THE GAINS FROM INPUT TRADE IN FIRM-BASED MODELS OF IMPORTING*

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Abstract

Trade in intermediate inputs allows firms to reduce their costs of production by using better, cheaper, or novel inputs from abroad. The extent to which firms participate in foreign input markets, however, varies substantially. We show that accounting for this heterogeneity in import behavior is important to quantify the effect of input trade on consumer prices. We provide a theoretical result that holds in a wide class of models of importing: the firm-level data on value added and domestic expenditure shares in material spending is sufficient to compute the change in consumer prices relative to input autarky. In an application to French data, we find that consumer prices of manufacturing products would be 27% higher in the absence of input trade. Relying on aggregate data leads to substantially biased results. We then extend the analysis to study counterfactuals other than autarky and the measurement of welfare. We find that the observable micro data on value added and domestic shares contains crucial information about the effects of the shocks. JEL Codes: F11, F12, F14, F62, D21, D22

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1 Introduction

International trade benefits consumers by lowering the prices of the goods they consume. An important distinction is that between trade in final goods and trade in intermediate inputs. While the former benefits consumers directly, the latter operates only indirectly: by allowing firms to access novel, cheaper or higher quality inputs from abroad, input trade reduces firms' production costs and thus the prices of locally produced goods. Because intermediate inputs account for about two thirds of the volume of world trade, understanding the normative consequences of input trade is important. In this paper, we argue that spending patterns on foreign inputs at the firm level are key to doing so.

A recent body of work has incorporated input trade into quantitative trade models - see e.g. Eaton et al. (2011), Caliendo and Parro (2015) and Costinot and Rodríguez-Clare (2014). These frameworks have the convenient implication that the change in consumer prices due to input trade can be measured with aggregate data. This property, however, holds only when firms' import intensities are equalized – a feature that is at odds with the data. This is shown in Figure 1, which depicts the cross-sectional distribution of French manufacturing firms' domestic expenditure shares, i.e. the share of material spending allocated to domestic inputs. These differ markedly. While the majority of importers spend more than 90% of their material spending on domestic inputs, some firms are heavy importers with import shares exceeding 50%. In this paper, we show that accounting for this heterogeneity in import behavior, which requires resorting to firm-based models of importing, is crucial to quantify the aggregate effects of input trade.

[Figure 1 here]

We provide a theoretical result that characterizes the effect of input trade on consumer prices in a wide class of models of importing, where firms' demand system between domestic and foreign inputs is CES.[1] We start by focusing on the case of a reversal to input autarky, where firms can only use domestic inputs. We show that firm-level data on domestic shares and value added is sufficient to compute the change in consumer prices between the observed equilibrium and autarky. Importantly, this result does not rely on specific assumptions on firms' import environment. We do not require information on the prices and qualities of the foreign inputs, nor how firms find their suppliers, e.g. whether importing is limited by fixed costs or a process of network formation. Therefore, many positive aspects of import behavior, such as the number of supplier countries or the distribution of spending across trading partners, are irrelevant for the link between input trade and consumer prices. All models in the above class predict the exact same change in consumer prices given the micro data. Conversely, models that do not match these aspects of the micro data give biased predictions.

The intuition behind this result is simple. Domestic consumers are affected by input trade solely through firms' unit costs. By inverting the demand system for intermediates, we can link each firm's unit cost to its spending pattern on domestic inputs. When such a demand system is CES,

[1] Besides the aggregate models mentioned above, this class nests several frameworks used in the literature, e.g. Halpern et al. (2011), Gopinath and Neiman (2014), Antràs et al. (2014) and Goldberg et al. (2010).

the unit cost reduction from importing can be recovered from the domestic expenditure share. In particular, a low domestic share indicates that the firm benefits substantially from input trade. In this sense, Figure 1 shows that the gains from input trade are heterogeneous at the micro-level. To correctly aggregate these firm-level gains, one needs to know each firm's relative importance in the economy. In a multi-sector general equilibrium trade model with intersectoral linkages and monopolistic competition, we show that the aggregate effect of input trade on the consumer price index is akin to a value-added weighted average of the firm-level gains. Hence, a key aspect of the data is how firm size and domestic shares correlate; if bigger firms feature lower domestic shares, the aggregate effects of input trade will turn out to be large.

The extent to which this is the case in France is depicted in Figure 2. In the left panel, we display the distribution of value added by import status. In the right panel, we focus on the population of importers and show the distribution of domestic shares for different value added quantiles. We see that importing and firm size are far from perfectly aligned. While importers are significantly larger than non-importers, there is ample overlap in their distribution of value added. Furthermore, conditional on importing, the relationship between import intensity and size is essentially flat and there is substantial dispersion in import shares conditional on size. We show that these patterns are quantitatively important for our understanding of input trade.

[Figure 2 here]

This logic can be applied to shocks other than reversals to input autarky. More precisely, we show that the effect of any shock to the import environment (e.g. a decline in trade costs or foreign input prices) on the domestic consumer price index is fully determined from the joint distribution of value added and the *changes* in firms' domestic shares. This result is helpful to compare models: comparing different models reduces to comparing their predictions for firm size and the change in domestic shares. As long as two models share these predictions, they will imply the same effect of the shock on consumer prices.

We apply our methodology to data from the population of manufacturing firms in France. We first quantify the change in consumer prices relative to autarky. We estimate the distribution of trade-induced changes in unit costs across firms implied by the distribution of domestic expenditure shares displayed in Figure 1 above. While the median unit cost reduction is 11%, it exceeds 80% for 10% of the firms. We then aggregate these firm-level gains to compute the consumer price gains by relying on the joint distribution of domestic shares and value added displayed in Figure 2 above. We find that input trade reduces consumer prices of manufacturing products by 27%.[2] There are three reasons why the consumer price gains exceed the median firm-level gains, which go back to the above-mentioned patterns. First, the dispersion in firm-level gains is valued by consumers given their elastic demand. Second, the weak but positive relation between import intensity and firm size is beneficial because the endogenous productivity gains from importing and firm efficiency

[2]When we include the non-manufacturing sector, the consumer price gains amount to 9%. Note that manufacturing accounts for a relatively small share in aggregate consumer spending and that production links between the manufacturing and the non-manufacturing sector, which we assume to be closed to international trade, are limited.

are complements. Third, there are important linkages between firms whereby non-importers buy intermediates from importing firms.

We then calculate these consumer price gains in the context of aggregate models. By relying on aggregate statistics, instead of the micro data in Figures 1 and 2, these models yield biased results. We first show theoretically that, while the magnitude of this bias depends on the underlying micro data, its sign only depends on a small set of parameters - the elasticity of substitution between domestic and foreign inputs, the elasticity of consumers' demand, and the share of materials in production. Our estimates for these parameters imply that aggregate models are upward biased. In particular, they overestimate the change in consumer prices relative to autarky by about 10%.

Finally, we turn to counterfactuals other than autarky. In particular, we study a shock that makes all foreign inputs more expensive (e.g. a currency devaluation) and evaluate quantitatively whether the micro data on size and domestic shares is important for the estimates of the effects. To do so, we consider a framework where importing is subject to fixed costs and compare parametrizations which differ in the extent to which they match the data displayed in Figures 1 and 2. Our findings deliver a sort of quantitative extension of our theoretical sufficiency result. First, we find that versions of the model that do not match the data in Figures 1 and 2 tend to over-predict the increase in consumer prices resulting from the devaluation by 13-18%. For example, models where efficiency is the single source of heterogeneity imply a one-to-one, and hence counterfactual, relation between firm size and domestic shares and predict effects that are too large. Second, models that match the data in Figures 1 and 2 predict very similar effects of the shock. Conditional on the observable micro data, the details of the import environment, e.g. whether firms differ in fixed costs or home bias, are not crucial to predict consumer prices.

We also extend the analysis beyond the measurement of consumer prices and calculate the effect of input trade on welfare. While consumer prices are an important component of welfare, they may not capture the full welfare effect of input trade if firms need to spend resources to engage in importing. Because we do not observe such resource loss in the data, welfare has to be quantified in the context of a fully-specified model. In our model with fixed costs, we show that the specific mechanism that generates firms' domestic shares matters: different models that match the same moments of the micro data differ substantially in their implications for welfare. This is contrast to the results for consumer prices, which provide an upper bound for the effect of input trade on welfare that is robust across models.

An important parameter throughout the analysis is the elasticity of substitution between domestically sourced and imported inputs. Because firm-based models do not generate a standard gravity equation for aggregate trade flows, we devise a strategy to identify this elasticity from firm-level variation. By expressing firms' output in terms of material spending, the domestic share appears as an additional input in the production function. Because the sensitivity of firm revenue to domestic spending depends on the elasticity of substitution, we can estimate this parameter with methods akin to production function estimation. To address the endogeneity concern that unobserved productivity shocks might lead to both lower domestic spending and higher revenue, we use changes in the world supply of particular varieties as an instrument for firms' domestic spending. Using the variation across firms is important as we obtain a value for the elasticity close to two. Estimation approaches that rely on aggregate data typically find values closer to five. Using such aggregate elasticity would lead to under-estimating the change in consumer prices relative to autarky by 65%. Thus, the magnitude of the bias from using aggregate data can be substantial.

Our paper contributes to a recent literature on quantitative models of input trade. On the one hand, there are aggregate trade models as Eaton et al. (2011), Caliendo and Parro (2015) and Costinot and Rodríguez-Clare (2014). Because these frameworks abstract from fixed costs of importing and assume that import prices are common across firms, they imply that domestic shares are equalized. In contrast, we focus on the heterogeneity in import patterns and show that doing so substantially affects the estimates of the gains from input trade. On the other hand, there is a literature on firm-based models of importing - see Halpern et al. (2011), Gopinath and Neiman (2014), Antràs et al. (2014) or Ramanarayanan (2014). Relative to these contributions, we exploit the information contained in firms' domestic expenditure shares. For a reversal to input autarky, we show that this data is sufficient to quantify the effect on consumer prices. For the case of other counterfactuals, we show quantitatively that calibrating the model to such data is important. For example, Ramanarayanan (2014) studies a reversal to autarky in the context of a model that generates a perfect, and hence counterfactual, correlation between firm size and domestic shares. We explicitly show that the consumer price gains in such type of model are too high. Finally, Antràs et al. (2014) develop a model of importing to match positive aspects of firms' sourcing behavior, e.g. the number of firms by sourcing country. In contrast, we focus on the normative aspects of input trade.

Our paper is also related to the literature that quantifies the effect of international trade on consumer prices - see e.g. Feenstra (1994) and Broda and Weinstein (2006). We focus on trade in intermediate inputs rather than final good trade and use micro data to measure input demand by foreign destination at the firm-level. At a conceptual level, our paper relates to Arkolakis et al. (2012). We first show that their formula for aggregate welfare does not apply when firms' domestic shares are heterogeneous. However, our theoretical characterization is similar in spirit, albeit at the firm-level. We show that the distribution of firms' domestic shares together with a "trade elasticity", which in our setup corresponds to the elasticity of substitution between domestic and foreign inputs in firms' production function, is sufficient to compute the gains from trade in a wide class of models.

Finally, a number of empirically oriented papers study trade liberalization episodes to provide evidence on the link between imported inputs and firm productivity - see e.g. Amiti and Konings (2007), Goldberg et al. (2010) or Khandelwal and Topalova (2011).[3] Our results are complementary to this literature as we provide a structural interpretation of this empirical evidence. In particular, our sufficiency result implies that the effect of the policy on firms' unit costs can be recovered from the effect of the policy on domestic expenditure shares. If micro-data on value added is also available, our results can be used to gauge the full effect of the policy on consumer prices in general equilibrium.

The remainder of the paper is structured as follows. Section 2 lays out the class of models we

[3] Kasahara and Rodrigue (2008) study the effect of imported intermediates on firm productivity through a production function estimation exercise. See also the recent survey in De Loecker and Goldberg (2013) for a more general empirical framework to study firm performance in international markets.

consider and derives our results for the effect of input trade on firms' unit costs and consumer prices. The application to France is contained in Sections 3 and 4. In Section 3, we study a reversal to autarky. In Section 4, we extend the analysis to other counterfactuals in the context of a fully specified framework of importing. Section 5 concludes.

2 Theory

In this section, we lay out the theoretical framework of importing that we use to quantify the effects of input trade. In Section 2.1, we study the firm's import problem and provide a sufficiency result for the unit cost. In Section 2.2, we embed the firm problem into a general equilibrium trade model with input-output linkages to quantify the effect of input trade on consumer prices.

2.1 The Firm-Level Gains from Input Trade

Consider the problem of a firm, which we label as i, that uses local and foreign inputs according to the following production structure:

$$y = \varphi_i f(l,x) = \varphi_i l^{1-\gamma} x^{\gamma} \tag{1}$$

$$x = \left(\beta_i (q_D z_D)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\beta_i) x_I^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{2}$$

$$x_I = h_i\left([q_{ci} z_c]_{c\in\Sigma_i}\right). \tag{3}$$

where $\gamma, \beta_i \in (0,1)$ and $\varepsilon > 1$.[4] The firm combines intermediate inputs x with primary factors l, which we for simplicity refer to as labor, in a Cobb-Douglas fashion with efficiency φ_i.[5] Intermediate inputs are a CES composite of a domestic variety, with quantity z_D and quality q_D, and a foreign input bundle x_I, with relative efficiency for domestic inputs given by β_i. We refer to β_i as the firm's home-bias. The firm has access to foreign inputs from multiple countries, whose quantity is denoted by $[z_c]$, which may differ in their quality $[q_{ci}]$, where c is a country index.[6] Foreign inputs are aggregated according to a constant returns to scale production function $h_i(\cdot)$.[7] An important endogenous object in the production structure is the set of foreign countries the firm sources from, which we denote by Σ_i and henceforth refer to as the sourcing strategy. We do not impose any restrictions on how Σ_i is determined until Section 4.

[4]While the case of $\varepsilon \leq 1$ can also be accommodated by the theory, it implies that all firms are importers - a feature that is inconsistent with the data.

[5]We consider a single primary factor for notational simplicity. It will be clear below that our results apply to $l = g(l_1, l_2, ..., l_T)$, where $g(\cdot)$ is a constant returns to scale production function and l_j are primary factors of different types. In the empirical application of Section 3, we consider labor and capital.

[6]We discuss below how to generalize the results of this section when the Cobb-Douglas and CES functional forms in (1)-(2) are not satisfied. In particular we consider the cases where (1) takes a CES form so that intermediate spending shares are not equalized, and a multi-product version of (2), where domestic and foreign inputs are closer substitutes within a product nest.

[7]Note that this setup nests the canonical Armington structure where all countries enter symmetrically in the production function. Additionally, this setup allows for an interaction between quality flows and the firm's efficiency, i.e. a form of non-homothetic import demand that is consistent with the findings in Kugler and Verhoogen (2011) and Blaum et al. (2013).

As far as the market structure is concerned, we assume that the firm takes prices of domestic and foreign inputs $(p_D, [p_{ci}])$ as parametric, i.e. it can buy any quantity at given prices. Note that p_{ci} includes all variable trade costs. Similarly, we assume that labor can be hired frictionlessly at a given wage w. On the output side, we do not impose any restrictions, i.e. we do not specify whether firms produce a homogeneous or differentiated final good and how they compete.

The setup above describes a class of models of importing that have been used in the literature. First, it nests the aggregate approaches used in recent quantitative trade models (Eaton et al., 2011; Costinot and Rodríguez-Clare, 2014; Caliendo and Parro, 2015). In these models, firms' import intensities are equalized. In the above setup, this corresponds to the case where firms' sourcing strategies are equalized, all firms face the same prices and qualities and there is no heterogeneity in the home-bias (i.e. $\Sigma_i = \Sigma$, $[p_{ci}, q_{ci}] = [p_c, q_c]$, $\beta_i = \beta$). Second, it nests the recent examples of firm-based import models by Gopinath and Neiman (2014), Halpern et al. (2011), Antràs et al. (2014), Kasahara and Rodrigue (2008), Amiti et al. (2014) and Goldberg et al. (2010).[8] A unifying feature of all models in this class is that firms engage in input trade because it lowers their unit cost of production via love of variety and quality channels. Additionally, most of these contributions generate heterogeneity in firms' import intensities through variation in their sourcing strategies (e.g. due to the presence of fixed costs).

The assumptions made above, most importantly parametric prices and constant returns to scale, guarantee that the unit cost is constant *given the sourcing strategy* Σ. Crucially, this separability between the intensive and extensive margin allows us to characterize the unit cost without solving for the optimal sourcing set. Formally, the unit cost is given by

$$u\left(\Sigma_i; \varphi_i, \beta_i, [q_{ci}], [p_{ci}], h_i\right) \equiv \min_{z,l} \left\{ wl + p_D z_D + \sum_{c \in \Sigma_i} p_{ci} z_c \text{ s.t. } \varphi_i l^{1-\gamma} x^{\gamma} \geq 1 \right\}, \tag{4}$$

subject to (2)-(3). For simplicity, we refer to the unit cost as u_i. Standard calculations imply that there is an *import price index* given by

$$A\left(\Sigma_i, [q_{ci}], [p_{ci}], h_i\right) \equiv m_I / x_I, \tag{5}$$

where m_I denotes import spending and x_I is the foreign import bundle defined in (3). Importantly, conditional on Σ_i, this price-index is exogenous from the point of view of the firm and we henceforth denote it by $A_i\left(\Sigma_i\right)$. Next, given the CES production structure between domestic and foreign inputs, the price index for intermediate inputs is given by

$$Q_i\left(\Sigma_i\right) = \left(\beta_i^{\varepsilon}\left(p_D/q_D\right)^{1-\varepsilon} + \left(1-\beta_i\right)^{\varepsilon} A_i\left(\Sigma_i\right)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}, \tag{6}$$

so that intermediate inputs $x = m/Q_i(\Sigma_i)$ where m denotes total spending in materials. It follows

[8] While Antràs et al. (2014) consider a model of importing in the spirit of Eaton and Kortum (2002) instead of a variety-type model, the Fréchet assumption implies that these models are isomorphic.

that the firm's unit cost is given by[9]

$$u_i = \frac{1}{\varphi_i} w^{1-\gamma} \left(Q_i\left(\Sigma_i\right)\right)^{\gamma}. \tag{7}$$

We see that input trade affects the unit cost through the price index for intermediate inputs. This price index, however, depends on a number of unobserved parameters related to the trading environment, e.g. the prices and qualities of the foreign inputs. We use the fact that the *unobserved* price index $Q_i\left(\Sigma_i\right)$ is related to the *observed* expenditure share on domestic inputs s_{Di} via

$$s_{Di} = \left(Q_i\left(\Sigma_i\right)\right)^{\varepsilon-1} \beta_i^{\varepsilon} \left(\frac{q_D}{p_D}\right)^{\varepsilon-1}. \tag{8}$$

Substituting (8) into (7) yields

$$u_i = \frac{1}{\tilde{\varphi}_i} \times \left(s_{Di}\right)^{\frac{\gamma}{\varepsilon-1}} \times \left(\frac{p_D}{q_D}\right)^{\gamma} w^{1-\gamma}, \tag{9}$$

where $\tilde{\varphi}_i \equiv \varphi_i \beta_i^{\frac{\varepsilon\gamma}{\varepsilon-1}}$. (9) is a sufficiency result: conditional on the firm's domestic expenditure share s_{Di}, no aspects of the import environment, including the sourcing strategy Σ_i, the prices p_{ci}, the qualities q_{ci} or the technology h_i, affect the unit cost. With (9) at hand, we can derive the effect of input trade on the firm's unit cost, which is sometimes referred to as the "productivity effect" from importing.

Proposition 1. *Consider a shock to the import environment, i.e. a change in foreign prices, qualities, trade-costs or the sourcing strategy. The change in the firm's unit cost resulting from the shock, holding prices* (p_D, w) *constant, is given by*

$$ln\left(\frac{u_i^{'}}{u_i}\right)\Bigg|_{p_D,w} = \frac{\gamma}{1-\varepsilon} \times ln\left(\frac{s_{Di}}{s_{Di}^{'}}\right), \tag{10}$$

where $u_i^{'}$ *and* $s_{Di}^{'}$ *denote the unit cost and the domestic expenditure share after the shock. In the special case of a reversal to input autarky, the change in unit cost is given by*

$$ln\left(\frac{u_i^{Aut}}{u_i}\right)\Bigg|_{p_D,w} = \frac{\gamma}{1-\varepsilon} \times ln\left(s_{Di}\right). \tag{11}$$

Proof. (10) follows directly from (9). (11) follows from (10) and the fact that the domestic share in autarky is unity. □

Proposition 1 shows that the effect of shocks to the import environment on the firm's unit cost is observable given data on the domestic share before and after the shock and values of the elasticities γ and ε. Intuitively, an adverse trade shock, such as an increase in foreign prices or a reduction in the set of trading partners, hurts the firm by increasing the price index of intermediate inputs

[9] With a slight abuse of notation we suppress the constant $\left(\frac{1}{1-\gamma}\right)^{1-\gamma}\left(\frac{1}{\gamma}\right)^{\gamma}$ in the definition of (7).

Q_i. Conditional on an import demand system, we can invert the change in this price index from the change in the domestic expenditure share.[10] The sufficiency result in equation (10) allows us to measure the change in the unit cost without specifying several components of the theory. While the firm's unit cost depends on all of the import environment parameters $[p_{ci}, q_{ci}, h_i, \beta_i]$, the domestic expenditure share conveniently encapsulates the information that is relevant for the unit cost. This is in contrast to an alternative approach which consists of estimating a fully-specified model of importing to evaluate the consequences of the shock.

It is straightforward to apply Proposition 1 when the domestic share is observed after the shock. The case of autarky is especially attractive because the counterfactual domestic share is trivially given by unity. In this case, the gains from input trade at the firm-level can be read off directly from the cross-sectional data: the increase in production costs that firm i would experience if it (and only it) was excluded from international markets can be recovered from the observed domestic expenditure share.[11] While Proposition 1 is a partial equilibrium result, we note that it identifies the dispersion in unit cost changes across firms in general equilibrium, and hence the distributional effects of input trade.[12] We explore the case of autarky quantitatively in Section 3 below. Another application of Proposition 1 are structural evaluations of observed trade policy, e.g. an episode of trade liberalization.[13]

Proposition 1 can also be used to study counterfactual shocks. In particular, it is a useful tool for evaluating quantitative firm-based models. According to Proposition 1, comparing the quantitative implications of different models reduces to comparing the estimates of the two parameters γ and ε and the models' outcome for firms' responses to the shock.

Finally, Proposition 1 can be generalized in a number of ways. In Section 7.1 of the Appendix, we consider the following. First, we derive a local version of (10) for the case where domestic and foreign inputs are not combined in a CES fashion. Second, we consider the case where the output elasticity of material inputs is not constant. Finally, we allow firms to source multiple products from different countries.[14] We also discuss what additional data, relative to Proposition 1, is required to perform counterfactual analysis in these cases.

[10] Hence, Proposition 1 is akin to a firm-level analogue of Arkolakis et al. (2012). In the same vein as consumers gain purchasing power by sourcing cheaper or complementary products abroad, firms can lower the effective price of material services by tapping into foreign input markets.

[11] We explicitly extend Proposition 1 to allow for general equilibrium effects in Section 2.2 below.

[12] Note that (9) implies that u_i/u_j does not on p_D, w.

[13] Examples of such trade liberalizations are Chile (Pavcnik, 2002), Indonesia (Amiti and Konings, 2007) or India (De Loecker et al., 2012). If one wants to use Proposition 1 to measure the causal effect of the trade reform on the unit costs, one has to ensure to only use the change in domestic shares that is due to the change in policy. In the context of a trade liberalization, one can use the change in policy to construct instruments, e.g. by exploiting cross-sectional differences in firms' exposure to the policy. See also Section 3, where we use a related identification strategy. We also note that opening up to trade might induce firms to engage in productivity enhancing activities that directly increase efficiency φ, such as R&D. Such increases in complementary investments are not encapsulated in Proposition 1, which only measures the static gains from trade holding efficiency fixed. To disentangle the dynamic from the static gains from trade, more structure and data is required - see for example Eslava et al. (2014).

[14] In the empirical analysis below, we abstract from the product dimension because we do not observe firm-level domestic spending by product.

2.2 Input Trade and Consumer Prices

In this section, we embed the model of firm behavior of Section 2.1 in a macroeconomic environment and study the aggregate effects of input trade. We focus on the change in consumer prices.[15] To isolate the effect of input trade, we abstract from trade in final goods. Domestic consumers therefore benefit from trade openness only indirectly through firms' cost reductions. The micro result in Proposition 1 above is crucial as it allows us to measure such firm-level unit cost reductions in the data. To aggregate these firm-level gains, we need to take a stand on two aspects of the macroeconomic environment: (i) the nature of input-output linkages across firms and (ii) the degree of pass-through, which depends on consumers' demand system and the output market structure. While the former determines the effect of trade on the price of domestic inputs p_D, the latter determines how much of the trade-induced cost reductions actually benefit consumers.

