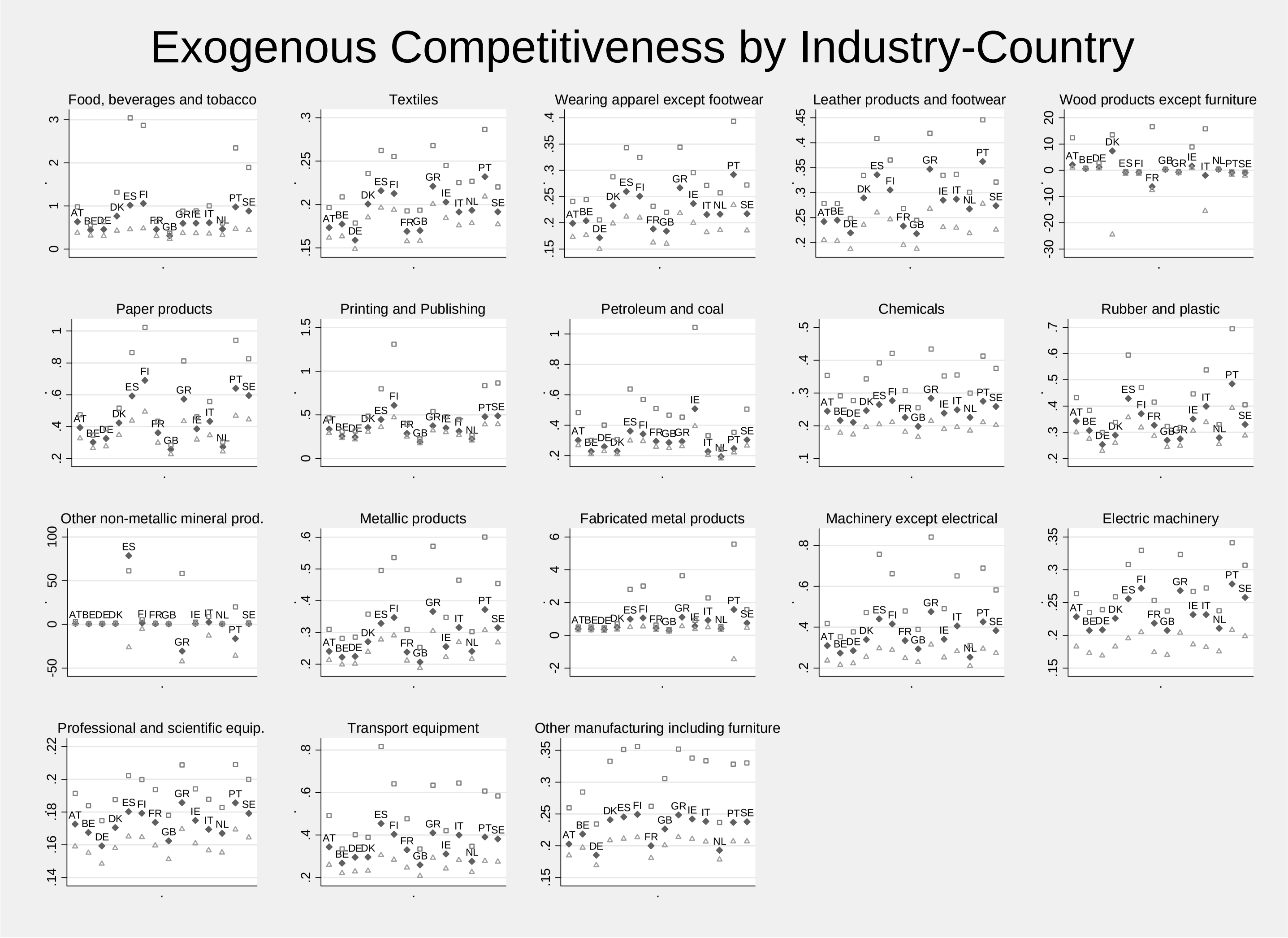
	5% decr. inter-national frictions				5% decr. intra-national frictions			
	% incr. $1/\bar{m}$				% incr. $1/\bar{m}$			
Country	Baseline	OLS	LP	BEJK	Baseline	OLS	LP	BEJK
Ile de France	0.54	0.23	0.61	1.82	0.14	0.06	0.15	0.18
Champagne-Ardennes	9.96	7.39	13.08	10.94	4.56	2.51	4.69	7.48
Picardie	7.92	4.45	10.86	13.67	4.12	3.15	4.20	6.84
Haute-Normandie	6.46	3.05	8.37	11.06	2.44	1.24	2.50	3.73
Centre	4.84	3.00	5.85	7.72	2.77	2.17	2.83	4.31
Basse-Normandie	13.23	6.29	9.03	17.92	3.11	1.60	3.20	4.83
Bourgogne	8.56	4.22	13.14	18.67	3.57	2.21	3.67	5.63
Nord-Pas de Calais	3.17	1.87	3.72	8.91	1.01	0.45	1.04	1.46
Lorraine	8.09	4.40	11.16	12.55	1.74	0.81	1.79	2.56
Alsace	17.25	5.04	8.40	19.65	1.96	0.79	2.02	2.92
Franche-Comté	9.73	5.78	10.93	22.71	3.94	1.91	4.06	6.31
Pays de la Loire	3.80	2.17	4.53	9.13	1.31	0.80	1.35	1.91
Bretagne	6.40	3.84	8.39	14.47	1.46	0.79	1.50	2.15
Poitou-Charentes	6.33	2.76	7.98	9.12	2.77	1.61	2.85	4.23
Aquitaine	3.63	1.66	4.20	7.89	1.40	0.79	1.44	2.04
Midi-Pyrénées	3.78	1.56	4.38	7.85	1.55	0.84	1.59	2.27
Limousin	9.11	4.31	10.69	13.51	6.16	2.89	6.38	10.68
Rhône-Alpes	1.97	1.10	2.19	5.17	0.68	0.42	0.69	0.95
Auvergne	7.37	2.78	10.56	9.53	3.46	1.83	3.56	5.40
Languedoc-Roussillon	4.57	1.88	5.39	9.90	1.89	1.03	1.94	2.83
PACA	2.78	1.32	3.12	5.54	0.84	0.45	0.87	1.22
France	4.15	2.06	4.67	7.76	1.41	0.80	1.45	2.16

