Export Destinations and Input Prices*

Paulo Bastos†
Joana Silva‡
Eric Verhoogen§

Jan. 2016

Abstract

This paper examines the extent to which the destination of exports matters for the input prices paid by firms, using detailed customs and firm-product-level data from Portugal. We use exchange-rate movements (interacted with indicators for initial exports) as a source of variation in destinations and find that exporting to richer countries leads firms to pay higher prices for inputs, other things equal. The results are supportive of what we call the income-based quality-choice hypothesis: an exogenous increase in average destination income leads firms to raise the average quality of goods they produce and to purchase higher-quality inputs.

* We are grateful to Mine Senses, Michael Sposi, participants in several seminars, and especially the editor, Penny Goldberg, and three anonymous referees for helpful comments. We thank Golvine de Rochambeau, Nicolás de Roux, Jonathan Dingel and Alejandra Martinez for excellent research assistance. Verhoogen thanks the New York Federal Reserve Bank for support and hospitality while the working paper was being completed. The views expressed in this paper are of the authors only, and should not be attributed to the World Bank. Silva thanks Instituto Nacional de Estatística for providing access to the microdata employed in this paper, and is especially grateful to Ana Chumbau, Ana Dulce Pinto and Maria Jose Gil for their kind help with the data. We remain responsible for any errors.

† The World Bank, pbastos@worldbank.org.

‡ The World Bank, jsilva@worldbank.org.

§ Columbia University, eric.verhoogen@columbia.edu.

1 Introduction

A growing body of research suggests that exporting has important effects on firm behavior. Although results for residual-based measures of productivity are mixed (Clerides, Lach, and Tybout, 1998; Bernard and Jensen, 1999; Alvarez and López, 2005; Van Biesebroeck, 2005; De Loecker, 2007), recent studies have found causal effects of exporting on a variety of directly observable outcomes. For instance, Bustos (2011) and Lileeva and Trefler (2010) find effects on technology investments by Argentinian and Canadian firms, respectively. Verhoogen (2008) finds effects on wages and ISO 9000 certification (an international production standard) in Mexico. Atkin, Khandelwal, and Osman (2014) find that randomly allocated contacts with foreign buyers lead Egyptian rug producers to improve quality on various directly observable dimensions. Tanaka (2015) finds that exporting leads to improvements in working conditions in garment and food-processing firms in Myanmar.

A number of theoretical explanations for such effects have been advanced. Perhaps the most common class of models emphasizes *scale effects:* in the presence of fixed investment costs, for instance for purchases of technology or worker screening, increases in sales volume due to exports reduce the fixed costs per unit and tend to induce firms to undertake such investments (Yeaple, 2005; Bustos, 2011; Helpman, Itskhoki, and Redding, 2010). A key feature of this class of models is that the effects of exporting on firm behavior depend on the volume of exports *per se*, and not on the characteristics of particular export destinations. A separate class of explanations focuses on *quality choice:* the varieties that firms sell on export markets may differ from those that they sell on domestic markets, and the different varieties may require different technologies, skills and other inputs in production. This class encompasses two distinct mechanisms. One is that per-unit transport costs may lead firms to export goods with higher value per unit, a phenomenon known as the "Washington apples" effect following the famous example in Alchian and Allen (1964).[1] The other is that, if richer consumers are more willing to pay for product quality, firms may choose to sell higher-quality varieties in richer markets to appeal to them.[2] These mechanisms both suggest that destinations matter, but they emphasize different characteristics. In the first, what matters is distance from the home market (or trade costs more broadly). In the second,

[1] See also Feenstra (1988), Hummels and Skiba (2004), and Feenstra and Romalis (2014).

[2] The idea that richer consumers are more willing to pay for product quality has been in the trade literature at least since Linder (1961). See also Markusen (1986), Flam and Helpman (1987), and Hallak (2006). We believe that Verhoogen (2008) was the first to formalize the idea that an individual firm would choose to sell higher-quality varieties in richer destination markets than in poorer ones in a heterogeneous-firms model.

what matters is the income level of consumers in the destination.[3]

Empirically, the relative importance of these different mechanisms remains an open question. Plant-level datasets typically do not provide information on the destination of exports, which makes it difficult to distinguish among the various channels. Newly available customs datasets on firms' international transactions have provided some support for the income-based quality-choice mechanism. In Portuguese data, Bastos and Silva (2008, 2010) show that individual firms charge higher "free on board" (f.o.b.) prices for goods sold to richer destination markets within narrow product categories, controlling for distance and other destination characteristics.[4] Subsequent papers have documented a similar pattern in data from China, France and Hungary (Manova and Zhang, 2012; Martin, 2012; Görg, Halpern, and Muraközy, 2010). This cross-sectional evidence is not definitive, however, for two reasons. First, firms may charge higher mark-ups in richer countries, even for homogeneous goods (Krugman, 1987; Goldberg and Knetter, 1997; Goldberg and Hellerstein, 2008; Alessandria and Kaboski, 2011; Fitzgerald and Haller, 2013; Simonovska, 2015). Second, the cross-sectional evidence does not settle the issue of causality: even if export prices do reflect product quality, shocks at the firm level may affect both which products a firm chooses to sell and where it is able to sell them, leading to a positive correlation between price and destination income even in the absence of a causal effect of exporting on firm behavior.