We consider the following multi-sector CES monopolistic competition environment. There are S sectors, each comprised of a measure N_s of firms which we treat as fixed. There is a unit measure of consumers who supply L units of labor inelastically and whose preferences are given by

$$U = \prod_{s=1}^{S} C_s^{\alpha_s} \tag{12}$$

$$C_s = \left(\int_0^{N_s} c_{is}^{\frac{\sigma_s - 1}{\sigma_s}} \, di \right)^{\frac{\sigma_s}{\sigma_s - 1}}, \tag{13}$$

where $\alpha_s \in (0,1)$, $\sum_s \alpha_s = 1$ and $\sigma_s > 1$. Firm i in sector $s = 1, ..., S-1$ produces according to the production technology given by (1)-(3) in Section 2.1 above, where the structural parameters ε and γ are allowed to be sector-specific. As before, we do not assume any particular mechanism of how the extensive margin of trade is determined nor impose any restrictions on $[p_{ci}, q_{ci}, h_i, \beta_i]$. That is, the distribution of prices and qualities across countries and the aggregator of foreign inputs can take any form. Additionally, these parameters can vary across firms in any way. We assume sector S to be comprised of firms that do not trade inputs and refer to it as the non-manufacturing sector.[16]

We assume the following structure of roundabout production, which is also used in Caliendo and Parro (2015). Firms use a sector-specific domestic input that is produced using the output of all other firms in the economy according to

$$z_{Ds} = \prod_{j=1}^{S} Y_{js}^{\zeta_j^s} \text{ and } Y_{js} = \left(\int_0^{N_j} y_{\nu js}^{\frac{\sigma_j - 1}{\sigma_j}} \, d\nu \right)^{\frac{\sigma_j}{\sigma_j - 1}}, \tag{14}$$

[15]Throughout the paper, we use the term "consumer prices" to denote the price index associated with consumer preferences. We note that the change in such index does not necessarily capture the full effect of input trade on welfare, as firms may spend resources to attain their sourcing strategies - see Section 4 below.

[16]We introduce this sector for empirical reasons. In the next section, we consider an application to France where we do not have data on firm-level imports outside of the manufacturing sector. To make aggregate statements about input trade, we take the non-manufacturing sector into account. See Section 3 for details.

where z_{Ds} denotes the bundle of domestic inputs, ζ_j^s is a matrix of input-output linkages with $\zeta_j^s \in [0,1]$ for all s and j and $\sum_{j=1}^{S} \zeta_j^s = 1$ for all s, and $y_{\nu js}$ is the output of firm ν in sector j demanded by a firm in sector s. In this setting, the price of the domestic input p_{Ds} is endogenous so that domestic firms are affected by trade policy via their purchases of intermediate inputs from importers.

Building on our result from Section 2.1, we now express the effect of input trade on the consumer price index associated with (12)-(13) in terms of observables. Given the CES demand and monopolistic competition structure, the consumer price index for sector s is given by

$$P_s = \mu_s \left(\int_0^{N_s} u_i^{1-\sigma_s} di \right)^{\frac{1}{1-\sigma_s}} = \mu_s \left(\frac{p_{Ds}}{q_{Ds}} \right)^{\gamma_s} \times \left(\int_0^{N_s} \left(\frac{1}{\tilde{\varphi}_i} \left(s_{Di} \right)^{\gamma_s / (\varepsilon_s - 1)} \right)^{1-\sigma_s} di \right)^{\frac{1}{1-\sigma_s}}, \qquad (15)$$

where $\mu_s \equiv \sigma_s / \left(\sigma_s - 1 \right)$ is the mark-up in sector s and we treat labor as the numeraire. The second equality follows from (9) above which allows us to express firms' unit costs in terms of their domestic expenditure shares (s_{Di}) and efficiency ($\tilde{\varphi}_i$). Equation (15) shows that, holding domestic input prices fixed, the effect of input trade on consumers' purchasing power is an efficiency-weighted average of the firm-level gains. While firm efficiency $\tilde{\varphi}_i$ is not observed, it can be recovered up so scale from data on value added and domestic spending as[17]

$$va_i \propto \left(\tilde{\varphi}_i \left(s_{Di} \right)^{\gamma_s / (1-\varepsilon_s)} \right)^{\sigma_s - 1}. \qquad (16)$$

As in Proposition 1, consider any shock to the import environment, i.e. a change in foreign prices, qualities, trade-costs or the sourcing strategies. Combining (15) and (16), the change in the sectoral consumer price index due to the shock is given by

$$ln \left(P_s^{'} / P_s \right) = \gamma_s ln \left(p_{Ds}^{'} / p_{Ds} \right) + \Lambda_s, \qquad (17)$$

where

$$\Lambda_s = \frac{1}{1-\sigma_s} ln \left(\int_0^{N_s} \omega_i \left(\frac{s_{Di}}{s_{Di}^{'}} \right)^{\frac{\gamma_s}{1-\varepsilon_s}(1-\sigma_s)} di \right), \qquad (18)$$

and ω_i denotes firm i's share in sectoral value added. Equation (17) shows that shocks to firms' ability to source inputs from abroad affect consumer prices through two channels. First, there is a direct effect stemming from firms in sector s changing their intensity to source inputs internationally, Λ_s. Second, there is an indirect effect as the price of domestic inputs changes because of input-output linkages, $p_{Ds}^{'} / p_{Ds}$.

Akin to Proposition 1, (17) and (18) contain a sufficiency result for the change in aggregate consumer prices. Note first that the direct price reduction Λ_s can be computed with data on value added and domestic shares. Next, because of the structure of roundabout production in (14), the

[17]This assumes that the data on value added does not record firms' expenses to attain their sourcing strategies. If it did, one could express (16) in terms of sales or employment.

change in domestic input prices p'_{Ds}/p_{Ds} is a function of the Λ_s of all sectors. Hence, the change in the consumer price index resulting from the shock can be expressed in terms of micro data.

Proposition 2. *Consider a shock to firms' import environment and let P and P' be the consumer price indices before and after the shock. The change in consumer prices is then given by*

$$ln\left(\frac{P'}{P}\right) = \alpha'\left(\Gamma\left(\mathcal{I} - \Xi \times \Gamma\right)^{-1}\Xi + \mathcal{I}\right) \times \Lambda, \tag{19}$$

where $\Lambda = [\Lambda_1, \Lambda_2, ..., \Lambda_S]$, Λ_s is given in (18), $\Xi = \left[\zeta_j^s\right]$ is the $S \times S$ matrix of production interlinkages, α is the $S \times 1$ vector of demand coefficients, $\mathcal{I}$ is an identity matrix and $\Gamma = diag(\gamma)$, where γ is the $S \times 1$ vector of input intensities.

In the special case of a reversal to input autarky, the increase in consumer prices is given by (19), where Λ_s is given by

$$\Lambda_s^{Aut} = \frac{1}{1-\sigma_s} ln\left(\int_0^{N_s} \omega_i s_{Di}^{\frac{\gamma_s}{1-\varepsilon_s}(1-\sigma_s)} di\right) \geq 0. \tag{20}$$

Proof. See Section 7.2 in the Appendix. □

By extending Proposition 1 to a general equilibrium environment, Proposition 2 shows that the micro data on domestic spending and value added is sufficient to fully characterize the consumer price consequences from input trade in the class of models considered in this section. The vector of Λ_s contains the direct effects of changes in firms' sourcing behavior on consumer prices. The other terms in (19) reflect the input-output linkages across firms, by which changes in importers' unit costs diffuse through the economy. To understand this amplification effect, it is instructive to consider the case of a single sector economy. In this case, expression (19) becomes

$$ln\left(\frac{P'}{P}\right) = \frac{\Lambda}{1-\gamma}, \tag{21}$$

that is, the change in the consumer price index is simply given by the direct price changes Λ, inflated by $1/(1-\gamma)$ to capture the presence of roundabout production.

Proposition 2 is applicable in very much the same way as Proposition 1. In the case of observed policies, the aggregate impact of trade on consumer prices can be easily computed as long as data on domestic shares before and after the change is available.[18] Such gains at the aggregate level can essentially be read off the micro data given the parameters for consumer demand and production. Information about firms' import environment or firms' endogenous choice of their extensive margin of importing is not required.

A special case of interest is a reversal to input autarky, where firms' counterfactual domestic shares are given by unity and hence trivially observable. As Λ_s^{Aut} can be directly calculated from the data in Figures 1 and 2, such data is sufficient to quantify the consumer price gains relative to autarky for the class of models we consider. We quantify these gains in Section 3 below.

[18] This is subject to the caveat discussed above that the changes in domestic shares are due to the policy - see footnote 13.

As far as counterfactual shocks are concerned, Proposition 2 provides guidance on how to compare different models which may differ in their microstructure and hence in their positive implications. As far as consumer prices are concerned, the models in our class differ only to the extent they predict different responses of firms' domestic shares after the shock. While the underlying import environment matters for the predicted domestic shares, conditional on such predictions the implied consumer gains are the same. Whether or not the different models are consistent with other micro facts, e.g. about the number of sourcing countries or the distribution of expenditure across trading partners, is irrelevant. In Section 4 below, we consider the case of a currency devaluation and quantitatively compare the implications of models with different micro structures.

Prices vs. Welfare. Proposition 2 focuses on changes in consumer prices and therefore may not capture the full welfare effects of input trade. In particular, this may be the case when firms need to spend resources to find their trading partners. If the shock to the import environment results in changes in firms' sourcing strategies, the shock may affect the share of aggregate profits in income and hence welfare beyond consumer prices. This feature is not specific to theories of importing but also arises in models of exporting. For example, the welfare formula of Arkolakis et al. (2012) relies on the condition that profits are a constant share of aggregate income, which is one of their three macro level restrictions. Whether or not this condition is satisfied in our context depends on details of the environment which we did not have to specify to derive Proposition 2. In Section 4 below, we provide examples of fully-specified models of importing where consumer prices are a very good proxy for welfare or are substantially different.

Nevertheless, we note that the increase in consumers prices gives an upper bound for the welfare effect of a reversal to autarky - we show this formally in Section 4. The reason is that a move to autarky may allow firms to save on resources spent to attain their sourcing strategies. Importantly, as shown above, this upper bound is robust across models in a class and can be measured directly from the data. In contrast, welfare has to be quantified in the context of a fully specified model, because the resource loss associated with firms' sourcing strategies is not directly observable.

The Bias of Aggregate Models. Proposition 2 is a useful organizing tool for the existing models of importing. Consider first the aggregate models of importing where firms' domestic expenditure shares are equalized - see Eaton et al. (2011), Caliendo and Parro (2015) and Costinot and Rodríguez-Clare (2014). For simplicity, consider the case of autarky. In these models, the direct price reductions from input trade are given by

$$\Lambda^{Aut}_{Agg,s} = \frac{\gamma_s}{1-\varepsilon_s} ln\left(s^{Agg}_{Ds}\right) = \frac{\gamma_s}{1-\varepsilon_s} ln\left(\int_0^{N_s} \omega_i s_{Di} di\right), \tag{22}$$

where s^{Agg}_{Ds} is the aggregate domestic expenditure share in sector s.[19] While these frameworks have the benefit of only requiring aggregate data, Figure 1 shows that their implication of equalized

[19] Note that, because of Cobb-Douglas production, firm value added is proportional to material spending, so that s^{Agg}_{Ds} is indeed equal to the aggregate share of material spending allocated towards domestic producers.

domestic shares is rejected in the micro data, and Proposition 2 shows that such deviation has aggregate consequences. In particular, (18) and (22) imply that the bias from measuring the price reduction in sector s through the lens of an aggregate model is given by

$$Bias_s \equiv \Lambda^{Aut}_{Agg,s} - \Lambda^{Aut}_{s} = \frac{\gamma_s}{\varepsilon_s - 1} \times ln\left[\frac{\left(\int_0^{N_s} \omega_i s_{Di}^{\chi_s} di\right)^{1/\chi_s}}{\int_0^{N_s} \omega_i s_{Di} di}\right], \tag{23}$$

where $\chi_s = \frac{\gamma_s(\sigma_s - 1)}{\varepsilon_s - 1}$. Heterogeneity in import shares induces a bias in the estimates of the gains from trade of aggregate models, as long as $\chi_s \neq 1$. The *magnitude* of the bias depends on the underlying dispersion in domestic shares and their correlation with firm size - we quantify it in our empirical application below. The *sign* of the bias, however, depends only on parameters and not on the underlying micro-data. In particular, (23) together with Jensen's inequality directly imply that

$$Bias_s > 0 \text{ if and only if } \chi_s = \frac{\gamma_s(\sigma_s - 1)}{\varepsilon_s - 1} > 1. \tag{24}$$

Hence, as long as $\chi_s > 1$, which is the case if consumer demand is elastic (σ_s is large) and the elasticity of unit costs with respect to the domestic share is large ($\frac{\gamma}{\varepsilon - 1}$ is high), an analysis based on aggregate data would imply consumer gains that are too large. The economic intuition of this result is as follows. Because the current trade equilibrium is observed in the data, quantifying the gains from trade boils down to predicting consumer prices in the counterfactual autarky allocation - see (15) and (16). Such prices are fully determined from producers' efficiencies, i.e. $\tilde{\varphi}_i^{\sigma-1}$. As these are unobserved, they are inferred from data on value added and domestic shares. More specifically, given the data on value added, (16) shows that $\tilde{\varphi}_i^{\sigma-1}$ is proportional to s_{Di}^{χ}. In the same vain as dispersion in prices is valued by consumers whenever demand is elastic, dispersion in domestic shares is valued as long as $\chi > 1$. In this case, the autarky price index inferred by an aggregate model is too high, making the gains from trade *upward* biased.

To fix ideas, consider an example where firms differ in their domestic shares but value added is equalized across producers. In this case, an aggregate model would conclude that efficiency is also equalized across firms - see (16). This, however, cannot be the case as the dispersion in domestic shares implies that efficiency has to vary given a common level of value added. Whether or not consumers prefer the autarky allocation with equalized efficiency depends on χ. If $\chi > 1$, the absence of productivity dispersion will imply higher consumer prices and therefore higher gains from trade in an aggregative framework.

Note also that $\Lambda^{Aut}_{Agg,s}$ provides a bound for the normative consequences of input trade across models. More specifically, (23) and (24) directly imply that if $\chi > 1$ ($\chi < 1$) an aggregate model provides an upper (lower) bound for effect of input trade on consumer prices for *any* model that is calibrated to the aggregate domestic share. Thus, the aggregate approach of Arkolakis et al. (2012) can be used to derive a bound in cases where the micro data is not available. In the quantitative analysis in Section 4, we explicitly show that this intuition carries over to counterfactuals beyond autarky.

The Bias of Firm-based Models. On the other side of the spectrum are firm-based models of importing. These models generate heterogeneity in firms' import shares, typically via sorting into different import markets, thereby inducing a non-trivial joint distribution of import intensity and size. Gopinath and Neiman (2014), Amiti et al. (2014) and Ramanarayanan (2014) for example assume that firms differ only in their efficiency and thus generate a perfect negative correlation between domestic shares and value added conditional on importing. They also imply that all importers are larger than domestic firms. By assigning the largest unit cost reductions to the most efficient firms, this tends to magnify the aggregate gains from trade.[20] Figure 2, however, shows that the correlation between firm size and domestic spending is negative but far from perfect, and that many importers are small. Because models with a single source of firm heterogeneity cannot match these features of the data, they will tend to yield biased estimates of the gains from trade.[21]Antràs et al. (2014) and Halpern et al. (2011) allow for heterogeneity in efficiency and fixed costs and thus generate a non-trivial distribution of value added and domestic spending. Neither of these contributions, however, explicitly targets the observed micro data. In Section 4, we show quantitatively that failing to match such data can lead to substantial biases both for the case of autarky and general counterfactuals.

3 Quantifying the Gains from Input Trade

We now take the framework laid out above to data on French firms to quantify the gains from input trade both at the firm and aggregate level. We start by focusing on the case of a reversal to input autarky because, as argued above, the observed micro data is sufficient to compute the consumer price gains. Implementing Propositions 1 and 2 empirically requires a set of parameters, which are estimated in Section 3.1. Section 3.2 contains the changes in firms' unit costs and consumer prices. Studying counterfactuals other than autarky requires specifying additional theoretical structure. We perform such analysis in Section 4.

3.1 Estimation of Parameters

Our approach relies on both micro and aggregate data. We use the micro data to estimate the production function parameters, i.e. the material elasticities $[\gamma_s]$ and the elasticities of substitution $[\varepsilon_s]$, as well as the sector-specific demand elasticities $[\sigma_s]$. We identify the input-output structure on the production side $\left[\zeta_j^s\right]$ and the aggregate demand parameters $[\alpha_s]$ from the input-output tables. This allows us to account for the non-manufacturing sector and doing so is quantitatively important.

[20]Because the trade-induced unit cost reductions $s_D^{\gamma/(1-\varepsilon)}$ and physical efficiency $\tilde{\varphi}$ are complements, the gains from trade are maximized when $\tilde{\varphi}$ and $s_D^{\gamma/(1-\varepsilon)}$ are matched assortatively. Put differently, given two marginal distributions of domestic shares $F(s_D)$ and value added shares $F(\omega)$, the gains from input trade relative to autarky are maximized whenever the smallest domestic share is assigned to the largest firm. Note, however, that such assignment would change the aggregate domestic share share.

[21]In our quantitative analysis in Section 4 we indeed find that models with a single source of heterogeneity give results, which are upward biased.

Data. The main source of information we use is a firm-level dataset from France. A detailed description of how the data is constructed is contained in Section 7.3 of the Appendix. We observe import flows for every manufacturing firm in France from the official custom files.[22] Manufacturing firms account for 30% of the population of French importing firms and 53% of total import value in 2004. Import flows are classified at the country-product level, where products are measured at the 8-digit (NC8) level of aggregation. Using unique firm identifiers, we can match this dataset to fiscal files which contain detailed information on firm characteristics. Most importantly, we retrieve the total input expenditures from these files, which allow us to compute domestic shares as the difference between total input expenditures and total imports.[23] The final sample consists of an unbalanced panel of roughly 170,000 firms which are active between 2002 and 2006, 38,000 of which are importers. Table 8 in the Appendix contains some basic descriptive statistics. We augment this data with two additional data sources. First, we employ data on input-output linkages in France from the STAN database of the OECD. Second, we use global trade flows from the UN Comtrade Database to measure aggregate export supplies which we use to construct an instrument to estimate the elasticity of substitution ε below.

Identification of α, ζ and σ. We compute the demand parameters α_s and the matrix of input-output linkages $\left[\zeta_j^s\right]$ using data from the French input-output tables on the distribution of firms' intermediate spending and consumers' expenditure by sector.[24] Sectors are classified at the 2-digit level. Letting Z_j^s denote total spending on intermediate goods from sector j by firms in sector s and E_s total consumption spending in sector s, our theory implies

$$\zeta_j^s = \frac{Z_j^s}{\sum_{j=1}^S Z_j^s} \text{ and } \alpha_s = \frac{E_s}{\sum_{j=1}^S E_j}. \tag{25}$$

We aggregate all non-manufacturing sectors into one residual sector, which we denote by S, and construct its consumption share α_S and input-output matrix ζ_j^S directly from the Input-Output Tables.

Our dataset does not have information on firm-specific prices but only revenues. We therefore use industry-specific average mark-ups to get the demand elasticities $[\sigma_s]$. In the model, mark-ups in sector s are equal to $\sigma_s/(\sigma_s-1)$. As in Oberfield and Raval (2014), we identify mark-ups from firms' ratios of revenues to total costs.[25] We calculate total costs as the sum of material spending, payments to labor and the costs of capital. We compute averages at the sector level to identify σ_s.

Table 1 below contains the results. Column three reports the consumption share α_s for each sector

[22] We do not observe imports of service inputs.

[23] Domestic shares are therefore observed at the firm-level, but not at the product level.

[24] See the Online Appendix for a detailed description of how we construct the input-output matrix.

[25] The main benefit of this methodology is its robustness, especially in approaches that rely on a bootstrap procedure to compute standard errors. Furthermore, it delivers estimates of mark-ups that are consistent with the literature in spite of the Bresnahan (1989) critique. An alternative approach would be to rely on the techniques suggested by Klette and Griliches (1996) and De Loecker (2011), but these methods appear to be relatively unstable in our sample. We cannot apply the methodology in De Loecker (2009) as we do not have information on firms' physical output.

in France. The non-manufacturing sector is important as it account for a large share of the budget of consumers. Column four reports the demand elasticities σ_s which, consistent with the literature, are estimated at around 3. For brevity, we report the input-output matrix ζ_j^s in the Online Appendix.

[Table 1 here]

Estimation of ε and γ. Of particular importance are the elasticities of substitution ε_s and the intermediate input shares γ_s, as they directly affect the firm-level gains from importing. To understand our identification strategy, note that firm output can be written as[26]

$$y_{is} = \tilde{\varphi}_i s_{Di}^{-\frac{\gamma_s}{\varepsilon_s - 1}} k_i^{\phi_{ks}} l_i^{\phi_{ls}} m_i^{\gamma_s} \times B \tag{26}$$

where m_i is total material spending by firm i and B collects all general equilibrium variables, which are constant across firms within an industry. By expressing output in terms of *spending* in materials instead of quantities, (26) shows that we can estimate ε_s by treating the domestic share as an additional input in a production function estimation exercise.[27,28] We also see that the domestic share is akin to a productivity shifter.

Because we do not observe firm-specific prices, we rely on the demand structure assumed in Section 2.2 and express (26) in terms of firm revenue

$$ln\left(Rev_{is}\right) = \delta + \tilde{\phi}_{ks} ln\left(k_i\right) + \tilde{\phi}_{ls} ln\left(l_i\right) + \tilde{\gamma}_s ln\left(m_i\right) + ln\left(\vartheta_i\right), \tag{27}$$

where the productivity residual ϑ_i is given by

$$ln\left(\vartheta_i\right) \quad = \quad \frac{1}{1-\varepsilon_s} \tilde{\gamma}_s ln\left(s_{Di}\right) + \frac{\sigma_s - 1}{\sigma_s} ln\left(\tilde{\varphi}_i\right) \tag{28}$$

and $\tilde{\gamma_s} = \frac{\sigma_s - 1}{\sigma_s}\gamma_s$ and $\tilde{\phi_{ks}}$ and $\tilde{\phi_{ls}}$ are defined accordingly.

We use equations (27) and (28) to estimate ε_s and γ_s following three complementary approaches. The first two methods estimate (27) and (28) separately. They only differ in the way in which the output elasticities $[\phi_{ks}, \phi_{ls}, \gamma_s]$ are obtained from (27). We consider both a factor shares approach and a proxy method. We then use such elasticities to construct productivity residuals $ln\left(\vartheta_i\right)$ and use (28) together with data on domestic shares to estimate ε_s. To increase the power of the estimation, we pool firms from all sectors together and estimate a single ε. The third approach treats the

[26]In this section, we augment the production function considered in Section 2 to include capital, i.e. $y_{is} = \varphi_i k^{\phi_{ks}} l^{\phi_{ls}} x^{\gamma_s}$, where ϕ_{ks} and ϕ_{ls} denote the capital and labor output elasticities in sector s. We also assume that the the input measures (k, l, m) observed in the data are used for production and not required for overhead or for firms to attain their sourcing strategies. This allows us to estimate the parameters of the model needed to compute the consumer price gains without taking a stand on the extensive margin.

[27]Note that it is common in the literature to rely on material spending as a measure of input use, as quantities are rarely observed. (26) shows that in this case the domestic expenditure share turns out to be the appropriate deflator for material spending. Not controlling for the domestic share may therefore result in biased estimates.

[28]Because our data does not contain a reliable measure of quality-adjusted input prices, we do not estimate ε from the firm's import demand system (6)-(8).

domestic share as an additional input and estimates all parameters in (27)-(28) simultaneously. In this approach we allow for sector-specific ε_s.

Consider first the approach based on observed factor shares, which is a simple and easy-to-implement benchmark (Syverson, 2011). The Cobb-Douglas production structure implies that

$$\tilde{\gamma_s} = \frac{m_i}{p_i y_i}, \tag{29}$$

so that we can measure $\tilde{\gamma_s}$ as the average share of material spending across firms. We can similarly measure $\tilde{\phi}_{ks}$ and $\tilde{\phi}_{ls}$, and hence construct the productivity residuals $ln\left(\vartheta_i\right)$ from (27) up to an inconsequential constant. In a second step, we then use the estimated $\tilde{\gamma_s}$, the productivity residuals and the data on domestic shares to estimate equation (28).