Table 12: *Country coverage of our Amadeus dataset.*

Country	Number of Firms	Number of Observations
Austria	441	703
Belgium	1,872	9,227
Denmark	1,022	1,418
Finland	491	3,214
France	5,319	24,261
Germany	1,022	2,659
Great Britain	6,048	26,907
Italy	7,045	34,119
Netherlands	1,222	5,059
Norway	3,168	5,168
Portugal	422	1,032
Spain	3,415	15,901
Sweden	1,641	7,616

Table 13: *Industry coverage of our Amadeus dataset.*

Industry	Number of Firms	Number of Observations
Food beverages and tobacco	4,905	20,375
Textiles	1,315	5,809
Wearing apparel except footwear	697	3,052
Leather products and footwear	394	1,877
Wood products except furniture	1,142	4,080
Paper products	1,035	4,596
Printing and Publishing	2,012	7,989
Petroleum and Coal	171	799
Chemicals	3,073	13,609
Rubber and plastic	1,779	7,759
Other non-metallic mineral products	1,622	6,905
Metallic products	1,262	5,595
Fabricated metal products	3,104	12,661
Machinery except electrical	3,431	14,397
Electric machinery	2,256	9,305
Professional and scientific equipment	861	3,522
Transport equipment	1,940	7,703
Other manufacturing	1,841	7,251



(a) AT = Austria; BE = Belgium; DE = Germany; DK = Denmark; ES = Spain; FI = Finland; FR = France; GB = Great Britain; GR = Greece; IE = Ireland; IT= Italy; NL = Netherlands; PT = Portugal; SE = Sweden.
Triangles and squares depict, respectively, the 5th and 95th percentiles of the distribution obtained by bootstrapping.

Figure 1: *Exogenous competitiveness of EU-15 countries across the 18 manufacturing industries and confidence intervals.*

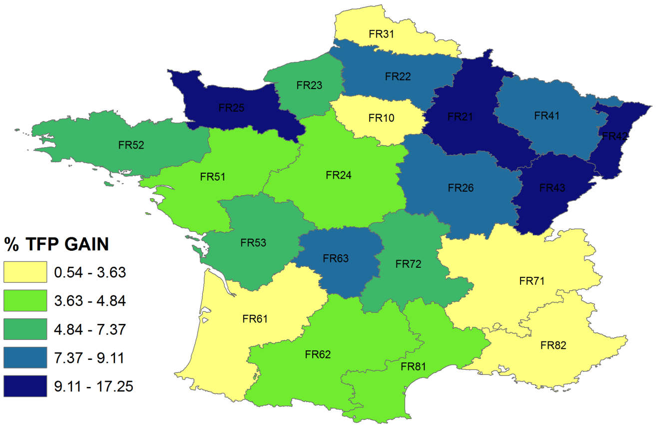


Figure 2: *French regions productivity gains (i.e. increase in* $1/\bar{m}$*) stemming from a 5% decrease in inter-national trade frictions.*

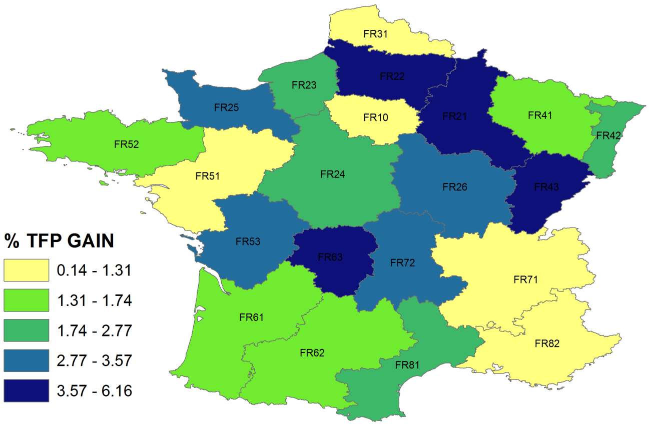


Figure 3: *French regions productivity gains (i.e. increase in* $1/\bar{m}$*) stemming from a 5% decrease in intra-national trade frictions.*