In this paper, we use a rich combination of customs and firm-product-level price data from Portugal to further investigate the income-based quality-choice channel, using exchange-rate movements as a source of exogenous variation in the destination of Portuguese firms' sales. Our approach is motivated by two theoretical ideas. First, as mentioned above, countries are asymmetric in income and in consumers' willingness to pay for product quality and individual firms choose to sell higher-quality varieties in richer markets. Second, firm productivity and input quality are complements in producing output quality, as in Verhoogen (2008) and Kugler and Verhoogen (2012); as a result, in equilibrium more-productive firms use higher-quality inputs to produce higher-quality products. The implication is that an exogenous shift in the destination of

[3] The list above is not exhaustive. Matsuyama (2007) formalizes the idea that exporting requires expenditures on marketing and distribution that are not required on domestic markets, suggesting that the volume of exports rather than destination characteristics should matter for firms' decisions. A number of authors have highlighted learning-by-exporting effects, although the extent to which such effects depend on characteristics of destination markets is typically not specified. An argument that learning-by-exporting effects are particularly strong when exporting to richer foreign markets, for instance because of stricter standards or more demanding buyers, is very much in the spirit of the income-based quality-choice story described above (see e.g. De Loecker (2007)).

[4] The f.o.b. prices in principle should not include transport costs, which are likely to vary across countries. Bastos and Silva (2008, 2010) also find a positive correlation between price and distance, consistent with the "Washington apples" hypothesis.

exports toward a richer market will lead a firm not only to produce higher-quality products, but also to use higher-quality inputs on average.

While this prediction is conceptually straightforward, taking it to the data presents a challenge. Direct measures of product quality are not available in the Portuguese data, nor in any other nationally representative data we are aware of. Our strategy in this paper is to draw inferences about quality from detailed information about prices at the firm-product (and firm-product-destination) level. But prices may reflect mark-ups rather than product quality. A large literature has documented not only that mark-ups vary within firms across destinations, as mentioned above, but also that mark-ups respond within firm-product-destination over time in response to exchange-rate movements.[5] Our key contention is that while endogenous mark-ups may confound attempts to draw inferences about product quality from *output* prices, they are not expected to influence the *input* prices paid by Portuguese firms. That is, in the absence of effects on product quality, we would not expect a systematic relationship between destination-market income and input prices, controlling for the scale of output and other observable factors.

To organize our thinking about the empirical work, we develop a model of output and input quality choice by heterogeneous firms with variable mark-ups, adding the quality choices to the framework of Atkeson and Burstein (2008). Following Amiti, Itskhoki, and Konings (2014), we focus on the variant of the Atkeson-Burstein model with Bertrand competition, and take as given the entry decisions of firms into destination markets. While conditioning on entry decisions in this way clearly limits the applicability of our framework for the analysis of long-run outcomes, we believe that it is a useful guide in our empirical setting, where we examine short-term responses by firms. The model provides a formal justification for the intuitive statement above: while endogenous mark-ups influence the choice of output price, they are not expected to influence the input prices paid by firms. The model we write down employs a specific demand system and has a number of other special characteristics, but we believe that the same implication would follow in a variety of frameworks commonly used in the trade literature.

In the empirical section, we relate input prices to the average income of a firm's destination markets, instrumenting average destination income with real-exchange-rate changes interacted with indicators of whether firms had positive exports to each destination in an initial year. In our preferred specification, we include instruments only for non-Euro-zone export destinations, which

[5] See Goldberg and Knetter (1997) and more recent work by Nakamura and Zerom (2010), Goldberg and Hellerstein (2008, 2013), Berman, Martin, and Mayer (2012), Chatterjee, Dix-Carneiro, and Vichyanond (2013) and Amiti, Itskhoki, and Konings (2014).

represent a minority of Portuguese exports, and there is reason to be concerned that the first stage of the IV procedure is weak. But both weak-instrument-robust statistics and arguments about the direction of the weak-instrument bias lead us to the conclusion that there is an economically significant, positive relationship between average destination income and average input prices, controlling for the scale of exports, average destination distance, and total sales. We consider the possibility that different types of market power in input markets could be generating the price effects even in the absence of effects on quality choice, but it does not appear that these mechanisms can completely explain our baseline results. Overall, we interpret the results as supportive of the hypothesis that an increase in average destination income leads firms to raise the average quality of goods they produce and to purchase higher-quality inputs.