Clearly, we cannot estimate (28) via OLS as the required orthogonality restriction fails: s_D is not orthogonal to efficiency φ under most reasonable models of import behavior. In particular, more efficient firms are likely to sort into more and different sourcing countries and this variation in the extensive margin of trade may induce variation in firm-specific price indices and hence domestic shares. Hence, we estimate ε from (28) using an instrumental variable strategy. In particular, we follow Hummels et al. (2011) and instrument s_D with shocks to world export supplies, which we construct from the Comtrade data. More precisely, we construct the instrument

$$z_{it} = \Delta ln\left(\sum_{ck} WES_{ckt} \times s_{cki}^{pre}\right), \tag{30}$$

where WES_{ckt} denotes the total exports of product k from country c in year t to the entire world excluding France, s_{cki}^{pre} is firm i's import share on product k from country c *prior* to our sample, and Δ denotes the change between year $t-1$ and year t. Hence, z_{it} can be viewed as a firm-specific index of shocks to the supply of the firm's input bundle. Movements in this index should induce variation in firms' domestic shares that are plausibly orthogonal to changes in firm efficiency.[29] Intuitively, if we see China's exports of product k increasing in year t, French importers that used to source product k from China will be relatively more affected by this positive supply shock and should increase their import activities.[30] Using this source of variation in import prices at the firm-level, we can identify the elasticity of substitution ε.

We estimate (28) in first differences using (30) as an instrument for the domestic share according to the following specification

$$\Delta ln\left(\hat{\vartheta}_{ist}\right) = \delta_s + \delta_t + \frac{1}{1-\varepsilon} \times \Delta\tilde{\gamma}_s ln\left(s_{ist}^D\right) + o_{ist}'\xi + u_{ist}, \tag{31}$$

where δ are sector and year fixed effects, o_{ist} is a vector of firm-level controls, $\Delta ln\left(\hat{\vartheta}_{ist}\right)$ is the

[29] In other words, we assume that changes in firm efficiency $\tilde{\varphi}$ are uncorrelated with the changes in aggregate exports of the countries in the firm's initial sourcing set.

[30] In Table 10 in the Appendix, we also report the reduced form results of regressing performance measures such as log value added or changes in productivity on the export supply shock z_{it}. Reassuringly, we find a positive correlation that is highly statistically significant.

change in firm residual productivity, and $\Delta\tilde{\gamma}_s ln\left(s_{Dist}\right)$ is the change in domestic shares, which is instrumented by (30). We define products at the 6-digit level and take firms' respective first year as an importer to calculate the pre-sample expenditure shares s^{pre}_{cki}. As stated above, to increase statistical power we estimate a unique ε from (31) by pooling firms from all sectors together.[31]

As an alternative to the factor shares approach, we employ a proxy method from the production function estimation literature, akin to Levinsohn and Petrin (2012), to obtain the output coefficients in equation (27). We allow labor to be a dynamic input, which seems more adequate for the French labor market, and estimate the obtained equation using GMM as in Wooldridge (2009) to arrive at estimates of the vector of coefficients $[\phi_{ks}, \phi_{ls}, \gamma_s]$. We follow De Loecker and Warzynski (2012) and allow the productivity process to be affected by the endogenous domestic shares (which are analogous to firms' export status in their setting). We experiment with the standard Cobb-Douglas specification, as well as a more flexible translog specification where we continue to assume a constant output elasticity for intermediate inputs but allow for second-order terms in capital and labor. The second step is as in our previous approach: we construct productivity residuals $ln\left(\vartheta_i\right)$ for each firm and estimate ε from (31) using the instrumental approach described above. Hence, if the production function estimation were to give us the same $[\phi_{ks}, \phi_{ls}, \gamma_s]$ as the factor shares approach, the implied estimate for ε would be numerically identical.

Our third method consists of estimating firms' production function with an integrated GMM approach. Instead of treating (27) and (28) as separate estimation equations, we estimate the firms' production function in a single step with four inputs and again follow Wooldridge (2009) to estimate the four parameters via GMM. We follow the literature in using lagged values of capital, labor and materials to proxy for φ, and two-years lagged values of intermediate inputs as an instrument for current intermediate inputs (the only static input). We use the trade instrument discussed above to account for the endogeneity of firms' domestic shares.

The results of the three estimation approaches for ε are reported in Table 2 and Figure 3 below. Table 2 contains the estimates of ε using the factor shares approach and the proxy method based on Levinsohn and Petrin (2012) and Wooldridge (2009).[32] For the latter procedure, we report the results based on both the Cobb Douglas and the more general translog specifications. In the respective first column, we show the first stage relationship between changes in world export supply z_{it} and firms' changes in domestic spending. Reassuringly, there is a negative relationship that is statistically significant, i.e. firms whose trading partners see an increase in their total world exports reduce their domestic spending.[33] Turning to the results for ε, we see that the different procedures yield relatively similar results as the estimates lie between 1.7 and 2.4.[34] In particular, the point estimates remain relatively unchanged when we estimate the second stage equation on importing firms only.

[31] We retrieve $\hat{\varepsilon}$ from (31) using the standard delta-method. The obtained estimator is convergent and asymptotically Gaussian. However, in our setting, $\hat{\gamma}_s$ and $1/\widehat{(1-\varepsilon)}$ are estimated in two separate regressions. It is therefore not convenient to use the delta-method approach to estimate the standard error associated with $\hat{\varepsilon}$. We rely on a bootstrap procedure with 200 replications.

[32] For brevity, we report the estimates of the other production function parameters in the Online Appendix.

[33] The reason why the first stage results are not numerically equivalent across the different specifications is that the estimated material elasticity is different. Recall that the independent variable is $\Delta\tilde{\gamma}_s ln\left(s^D_{ist}\right)$.

[34] Our estimates are close to the ones of Antràs et al. (2014) who rely on cross-country variation.

Note, however, that the standard errors increase substantially as we lose a large amount of data by conditioning on import status. [35]

[Table 2 here]

[Figure 3 here]

The results of the integrated GMM approach are summarized in Figure 3. Because we estimate firms' production function for each industry, this procedure gives sector-specific estimates of ε. We depict both the point estimates and confidence intervals based on two standard deviations. While we lack precision in some industries, the point estimates are mostly in the same ballpark as the pooled results from above.[36,37]

For the remainder of the paper, we take the estimate stemming from the factor shares approach, i.e. $\varepsilon = 2.38$, as the benchmark. While the two-step approaches use firms' changes in domestic shares to identify ε (see (31)), the one-step GMM approach relies on the heterogeneity of the levels of domestic shares. Conceptually, we prefer the identification strategy in first differences as we find the underlying exogeneity assumptions more plausible. It is nevertheless comforting to see that all these approaches yield consistent results. While we lock in to the factor shares estimate, we report confidence intervals for all quantitative results which take into account the sampling variation in this benchmark estimate. Note additionally that our choice of benchmark ε is conservative as far as the magnitude of the gains from trade is concerned, since the unit cost reductions are decreasing in ε.

3.2 A Reversal to Autarky

With the structural parameters at hand, we now quantify the gains from input trade in France. We proceed as in the theory. We follow Proposition 1 and use data on domestic expenditure shares to measure the distribution of unit cost reductions relative to autarky across firms. We then augment this data with information on firm size and use Proposition 2 to measure the corresponding change in consumer prices. We also compare our results to an analysis based on aggregate data.

Input Trade and Producer Gains. Given our estimates of ε and γ_s and the micro-data on firms' domestic shares, Proposition 1 states that the unit cost reductions from input trade are given by $\frac{\gamma_s}{1-\varepsilon} ln\left(s_D\right)$. We depict these firm-level gains in Figure 4 and summarize them in Table 3. We see

[35] Note also that the F-statistic only ranges between 3 and 4 in this sub-sample. In Section 7.4 in the Appendix, we provide further robustness checks to our estimates of ε, which lead to similar conclusions. In particular, we keep the year used for the pre-sample weights s_{cki}^{pre} fixed at 2001 for all firms.

[36] Kasahara and Rodrigue (2008) find estimates of the elasticity of substitution in the range of 3.1 to 4.4 using a related approach for Chilean data. However, they do not use an external instrument for firms' imported intermediates. Halpern et al. (2011) use Hungarian data and derive a production function equation analog to (27)-(28), as well as an import demand equation. They find an elasticity of substitution of 7.3. The main difference with our approach is that they obtain the parameters of their structural model by *simultaneously* estimating the production function and import demand equations. In contrast, we identify ε solely from (27)-(28) by using exogenous variation in input supplies.

[37] This suggests that the relatively low value for ε found in the pooled factor shares approach is not a result of the sectoral pooling of our data. This is in contrast to estimations on aggregate data, which find a downward bias (Imbs and Mejean, 2015).

that there is substantial dispersion in the gains from trade. While the median firm would see its unit cost increase by 11.2% if moved to autarky, firms above the 90th percentile of the distribution would experience losses of 85% or more. According to Proposition 1, any model within the class covered in Section 2.1 will arrive at exactly the same conclusions about the distribution of the gains from trade at the micro-level, as long as it matches the micro data on domestic shares and utilizes the same values for γ_s and ε.

[Figure 4 here]

[Table 3 here]

We can also use the micro-data to learn about firm characteristics that are correlated with the producer gains. In particular, consider the following regressions:

$$\frac{\gamma_s}{1-\varepsilon} ln\left(s_{Dist}\right) = \delta_s + \delta_t + o_{ist}'\psi + u_{ist}, \tag{32}$$

where δ_s and δ_t are industry and time fixed effects and o_{ist} is a vector of firm characteristics. To interpret ψ, recall from (8) that the observed domestic shares can reflect firm-variation in exogenous "import capabilities" (such as prices $[p_{ci}/q_{ci}]$ or the home bias β_i) and firms' endogenous sourcing strategies Σ_i. The results are contained in Table 4 and are intuitive. Bigger firms, as measured by either value added or employment, see higher gains. Being an exporter or a member of an international group is associated with a reduction in the unit cost of 8.5% and 14.8%, respectively. When we restrict the analysis to the sample of importers, the positive relation between firm size and the producer gains becomes substantially weaker. This is consistent with the pattern documented in Figure 2 above which showed a mild correlation between import intensity and value added for importers. Next, we consider the role of the firm's sourcing strategy, which we measure by the average number of countries that the firm sources its products from. According to the theory of Section 2, firms source their inputs internationally to reduce their unit cost. Consistent with the theory, we find a strong positive relation between firms' extensive margin of importing and the producer gains. Note that the importance of other firm characteristics is diminished once the number of varieties is controlled for.[38]

[Table 4 here]

Input Trade and the Consumer Price Gains. We now use Proposition 2 to quantify the effect of input trade on consumer prices. Table 5 contains the results. We find that French consumer prices in the manufacturing sector would be 27.5% higher if French producers were forced to source their inputs domestically. When the price of the non-manufacturing sector is taken into account,

[38]In particular, firm size is substantially negatively correlated with import spending holding the number of imported varieties fixed. This is intuitive. If a small firm decides to source from the same number of sourcing countries as a large firm, then it is likely that the small firm is a proficient importer, i.e. has a low home bias β, which manifests itself in a low share of domestic spending.

the consumer price gains amount to 9%.[39] The reason why these economy-wide gains are smaller is that the non-manufacturing sector experiences only a 3% price reduction but accounts for 70% of consumers' budget - see Table 1.

In Table 5, we also report the consumer price gains predicted by an aggregate approach that only uses data on domestic spending at the sector level - see (22). This aggregate approach implies gains of 31.4% and 9.9% in the manufacturing sector and the entire economy, respectively. Ignoring the heterogeneity in firms' import behavior within sectors therefore results in an over-estimation of the consumer price gains by 3.4 and 1 percentage points for the manufacturing sector and the entire economy, respectively. The aggregate approach is upward biased because the estimated parameters imply that, for most sectors, Λ_s is a convex aggregator of firms' domestic shares - see (23)-(24).

[Table 5 here]

Importantly, there is a second source of bias that arises when using an aggregate approach which pertains to the "correct" elasticity of substitution ε. While we treat ε as a production function parameter and estimate it from micro-data, aggregate models often estimate ε from a gravity equation using aggregate trade flows. While there is a large literature concerning this particular parameter, most aggregate approaches find estimates that are larger than our preferred estimate of 2.38.[40] Costinot and Rodríguez-Clare (2014) for example use a trade elasticity of five as their benchmark value.[41] As the implied gains from trade are decreasing in the elasticity of substitution, such choice would lead to substantially smaller gains from trade. In Section 7.5 of the Appendix, we redo the analysis of Table 5 for a range of values of ε spanning the estimates from the literature. Moving to $\varepsilon = 5$, for example, reduces the consumer price gains from trade of the aggregate approach by 65%. This "elasticity bias" can therefore be substantial.

We also use the micro-data to quantify our confidence in the estimates of the gains from input trade. Table 5 reports the 90-10 confidence intervals of the bootstrap distribution of the point estimates in italics.[42] Note that the uncertainty in the point estimates stem from two sources. First, because we base our analysis on a large but finite sample, there is uncertainty in our aggregate statistics for given parameters. Second, the structural parameters ε, γ_s and σ_s are estimated with error. These two forces induce quite a bit of variation in the estimates. With 80% probability, the consumer price gains in the manufacturing sector lie between 21% and 36% and the gains for the

[39] Formally, the economy-wide gains P^{Aut}/P are related to the gains in the manufacturing sector P_M^{Aut}/P_M via $P^{Aut}/P = \left(P_M^{Aut}/P_M\right)^{1-\alpha_S}\left(P_S^{Aut}/P_S\right)^{\alpha_S}$, where α_S is the expenditure share in the non-manufacturing sector.

[40] Recall that our benchmark was chosen conservatively, as all other estimates of ε in Table 2 are smaller. See also Goldberg et al. (2010) for indirect evidence on the low substitutability between domestic and imported inputs for Indian manufacturing firms.

[41] See also Simonovska and Waugh (2013) and Simonovska and Waugh (2014) who report estimates of 4 and between 3 and 4 respectively.

[42] We explain the details of the bootstrap procedure in Section A.3 of the Online Appendix. A sketch of the procedure is as follows. For each bootstrap iteration, we construct a new sample of the French manufacturing sector by drawing firms from the empirical distribution with replacement. We then redo the analysis of Section 3.1 and obtain new estimates for the structural parameters. Finally, for each iteration, we recalculate the consumer price gains and the other statistics of interest.

entire economy lie between 7% and 12%.[43] We also find that the aggregate approach yields more uncertain estimates (second row) and leads to an over-estimation of the gains with 80% probability (third row). A graphical depiction of this sampling uncertainty is contained in Figure 5. We see that the bootstrap distribution of the consumer price gains using the aggregate approach features a thicker right tail (upper panels) and the resulting bias has the majority of its mass on positive numbers (lower panels).

[Table 6 here]

Table 6 reports the gains by sector and provides a decomposition to isolate the importance of production linkages across sectors. We first report the sectoral consumer price gains, P_s^{Aut}/P_s, which measure the change in the price of the output bundle of sector s. We find substantial heterogeneity in the effect of input trade across sectors: while e.g. prices for textile products would be 56% higher if producers were not allowed to source their inputs from abroad, this effect is only 18% for metal products. We then decompose these price changes into the direct price reduction from firms in sector s sourcing internationally, Λ_s, and the indirect gains stemming from firms in sector s buying domestic inputs from other firms who in turn may engage in trade, p_{Ds}^{Aut}/p_{Ds}.[44] We find that interlinkages are important as they account for roughly 50% of the sectoral price gains. Note also that the importance of interlinkages varies substantially across industries as a result of the underlying heterogeneity in the input-output matrix: sectors that rely on relatively open sectors more intensively benefit more from input trade as their upstream suppliers experience larger unit cost reductions.

We also assess the importance of interconnections by considering the case with no cross-industry input-output linkages, i.e. where each sector uses only its own products as inputs.[45] In this case, we find a point estimate for the consumer prices gains from trade of

$$G = \sum_{s=1}^{S} \alpha_s \frac{\Lambda_s}{1-\gamma_s} = 12\%.$$

That is, shutting down input trade would increase consumer prices by 12%. Compared to the actual gains of 9%, the economy without interlinkages over-estimates the aggregate gains by about a third. The reason is that the non-manufacturing sector is not only important for final consumers but also as a provider of inputs to other manufacturing firms. As this sector is not a direct beneficiary of foreign sourcing in the model, such linkages actually dampen the aggregate effect of input trade.

Finally, Table 6 also contains the direct price reductions that arise from an aggregate model, Λ_s^{Agg}. In line with the results of Table 5, in 12 of the 18 manufacturing sectors the gains based on aggregate data are upward biased. The reason for this pattern goes back to the condition in (24) which characterizes the sign of the bias as a function of parameters encapsulated in χ_s. It turns out that for most sectors our estimated parameters imply that $\chi_s > 1$ (see last column) so that the

[43]Given the large sample size, most of the uncertainty stems from the variation in the structural parameters and not from the re-sampling of firms. See Figure 6 in the Online Appendix.

[44]Formally, p_{Ds} is the sector-specific price index of a unit of the bundle of domestic inputs, which is an aggregator of all the goods produced locally, see (14).

[45]In this case, the matrix of input-output linkages is given by $\zeta_j^s = 0$ for $j \neq s$ and $\zeta_j^j = 1$.

aggregate models are upward biased. Note also that the bias can be quite substantial. Consider for example the office and computing machinery sector. While the aggregate approach would imply a direct price reduction of 37%, the exact firm-based formula tells us that this number should be only 20%.

In this section, we have focused on the heterogeneity in firms' import intensities. This is a natural starting point to study the effects of input trade. There are other dimensions of heterogeneity which our analysis abstracts from, most importantly heterogeneity in markups and material shares. In the case of non-constant material shares, firms' unit costs would be determined from the micro data on domestic shares and material shares, and the counterfactual change in unit costs would be determined from the changes in these shares. We discuss this case in more detail in Section 7.1 of the Appendix.[46] As for mark-ups, we can combine Proposition 1, which allows us to measure the distribution of unit costs changes directly from the data, with any macroeconomic model of consumer demand and market structure, and hence map such unit cost changes into changes in consumer prices. The aggregate consequences of input trade depend on the degree of pass-through and on the correlation between pass-through and firm-size. While such extensions are likely to change the magnitude of the aggregate effects of input trade, it is less clear whether they would eliminate the bias from not relying on firms' domestic shares reported in Table 5.

4 Beyond Autarky and Consumer Prices

So far, we quantified the effect on consumer prices of moving to input autarky. In this section, we consider the general case of Proposition 2 to study counterfactuals beyond autarky. More precisely, we consider shocks that make all foreign varieties more expensive without leading the economy into autarky, as is for example the case under a currency devaluation. While the effect of the shock on consumer prices is still fully determined from the changes in firms' domestic shares, such changes are no longer observed and one needs a model to predict them. Hence, we now specify additional components of the theory. Doing so also allows us to quantify the effect of input trade on welfare, taking into account the resources (if any) spent by firms to attain their sourcing strategies.

The goal of this section is to assess whether the *observable* micro data is important to quantify the effects of counterfactuals, which - by construction - are *unobserved*. To do so, we consider different models of importing which vary in the extent to which they match the micro data (i.e. the level of domestic shares and firm size), and compare their counterfactual implications (i.e. the changes in domestic shares).

[46] We also note that empirically the dispersion in domestic shares exceeds the one of material shares. Focusing on the sample of importing firms, the average interquartile range of material spending shares (domestic expenditure shares) within 2-digit industries is 0.25 (0.42). The average difference between the 90th and 10th percentile is 0.46 (0.71).

4.1 Modeling Domestic Shares

To construct a model of firms' domestic shares, we start from the general framework laid out in Section 2 and impose restrictions.[47] For brevity, we provide all derivations in Section 7.6 of the Appendix. We consider settings where firms' extensive margin is limited through the presence of fixed costs so that firms choose their sourcing strategy by trading off the import-induced reduction in unit costs vs the payment of fixed costs. While this seems a natural starting point, one could extend the analysis to other models of the extensive margin.

We assume that the fixed cost of sourcing from a given country varies across firms but is constant across countries, i.e. $f_{ci} = f_i$. In this case, the firm selects its sourcing countries based purely on their price-adjusted qualities and the sourcing strategy reduces from a set Σ to a scalar, a price-adjusted quality cutoff.[48] We also impose the following functional form assumptions: (i) the import bundle takes a CES form with elasticity of substitution κ[49]:

$$x_I = \left(\int_{c \in \Sigma} (q_c z_c)^{\frac{\kappa-1}{\kappa}} \, dc \right)^{\frac{\kappa}{\kappa-1}}, \tag{33}$$

and (ii) that country quality q_c is Pareto distributed:

$$G(q) = \Pr(q_c \leq q) = 1 - (q_{\min}/q)^{\theta} \text{ for } q \geq q_{\min}, \tag{34}$$

where $\theta > \min[1, \kappa - 1]$ and $q_{min} > 0$. These assumptions imply that the import price index depends only on the mass of countries sourced from and takes a convenient power form:

$$A(\Sigma) = \left(\int_{c \in \Sigma} q_c^{-(1-\kappa)} dc \right)^{\frac{1}{1-\kappa}} = \frac{1}{q_{\min}} \left(\frac{\theta}{\theta - (\kappa - 1)} \right)^{\frac{1}{1-\kappa}} n^{-\left(\frac{1}{\kappa-1}\right)} \equiv z n^{-\eta} = A(n). \tag{35}$$

Here n is the share of countries the firm sources foreign inputs from and z and η are "auxiliary" parameters which depend on the parameters governing the distribution of quality $(q_{\min}, \theta)$ and the elasticity of substitution across foreign varieties κ. In particular, z parametrizes the average price of foreign inputs. We will consider changes in z as our counterfactual shock.[50] While the reversal to autarky considered above corresponds to $z \to \infty$, we are now able to study finite increases in z.

Under the above assumptions, the firm's profit maximization problem is given by

[47] For expositional simplicity, we consider a one-sector version of the model. See the Online Appendix for the analysis with multiple sectors.

[48] More precisely, as long as fixed costs are constant across countries, if country c with price-adjusted quality q_c/p_c is an element of Σ so are all countries c' with $q_{c'}/p_{c'} > q_c/p_c$. Computing firms' optimal sourcing strategies can be challenging when prices, qualities and fixed costs vary by country in an arbitrary way - see Antràs et al. (2014). Allowing for country-specific fixed costs will only matter for normative questions as long as it translates into a different predicted distribution of domestic shares - see Proposition 2. Whether this additional degree of freedom is quantitatively important is outside the scope of this paper.

[49] For simplicity, we assume a continuum of countries so that firms' extensive margin can be characterized by a first order condition. It is straight-forward to work with a discrete number of countries. Also, without loss of generality, we normalize all foreign prices to unity.

[50] In principle, we can also study a change in the price of a particular country. To do so, we would need to consider a version of the model with a discrete number of countries.

$$\pi = \max_n \left\{ u(n)^{1-\sigma} \times B - w\left(nf + f_I \mathbb{I}(n>0)\right) \right\}, \tag{36}$$

where f denotes the fixed cost per country, f_I is a fixed cost to start importing, $\mathbb{I}(\cdot)$ is an indicator of import status and $B \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P^{\sigma-1}S$, with P and S denoting the consumer price index and aggregate spending, which are determined in general equilibrium. The unit cost function u is given by the analogues of equations (8) and (9), which we replicate here for convenience:

$$u(n) \equiv \frac{1}{\tilde{\varphi}} w^{1-\gamma} \left(\frac{p_D}{q_D}\right)^{\gamma} s_D(n)^{\frac{\gamma}{\varepsilon-1}} \tag{37}$$

$$s_D(n) = \left(1 + \left(\frac{1-\beta}{\beta}\right)^{\varepsilon} \left(\left(\frac{p_D}{q_D}\right)\frac{1}{z} n^{\eta}\right)^{\varepsilon-1}\right)^{-1}. \tag{38}$$

While (37) shows that the effect of input trade on firms' unit costs is fully summarized by the domestic share, (38) now contains *a theory of domestic shares*: these can be small either because the firm sources from many countries (n is large) or because of a technological bias towards foreign inputs (β is low).

Equations (36)-(38) fully describe firms' optimal import behavior.[51] To close the model in general equilibrium, we impose equilibrium in the labor market and balanced trade between the domestic economy and the rest of the world.[52] We assume that foreigners demand the output of local firms with the same CES demand structure as domestic consumers and producers[53] and that the supply of foreign inputs from country c is perfectly elastic. Letting y_i^{ROW} be the foreign demand for firm i's production, balanced trade requires that

$$\int_i p_i y_i^{ROW} di = \int_i (1 - s_{Di}) m_i di, \tag{39}$$

where m_i denotes material spending of firm i, so that $(1 - s_{Di}) m_i$ is firm i's spending on imported varieties, and p_i is firm i's price. An equilibrium is attained when firms maximize profits, consumers maximize utility, trade is balanced and labor and good markets clear.[54]

In this context, it can be shown that the equilibrium change in consumer welfare relative to autarky is given by

$$\frac{W}{W^{Aut}} = \frac{P^{Aut}}{P} \times \left(\frac{L - \int_i l_{\Sigma_i} di}{L}\right), \tag{40}$$

where W denotes consumer welfare and $\int_i l_{\Sigma_i} di$ denotes the aggregate resource loss due to fixed costs.

[51] In Section 7.6 in the Appendix, we fully characterize the solution to this problem. There we also show that, conditional on importing, the optimal mass of sourcing countries n is increasing in φ and decreasing in f.

[52] We abstract from trade in final goods. In this single sector economy with roundabout production, domestic inputs and final goods are equivalent. This is no longer the case with multiple sectors - see Section A.4 of the Online Appendix.

[53] This simplifies the problem of local producers as the demand of their different customers (consumers, local firms and foreigners) can be aggregated into a single iso-elastic demand function. The term B in (36) incorporates the sum of spending across the three types of customers.

[54] See Section 7.6 in the Appendix for a formal definition.

Hence, the welfare gains from input trade consist of two components. First, there is the reduction in consumer prices associated with input trade. This was the focus of Sections 2 and 3 above. Second, there is the resource loss due to fixed costs, which results in (weakly) fewer workers left for production. Because this second term in (40) is weakly smaller than unity, the change in the consumer price index provides an upper bound for the change in welfare in the class of models of Section 2. While we calculate $\int_i l_{\Sigma_i} di$ within a model of fixed costs, we note that (40) is consistent with any extensive margin mechanism. For example, if importers found their trading partners through a process of network formation, (40) would still hold but the environment to calculate $\int_i l_{\Sigma_i} di$ would be different.

4.2 Calibration and Results

We now calibrate this model to the French micro data. In order to generate the rich distribution of domestic shares and value added shown in Figures 1 and 2, we have to allow for (at least) two sources of firm heterogeneity. As is standard, we allow firms to differ in efficiency $\tilde{\varphi}_i$. For the second source of heterogeneity, we consider two options: (i) a model with *heterogeneous fixed costs,* where firms differ in their f_i[55], and (ii) a model with *heterogenous home bias*, where firms differ in their β_i.[56]

As $\tilde{\varphi}_i$ and the endogenous unit costs reduction through input trade are complements, there is a firm-specific efficiency cutoff, either $\overline{\varphi}(f_i)$ or $\overline{\varphi}(\beta_i)$, above which firms select into importing. This sorting generates overlap in the size distribution of importers and non-importers as seen in Figure 2. Furthermore, both models generate variation in import intensity conditional on size. While the heterogenous fixed cost model generates dispersion in import shares fully via variation in the extensive margin n_i, the bias-model is the polar opposite in that firms gain differentially from international trade because of variation in β_i.

In order to calibrate these parametrizations of the model to the data, we adopt the following strategy. First, we use the estimates of ε, γ and σ from Section 3.1 above.[57] Next, for the model with heterogeneous fixed costs we need to estimate η, which determines the price index of the import bundle - see (35) - and hence the demand for foreign varieties. We estimate η directly from the micro data: we identify it from the cross-sectional relationship between firms' extensive margin of trade and their domestic shares.[58] Without loss of generality, we can normalize the quality of the domestic variety (q_D) and the average price of foreign varieties (z) to unity.[59]

Finally, we parametrize the distributions for firm heterogeneity. For efficiency, we take a log-

[55]For simplicity, we assume that the fixed cost to start importing f_I is constant across firms.

[56]In this model, we assume there are no fixed costs of importing per country ($f = 0$), but we still assume a positive fixed cost to start importing ($f_I > 0$) to be able to match the existence of non-importing firms.

[57]Section 3.1 provides estimates of σ and γ by sector. In this section, we use value-added weighted averages of these sectoral estimates, which yield $\sigma = 3.83$ and $\gamma = 0.61$.

[58]In particular, (38) predicts a log-linear relation between n and $(1 - s_D)/s_D$, with a slope given by η. See Section 7.7 in the Appendix for details and the results. Our preferred specification yields a value of η of 0.382 that is precisely estimated. This implies that the elasticity of substitution between foreign varieties κ is given by $\kappa = 1 + \eta^{-1} = 3.63$. Note also that we do not require η for the heterogeneous bias model as all firms decide to source from all countries (conditional on importing), i.e. $n = 1$, see (38).

[59]See Section A.5 of the Online Appendix.

normal distribution and normalize its mean to unity

$$ln\left(\tilde{\varphi}\right) \sim \mathcal{N}\left(-\frac{1}{2}\sigma_{\varphi}^{2}, \sigma_{\varphi}^{2}\right). \tag{41}$$

For the heterogeneous fixed cost model, we parametrize the conditional distribution of fixed costs also as a log-normal

$$ln\left(f\right)|_{ln(\tilde{\varphi})} \sim \mathcal{N}\left(a_0 + a_{\varphi} ln\left(\tilde{\varphi}\right), \sigma_{f|\varphi}^{2}\right). \tag{42}$$

That is, we allow for fixed costs to be correlated with efficiency and we can link the parameters a_0, a_{φ} and $\sigma_{f|\varphi}^{2}$ to the average (log) fixed costs (μ_f), the dispersion of fixed costs $\left(\sigma_f^2\right)$ and the correlation of (log) efficiency and (log) fixed costs($\rho_{f\varphi}$).[60] Similarly, we assume that the degree of home-bias, $\tilde{\beta} \equiv \frac{\beta}{1-\beta} \in [0, \infty]$, is conditionally log-normally distributed

$$ln\left(\tilde{\beta}\right)|_{ln(\tilde{\varphi})} \sim \mathcal{N}\left(b_0 + b_{\varphi} ln\left(\tilde{\varphi}\right), \sigma_{\tilde{\beta}|\varphi}^{2}\right). \tag{43}$$

Again, we can link b_0, b_{φ} and $\sigma_{\tilde{\beta}|\varphi}^{2}$ to the average (log) home-bias $\left(\mu_{\tilde{\beta}}\right)$, the home bias dispersion $\left(\sigma_{\tilde{\beta}}^2\right)$ and the correlation of (log) efficiency and (log) home-bias $\left(\rho_{\tilde{\beta}\varphi}\right)$.

Calibration. Our calibration strategy is as follows.[61] The distributions of firm heterogeneity are parametrized by four parameters. For the model with heterogenous fixed costs (resp. home bias), such parameters control the dispersion in efficiency, the dispersion in fixed costs (resp. home bias), the average fixed cost (resp. home bias) and the correlation of fixed costs (resp. home bias) with efficiency. For each model, we calibrate these parameters by targeting salient features of the joint distribution of value added and domestic shares displayed in Figures 1 and 2. In particular, we match the aggregate domestic share, the dispersion in value added, the dispersion in domestic shares and their correlation with value added. Finally, we also need to calibrate the fixed cost to start importing f_I and to do so we target the share of non-importing firms.

To assess the value of the micro data, we also calibrate the above models *without* targeting the moments associated with the heterogeneity in domestic shares, i.e. their dispersion and correlation with firm size. As we drop these two moments, we also drop two parameters in each model. In the heterogeneous fixed costs model, we set $\sigma_f = \rho_{f\varphi} = 0$, which corresponds to assuming constant fixed costs across firms. We call this parametrization the *homogeneous fixed cost* model. In the heterogeneous home bias model, we set $\sigma_{\beta} = \rho_{\beta\varphi} = 0$, which corresponds to a *homogeneous home bias* model. As in the heterogeneous home bias model, this model features a fixed cost to start importing, $f_I > 0$, but no fixed costs of importing per country, $f_i = 0$. Finally, we consider a model with no fixed costs of any kind, $f_i = f_I = 0$ and a constant home bias. This version of the model implies that firms' import intensities are equalized and hence we refer to it as the *aggregate model.*[62]

[60]These are related via $\mu_f = a_0 - \frac{a_{\varphi}}{2}\sigma_{\varphi}^2$, $\sigma_f^2 = a_{\varphi}^2\sigma_{\varphi}^2 + \sigma_{f|\varphi}^2$ and $\rho_{f\varphi} = a_{\varphi}\frac{\sigma_{\varphi}}{\sigma_f}$.

[61]We describe the algorithm used to calibrate the model in Section A.5 of the Online Appendix.

[62]This model is parametrized by two parameters: the dispersion of efficiency and the home-bias $\tilde{\beta}$, which is constant across firms. We calibrate these parameters to match the dispersion in value added and the aggregate domestic share.

Table 7 summarizes the five parametrizations of the model we consider and contains the calibration results. In Panel A, we report the calibrated parameters. Panel B contains the model-generated moments, as well as the targeted ones in bold letters. We first note that all versions of the model match the targeted moments *exactly.* As expected, the aggregate model (column 5) generates full participation in import markets and equalized domestic shares. The homogeneous fixed cost and home bias models (columns 3 and 4) improve on these counterfactual implications by allowing for fixed costs. However, because they feature efficiency as the single source of firm heterogeneity, these models predict too strong a correlation between firm-size and domestic shares relative to the data, as well as no overlap in the size distribution of importers and domestic firms (see Figure 2). By allowing for an additional dimension of heterogeneity, the heterogenous fixed costs or home-bias models (columns 1 and 2) improve the fit along these dimensions. First, they increase the dispersion in domestic shares by introducing variation in import demand conditional on efficiency. Second, they reduce the correlation between size and domestic shares. Intuitively, to be consistent with the low correlation of size and import intensity both parametrizations require that some efficient firms have a *lower* incentive to import compared to a model with a single source heterogeneity. This is achieved by having a positive correlation between firm efficiency and fixed costs (resp. home bias).

[Table 7 here]

Results. With the calibrated models at hand, we can now study the effect of any shock to the trading environment on both consumer prices and welfare. We focus on two counterfactuals: (i) a reversal to input autarky ($z \to \infty$) and (ii) an increase in the relative price of all foreign inputs. More precisely, the latter exercise corresponds to increasing z to attain a decrease in the aggregate import share of 5%, 10% or 20%. Table 7 contains the results, from which we draw three main conclusions.

First, we find that the two models that match the micro data on size and domestic shares predict the same counterfactual change in consumer prices. To see this, consider the two models in columns 1 and 2. While both models perfectly match the four moments of the joint distribution of value added and domestic shares, their underlying microstructure is very different. They nevertheless give very similar predictions for the change in consumer prices across the different counterfactuals. That this result is exact for a reversal to input autarky (Panel C) is the content of Proposition 2: both models predict an increase in consumer prices of 38%.[63] Panel D shows that this is also the case for the non-autarky counterfactuals: the difference in the implied changes in consumer prices between the two models is less than 1%. In this sense, Panel D provides a quantitative extension of Proposition 2.

Second, the models that do *not* match the data on domestic shares and value added (columns 3- 5) yield quantitatively meaningful biases. In panel C, we report the change in consumer prices relative to autarky: the three models predict changes that are 14-18% too high. That such biases are not confined to the autarky-counterfactual is seen in Panel D. The estimated effects of the three

[63] This number does not coincide with that reported for the Manufacturing sector in Table 5 above, i.e. 27.5%. The reason is that we calibrated a one-sector version of the model of Section 2 to moments obtained from pooling all industries. Additionally, we targeted only five moments of the joint distribution of size and domestic shares.

devaluations are also upward biased by similar magnitudes. To understand why these biases are positive it is helpful to go back to our theoretical results. That the aggregate model in column 5 predicts the largest change in consumer prices in the autarky counterfactual follows from our characterization of the bias in (24): because $\gamma(\sigma - 1)/(\varepsilon - 1) > 1$, the aggregate model provides an upper bound for any model of importing. It is also intuitive that the models with homogeneous fixed costs and home-bias are upward biased viz-a-viz the models that match the microdata on firm-size and domestic shares. By relying on efficiency as the single source of firm heterogeneity, the models in column 3 and 4 generate a perfectly negative correlation between efficiency and the domestic share. This means that more efficient firms experience a larger reduction in their unit cost, a feature that tends to make input trade more attractive. Given the estimated parameters, this result is further reinforced by the lower dispersion in domestic shares generated by these models.

Finally, we also calculate the change in welfare taking the resource loss of fixed costs into account. We report the results for the reversal to autarky in the last row of Panel C. In contrast to the results for consumer prices, the implications for welfare can vary substantially across models, even conditional on fully matching the micro data. Specifically, columns 1 and 2 in Panel C show that the heterogeneous fixed cost and home bias models predict very different changes in welfare relative to input autarky. While the former predicts an increase of 17% in welfare, the latter predicts an increase of 36%.[64] Thus, the share of the consumer price gains that is lost by firms' attaining their sourcing strategies crucially depends on how domestic shares are modeled.

5 Conclusion

Firms around the world routinely engage in input trade to reduce their costs of production, thereby benefiting domestic consumers through lower prices. Quantifying these gains from input trade, however, is not straightforward. As firms differ vastly in the intensity with which they participate in international markets, aggregate trade models cannot be applied. One therefore has to resort to firm-based models of importing to study the normative implications of input trade. In this paper, we identify the aspects of the data that are crucial to credibly doing so.

Our main theoretical result is akin to a sufficiency result and shows that the change in consumer prices due to changes in the import environment (e.g. a change in trade costs or a change in foreign prices) is fully determined from the joint distribution of firm size and changes in domestic expenditure shares. A focal point of our analysis is the special case of a reversal to input autarky. As firms' counterfactual domestic shares in autarky are equal to unity, the gains from input trade relative to autarky are fully determined from firms' value added and domestic shares, which we observe. In our application to France, we find that consumers would face 27% higher prices for manufacturing

[64]Note that this difference is not due to the fact that the home bias model does not feature any fixed cost per sourcing country. The homogenous home bias model of column 4 does not feature any fixed costs per country either, but implies that the fixed costs to start importing account for about 40% of the consumer price gains. The reason why heterogeneity in the efficiency of using imported inputs generates a tighter bound between welfare and consumer prices is the discrepancy between the marginal importer, whose cost reductions determine the calibrated value of fixed costs, and the set of *infra*marginal firms, who might benefit from input trade substantially.

products under input autarky. Importantly, a broad class of models used in the literature will arrive at the exact same number, conditional on the micro-data.

We then show quantitatively that this result extends to non-autarky counterfactuals such as an increase in the price of foreign inputs. In the context of a model with fixed costs, we find that parametrizations of the model that are calibrated to the micro data on firm size and domestic shares imply similar changes in consumer prices. Conversely, models that do not match this data give biased predictions. We conclude that the information contained in the firm-level data on domestic shares and size is crucial to discipline quantitative models of importing.

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6 Tables and Figures

Industry	ISIC	α_s	σ_s	γ_s	VA share	s_{Ds}^{Agg}
Mining	10-14	0.02%	2.58	0.33	1.28%	0.90
Food, tobacco, beverages	15-16	9.90%	3.85	0.73	15.24%	0.80
Textiles and leather	17-19	3.20%	3.35	0.63	3.96%	0.54
Wood and wood products	20	0.13%	4.65	0.60	1.67%	0.81
Paper, printing, publishing	21-22	1.37%	2.77	0.50	7.96%	0.75
Chemicals	24	2.04%	3.29	0.67	12.91%	0.60
Rubber and plastics products	25	0.44%	4.05	0.59	5.88%	0.63
Non-metallic mineral products	26	0.24%	3.48	0.53	4.54%	0.72
Basic metals	27	0.01%	5.95	0.67	2.07%	0.60
Metal products (ex machinery and equipment)	28	0.26%	3.27	0.48	9.27%	0.81
Machinery and equipment	29	0.66%	3.52	0.62	7.00%	0.69
Office and computing machinery	30	0.43%	7.39	0.81	0.35%	0.59
Electrical machinery	31	0.47%	4.49	0.60	3.99%	0.64
Radio and communication	32	0.63%	3.46	0.62	1.92%	0.64
Medical and optical instruments	33	0.35%	2.95	0.49	3.83%	0.66
Motor vehicles, trailers	34	4.31%	6.86	0.76	9.99%	0.82
Transport equipment	35	0.37%	1.87	0.35	4.72%	0.64
Manufacturing, recycling	36-37	1.79%	3.94	0.63	3.42%	0.75
Non-manufacturing		73.39%	na	0.41		1

Notes: σ_s denotes the demand elasticity, which is measured with industry-specific average markups. Markups are constructed as the ratio of firm revenues to total costs, which are computed as the sum of material spending, labor payments and the costs of capital. The costs of capital are measured as Rk where k denotes the firm's capital stock and R is the gross interest rate, which we take to be 0.20. α_s denotes the sectoral share in consumer expenditure, which is taken from the Input-Output Tables according to (25). γ_s denotes the sectoral share of material spending in total costs, which is measured at the firm level and then averaged at the sector level. "VA share" is the sectoral share of value added in manufacturing, computed from the firm-level data. s_{Ds}^{Agg} are the sectoral aggregate domestic shares, computed as $s_{Ds}^{Agg} = \Sigma_{i=1}^{n} s_{Dis} \times \omega_{is}$, where ω_{is} is the firm share in sectoral value added. See Appendix for the details.

Table 1: Structural Parameters by Industry

	Factor shares			2-step GMM					
				Cobb-Douglas			Translog		
	First stage	ϵ	N	First stage	ϵ	N	First stage	ϵ	N
Full sample	-0.019***	2.378***	526,687	-0.014***	1.551***	331,421	-0.014***	1.524***	331,412
	(0.003)	(0.523)		(0.002)	(0.184)		(0.002)	(0.181)	
	[10.5]			[7.4]			[7.5]		
Importers	-0.010***	2.322**	65,799	-0.007**	1.841*	53,349	-0.006**	1.746**	53,349
	(0.004)	(1.014)		(0.003)	(1.017)		(0.003)	(0.881)	
	[4.0]			[3.0]			[3.0]		

Notes: Robust standard errors in parentheses with ***, **, and * respectively denoting significance at the 1%, 5% and 10% levels. The table contains the results of estimating (31) with the instrument given in (30). We employ estimates of γ_s based on factor shares as per (29), or on the proxy method used in Levinsohn and Petrin (2012) and Wooldridge (2009). For the latter, we report results based on Cobb-Douglas and Translog technology. For the factor share specification, we use data for the years 2002-2006. For the 2-step GMM procedure, we use data for the years 2004-2006 as two lagged values are required to build the appropriate instruments for the estimation of the production function. Standard errors in the 2-step GMM procedure are constructed via bootstrap to take the sampling variation in the generated regressor $\gamma_s \Delta ln\left(s_D\right)$ into account. For non-importers, the instrument is set to zero in the full sample specifications. The F-statistics for the first stage are reported in brackets.

Table 2: Estimating the Elasticity of Substitution ε

Mean	Quantile				
	10	25	50	70	90
24.87	0.64	2.79	11.18	33.74	85.73

Notes: The table reports quantiles of the empirical distribution of the firm-level gains from input trade relative to autarky, i.e. $\left(s_{Di}^{\gamma_s/(1-\varepsilon)} - 1\right) \times 100$ - see Proposition 1. The data for the domestic expenditure share corresponds to the cross-section of importing firms in 2004. For ε and γ_s, the estimates from the factor shares approach contained in Tables 1 and 2 are used.

Table 3: Moments of the Distribution of Producer Gains in France

	Dependent variable: Firm-level gains $\frac{\gamma}{1-\varepsilon} ln\left(s_{Di}\right)$							
ln(Value Added)	0.028***		0.013***	0.005***		-0.008***		-0.029***
	(0.000)		(0.000)	(0.001)		(0.001)		(0.001)
ln(Employment)		0.028***			-0.000			
		(0.000)			(0.001)			
Exporter			0.085***			0.040***		0.024***
			(0.001)			(0.002)		(0.002)
Intl. Group			0.148***			0.138***		0.113***
			(0.003)			(0.003)		(0.003)
ln (Num. Varieties)							0.128***	0.144***
							(0.002)	(0.002)
Sample	Full sample			Importers Only				
Observations	633,240	640,610	633,240	118,799	120,344	118,799	120,344	118,799

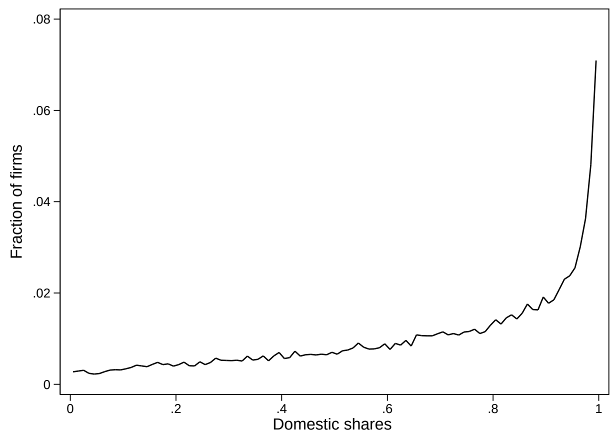
Notes: Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. The table contains the results of estimating (32). All regressions include year fixed effects and 3-digit industry fixed effects. The data corresponds to the full sample of firms between 2002 and 2006. The number of varieties is the number of countries the firm sources from (averaged across products). A firm is a member of an international group if at least one affiliate or the headquarter is located outside of France.

Table 4: Correlates of the Producer Gains

	Manufacturing Sector		Entire Economy	
Consumer Price Gains	27.52	*[21.2,35.9]*	9.04	*[7.1,11.6]*
Aggregate Data	30.86	*[21.5,45.3]*	9.92	*[7.1,14]*
Bias	3.34	*[0.2,10]*	0.88	*[0,2.6]*

Notes: The table reports the reduction in consumer prices for the manufacturing sector $(P_M^{Aut}/P_M - 1) \times 100$ (left panel) and the entire economy $(P^{Aut}/P - 1) \times 100$ (right panel) associated with input autarky. The measure in the first row is based on Proposition 2 where the associated Λ_s^{Aut} are reported in Table 6 and the structural parameters Ξ, γ_s, σ_s and α_s given in Table 1. The second row contains results based on an aggregate model with identical input-output structure and parameters. Specifically, they are based on Proposition 2 where the sectoral gains are measured by $\Lambda_{Agg,s}^{Aut}$ as per (22) instead of Λ_s^{Aut}. The third row reports the bias, defined as the difference between the first two rows - see (23). 90-10 confidence intervals are reported in brackets for all measures. These are calculated via a bootstrap procedure which we describe in Section A.3 of the Online Appendix. The empirical distributions of all statistics are estimated using 200 bootstrap iterations.

Table 5: The Consumer Price Gains From Input Trade in France



Notes: The figure shows the cross-sectional distribution of domestic expenditure shares, i.e. the share of material spending allocated to domestic inputs, for the population of importing manufacturing firms in France in 2004.

Figure 1: The Dispersion in Domestic Shares

Industry	ISIC	Direct Price Reductions		Domestic Inputs		Sectoral Price Gains		Aggregate Data		χ_s
Mining	10-14	3.0	*[1.8,4.2]*	14.9	*[11.1,19.2]*	7.8	*[5.2,10.3]*	2.5	*[1.6,3.6]*	0.38
Food, tobacco, beverages	15-16	11.1	*[7.5,14.6]*	8.4	*[6.2,10.6]*	17.8	*[12.4,23.4]*	12.6	*[7.8,18.2]*	1.50
Textiles and leather	17-19	31.1	*[24.2,39.9]*	31.4	*[24.3,40.3]*	55.6	*[42.4,74]*	31.9	*[22.4,46.9]*	1.07
Wood and wood products	20	8.2	*[6.4,10.5]*	9.6	*[7.4,12.1]*	14.4	*[11.1,18.2]*	9.6	*[6.7,13.7]*	1.59
Paper, printing, publishing	21-22	12.2	*[9,16]*	14.5	*[10.9,18.7]*	20.1	*[14.7,26.5]*	11.0	*[7.7,15.4]*	0.64
Chemicals	24	27.2	*[20.1,36.4]*	21.6	*[16.1,28.2]*	45.1	*[32.7,60.7]*	28.1	*[18.7,41.8]*	1.11
Rubber and plastics products	25	20.1	*[14.3,26.5]*	27.3	*[20.2,36]*	38.4	*[27.5,50.9]*	21.5	*[13.9,31]*	1.30
Non-metallic mineral products	26	13.4	*[9.6,17.9]*	12.7	*[9.7,16.3]*	20.8	*[15.3,27.4]*	13.3	*[9,19]*	0.95
Basic metals	27	21.8	*[16.3,27.7]*	21.5	*[16.4,27.3]*	38.9	*[28.2,50.2]*	28.8	*[19,41.6]*	2.42
Metal products (ex machinery and equipment)	28	8.2	*[6.2,10.5]*	20.5	*[15.5,26.2]*	18.3	*[13.8,23.5]*	7.7	*[5.5,10.8]*	0.79
Machinery and equipment	29	17.6	*[12.8,23.2]*	20.0	*[15,25.7]*	31.7	*[23,41.6]*	18.2	*[12.2,26.2]*	1.13
Office and computing machinery	30	20.4	*[15.4,25.5]*	25.2	*[18.3,32.1]*	44.6	*[31.9,57]*	37.0	*[22.4,60.3]*	3.76
Electrical machinery	31	19.8	*[14.6,25.6]*	23.9	*[17.7,30.6]*	36.1	*[26.4,46.6]*	21.6	*[14.8,30.7]*	1.51
Radio and communication	32	21.5	*[13.1,31.1]*	23.3	*[16.6,30.5]*	38.5	*[23.5,54.8]*	22.1	*[12.5,36.1]*	1.11
Medical and optical instruments	33	17.9	*[12.8,23.4]*	20.4	*[15.1,26.2]*	29.2	*[21.1,38.3]*	15.9	*[10.7,22.5]*	0.70
Motor vehicles, trailers	34	6.2	*[3.2,16.4]*	21.7	*[17,29.3]*	23.3	*[17.4,39]*	11.2	*[6.1,24.3]*	3.22
Transport equipment	35	15.3	*[10.5,22]*	19.9	*[14.5,27.2]*	22.9	*[16,33.2]*	11.8	*[7.9,18.2]*	0.22
Manufacturing, recycling	36-37	12.9	*[9.7,16.3]*	19.0	*[14.5,24]*	26.0	*[19.2,33.4]*	14.1	*[9.5,20.4]*	1.35
Non-manufacturing		0.0	*[0,0]*	7.5	*[5.7,9.4]*	3.0	*[2.3,3.8]*	0.0	*[0,0]*	

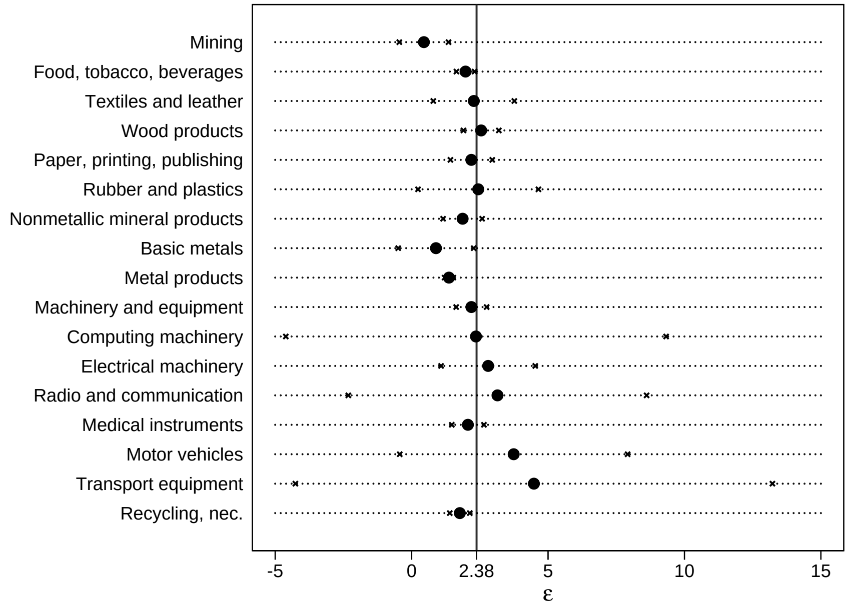
Notes: The first column reports the direct price reductions from international sourcing relative to autarky, $(exp(\Lambda_s^{Aut}) - 1) \times 100$, which are calculated according to (18). The second column reports the reductions in the price of domestically sourced intermediate inputs, $(p_{Ds}^{Aut}/p_{Ds} - 1) \times 100$. The third column contains the full change in sectoral prices relative to autarky, $(P_s^{Aut}/P_s - 1) \times 100$. Column four reports the direct price reductions predicted by an aggregate approach, $(exp(\Lambda_{Agg,s}^{Aut}) - 1) \times 100$, as per (22). 90-10 confidence intervals are reported in brackets for all measures. These are calculated via a bootstrap procedure which we describe in the Online Appendix. The empirical distributions of all statistics are estimated using 200 bootstrap iterations. In column five we report $\chi_s = \gamma_s \frac{\sigma_s - 1}{\varepsilon_s - 1}$, which is calculated using the data from Table 1.

Table 6: The Gains from Input Trade: Sectoral Variation

		Firm-Based Models				Aggregate Model
		Heterogeneous Fixed Costs	Heterogeneous Home Bias	Homogeneous Fixed Costs	Homogeneous Home Bias	
		Panel A: Structural Parameters				
Dispersion in efficiency	σ_φ	0.528	0.528	0.513	0.496	0.556
Fixed cost of importing	f_I	0.047	0.058	0.047	0.561	-
Average home bias	$\mu_{\tilde{\beta}}$	$1^\dagger$	2.595	$1^\dagger$	1.193	1.284
Dispersion in home bias	$\sigma_{\tilde{\beta}}$	-	1.028	-	0	-
Correlation of home bias and efficiency	$\rho_{\tilde{\beta}\varphi}$	-	0.124	-	0	-
Average fixed cost	μ_f	5.059	-	5.475	-	-
Dispersion in fixed cost	σ_f	2.373	-	0	-	-
Correlation of fixed cost and efficiency	$\rho_{f\varphi}$	0.739	-	0	-	-
		Panel B: Moments				
	Data					
Aggregate domestic share	0.720	**0.720**	**0.720**	**0.720**	**0.720**	**0.720**
Dispersion in ln va	1.520	**1.520**	**1.520**	**1.520**	**1.520**	**1.520**
Share of importers	0.199	**0.199**	**0.199**	**0.200**	**0.199**	1.000
Dispersion in ln s_D	0.360	**0.360**	**0.360**	0.137	0.179	0.000
Correlation of ln va and ln s_D	-0.310	**-0.310**	**-0.310**	-0.720	-0.768	0.000
		Panel C: Reversal to Autarky				
Change in Consumer Prices	$\frac{P^{Aut}-P}{P}$	37.87%	38.01%	43.09%	43.89%	44.73%
	Bias			*13.78%*	*15.90%*	*18.10%*
Change in Welfare	$\frac{W-W^{Aut}}{W}$	17.43%	36.42%	21.59%	27.81%	44.73%
		Panel D: Non-autarky Counterfactuals (Devaluations)				
Change in aggregate import share by ...						
... 5%	$\frac{P'-P}{P}$	1.85%	1.87%	2.08%	2.15%	2.19%
	Diff.		*0.79%*	*12.47%*	*16.05%*	*18.21%*
... 10%	$\frac{P'-P}{P}$	3.71%	3.73%	4.17%	4.30%	4.39%
	Diff.		*0.67%*	*12.58%*	*16.08%*	*18.31%*
... 20%	$\frac{P'-P}{P}$	7.42%	7.47%	8.37%	8.63%	8.80%
	Diff.		*0.67%*	*12.86%*	*16.31%*	*18.55%*

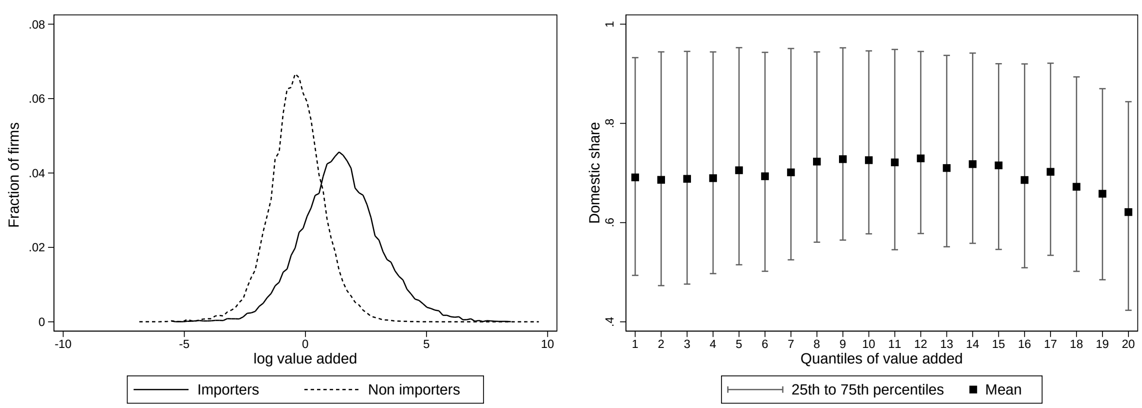
Notes: In panel A, we report the calibrated structural parameters for the respective models. In the models of columns 1 and 3 we can normalize the level of the home bias to unity and we denote this normalization by "†". Panel B contains the moments. We report both the moments which are observed in the data and which are generated by the models. The moments which the respective models are calibrated to are displayed in bold figures. Note that the number of calibrated moments equals the number of parameters for the respective model. In panel C, we report the results from a reversal to autarky. We report the change in consumer prices (row 1) and the change in welfare (row 3). We also report the bias of the change in consumer prices relative to the model with heterogeneous fixed costs (row 2). We calculate this number as the percentage difference between the respective change in consumer prices. In panel D, we report the effects of a shock which increases the prices of all foreign varieties to reduce the aggregate import share by 5,10 and 20 percent. We report the implied change in consumer prices ($(P'-P)/P$ in rows 1,3 and 5) and the difference relative to the model with heterogeneous fixed costs (Diff. in rows 2,4 and 6). See Section A.5 in the Online Appendix for details of the computational procedure.

Table 7: Calibrating Models of Importing: The Value of the Micro Data



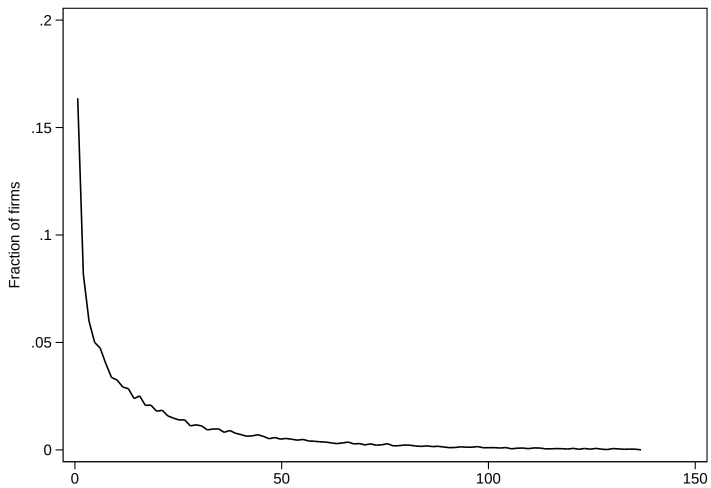
Notes: The figure displays the sector-specific estimates for ε from the integrated GMM approach, which estimates (27)-(28) in a single step following Wooldridge (2009). We display the point estimates and two standard deviations confidence intervals. We also show the benchmark estimate for the factor shares approach $\varepsilon = 2.38$ as a vertical line. We omit the Chemicals sector from the figure because its point estimate is negative and imprecisely estimated. The full results are contained in Table 18 in the Online Appendix.

Figure 3: Estimates of ε_s from Integrated GMM Approach



Notes: The left panel displays the distribution of log value added by import status. The right panel shows the mean and the 25th and 75h percentiles of domestic shares for twenty quantiles of value added for importers. The data corresponds to the population of manufacturing firms in France in 2004.

Figure 2: Domestic Shares and Firm Size



Notes: The figure reports the empirical distribution of the firm-level gains from input trade relative to autarky, i.e. $(s_{Di}^{\gamma_s/(1-\varepsilon)} - 1) \times 100$ - see Proposition 1. The data for the domestic expenditure shares corresponds to the cross-section of French importing firms in 2004. The values for ε and γ_s are taken from the factor shares approach contained in Table 2.

Figure 4: The Producer Gains from Input Trade in France

7 Appendix

7.1 Generalizations of Proposition 1

In this section, we consider three generalizations of equation (9), which states that the firm's unit costs is given by

$$u_i = \frac{1}{\tilde{\varphi}_i} \times (s_{Di})^{\frac{\gamma}{\varepsilon-1}} \times \left(\frac{p_D}{q_D}\right)^{\gamma} w^{1-\gamma}. \tag{44}$$

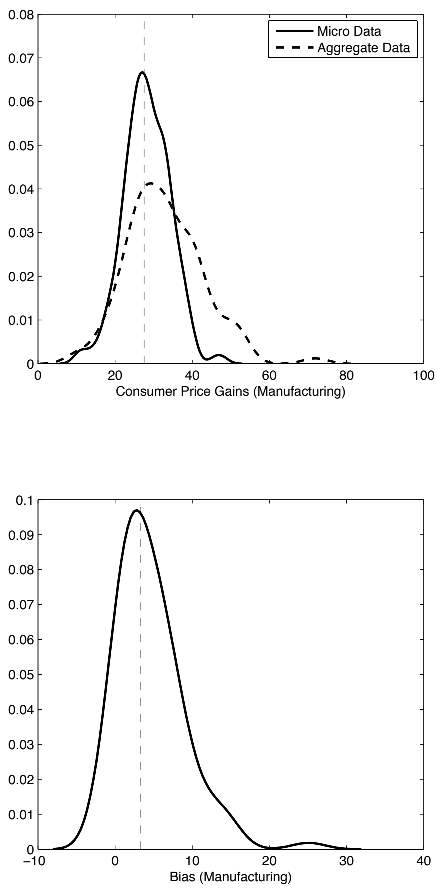
(44) was derived under the restrictions: (i) the production function has a constant elasticity of materials γ, (ii) domestic and foreign inputs are combined in a CES fashion with elasticity of substitution ε and (iii) foreign inputs are differentiated at the country, but not at the product level. We now relax these assumptions and derive expressions akin to (44).

Extension 1: CES Upper Tier. Suppose that the production function between materials x and primary factors l is CES instead of Cobb-Douglas, i.e.

$$y = \varphi \left((1-\gamma)\, l^{\frac{\zeta-1}{\zeta}} + \gamma x^{\frac{\zeta-1}{\zeta}} \right)^{\frac{\zeta}{\zeta-1}}.$$

The rest of the environment is exactly as in Section 2. Let Q denote again the price index of materials x and w denote the price of primary factors l. In this case, the firm's unit cost is given by

$$u = \frac{1}{\varphi} \left(\gamma^{\zeta} Q^{1-\zeta} + (1-\gamma)^{\zeta} w^{1-\zeta} \right)^{\frac{1}{1-\zeta}}.$$



Notes: The top panels of the figure depict the bootstrap distribution of the consumer price gains from input trade for the manufacturing sector $(P_M^{Aut}/P_M - 1) \times 100$ (left panel) and the entire economy $(P^{Aut}/P - 1) \times 100$ (right panel). These are computed according to Proposition 2. We display the gains based on the micro data, i.e. using Λ_s^{Aut}, and aggregate data, i.e. using $\Lambda_{Agg,s}^{Aut}$. The bottom panels depict the bootstrap distribution of the bias from using aggregate data, which is computed according to (23). The bootstrap procedure is described in the Online Appendix. We use 200 iterations.

Figure 5: Sampling Variation in the Consumer Price Gains and the Bias

Noting that the optimal expenditure share on materials is given by

$$s_M = \frac{\gamma^\zeta Q^{1-\zeta}}{\gamma^\zeta Q^{1-\zeta} + (1-\gamma)^\zeta w^{1-\zeta}}, \tag{45}$$

we can write the firm's unit cost as

$$u = \frac{1}{\varphi} s_M^{\frac{1}{\zeta-1}} \left(\frac{1}{\gamma}\right)^{\frac{\zeta}{\zeta-1}} s_D^{\frac{1}{\varepsilon-1}} \left(\frac{1}{\beta}\right)^{\frac{\varepsilon}{\varepsilon-1}} \left(\frac{p_D}{q_D}\right) \propto s_M^{\frac{1}{\zeta-1}} s_D^{\frac{1}{\varepsilon-1}}, \tag{46}$$

where we have substituted for Q using (8). (46), which is a generalization of (9), shows that measuring the effect of input trade on the unit cost requires knowledge of the counterfactual material share in the autarky equilibrium, s_M^{Aut}.[65] Because this object is not observed in the data, we can use (6) and (45) to compute it:

$$s_M^{Aut} = \frac{\left(\frac{\gamma}{1-\gamma}\right)^\zeta \beta^{-\frac{\varepsilon}{\varepsilon-1}(1-\zeta)} \left(\frac{p_D/q_D}{w}\right)^{1-\zeta}}{1 + \left(\frac{\gamma}{1-\gamma}\right)^\zeta \beta^{-\frac{\varepsilon}{\varepsilon-1}(1-\zeta)} \left(\frac{p_D/q_D}{w}\right)^{1-\zeta}}. \tag{47}$$

The firm-level gains from input trade are therefore given by

$$ln\left(\frac{u^{Aut}}{u}\right)\Bigg|_{p_D,w} = ln\left(\frac{1+\left(\frac{\gamma}{1-\gamma}\right)^\zeta \beta^{-\frac{\varepsilon}{\varepsilon-1}(1-\zeta)} \left(\frac{p_D/q_D}{w}\right)^{1-\zeta} s_D^{\frac{1-\zeta}{\varepsilon-1}}}{1+\left(\frac{\gamma}{1-\gamma}\right)^\zeta \beta^{-\frac{\varepsilon}{\varepsilon-1}(1-\zeta)} \left(\frac{p_D/q_D}{w}\right)^{1-\zeta}}\right)^{\frac{1}{\zeta-1}}. \tag{48}$$

(48) is the generalization of Proposition 1 for the case where the aggregator between materials and primary factors is CES. We see that, in this case, quantifying the change in the unit cost relative to autarky requires knowledge of additional parameters $[\beta, \zeta, p_D/q_D]$ to predict the material share in autarky. Under the *additional* assumption that there is no variation in β and p_D/q_D across firms, we can bypass the estimation of some of these additional parameters. In this case, all firms would feature the same material share in autarky, which is given by the material share of a domestic firm in the observed trade equilibrium, s_M^D. In this case, (48) reduces to

$$ln\left(\frac{u^{Aut}}{u}\right)\Bigg|_{p_D,w} = ln\left(1 - s_M^D + s_D^{\frac{1-\zeta}{\varepsilon-1}} \times s_M^D\right)^{\frac{1}{\zeta-1}}, \tag{49}$$

so that only micro-data on domestic expenditure shares s_D and the two elasticities of substitution ε and ζ are required.[66]

[65] The Cobb-Douglas assumption in (1) in the main text bypasses this issue because it implies that the material share is constant and given by γ. In the non-Cobb-Douglas case, the material share endogenously reacts to changes in the import environment. A move to autarky, for example, makes materials relatively more expensive and should induce firms to substitute towards primary inputs.

[66] Note that, when $\zeta \to 1$, (49) reduces to the expression in Proposition 1:

$$\lim_{\zeta\to 1} ln\left(\frac{u^{Aut}}{u}\right)\Bigg|_{p_D,w} = \frac{\gamma}{1-\varepsilon} ln\left(s_D\right)$$

Extension 2: General Production Function for Materials. In Section (2), we assumed that material services were a CES aggregator of a domestic variety z_D and a foreign input bundle x_I. Suppose now that the aggregator for materials is given by a general function

$$x = g\left(q_D z_D, x_I\right). \tag{50}$$

We continue to assume that materials x and primary factors l are combined with a Cobb-Douglas production function given in (1). Again let $A\left(\Sigma\right)$ be the price index of the import bundle and $Q\left(\Sigma\right)$ be the price index of materials. Consider any shock to the trading environment that affects $A\left(\Sigma\right)$. Then

$$dln\left(u\right)\big|_{p_D,w} = \gamma \times dln\left(Q\right)\big|_{p_D} = \gamma \frac{z_I A}{u}\frac{dA}{A} = \gamma\left(1-s_D\right)dln\left(A\right). \tag{51}$$

The optimality conditions from the cost-minimization problem imply that

$$dln\left(A\right) = -\frac{\left(-\frac{1}{\varepsilon_L}\right)}{1-\frac{1}{\varepsilon_L}}\frac{1}{1-s_D}dln\left(s_D\right),$$

where

$$-\frac{1}{\varepsilon_L} \equiv \frac{\partial ln\left(\frac{\partial g(q_D z_D, x_I)/\partial x_D}{\partial g(q_D z_D, x_I)/\partial x_I}\right)}{\partial ln\left(\frac{q_D z_D}{x_I}\right)}$$

is the local elasticity of substitution. Substituting this into (51) yields

$$dln\left(u\right)\big|_{p_D,w} = \gamma\frac{\frac{1}{\varepsilon_L}}{1-\frac{1}{\varepsilon_L}}dln\left(s_D\right) = -\frac{\gamma}{1-\varepsilon_L}dln\left(s_D\right). \tag{52}$$

In case the elasticity of substitution is constant, i.e. $\varepsilon_L = \varepsilon$, (52) can be integrated to yield (9).

Extension 3: Multiple Foreign Products. In the main analysis, we assumed that firms source a single product from each sourcing country. In the data, firms often import multiple products from a given country. We now explore how (44) would change in a multi-product environment. Consider first the case where the product aggregator is nested in the country aggregator, i.e. the production structure is given by (1)-(3), where

$$q_{ci}z_c \equiv \psi_{ci}\left(\left[q_{kci}z_{kc}\right]_{k\in K_{ci}}\right), \tag{53}$$

k is a product index, K_{ci} denotes the set of products that firm i sources from country c, ψ_{ci} is a constant-returns-to-scale production function and (53) applies also to the domestic variety. As long as the number of products sourced domestically does not change when firms are forced into input-autarky, the analysis in the main text remains entirely unchanged and the producer gains are still given by Proposition 1.

Consider next the case where the country aggregator is nested in the product aggregator. Suppose for example that the production structure for intermediates x is given by

$$x = \left(\sum_{k=1}^{K} (\eta_k x_k)^{\frac{\iota-1}{\iota}} \right)^{\frac{\iota}{\iota-1}} \tag{54}$$

$$x_k = \left(\beta_{ki} (q_{kD} z_{kD})^{\frac{\varepsilon_k - 1}{\varepsilon_k}} + (1 - \beta_{ki}) x_{kI}^{\frac{\varepsilon_k - 1}{\varepsilon_k}} \right)^{\frac{\varepsilon_k}{\varepsilon_k - 1}} \tag{55}$$

$$x_{kI} = h_{ki} \left([q_{kci} z_{kc}]_{c \in \Sigma_{ki}} \right). \tag{56}$$

Note that the sourcing strategy is now a list of countries for each product. Letting Q_i and Q_{ki} denote the price indices for materials x and product-specific material services x_k respectively, it can be easily shown that

$$Q_i = \left(\sum_{k=1}^{K} (Q_{ki}/\eta_k)^{1-\iota} \right)^{\frac{1}{1-\iota}}$$

$$Q_{ki} = (s_{kDi})^{\frac{1}{\varepsilon_k - 1}} \beta_{ki}^{-\frac{\varepsilon_k}{\varepsilon_k - 1}} p_{kD}/q_{kD},$$

where s_{kDi} is firm i's domestic expenditure share for product k. The firm-level gains are therefore given by

$$ln \left(\frac{u^{Aut}}{u} \right) \Big|_{p_D, w} = \frac{\gamma}{\iota - 1} \times ln \left(\sum_{k=1}^{K} \chi_{ki} (s_{kDi})^{\frac{\iota-1}{1-\varepsilon_k}} \right), \tag{57}$$

where

$$\chi_{ki} \equiv \frac{\left(\beta_{ki}^{-\frac{\varepsilon_k}{\varepsilon_k - 1}} p_{kD}/q_{kD} \right)^{1-\iota}}{\sum_{k=1}^{K} \left(\beta_{ki}^{-\frac{\varepsilon_k}{\varepsilon_k - 1}} p_{kD}/q_{kD} \right)^{1-\iota}}.$$

We see that the producer gains are akin to a weighted average of the product-specific producer gains $(s_{kDi})^{\frac{\iota-1}{1-\varepsilon_k}}$. In our empirical application, we cannot implement (57) because we do not observe domestic shares at the product level s_{kDi} in the French data. Note that implementing (57) also requires measuring the weights χ_{ki}. In the case where (54) takes the Cobb-Douglas form, i.e. $\iota = 1$ as in Halpern et al. (2011), (57) simplifies to

$$ln \left(\frac{u^{Aut}}{u} \right) \Big|_{p_D, w} = \sum_{k=1}^{K} \eta_k \frac{\gamma}{1 - \varepsilon_k} ln \left(s_{Di}^{k} \right).$$

Thus, in the Cobb-Douglas case, the producer gains are a weighted average of the product-specific producer gains.

7.2 Proof of Proposition 2

The consumer price index associated with (12)-(13) is given by

$$P = \prod_{s=1}^{S} (P_s/\alpha_s)^{\alpha_s} \text{ where } P_s = \left(\int_0^{N_s} p_{is}^{1-\sigma_s} di\right)^{\frac{1}{1-\sigma_s}}, \tag{58}$$

and P_s is the price index for sector s. Using (58), the consumer price gains from input trade can be expressed as

$$G \equiv ln\left(\frac{P^{Aut}}{P}\right) = \sum_{s=1}^{S} \alpha_s ln\left(\frac{P_s^{Aut}}{P_s}\right).$$

We now express P_s^{Aut}/P_s in terms of observables. Note that monopolistic competition implies a constant markup pricing rule, $p_{is} = \frac{\sigma_s}{\sigma_s-1} u_{is}$. Using the expression for the firm's unit cost in terms of its domestic expenditure share in (9), we find that

$$P_s = \frac{\sigma_s}{\sigma_s - 1}\left(\frac{1}{\gamma_s}\right)^{\gamma_s}\left(\frac{1}{1-\gamma_s}\right)^{1-\gamma_s}\left(\frac{p_{Ds}}{q_{Ds}}\right)^{\gamma_s}\left(\int_0^{N_s}\left(\tilde{\varphi}_i^{-1}\left(s_{Di}\right)^{\gamma_s/(\varepsilon_s-1)}\right)^{1-\sigma_s} di\right)^{\frac{1}{1-\sigma_s}}, \tag{59}$$

which is (15) in the main text. Given the aggregator in (14), the price index of the domestic bundle is given by

$$p_{Ds} = \zeta_s^* \prod_{j=1}^{S} P_j^{\zeta_j^s} \text{ where } \zeta_s^* \equiv \prod_{j=1}^{S}\left(\zeta_j^s\right)^{-\zeta_j^s} \tag{60}$$

Note that (59) implies

$$\frac{P_s^{Aut}}{P_s} = \left(\frac{p_{Ds}^{Aut}}{p_{Ds}}\right)^{\gamma_s}\left(\frac{\int_0^{N_s}\tilde{\varphi}_i^{\sigma_s-1} di}{\int_0^{N_s}\left(\tilde{\varphi}_i s_{Di}^{\frac{\gamma_s}{1-\varepsilon_s}}\right)^{\sigma_s-1} di}\right)^{\frac{1}{1-\sigma_s}} = \left(\frac{p_{Ds}^{Aut}}{p_{Ds}}\right)^{\gamma_s}\left(\int_0^{N_s}\omega_i s_{Di}^{\frac{\gamma_s(1-\sigma_s)}{1-\varepsilon_s}} di\right)^{\frac{1}{1-\sigma_s}}, \tag{61}$$

where ω_i is firm $i's$ share in total value added in sector s and the second equality follows from $va_i = \kappa_s \tilde{\varphi}_i^{\sigma_s-1} s_{Di}^{\frac{\gamma_s(\sigma_s-1)}{1-\varepsilon_s}}$. With (61) at hand, we can express the consumer price gains as

$$G = \sum_{s=1}^{S} \gamma_s \alpha_s \pi_s + \sum_{s=1}^{S} \alpha_s \Lambda_s \tag{62}$$

where $\pi_s \equiv ln\left(\frac{p_{Ds}^{Aut}}{p_{Ds}}\right)$ and Λ_s is given by (18) in the main text. As Λ_s are observable from the micro-data, obtaining G reduces to solving for $[\pi_s]_{s=1}^{S}$. Note that (60) and (61) jointly imply

$$\pi_s = \sum_{j=1}^{S} \zeta_j^s \gamma_j \pi_j + \sum_{j=1}^{S} \zeta_j^s \Lambda_j. \tag{63}$$

(63) gives an $S \times S$ system of equations that characterizes the equilibrium $[\pi_s]_{s=1}^{S}$. Letting $\pi \equiv [\pi_1, \pi_2, ..., \pi_s]$ be a column vector, we can express the system in (63) in matrix form as $\pi = \Xi\Gamma\pi + \Xi\Lambda$. Its solution is given by $\pi = (\mathcal{I} - \Xi\Gamma)^{-1}\Xi\Lambda$. Using (62), the consumer price gains G are therefore given by

$$G \quad = \quad \alpha'\Gamma\pi + \alpha'\Lambda = \alpha'\Gamma\left(\mathcal{I} - \Xi \times \Gamma\right)^{-1}\Xi\Lambda + \alpha'\Lambda. \tag{64}$$

For counterfactuals other than autarky, (61) should be replaced by

$$\frac{P'_s}{P_s} = \left(\frac{p'_{Ds}}{p_{Ds}}\right)^{\gamma_s}\left(\frac{\int_0^{N_s}\left(\tilde{\varphi}_i\left(s'_{Di}\right)^{\gamma_s/(1-\varepsilon_s)}\right)^{\sigma_s-1}di}{\int_0^{N_s}\left(\tilde{\varphi}_i\left(s_{Di}\right)^{\gamma_s/(1-\varepsilon_s)}\right)^{\sigma_s-1}di}\right)^{\frac{1}{1-\sigma_s}} = \left(\frac{p'_{Ds}}{p_{Ds}}\right)^{\gamma_s}\left(\int_0^{N_s}\omega_i\left(\frac{s_{Di}}{s'_{Di}}\right)^{\frac{\gamma_s(1-\sigma_s)}{1-\varepsilon_s}}di\right)^{\frac{1}{1-\sigma_s}}, \tag{65}$$

where s'_{Di} denotes the counterfactual domestic share and P'_s, p'_{Ds} denote the counterfactual price indices. It follows that the consumer price gains associated with the policy, $G \equiv ln\left(P'/P\right)$, are given by (64) where Λ_s is given by (18). This proves Proposition 2.

7.3 Data Description

Our main data set stems from the information system of the French custom administration (DGDDI) and contains the majority of import and export flows by French manufacturing firms. The data is collected at the 8-digit (NC8) level. A firm located within the French metropolitan territory must report detailed information as long as the following criteria are met. For imports from outside the EU, reporting is required from each firm and flow if the imported value exceeds 1,000 Euros. For within EU imports, import flows have to be reported as long as the firm's annual trade value exceeds 100,000 Euros.[67] However, some firms that are below the threshold (ca. 10,000 firm-year observations out of ca. 130,000) voluntarily report.[68]

In spite of this limitation, the attractive feature of the French data is the presence of unique firm identifiers (the SIREN code) that is available in all French administrative files. Hence, various datasets can be matched to the trade data at the firm level. To learn about the characteristics of the firms in our sample we employ fiscal files.[69] Sales are deflated using price indices of value added at the 3 digit level obtained from the French national accounts. To measure the expenditure on

[67]This threshold was in effect between 2001 and 2006, which is period we focus on. Between 1993 and 2001, the threshold was ca. 40,000 euros. After 2006, it was raised to 150,000 euros and to 460,000 euros after 2011.

[68]The existence of this administrative threshold induces a censoring of small EU importers. In results available upon request, we use the time-variation in the reporting thresholds (see footnote 67) to show that this concern is unlikely to severely affect our results. The reason is related to the weak relation between domestic expenditure shares and firm size shown in Figure 2.

[69]The firm level accounting information is retrieved from two different files: the BRN ("Bénéfices Réels Normaux") and the RSI ("Régime Simplifié d'Imposition"). The BRN contains the balance sheet of all firms in the traded sectors with sales above 730,000 Euros. The RSI is the counterpart of the BRN for firms with sales below 730,000 Euros. Although the details of the reporting differs, for our purposes these two data sets contain essentially the same information. Their union covers nearly the entire universe of French firms.

	Full sample	Importers	Non importers	Exporters	Non exporters
Employment	25	92	8	81	9
Sales	5,455	21,752	1,379	19,171	1,468
Sales per worker	126	208	105	196	105
Value added	1,515	5,972	400	5,294	416
Value added per worker	45	55	43	55	43
Capital	2,217	8,728	588	7,661	634
Capital per worker	44	64	40	61	40
Inputs	2,600	10,225	693	8,943	756
Domestic share	0.943	0.698	1	0.790	0.986
Share of importers	0.200	1	0	0.677	0.061
Share of exporters	0.225	0.762	0.091	1	0
Share of firms that are part of an international group	0.029	0.131	0.004	0.113	0.005
Productivity (factor shares)	39.173	65.450	32.989	63.858	32.359
Number of observations (firm * year)	650,401	130,135	520,266	146,496	503,905
Number of firms	172,244	38,240	148,619	44,648	146,423

Notes: Sales, wages, expenditures on imports or exports are all expressed in 2005 prices using a 3-digit industry level price deflator. Our capital measure is the book value reported in firms' balance sheets ("historical cost"). A firm is member of an international group if at least one affiliate or the headquarter is located outside of France.

Table 8: Characteristics of importers, exporters and domestic firms

domestic inputs, we subtract the total import value from the total expenditure on wares and inputs reported in the fiscal files. Capital is measured at book value (historical cost).

Finally, we incorporate information on the ownership structure from the LIFI/DIANE (BvDEP) files. These files are constructed at INSEE using a yearly survey (LIFI) that describes the structure of ownership of all firms in the private sector whose financial investments in other firms (participation) are higher than 1.2 million Euros or have sales above 60 million Euros or have more than 500 employees. This survey is complemented with the information about ownership structure available in the DIANE (BvDEP) files, which are constructed using the annual mandatory reports to commercial courts and the register of firms that are controlled by the State.

Using these datasets, we construct a non-balanced panel dataset spanning the period from 2001 to 2006. Some basic characteristics of importing and non-importing firms are contained in Table 8. For comparison, we also report the results for exporting firms. As expected, importers are larger, more capital intensive and have higher revenue productivity - see also Bernard et al. (2012). Furthermore, import and export status are highly correlated.

7.4 Estimates of the Elasticity of Substitution ε: Robustness

In Section 3.1, we constructed the instrument for the estimation of ε using firms' first year of import activity as the initial period for the pre-sample weights, s_{cki}^{pre} - see (30). We now redo the analysis of estimating (31) keeping the year used for the pre-sample weights fixed at 2001 for all firms. Note that this reduces the size of the sample as all firms that start to import after 2001 are dropped. Table

			$\tilde{\gamma}_s \times \Delta \ln(s_D)$	ϵ	N
Factor shares	Full sample	All weights	-0.726***	2.378***	526,687
(bootstrapped SE)			(0.197)	(0.523)	
Sample: 2002-2006		Pre-sample weights	-1.407***	1.711***	443,954
			(0.356)	(0.166)	
	Importers	All weights	-0.756	2.322**	65,799
			(0.537)	(1.014)	
		Pre-sample weights	-1.121*	1.892***	54,604
			(0.632)	(0.541)	
2-step GMM	Full sample	All weights	-1.813**	1.551***	331,421
(bootstrapped SE)			(0.609)	(0.184)	
Sample: 2004-2006		Pre-sample weights	-2.981**	1.335***	258,957
			(1.003)	(0.107)	
	Importers	All weights	-1.189	1.841*	53,349
			(1.498)	(1.017)	
		Pre-sample weights	-2.450	1.408**	43,393
			(2.425)	(0.399)	
2-step GMM, translog	Full sample	All weights	-1.907**	1.524***	331,421
(bootstrapped SE)			(0.612)	(0.181)	
Sample: 2004-2006		Pre-sample weights	-3.215**	1.311***	258,957
			(1.047)	(0.095)	
	Importers	All weights	-1.340	1.746**	53,349
			(1.413)	(0.881)	
		Pre-sample weights	-2.710	1.369***	43,393
			(3.078)	(0.329)	

Notes: Robust standard errors in parentheses with ***, **, and * respectively denoting significance at the 1%, 5% and 10% levels. The first stage column refers to the estimation of (31) with the instrument given in (30). We estimate γ_s based on factor shares, as per (29), or on the proxy method used in Levinsohn and Petrin (2012) and Wooldridge (2009). For the latter, we report results based on Cobb-Douglas technology (27) and Translog. For the factor share specification, we use data for the years 2002-2006. For the proxy method we use data for the years 2004-2006, as two lagged values are required to build the appropriate instruments for the estimation of the production function. For the 2-step GMM procedure, we construct standard errors via bootstrap to take the sampling variation in the generated regressor $\gamma_s \Delta ln\,(s_D)$ into account. See the main text for details regarding the different subsamples for the respective specifications.

Table 9: Estimating the Elasticity of Substitution ε

9 contains the results for the factor shares and the 2-step GMM procedures with Cobb-Douglas and translog technology. The results of the main text are also reported for comparison - see the "All weights" rows. As before, we run the regressions on both the entire population and the sample of importers. Depending on the specification, the estimates of ε range from 1.4 to 2.4.

In Table 10 we also report the reduced form relationship between the instrument and two measures of firm-performance - productivity (column 2) and value added (column 3). We also report the first-stage relationship between the instrument and the change in domestic shares (column 1). There is a robust negative correlation between the instrument and domestic shares. If these indeed reflect unit-cost reductions, the instrument should be positively correlated with performance measures. Table 10 shows that this is the case for all our specifications.

7.5 The Elasticity Bias: Using ε from Aggregate Trade Flows

Tables 11 and 12 report the consumer price gains from input trade for the entire economy and at the sector level for different values of the elasticity of substitution ε. Columns one and two replicate the results for our baseline estimate $\varepsilon = 2.38$. While column one reports the results based on the

Dependent variable:			First stage	Δ ln productivity	$\Delta \ln VA$
Factor shares	Full sample	All weights	-0.019***	0.014***	0.050***
(bootstrapped SE)			(0.003)	(0.004)	(0.005)
Sample: 2002-2006		Pre-sample weights	-0.017***	0.024***	0.068***
			(0.004)	(0.004)	(0.006)
	Importers	All weights	-0.010***	0.005	0.030***
			(0.004)	(0.004)	(0.006)
		Pre-sample weights	-0.010**	0.009**	0.033***
			(0.005)	(0.004)	(0.006)
2-step GMM	Full sample	All weights	-0.014***	0.025***	0.058***
(bootstrapped SE)			(0.002)	(0.005)	(0.006)
Sample: 2004-2006		Pre-sample weights	-0.013***	0.038***	0.082***
			(0.003)	(0.005)	(0.008)
	Importers	All weights	-0.007**	0.008	0.034***
			(0.003)	(0.005)	(0.007)
		Pre-sample weights	-0.006*	0.015***	0.042***
			(0.003)	(0.005)	(0.007)
2-step GMM, translog	Full sample	All weights	-0.014***	0.026***	0.058***
(bootstrapped SE)			(0.002)	(0.005)	(0.006)
Sample: 2004-2006		Pre-sample weights	-0.013***	0.040***	0.082***
			(0.003)	(0.005)	(0.008)
	Importers	All weights	-0.006**	0.009*	0.034***
			(0.003)	(0.005)	(0.007)
		Pre-sample weights	-0.006*	0.016***	0.042***
			(0.003)	(0.005)	(0.007)

Notes: Robust standard errors in parentheses with ***, **, and * respectively denoting significance at the 1%, 5% and 10% levels. The first column refers to the first stage relationship, i.e. the relationship between $\Delta\tilde{\gamma}_s ln\left(s_{it}^D\right)$ and the instrument given in (30). We estimate γ_s based on factor shares, as per (29), or on the proxy method used in Levinsohn and Petrin (2012) and Wooldridge (2009). For the latter, we report results based on Cobb-Douglas technology (27) and Translog. For the factor share specification, we use data for the years 2002-2006. For the proxy method we use data for the years 2004-2006, as two lagged values are required to build the appropriate instruments for the estimation of the production function. For the 2-step GMM procedure, we construct standard errors via bootstrap to take the sampling variation in the generated regressor $\gamma_s \Delta ln\left(s_D\right)$ into account. See the main text for details regarding the different subsamples for the respective specifications. The second and third column column report the relationship between the change in log productivity (log value added) and the instrument given in (30). Productivity is constructed from (27). Value added is taken from the data. The differences between Panel 1 and Panels 2 and 3 in column 3 are due to differences in the sample.

Table 10: Trade shocks and firm performance

	Micro Data	Aggregate Data				
			ε			
	2.38	2.38	3	4	5	6
Entire Economy	9.04	9.9	6.72	4.43	3.31	2.64
Manufacturing Sector	27.52	30.8	20.32	13.12	9.69	7.68

Notes: The table reports the reduction in consumer prices for the entire economy $(P^{Aut}/P-1)\times 100$ (first row) and the manufacturing sector $(P_M^{Aut}/P_M-1)\times 100$ (second row) for different values of the elasticity of substitution ε. In the first two columns, we report the baseline results under $\varepsilon = 2.38$ for comparison. Column one is based on Proposition 2 where Λ_s are computed with micro data as reported in Table 6. The remaining columns contain results based on an aggregate model, i.e. they are based on Proposition 2 where the sectoral gains are measured by $\Lambda^{Aut}_{Agg,s}$ as per (22) instead of Λ^{Aut}_s. The values for Ξ, γ_s, σ_s and α_s employed for all calculations are given in Table 1.

Table 11: The Consumer Price Gains for Different Values of ε

micro-data, column two reports the gains based on aggregate data, $\Lambda^{Aut}_{Agg,s}$. These results correspond to the ones reported in Tables 5 and 6 above. In the remaining columns, we report the gains for a range of values of ε from studies that rely on aggregate data to estimate such elasticity. For example, Costinot and Rodríguez-Clare (2014) take $\varepsilon = 5$ as their baseline. The tables show that the gains are very sensitive to the value of ε. Table 11 shows that the economy-wide gains predicted by an aggregate approach under $\varepsilon = 5$ are about 65% lower than the gains predicted by the approach that relies on micro-data.

7.6 Comparing Models of Importing: Detailed Derivations for Section 4.1

Because of our assumption that fixed costs do not cay by country, countries can be indexed by their quality q. We first show that the price index of the import bundle takes the power form in (35). Using (33), the import price index is given by

$$A(\Sigma) = \left(\int_{q\in\Sigma} (p(q)/q)^{1-\kappa}\, dG(q)\right)^{\frac{1}{1-\kappa}} = \left(\int_{q\in\Sigma} q^{\kappa-1} dG(q)\right)^{\frac{1}{1-\kappa}}. \tag{66}$$

As quality is Pareto distributed (see (34)), (66) becomes

$$A(\Sigma)^{1-\kappa} = \theta q_{min}^{\theta} \int_{q\in\Sigma} q^{\kappa-1} q^{-\theta-1} dq.$$

Because fixed costs are constant across countries, the sourcing set Σ can be parametrized by a quality cutoff $\overline{q}$. In particular, the firm selects countries with high enough quality, i.e. $q \in \Sigma$ as long as $q \geq \overline{q}$. It follows that

$$A(\overline{q})^{1-\kappa} = q_{min}^{\theta} \frac{\theta}{\theta - (\kappa - 1)} \overline{q}^{\kappa-1-\theta}. \tag{67}$$

We can rewrite this expression in terms of the mass of countries sourced, n, which is given by

$$n = P(q \in \Sigma) = P(q \geq \overline{q}) = q_{\min}^{\theta} \overline{q}^{-\theta}. \tag{68}$$

Industry	ISIC	Micro Data	Aggregate Data				
				ε			
		2.38	2.38	3	4	5	6
Mining	10-14	2.96	2.5	1.72	1.14	0.86	0.68
Food, tobacco, beverages	15-16	11.06	12.62	8.53	5.61	4.18	3.33
Textiles and leather	17-19	31.14	31.87	20.99	13.55	10	7.92
Wood and wood products	20	8.23	9.58	6.51	4.29	3.2	2.55
Paper, printing, publishing	21-22	12.15	10.96	7.43	4.89	3.65	2.91
Chemicals	24	27.23	28.14	18.62	12.06	8.91	7.07
Rubber and plastics products	25	20.12	21.53	14.37	9.37	6.95	5.52
Non-metallic mineral products	26	13.42	13.29	8.98	5.9	4.39	3.5
Basic metals	27	21.8	28.83	19.07	12.34	9.12	7.23
Metal products (ex machinery and equipment)	28	8.17	7.7	5.24	3.47	2.59	2.07
Machinery and equipment	29	17.64	18.23	12.23	7.99	5.94	4.72
Office and computing machinery	30	20.42	37	24.22	15.56	11.45	9.06
Electrical machinery	31	19.77	21.64	14.45	9.41	6.98	5.55
Radio and communication	32	21.55	22.15	14.78	9.62	7.13	5.67
Medical and optical instruments	33	17.9	15.9	10.7	7.01	5.21	4.15
Motor vehicles, trailers	34	6.24	11.23	7.61	5.01	3.73	2.98
Transport equipment	35	15.32	11.83	8.01	5.27	3.93	3.13
Manufacturing, recycling	36-37	12.87	14.06	9.48	6.23	4.63	3.69
Non-manufacturing		0	0	0	0	0	0

Notes: The table reports the reduction in consumer prices at the sectoral level $(P_s^{Aut}/P_s - 1) \times 100$ for different values of the elasticity of substitution ε. In the first two columns, we report the baseline results under $\varepsilon = 2.38$ for comparison. Column one is based on Proposition 2 where Λ_s are computed with micro data as reported in Table 6. The remaining columns contain results based on an aggregate model, i.e. they are based on Proposition 2 where the sectoral gains are measured by $\Lambda_{Agg,s}^{Aut}$ as per (22) instead of Λ_s^{Aut}. The values for Ξ, γ_s, σ_s and α_s employed for all calculations are given in Table 1.

Table 12: The Sectoral Consumer Price Gains for Different Values of ε

Substituting (68) into (67) yields

$$A(n) = q_{\min}^{-1} \left(\frac{\theta}{\theta - (\kappa - 1)} \right)^{\frac{1}{1-\kappa}} n^{-\left(\frac{1}{\kappa-1}\right)}, \tag{69}$$

which is (35) in the main text where

$$z \equiv q_{min}^{-1} \left(\frac{\theta}{\theta - (\kappa - 1)} \right)^{\frac{1}{1-\kappa}} \tag{70}$$

$$\eta \equiv \frac{1}{\kappa - 1}. \tag{71}$$

This completes the characterization of (35). The following proposition characterizes the solution to the extensive margin problem.

Proposition 3. *Consider the setup above and suppose that*

$$\eta (\varepsilon - 1) < 1 \text{ and } \eta\gamma (\sigma - 1) < 1. \tag{72}$$

Then, the firm's profit maximization problem (36) *has a unique solution for any value of* $\tilde{\varphi}$ *and* f*. The optimal mass of countries sourced is given by a function* $n(\tilde{\varphi}, f)$ *and an efficiency cutoff* $\overline{\varphi}(f)$ *such that* $n(\tilde{\varphi}, f) = 0$ *for* $\varphi \leq \overline{\varphi}(f)$ *with* $\overline{\varphi}(\cdot)$ *increasing. Furthermore,* $n(\varphi, f)$ *is increasing in efficiency* $\tilde{\varphi}$ *and decreasing in the fixed costs of sourcing* f*.*

Proof. The firm's maximization problem follow from (36), (37) and (38) as

$$\pi = \max_n \left\{ \tilde{\varphi}^{(\sigma-1)} \left(\frac{p_D}{q_D}\right)^{\gamma(1-\sigma)} \left(\left(1 + \left(\frac{1-\beta}{\beta}\right)^{\varepsilon} \left(\left(\frac{p_D}{q_D}\right) \frac{1}{z} n^{\eta} \right)^{\varepsilon - 1} \right)^{\frac{\gamma(\sigma-1)}{\varepsilon-1}} \right) \times B - (nf + f_I \mathbb{I}(n > 0)) \right\}.$$

Conditional on importing, the optimal mass of countries is characterized by the following first order condition:

$$\left(\frac{1-\beta}{\beta}\right)^{\varepsilon \frac{\gamma(\sigma-1)}{\varepsilon-1}} \left(\left(\frac{\beta}{1-\beta}\right)^{\varepsilon} \left(\frac{q_D}{p_D}\right)^{\varepsilon-1} + \left(\frac{1}{z}\right)^{\varepsilon-1} n^{\eta(\varepsilon-1)} \right)^{\frac{\gamma(\sigma-1)}{\varepsilon-1}-1} z^{1-\varepsilon} n^{\eta(\varepsilon-1)-1} = \frac{1}{\eta\gamma(\sigma-1)} \frac{1}{B} \frac{f}{\tilde{\varphi}^{\sigma-1}}, \tag{73}$$

The second order condition is given by

$$\left(\left(\frac{\beta}{1-\beta}\right)^{\varepsilon} \left(\frac{q_D}{p_D}\right)^{\varepsilon-1} + z^{1-\varepsilon} n^{\eta(\varepsilon-1)} \right)^{\frac{\gamma(\sigma-1)}{\varepsilon-1}-1} n^{\eta(\varepsilon-1)-2} \times \tag{74}$$

$$\{(\eta(\varepsilon-1)-1) + (\gamma(\sigma-1) - \varepsilon + 1)\eta l(n)\} < 0$$

where

$$l(n) \equiv \frac{z^{1-\varepsilon} n^{\eta(\varepsilon-1)}}{\left(\frac{\beta}{1-\beta}\right)^{\varepsilon} \left(\frac{q_D}{p_D}\right)^{\varepsilon-1} + z^{1-\varepsilon} n^{\eta(\varepsilon-1)}} \in [0,1).$$

It follows that (74) is satisfied if and only if

$$\eta(\varepsilon-1) - 1 + (\gamma(\sigma-1) - \varepsilon + 1)\eta l(n) < 0. \tag{75}$$

Because we allow for arbitrary values of φ and f, we need to verify that (75) holds for any value of n. Sufficient conditions for this are given by

$$\eta(\varepsilon-1) < 1 \tag{76}$$

and

$$\eta\gamma(\sigma-1) < 1. \tag{77}$$

If (76) is not satisfied, there exists a range of values of n close enough to zero such that (75) is violated.[70] (76) is therefore necessary. If $\gamma(\sigma-1) - \varepsilon + 1 \leq 0$, then (75) is satisfied for all n. If $\gamma(\sigma-1) - \varepsilon + 1 > 0$, then (75) holds for all n if and only if

$$\eta(\varepsilon-1) - 1 + (\gamma(\sigma-1) - \varepsilon + 1)\eta l(1) < 0. \tag{78}$$

As $l(1) < 1$, a sufficient condition for (78) is given by (77). This proves that, under (76)-(77), the optimal mass of countries conditional on importing is uniquely characterized by (73) for any values of $\tilde{\varphi}$ and f.[71] The firm becomes an importer whenever $\pi_I \geq \pi_D$, where π_I are optimal profits conditional on importing and π_D are profits as a non-importer. It can be shown that this condition is satisfied whenever

$$\left[\left(1 + \left(\frac{1-\beta}{\beta}\right)^{\varepsilon} \left(\frac{p_D}{q_D} z^{-1} n^{\eta}\right)^{\varepsilon-1}\right)^{\frac{\gamma(\sigma-1)}{\varepsilon-1}} - 1\right] (q_D/p_D)^{\gamma(\sigma-1)} \Gamma \tilde{\varphi}^{\sigma-1} - fn - f_I > 0, \tag{79}$$

where n is the solution to (73). It follows the firm's profit maximization problem in (36) has a unique solution for any value of φ and f.

Note that, under (76)-(77), the left hand side of (73) is decreasing in n. Therefore, the optimal mass of countries sourced is weakly increasing in φ and weakly decreasing in f. Holding n fixed, an increase in φ tends to increase the left hand side of (79). Additionally, π_I is increasing in φ. It follows that $\pi_I - \pi_D$ is increasing in φ for a given f. This proves that $n = 0$ if and only if $\varphi \leq \overline{\varphi}(f)$ where $\overline{\varphi}(\cdot)$ is implicitly defined as the value of φ that makes the left hand side of (79) equal to zero. The fact that $\overline{\varphi}(f)$ is increasing in f follows from the fact that $\pi_I - \pi_D$ is decreasing in f for a given

[70] This follows from the fact that $l(n)$ is continuous and strictly increasing.

[71] When the solution to (73) exceeds unity, the solution is given by $n = 1$. Clearly, $n = 0$ cannot be a solution as the firm always prefers to be a non-importer and avoid payment of f_I. Note that our calibrated and estimated parameters satisfy (76)-(77) - see Table 1.

φ.[72] This proves Proposition 3. □

To solve for the aggregate allocations, we have to consider the general equilibrium of the economy. The formal derivation and the analytical characterization is contained in Section A.5 in the Online Appendix.

7.7 Estimation of η

To solve for firms' optimal domestic shares in the heterogenous fixed cost model, we require an estimate for η. To do so, we need to take a stand on what the counterpart of the number varieties, n, is in the data. We focus on the number of countries the firm sources its products from, i.e. the number of foreign varieties.[73] Using this assumption we can estimate η from the cross-sectional relationship between firms' domestic expenditure share and the number of sourcing countries, because the theory predicts a log-linear relationship between n and $\frac{1-s_D}{s_D}$ (see (38)). Hence, we estimate η from the following regression:

$$ln\left(\frac{1-s_{Dist}}{s_{Dist}}\right) = \delta_s + \delta_t + \delta_{NK} + \eta\left(\varepsilon - 1\right) ln\left(n_{ist}\right) + u_{ist}, \tag{80}$$

where n_{ist} denotes firm i's average number of countries per product sourced, δ_{NK} contains a set of fixed effects for the number of products sourced and δ_s and δ_t are sector and year fixed effects. Hence, we identify η from firms sourcing the same number of products from a different number of supplier countries. We measure products at the 8-digit level.

Table 13 contains the results of estimating (80). Columns one and two show that it is important to control for the number of products sourced as import-intensive firms source both more varieties per-product and more products on international markets - without the product fixed effects, the estimated η increases substantially.[74] Columns three and four show that the estimate of η is virtually unaffected by additional firm-level controls that can affect firms' import behavior conditional on the number of varieties sourced. In column five, we focus on a subsample of firm-product pairs that source their respective products from at least two supplier countries. In this case, the estimated η decreases as the single-variety importers have very high domestic shares in the data. For our quantitative analysis, we take column five as the benchmark.[75] The implied value of η is 0.382 and

[72] To see why this is the case, note that the left hand side of (79) is decreasing in f given φ and n. Additionally, π_I is decreasing in f.

[73] This notion of "varieties" is widely used in the literature - see e.g. Broda and Weinstein (2006) and Goldberg et al. (2010). Moreover, the choice of the number of products sourced may be determined to a large degree by technological considerations, while the demand for multiple supplier countries within a given product category may plausibly stem from love-for-variety effects, which are at the heart of the mechanism stressed by our theory. However, we note that the analysis that follows can be done under alternative interpretations of n.

[74] Recall that η is a combination of different structural parameters of the economy. While η is sufficient to characterize the welfare gains from trade, one might be interested in decomposing the returns to international sourcing into the the elasticity of substitution across varieties κ, the dispersion in input quality θ, and the elasticity of input prices with respect to quality ν. To do so, we need two additional pieces of information: import prices (to identify ν) and data on firms' expenditure shares across trading partners (to identify θ).

[75] We are concerned that the single-variety observations may not help identify the extensive margin channel emphasized by our theory but rather pick-up other variation across firms. Additionally, a non-parametric regression shows that the log linear relation between n and $(1 - s_D)/s_D$ in (80) fits the data better in the sample with at least two

it is precisely estimated.

Dep. Variable: $ln(\frac{1-s_D}{s_D})$						
	All Importers				> 1 variety	> 2 varieties
ln (Number of Varieties)	1.308***	0.707***	0.733***	0.739***	0.526***	0.463***
	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)	(0.019)
ln (Capital / Employment)				-0.070***		
				(0.006)		
Exporter Dummy			-0.395***	-0.388***	-0.254***	-0.198***
			(0.013)	(0.013)	(0.017)	(0.029)
International Group			0.150***	0.174***	0.216***	0.223***
			(0.016)	(0.016)	(0.016)	(0.019)
Control for Num of products	No	Yes	Yes	Yes	Yes	Yes
Implied Eta	0.950***	0.513***	0.532***	0.536***	0.382***	0.336***
	(0.260)	(0.142)	(0.147)	(0.148)	(0.106)	(0.096)
Observations	120,344	120,344	120,344	120,344	73,651	35,751

Notes: Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All regressions include year fixed effects and 3-digit industry fixed effects. The number of varieties is the average number of countries a firm sources its foreign products from. To back out the value for η, we use our benchmark value for $\varepsilon = 2.378$ from Section 3.1.

Table 13: Estimating η

varieties than in the full sample (results available upon request).

The Gains from Input Trade in Firm-Based Models of Importing *by* Joaquin Blaum, Claire Lelarge and Michael Peters

Online Appendix (Not for Publication)

This Appendix contains the following additional results and material:

1. Details about the identification of the Input-Output Matrix Ξ,
2. Estimates of the production function coefficients,
3. A description of the bootstrap procedure,
4. An extension of the welfare equation (40) to a multi-sector environment,
5. Details about the algorithm used to calibrate the model of Section 4.

A.1 Identification of the Input-Output and Demand Structure

We use the French input-output tables from the OECD to discipline the demand parameters $[\alpha_s]$ and the matrix of input-output linkages Ξ. To determine Ξ, we focus on the intermediate supply from each industry j to each industry s. We abstract from any taxes and subsidies. As Ξ can be identified from expenditure shares by sourcing sector, see (25), we set

$$\zeta_j^s = \frac{\text{Intermediate supply from industry } j \text{ to industry } s}{\text{Intermediate consumption at final prices from industry } s}.$$

That is, ζ_j^s measures the importance of sector j in the production process of sector s. By construction, this ensures that $\sum_{j=1}^{S} \zeta_j^s = 1$ for all s. We arrange the input-output matrix so that the columns contain the distribution of expenditure for the different sectors:

$$\Xi = \begin{bmatrix} \zeta_1^1 & \zeta_1^2 & & \zeta_1^S \\ \zeta_2^1 & & & \\ & & & \\ \zeta_S^1 & & & \zeta_S^S \end{bmatrix}.$$

To determine $[\alpha_s]$, we also use the input-output tables as they contain information on the composition of final demand. Since there is no trade in final goods in the theory, we exclude any exports and imports in final goods in the data. More specifically, the input-output tables report final consumption expenditure by households on sector j, denoted by $HHFC_j$. Following (25), we hence set

$$\alpha_s = \frac{HHFC_s}{\sum_{j=1}^{S} HHFC_j}.$$

Direct Data						Aggregation		
ISIC	α	Value Added	Intermediate Purchases	γ	Λ	Coarse Classification	α	γ
1	α_1	VA_1	X_1	$\frac{X_1}{X_1+VA_1}$	0	Non-Manufacturing	α_S from (81)	γ_S from (82)
2	α_2	VA_2	X_2	$\frac{X_2}{X_2+VA_2}$	0			
3					0			
...					0			
10	α_{10}	VA_{10}	X_{10}	Estimate from micro-data	"Read off" from micro-data	Manufacturing	α_{10}	γ_{10}
16								
...								
37	α_{37}	VA_{37}	X_{37}				α_{37}	γ_{37}
40	α_{40}	VA_{40}	X_{40}	$\frac{X_{40}}{X_{40}+VA_{40}}$	0	Non-Manufacturing	α_S from (81)	γ_S from (82)
...					0			
99	α_{99}	VA_{99}	X_{99}	$\frac{X_{99}}{X_{99}+VA_{99}}$	0			

Table 14: Measurement of α_s and γ_s

The OECD input-output tables report their data at the 2-digit level of ISIC Rev. 3, which gives 37 manufacturing industries. To deal with the non-manufacturing industries, we group them into a "residual" sector which we denote by S. To incorporate this sector in the analysis, we set

$$\alpha_S = 1 - \sum_{j \in M} \alpha_j, \tag{81}$$

where M is the set of manufacturing sectors. Because in our theory this sector is not engaged in foreign sourcing[76], we set

$$\Lambda_S = 0.$$

The input-output structure of sector S can be recovered from the input-output tables. In particular, we set

$$\zeta_j^S \equiv \frac{\sum_{n=1}^{NM} \text{Intermediate supply from industry } j \text{ to industry } n}{\sum_{n=1}^{NM} \text{Intermediate consumption at final prices to industry } n},$$

where NM is the set of non-manufacturing sectors. To measure the materials coefficient in the production of sector S, we employ the Input-Output Matrix for the non-manufacturing sectors. As we observe value added and intermediary spending for each sector, we set

$$\gamma_S = \frac{\sum_{n=1}^{NM} X_n}{\sum_{n=1}^{NM} (X_n + VA_n)}, \tag{82}$$

where X_n denotes total intermediary spending by sector n. Table 16 summarizes how $[\alpha_s]$ and $[\gamma_s]$ are computed. The input-output matrix Ξ used in our empirical analysis is contained in Table 15.

[76]Note that this sector may nevertheless benefit from input trade if it sources output from the manufacturing industries.

Sector	10-14	15-16	17-19	20	21-22	24	25	26	27	28	29	30	31	32	33	34	35	36-37	S
10-14	8.69	0.12	0	0.02	0.41	1.8	0.26	9.83	4.85	0.36	0.12	0.05	0.16	0.07	0.12	0	0	0.82	0.86
15-16	0.48	21.33	2.27	0.1	0.51	1.97	0.24	0.06	0.17	0.17	0.12	0.1	0.12	0.18	0.18	0.04	0.04	0.48	2.95
17-19	0.26	0.11	46.79	0.08	0.65	0.8	1.39	0.44	0.27	0.17	0.34	0.28	0.42	0.63	0.87	1.4	0.48	5.95	0.38
20	1.33	0.38	0.13	30.47	1.07	0.17	0.38	2.06	0.33	0.39	0.29	0.09	0.23	0.32	0.32	0.29	0.41	15.9	0.59
21-22	1.44	2.29	1.73	1.45	44.73	3.02	2.27	2.82	0.6	0.63	1.01	0.82	1.2	1.37	2.11	0.46	0.52	2.74	3.02
24	4.53	1.25	8.25	1.69	5.03	39.28	40.03	3.31	2.92	3.02	1.78	0.57	4.42	0.84	1.17	1.93	1.03	4.17	1.93
25	1.68	2.46	2.36	0.65	1.67	3.03	15.72	1.44	0.66	2.49	3.65	1.29	6.58	5.07	3.23	6.57	1.64	4.93	0.95
26	8.53	0.79	0.19	0.81	0.21	0.81	0.66	21.53	0.88	0.9	0.67	0.11	0.81	1.5	2.08	1.23	0.36	1.86	1.79
27	0.62	0.09	0.4	0.64	0.8	0.76	1.67	3.24	41.61	24.72	9	0.48	11.46	2.5	5.66	8.44	2.28	9.25	0.35
28	5.95	1.39	1.16	3.51	0.98	2.13	1.78	2.26	6.92	28.04	15.87	0.75	13.11	5.97	8.31	8.02	4.84	4.72	1.38
29	20.33	0.79	1.66	3.31	0.87	0.78	2.79	2.6	2	4.04	19.27	0.64	2.28	1.99	3.37	4.21	3.33	3.01	1.51
30	0	0.02	0.04	0.36	0.08	0.02	0.08	0.36	0.04	0.24	0.48	37.61	0.35	1.27	2.02	0	0.07	0.17	0.34
21	0.51	0.14	0.08	0.28	0.35	0.34	0.21	0.79	1.07	2.24	4.43	3.93	16.03	6.83	2.84	3.07	1.05	1.39	1.12
32	0.9	0.06	0.07	0.09	0.15	0.13	0.39	0.37	0.34	0.59	3.81	12.59	11	30.3	11.86	1.98	4.26	1.5	0.7
33	0.07	0.01	0.08	0.03	0.12	0.12	0.22	0.57	0.39	0.61	2.29	2.59	2.72	8.55	19.31	1.52	8.74	0.42	0.6
34	0.68	0.09	0.12	0.22	0.12	0.07	0.07	0.47	0.21	0.25	0.69	0.13	0.27	0.22	0.24	35.3	0.14	0.42	0.82
35	0.15	0.01	0.04	0.04	0.05	0.04	0.05	0.06	0.05	0.11	1.31	0.02	0.03	0.03	0.05	0.11	46.37	0.05	1.12
36-37	0.2	0.17	0.59	0.42	0.8	0.18	0.23	0.43	1.34	0.98	0.76	0.31	0.61	0.34	0.52	1.94	0.37	6.85	0.45
S	43.64	68.48	34.03	55.82	41.4	44.54	31.56	47.37	35.35	30.04	34.13	37.63	28.21	32.02	35.73	23.46	24.09	35.37	79.14

Notes: The table contains the French input-output matrix used in our empirical work. We report numbers in percentage terms. Sectors are classified at the 2-digit-level according to ISIC Rev. 3. The non-manufacturing sector S is constructed as explained in the main text and Table 16.

Table 15: Input-Output Linkages: Ξ

Industry	ISIC	ϕ_k		ϕ_l		γ	
Mining	10-14	0.374***	(0.039)	0.293***	(0.017)	0.333***	(0.043)
Food, tobacco, beverages	15-16	0.098***	(0.004)	0.177***	(0.003)	0.725***	(0.006)
Textiles and leather	17-19	0.081***	(0.003)	0.293***	(0.009)	0.626***	(0.012)
Wood and wood products	20	0.113***	(0.004)	0.285***	(0.006)	0.602***	(0.006)
Paper, printing, publishing	21-22	0.134***	(0.007)	0.362***	(0.011)	0.504***	(0.011)
Chemicals	24	0.124***	(0.008)	0.204***	(0.01)	0.671***	(0.014)
Rubber and plastics products	25	0.124***	(0.005)	0.289***	(0.007)	0.587***	(0.011)
Non-metallic mineral products	26	0.178***	(0.01)	0.294***	(0.012)	0.529***	(0.015)
Basic metals	27	0.124***	(0.01)	0.202***	(0.015)	0.674***	(0.021)
Metal products (ex machinery and equipment)	28	0.108***	(0.002)	0.412***	(0.008)	0.479***	(0.009)
Machinery and equipment	29	0.071***	(0.003)	0.313***	(0.015)	0.616***	(0.018)
Office and computing machinery	30	0.037***	(0.012)	0.150***	(0.032)	0.813***	(0.04)
Electrical machinery	31	0.096***	(0.008)	0.306***	(0.011)	0.598***	(0.014)
Radio and communication	32	0.055***	(0.006)	0.322***	(0.048)	0.624***	(0.052)
Medical and optical instruments	33	0.071***	(0.004)	0.435***	(0.026)	0.494***	(0.029)
Motor vehicles, trailers	34	0.106***	(0.009)	0.135***	(0.016)	0.759***	(0.014)
Transport equipment	35	0.152***	(0.019)	0.499***	(0.03)	0.349***	(0.044)
Manufacturing, recycling	36-37	0.084***	(0.003)	0.283***	(0.009)	0.633***	(0.012)

Notes: The table contains the production function parameters based on observed factor shares. See Section 3.1 in the main text for details.

Table 16: Production Function Coefficient Estimates, by 2-digit Sector: Factor Shares

A.2 Estimating the Parameters of the Production Function

We report the results of estimating the production function parameters using our different approaches. In Table 16, we report the results of the factor share approach. Note that this method imposes the assumption of constant returns, so that $\phi_{ks}+\phi_{ls}+\gamma_s = 1$. Table 17 reports the results based on proxy methods akin to Levinsohn and Petrin (2012) and Wooldridge (2009). We do not impose constant returns to scale for these approaches. We assume that labor is a dynamic input, which seems plausible given the stringent hiring and firing regulations of the French economy. Note that we do not include firms' domestic share in material spending in the production function as we estimate ε in the second stage. Finally, Table 18 contains the results of the integrated GMM approach, where we treat the domestic expenditure share as a distinct input and estimate the parameter vector $(\phi_{ks}, \phi_{ls}, \gamma_s, \varepsilon_s)$ in one step.

A.3 Bootstrap Procedure

We sample firms from the empirical distribution with replacement to construct 200 replicates of our micro-data. For each of these samples, we re-calculate σ_s and re-estimate ε and $[\gamma_s]$ following the factor shares approach explained in Section 3.1 and then re-calculate $[\Lambda_s]$ and $\left[s_{Ds}^{Agg}\right]$. Figure 6 depicts the bootstrap distributions of these variables. For the three sector-level variables, we report the distribution of the sectoral averages, e.g. the upper right panel displays the distribution of $\frac{1}{S}\sum_{s=1}^{S}\gamma_s$. While the variation in γ and s_D^{Agg} is relatively modest, there is a quite a bit of

Industry	ISIC	ϕ_k		ϕ_l		γ	
Mining	10-14	0.647***	(0.101)	0.626***	(0.087)	0.295**	(0.139)
Food, tobacco, beverages	15-16	0.174***	(0.010)	0.274***	(0.009)	0.538***	(0.060)
Textiles and leather	17-19	0.216***	(0.026)	0.513***	(0.037)	0.481***	(0.096)
Wood and wood products	20	0.138***	(0.023)	0.414***	(0.024)	0.521***	(0.058)
Paper, printing, publishing	21-22	0.061***	(0.022)	0.717***	(0.033)	0.600***	(0.099)
Chemicals	24	0.027	(0.081)	0.142	(0.134)	1.304***	(0.336)
Rubber and plastics products	25	0.148***	(0.031)	0.536***	(0.050)	0.357***	(0.115)
Non-metallic mineral products	26	0.221***	(0.037)	0.539***	(0.037)	0.357***	(0.119)
Basic metals	27	0.104	(0.096)	0.381***	(0.087)	0.481*	(0.263)
Metal products (ex machinery and equipment)	28	0.252***	(0.013)	0.655***	(0.016)	0.231***	(0.036)
Machinery and equipment	29	0.186***	(0.018)	0.563***	(0.025)	0.393***	(0.066)
Office and computing machinery	30	0.170**	(0.081)	0.574***	(0.110)	0.104	(0.210)
Electrical machinery	31	0.144***	(0.031)	0.448***	(0.044)	0.449***	(0.123)
Radio and communication	32	0.123**	(0.057)	0.565***	(0.114)	0.568***	(0.207)
Medical and optical instruments	33	0.231***	(0.021)	0.501***	(0.020)	0.421***	(0.073)
Motor vehicles, trailers	34	0.082	(0.091)	0.316**	(0.127)	0.765**	(0.355)
Transport equipment	35	0.194***	(0.073)	0.686***	(0.089)	0.997***	(0.256)
Manufacturing, recycling	36-37	0.242***	(0.018)	0.472***	(0.016)	0.430***	(0.055)

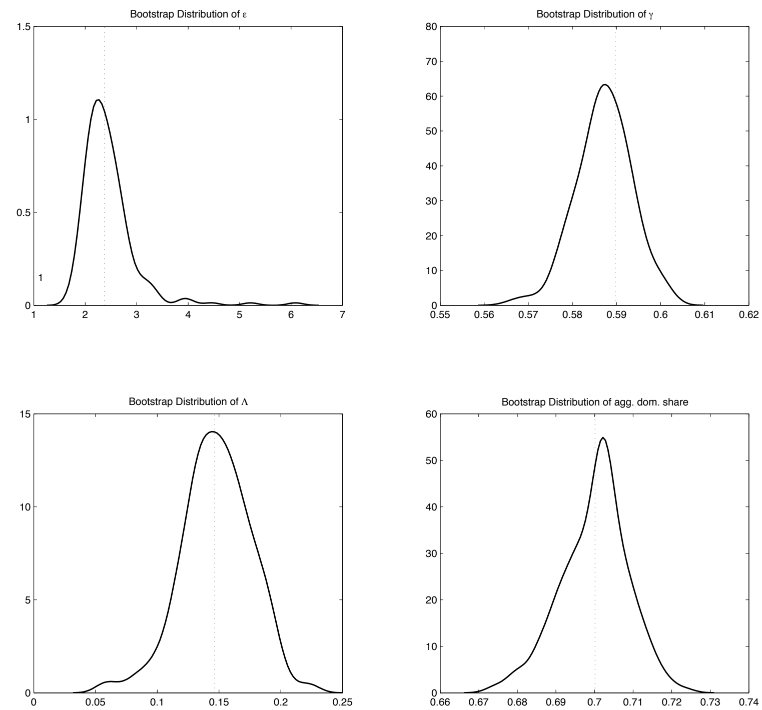
Notes: The table contains the production function parameters based on the GMM procedure by Levinsohn and Petrin (2012) and Wooldridge (2009). See Section 3.1 in the main text for details.

Table 17: Production Function Coefficient Estimates, by 2-digit Sector: GMM

Industry	ISIC	ϕ_k		ϕ_l		γ		ε	
Mining	10-14	0.679***	(0.100)	0.617***	(0.088)	0.257*	(0.148)	0.450	(0.451)
Food, tobacco, beverages	15-16	0.173***	(0.010)	0.278***	(0.009)	0.512***	(0.063)	1.976***	(0.166)
Textiles and leather	17-19	0.247***	(0.029)	0.555***	(0.035)	0.354***	(0.101)	2.279***	(0.743)
Wood and wood products	20	0.172***	(0.025)	0.437***	(0.025)	0.441***	(0.061)	2.548***	(0.324)
Paper, printing, publishing	21-22	0.089***	(0.022)	0.726***	(0.032)	0.465***	(0.099)	2.189***	(0.383)
Chemicals	24	0.072	(0.056)	0.250***	(0.084)	1.064***	(0.229)	-6.586	(6.818)
Rubber and plastics products	25	0.163***	(0.032)	0.584***	(0.055)	0.253**	(0.128)	2.442**	(1.103)
Non-metallic mineral products	26	0.221***	(0.036)	0.526***	(0.036)	0.354***	(0.121)	1.869***	(0.358)
Basic metals	27	0.151	(0.120)	0.540***	(0.177)	-0.084	(0.583)	0.892	(0.692)
Metal products (ex machinery and equipment)	28	0.254***	(0.014)	0.667***	(0.016)	0.191***	(0.036)	1.368***	(0.0796)
Machinery and equipment	29	0.183***	(0.018)	0.553***	(0.024)	0.381***	(0.065)	2.191***	(0.279)
Office and computing machinery	30	0.132	(0.087)	0.451***	(0.110)	0.126	(0.222)	2.358	(3.485)
Electrical machinery	31	0.138***	(0.028)	0.460***	(0.037)	0.428***	(0.110)	2.806***	(0.863)
Radio and communication	32	0.132*	(0.069)	0.614***	(0.144)	0.442*	(0.264)	3.147	(2.733)
Medical and optical instruments	33	0.237***	(0.021)	0.498***	(0.020)	0.372***	(0.073)	2.062***	(0.295)
Motor vehicles, trailers	34	0.089	(0.087)	0.354***	(0.120)	0.706**	(0.344)	3.741*	(2.088)
Transport equipment	35	0.170**	(0.081)	0.664***	(0.094)	0.955***	(0.282)	4.482	(4.371)
Manufacturing, recycling	36-37	0.263***	(0.019)	0.468***	(0.017)	0.361***	(0.059)	1.765***	(0.183)

Notes: The table contains the production function parameters based on the GMM procedure by Levinsohn and Petrin (2012) and Wooldridge (2009). See Section 3.1 in the main text for details.

Table 18: Production Function Coefficient Estimates, by 2-digit Sector: GMM with s_D as input



Notes: The upper left panel contains the bootstrap distribution of ε. The remaining panels depict the bootstrap distributions of $\frac{1}{S}\sum_{s=1}^{S}\gamma_s$, $\frac{1}{S}\sum_{s=1}^{S}\Lambda_s$ and $\frac{1}{S}\sum_{s=1}^{S}s_{Ds}^{Agg}$. The point estimates used in the main analysis are reported as vertical lines.

Figure 6: Bootstrap Distribution of Structural Parameters and Direct Price Reductions

uncertainty regarding ε. This is consistent with the non-negligible standard errors reported in Table 2. We conclude that it is the variation in ε which induces most of the variation in Λ and therefore in the consumer price gains from input trade reported in Tables 5-6 and shown in Figure 5.

A.4 General equilibrium and Welfare in the Model of Section 4.1

Consider the setup of Section 4.1. We now consider the aggregate allocations in this economy. An equilibrium has the usual definition:

Definition 1. *An equilibrium is a set of prices* $w, [p_i]$, *labor demands for production and fixed costs* $\left[l_i, l_i^F\right]$, *differentiated product quantities, consumption levels and foreign demands* $\left[y_i, c_i, y_i^{ROW}\right]$, *domestic and international input demands by local firms* $[y_{vi}], [z_{ci}]$ *and sourcing strategies* $[n_i]$ *such that:*

1. *Firms maximize profits given by* (36)-(37),

2. *Consumers maximize utility given by* (12) *and* (13) *subject to their budget constraint*

$$\int_i p_i c_i di = wL + \int_i \pi_i di, \tag{83}$$

3. *Trade is balanced* (39),

4. *Labor and good markets clear*

$$
\begin{aligned}
L &= \int_i \left(l_i + l_i^F \right) di \\
y_i &= c_i + y_i^{ROW} + \int_\nu y_{vi} dv.
\end{aligned}
$$

We fist characterize the general equilibrium in a multi-sector version of the economy of Section 4.1. In particular, we consider the multi-sector structure of Section 2.2. We derive a generalization of (40). We do not impose any assumptions on how firms' determine their extensive margin. That is, we allow for an arbitrary mapping l_{Σ_i}which gives the labor resources that firm i needs to spend in order to attain the sourcing strategy Σ_i. We assume that trade is balanced and that the value of exports in sector s is given by $\alpha_s^{ROW} \times IM$, where IM denotes the value of total spending on imported inputs.

Proposition 4. *Let W,I and S denote welfare, consumer income and total spending, respectively. Then, the change in welfare relative to input autarky is given by*

$$
\frac{W}{W^{Aut}} = \frac{I}{I^{Aut}} \times \frac{P^{Aut}}{P},
$$

where I and I^{Aut} are given by

$$
I = L + \sum_{s=1}^{S} S_s/\sigma_s - \sum_{s=1}^{S} \left(\int_0^{N_s} l_{\Sigma_i} di \right), \tag{84}
$$

$$
I^{Aut} = L + \sum_{s=1}^{S} S_s^{Aut}/\sigma_s, \tag{85}
$$

and $[S_j]$ and $\left[S_j^{Aut}\right]$ solve

$$
S_s = \alpha_s \left(L - \sum_{j=1}^{S} \left(\int_0^{N_j} l_{\Sigma_i} di \right) + \sum_{j=1}^{S} \frac{1 + \frac{\zeta_s^j}{\alpha_s} \gamma_j (\sigma_j - 1)}{\sigma_j} S_j \right) + \sum_{j=1}^{S} \left[\alpha_s^{ROW} - \zeta_s^j \right] \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_0^{N_j} (1 - s_{Di}) \omega_i di, \tag{86}
$$

and

$$
S_s^{Aut} = \alpha_s \left(L + \sum_{j=1}^{S} \frac{1 + \zeta_s^j \gamma_j (\sigma_j - 1) / \alpha_s}{\sigma_j} S_j^{Aut} \right), \tag{87}
$$

Furthermore, $G = \frac{P^{Aut}}{P}$ is given in Proposition 2.

Proof. As labor is the only factor of production, consumer welfare is given by real income $W = I/P$, consumer income is given by

$$I = L + \sum_{s=1}^{S} \left(\int_0^{N_s} \pi_i di \right).$$

Note that L represents total labor income and π_i denotes firm i's profits. To derive π_i, recall that firms in sector s have a mark-up of $\sigma_s/(\sigma_s - 1)$ so that variable profits gross of any extensive margin resource loss are given by

$$\pi_i^V = (p_i - u_i)\, y_i = p_i y_i / \sigma_s. \tag{88}$$

Total revenue for firm i is given by

$$p_i y_i = \left(\frac{p_i}{P_s} \right)^{1-\sigma_s} S_s, \tag{89}$$

where P_s is the consumer price index for sector s and S_s denotes total spending for sector s goods. Hence,

$$\pi_i = p_i y_i / \sigma_s - l_{\Sigma_i} = \frac{1}{\sigma_s} \left(\frac{p_i}{P_s} \right)^{1-\sigma_s} S_s - l_{\Sigma_i},$$

so that

$$I \quad = \quad L + \sum_{s=1}^{S} \frac{1}{\sigma_s} S_s - \sum_{s=1}^{S} \left(\int_i^{N_s} l_{\Sigma_i} di \right). \tag{90}$$

Hence, given $[S_s]$ and $[l_{\Sigma i}]$, total income I is fully determined. Now consider $[S_s]_s$. Note that

$$S_s = S_s^C + S_s^X + S_s^{ROW}, \tag{91}$$

where S_s^C, S_s^X and S_s^{ROW} denote total spending by consumers, intermediary producers and the rest of the world, respectively. For our economy, we have that $S_c^C = \alpha_s I$ and $S_s^{ROW} = \alpha_s^{ROW} Im$ as consumers spend a fraction α_s of their income I on sector s products and balanced trade requires that total spending by the rest of the world is equal to the value of imports Im, a fraction α_s^{ROW} of which is spent on sector s products. To derive S_s^X, let total domestic intermediary purchases in sector j be given by X_j. Then

$$S_s^X = \sum_{j=1}^{S} \zeta_s^j X_j. \tag{92}$$

Letting m_i be total material spending by firm i and s_i be total spending by firm i, we know that

$$\begin{aligned} X_j \quad &= \quad \int_0^{N_j} s_{Di} m_i di = \int_0^{N_j} s_{Di} \gamma_j s_i di = \int_0^{N_j} s_{Di} \gamma_j \frac{\sigma_j - 1}{\sigma_j} p_i y_i di \\ &= \quad \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_0^{N_j} s_{Di} \left(\frac{p_i}{P_j} \right)^{1-\sigma_j} di, \end{aligned} \tag{93}$$

where we used that firms in sector j spend a fraction γ_j of their total input spending s_i on materials and that total spending s_i accounts for a fraction $(\sigma_j - 1)/\sigma_j$ of revenue. Hence, (92) and (93) imply that

$$S_s^X = \sum_{j=1}^{S} \zeta_s^j \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_{i=0}^{N_j} s_{Di} \left(\frac{p_i}{P_s}\right)^{1-\sigma_s} di. \tag{94}$$

Similarly, total import spending is equal to

$$\begin{aligned} Im &= \sum_{j=1}^{S} Im_j = \sum_{j=1}^{S} \int_0^{N_j} (1 - s_{Di}) m_i di \\ &= \sum_{j=1}^{S} \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_{i=0}^{N_j} (1 - s_{D,i}) \left(\frac{p_i}{P_s}\right)^{1-\sigma_s} di. \end{aligned} \tag{95}$$

Hence (94) and (95) imply that

$$\begin{aligned} S_s &= \alpha_s I + \alpha_s^{ROW} \left(\sum_{j=1}^{S} \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_0^{N_j} (1 - s_{Di}) \left(\frac{p_i}{P_j}\right)^{1-\sigma_j} di \right) + \sum_{j=1}^{S} \zeta_s^j \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_0^{N_j} s_{Di} \left(\frac{p_i}{P_j}\right)^{1-\sigma_j} di \\ &= \alpha_s I + \sum_{j=1}^{S} \zeta_s^j \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j + \sum_{j=1}^{S} \left[\alpha_s^{ROW} - \zeta_s^j\right] \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_i^{N_j} (1 - s_{Di}) \left(\frac{p_i}{P_j}\right)^{1-\sigma_j} di. \end{aligned}$$

Using (90), we get that

$$S_s = \alpha_s \left(L - \sum_{j=1}^{S} \left(\int_i^{N_j} l_{\Sigma_i} di \right) + \sum_{j=1}^{S} \frac{1 + \frac{\zeta_s^j}{\alpha_s} \gamma_j (\sigma_j - 1)}{\sigma_j} S_j \right) + \sum_{j=1}^{S} \left[\alpha_s^{ROW} - \zeta_s^j\right] \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_i^{N_j} (1 - s_{Di}) \left(\frac{p_i}{P_j}\right)^{1-\sigma_j} di.$$

Now note that

$$\frac{va_i}{\int_0^{N_s} va_i di} = \frac{p_i y_i}{\int_0^{N_s} p_i y_i di} = \frac{(p_i/P_s)^{1-\sigma_s} S_s}{\int_0^{N_s} (p_i/P_s)^{1-\sigma_s} S_s di} = \left(\frac{p_i}{P_s}\right)^{1-\sigma_s}.$$

Hence,

$$S_s = \alpha_s \left(L - \sum_{j=1}^{S} \left(\int_0^{N_j} l_{\Sigma_i} di \right) + \sum_{j=1}^{S} \frac{1 + \frac{\zeta_s^j}{\alpha_s} \gamma_j (\sigma_j - 1)}{\sigma_j} S_j \right) + \sum_{j=1}^{S} \left[\alpha_s^{ROW} - \zeta_s^j\right] \gamma_j \frac{\sigma_j - 1}{\sigma_j} S_j \int_0^{N_j} (1 - s_{Di}) \omega_i di \tag{96}$$

where $\omega_i = \frac{va_i}{\int_i^{N_s} va_i di}$. Given $L^{NET} = L - \sum_{j=1}^{S} \left(\int_0^{N_j} l_{\Sigma_i} di \right)$, (96) are S equations in S unknowns S_s, which we can easily solve. Now consider the case of autarky. There we have $l_{\Sigma_i} = 0$ and $s_{Di} = 1$. Hence, (96) yields

$$S_s^{Aut} = \alpha_s \left(L + \sum_{j=1}^{S} \frac{1 + \frac{\zeta_s^j}{\alpha_s} \gamma_j (\sigma_j - 1)}{\sigma_j} S_j^{Aut} \right).$$

In the case of a single sector (i.e. $S = 1$) it has to be the case that

$$\alpha_S = \alpha_S^{ROW} = \zeta_S^S = 1.$$

Hence,

$$S^{Aut} = L + \frac{1 + \gamma (\sigma - 1)}{\sigma} S^{Aut} = \frac{\sigma}{(1 - \gamma)(\sigma - 1)} L.$$

Substituting this in (90) yields

$$I^{Aut}=L+\frac{1}{\sigma}S=\frac{1+(1-\gamma)(\sigma-1)}{(1-\gamma)(\sigma-1)}L.$$

Similarly, we get from (96) that

$$\sum_{j=1}^{S}\left[\alpha_s^{ROW}-\zeta_s^j\right]\gamma_j\frac{\sigma_j-1}{\sigma_j}S_j\int_0^{N_j}(1-s_{Di})\,\omega_i di=0$$

so that

$$S = \frac{\sigma}{(1-\gamma)(\sigma-1)}\left(L-\left(\int_i^N l_{\Sigma_i}di\right)\right) \tag{97}$$

$$I = \frac{1+(1-\gamma)(\sigma-1)}{(1-\gamma)(\sigma-1)}\left(L-\left(\int_i^N l_{\Sigma_i}di\right)\right). \tag{98}$$

This implies directly (40). This concludes the proof of Proposition 4. □

A.5 Calibrating the Model of Section 4

We adopt a solution algorithm that allows us to bypass the computation of the general equilibrium variables within the calibration. Intuitively, we work with a normalized version of fixed costs, where these are scaled by an appropriate transformation of the general equilibrium variables. Because the equilibrium variables depend on firms' import behavior only through the domestic shares, which are itself a calibration target, we can compute them *after* the calibration. That is, we can first ensure that the moments of the joint distribution of value added and domestic shares are matched[77], and then back out the underlying general equilibrium variables required to compute welfare. We also show that the parameter z is not required for the calibration.

We first start with three aggregate variables, which are determined in equilibrium. In the single-sector version of the model, characterized in Section A.4 in the Online Appendix, we have that aggregate spending S and the price level (which is also equal to the price of domestic varieties) is given by

$$S = \frac{\sigma}{(1-\gamma)(\sigma-1)}\left(L-\left(\int_i^N l_{\Sigma_i}di\right)\right) \tag{99}$$

$$P = \left(\frac{\sigma}{\sigma-1}\left(\frac{1}{\gamma}\right)^{\gamma}\left(\frac{1}{1-\gamma}\right)^{1-\gamma}\left(\frac{1}{q_D}\right)^{\gamma}\Upsilon\right)^{\frac{1}{1-\gamma}}, \tag{100}$$

where

$$\Upsilon=\left(\int_{i=0}^{N}\left(\frac{1}{\tilde{\varphi}_i}\left(s_{D,i}\right)^{\gamma/(\varepsilon-1)}\right)^{1-\sigma}di\right)^{\frac{1}{1-\sigma}}. \tag{101}$$

[77]For this step, it is important that the dispersion and correlation moments are in logs. See below.

We start by noting that the firm's optimality conditions from the profit maximization problem, contained in Section 7.6, can be expressed in terms of s_D instead of n. To see this, note that (8) and (35) imply

$$n^{\eta(\varepsilon-1)} = \left(\frac{1-s_D}{s_D}\right)\left(\frac{\beta}{1-\beta}\right)^{\varepsilon} z^{\varepsilon-1}\left(\frac{q_D}{p_D}\right)^{\varepsilon-1}. \tag{102}$$

Substituting (102) into the firm's first order condition (73), we obtain

$$s_D^{\frac{1-\gamma(\sigma-1)\eta}{(\varepsilon-1)\eta}}\left(1-s_D\right)^{1-\frac{1}{\eta(\varepsilon-1)}} = \left(\frac{\beta}{1-\beta}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} \frac{\tilde{f}}{\tilde{\varphi}^{\sigma-1}}, \tag{103}$$

where

$$\tilde{f} \equiv f \times \left(zq_D\right)^{1/\eta} \frac{1}{\eta\gamma\left(\sigma-1\right)} \frac{1}{\Theta} \times \frac{1}{P^{1/\eta}\Gamma}, \tag{104}$$

where

$$\Theta = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\left(\frac{1}{1-\gamma}\right)^{1-\gamma}\left(\frac{1}{\gamma}\left(\frac{1}{q_D}\right)\right)^{\gamma}\right)^{1-\sigma}, \tag{105}$$

$$\Gamma = \frac{S}{P^{(1-\gamma)(1-\sigma)}}. \tag{106}$$

Similarly, (102) and the import status condition (79) imply that the firm is an importer as long as

$$\left[s_D^{-\frac{\gamma(\sigma-1)}{\varepsilon-1}} - 1\right]\tilde{\varphi}^{\sigma-1} - \left(\frac{1-s_D}{s_D}\right)^{\frac{1}{\eta(\varepsilon-1)}} \gamma\left(\sigma-1\right)\eta\left(\frac{\beta}{1-\beta}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} \tilde{f} - \tilde{f}_I > 0, \tag{107}$$

where

$$\tilde{f}_I \equiv \frac{1}{\Gamma}\frac{1}{\Theta} \times f_I. \tag{108}$$

(103) and (107) show that we can solve for firms' optimal domestic share and import status with knowledge of $\tilde{\varphi}^{\sigma-1}$, $\tilde{f}$ and $\tilde{f}_I$ only. Thus, we can work with the joint distribution of $\left(\varphi, \tilde{f}\right)$ to match the moments of the joint distribution of domestic shares and value added. We can then back out the exogenous component of fixed costs f_I and f from $\tilde{f}_I$ and $\tilde{f}$ using the equilibrium variables S and P and (106).

To solve for S, we require the aggregate resource loss of fixed costs (see (99)). To do so, note that

$$\begin{aligned} l_{\Sigma_i} = l_i\left(s_{Di}\right) &= f_i \times \left(\frac{s_{Di}}{1-s_{Di}}\right)^{\frac{1}{\eta(1-\varepsilon)}}\left(\frac{1}{P}\right)^{1/\eta}\left(q_D z\right)^{1/\eta}\left(\frac{\beta_i}{1-\beta_i}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} + f_I \\ &= \Gamma\Theta\left\{\eta\gamma\left(\sigma-1\right) \times \tilde{f}_i \times \left(\frac{s_{Di}}{1-s_{Di}}\right)^{\frac{1}{\eta(1-\varepsilon)}}\left(\frac{\beta_i}{1-\beta_i}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} + \tilde{f}_I\right\}. \end{aligned}$$

Hence,

$$\int_i^N l_{\Sigma_i} di = \Gamma\Theta\left\{\eta\gamma\left(\sigma-1\right) \times \int_i^N \tilde{f}_i\left(\frac{s_{Di}}{1-s_{Di}}\right)^{\frac{1}{\eta(1-\varepsilon)}}\left(\frac{\beta_i}{1-\beta_i}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} di + \int_i^N \tilde{f}_I 1\left[s_{Di}\right] di\right\}. \tag{109}$$

The key is now to argue that Γ is known given the calibration. If so, we can calculate $\int_i^N l_{\Sigma_i} di$ from (109) given the calibrated $\tilde{f}$ and $\tilde{f}_I$ and parameters, as

$$\int_i^N l_{\Sigma_i} di = \Gamma \times \Theta \times \Delta,$$

where

$$\Delta \equiv \eta\gamma(\sigma-1) \times \int_i^N \tilde{f}_i \left(\frac{s_{Di}}{1-s_{Di}}\right)^{\frac{1}{\eta(1-\varepsilon)}} \left(\frac{\beta_i}{1-\beta_i}\right)^{\frac{\varepsilon}{\varepsilon-1}\frac{1}{\eta}} di + \int_i^N \tilde{f}_I 1\left[s_{Di}\right] di. \tag{110}$$

Recall that (106) and (99) imply that

$$\begin{aligned}
\Gamma &= \frac{S}{P^{(1-\gamma)(1-\sigma)}} = \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \left(L - \left(\int_i^N l_{\Sigma_i} di\right)\right) \\
&= \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} L - \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \Gamma\Theta\Delta.
\end{aligned}$$

Solving for Γ yields

$$\Gamma = \frac{\frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)}}{1 + \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \Theta\Delta} L. \tag{111}$$

As L is a normalization (see below), (111) shows that Γ is fully determined as P can be evaluated from the calibrated data on domestic shares (see (100) and (101)). Hence,

$$\int_i^N l_{\Sigma_i} di = \Gamma\Theta\Delta = \frac{\frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \Theta\Delta}{1 + \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \Theta\Delta} L.$$

This implies that

$$\frac{L - \int_i^N l_{\Sigma_i} di}{L} = \frac{1}{1 + \frac{1}{P^{(1-\gamma)(1-\sigma)}} \frac{\sigma}{(1-\gamma)(\sigma-1)} \Theta\Delta}, \tag{112}$$

so that L is indeed a normalization. Finally we only have to show that (112) does not depend on q_D, even though Θ does (see (105)). However, it can easily be shown that

$$\Theta P^{(1-\gamma)(\sigma-1)} = \Upsilon^{\sigma-1} \frac{1}{\sigma}. \tag{113}$$

Hence, the quality of domestic varieties q_D and the foreign price level z can be normalized for the calibration.

The five models we consider fit in this framework as follows:

1. The *aggregate model* assumes that $\beta_i = \beta$ and $f_i = f_I = 0$. Hence, $\int_i^N l_{\Sigma_i} di = 0$ and $s_{Di} = s_D$ can be solved from (102) using that $n = 1$ (as all firms are importers and import from every country). The level of β is chosen to match the aggregate domestic share. The dispersion in productivity σ_φ is chosen to match the dispersion in value added.

2. The *homogenous bias model* assumes that $\beta_i = \beta$ and $f_i = 0 < f_I$. Hence, conditional on

importing, we have that $s_{Di} = s_D$, which can be solved from (102) using that $n = 1$. The required level $\tilde{f}_I$ in (107) is chosen to match the share of importers. Given a distribution of productivity $[\tilde{\varphi}_i]_i$ we can then calculate Δ from (110), P from (100) and (101) and hence Γ from (111). This is sufficient to calculate welfare using (112) and P^{Aut}/P.

3. The *heterogeneous bias model* assumes that β_i varies across firms and $f_i = 0 < f_I$. As for the case with fixed costs, it is useful to consider a scaled version of the home-bias $\tilde{\beta}_i = \frac{\beta_i}{1-\beta_i}$. In particular, (102) shows that s_D only depends on $\beta^* = \left(\tilde{\beta}\right)^{\varepsilon} \left(\frac{1}{p}\right)^{\varepsilon-1}$ (again, we have $n = 1$ as there are no fixed costs per country). Hence, we draw $(\tilde{\varphi}, \beta^*)$ from a joint log-normal distribution. Using (102), this generates a joint distribution of $(\tilde{\varphi}_i, s_{Di})$. We can then calibrate $\tilde{f}_I$ from (107) to match the share of importers. Like for the case of the homogenous bias model, we can then use (110), P and (111) to compute all equilibrium objects.

4. For the *heterogenous fixed cost model,* we draw $\left(\tilde{\varphi}_i.\tilde{f}_i\right)$ from a joint log-normal distribution. Using the (103), this implies a joint distribution of $(\tilde{\varphi}_i, s_{Di})$. We can then calibrate $\tilde{f}_I$ from (107) to match the share of importers. As above, we can then use (110), P and (111) to compute all equilibrium objects.

5. The *homogenous fixed cost model,* is a special case of the heterogenous fixed cost model where $\tilde{f}_i = \tilde{f}$. Hence, the procedure is exactly the same given a marginal distribution for $\tilde{\varphi}_i$.