This paper is perhaps most closely related to a recent study by Brambilla, Lederman, and Porto (2012). Using trade-transactions data linked to a firm-level panel survey from Argentina, the authors analyze the effect of the Brazilian devaluation of 1999, which led Argentinian firms to reduce exports to Brazil and increase the share of exports to other destinations — principally the U.S. and Europe. They find that increased exports to richer countries led to higher skill composition and higher wages at the firm level, while increased exports *per se* had no such effect. Relative to Brambilla et al (2012), the main advantage of the current paper is that we have access to data on material input prices and can show how they respond to changes in destinations. Arm's-length supplier relationships are arguably less subject to the concern that prices are determined by particular factor-market institutions — e.g. collective bargaining, or fair/efficiency wages, which may be particularly relevant in Argentina. We also have output prices, which were not available in the previous study. In addition, we control for the average distance of export destinations. The fact that in the Portuguese case richer destinations (e.g. UK, Sweden) tend be nearer and poorer destinations (e.g. Brazil, Angola) tend to be further away — in contrast to the Argentinian case, where destination income and distance tend to be positively correlated — helps to strengthen our argument that the positive destination income-input price relationship is due to income-based quality choice and not distance. Overall, however, our findings remain quite consistent with the broader argument in Brambilla, Lederman, and Porto (2012) (as well as in Verhoogen (2008)).

In addition to the papers cited above, our paper is also related to a growing recent literature on the role of product quality in trade, including Schott (2004), Hummels and Klenow (2005), Sutton (2007), Choi, Hummels, and Xiang (2009), Hallak and Schott (2011), Baldwin and Harrigan (2011), Fajgelbaum, Grossman, and Helpman (2011), Eckel, Iacovone, Javorcik, and Neary

(2015), Crozet, Head, and Mayer (2012), Johnson (2012), Hallak and Sivadasan (2013), Amiti and Khandelwal (2013), Markusen (2013), Caron, Fally, and Markusen (2014), Di Comite, Thisse, and Vandenbussche (2014), Iacovone and Javorcik (2012), Harrigan, Ma, and Shlychkov (2015), and Gervais (forthcoming).

Although we focus on Portugal, a middle-income country, we believe that our findings have implications for our understanding of the upgrading process in developing countries as well. In particular, the results reinforce the idea that increasing exports to high income destinations may require quality upgrading of entire complexes of suppliers and downstream producers, not just of particular exporters (Kugler and Verhoogen, 2012). The particular empirical setting has the advantage that it allows us to identify cleanly a causal relationship between destination income and material input prices, but the basic findings seem likely to apply more broadly.

2 Theoretical Framework

In this section we develop a model of input and output quality choice of heterogeneous firms with endogenous mark-ups. The framework builds on the model of Atkeson and Burstein (2008), adding differences in willingness to pay for quality across countries (similar to Hallak (2006), Verhoogen (2008), and Hallak and Schott (2011)) and a complementarity between firm productivity and input quality in producing output quality (as in Verhoogen (2008) and Kugler and Verhoogen (2012)). Following Amiti, Itskhoki, and Konings (2014), we use the variant of the Atkeson-Burstein model where pricing is Bertrand, and we take the entry decision of firms into different markets as given.[6] In this sense the model is very "partial-equilibrium." On the other hand, in the empirical application we look at short-run responses to exchange-rate movements, and it is plausible that there is limited reshuffling of firms across markets over the time horizons we consider.

There are K countries, each with a continuum of sectors, with each sector populated by an exogenously given, finite set of heterogeneous firms. Firms are indexed by i, sectors by s, and years by t. In the model, we assume firms are active in just one sector; hence i identifies sector as well as firm. To reduce clutter, we suppress the time subscript until we begin to consider the response to exchange-rate movements in Section 2.4 below. Each firm is assumed to sell one

[6]While Amiti, Itskhoki, and Konings (2014) allow for endogenous choice of input origin, we abstract from this decision, in the interests of tractability, and treat all inputs as sourced domestically. In the empirical work, we take into account the fact that firms differ in their sourcing strategies, and allow exchange-rate changes to affect directly the input prices paid by firms.

product in each country. We use j to index production locations and k to index destination markets. We will be focusing on producers in one country, call it home, and will suppress the index for location when the meaning is clear. Let ϵ_{jk} be the nominal exchange rate between the production location j and destination market k, defined as units of j currency over units of k currency.

2.1 Demand

In each country, there is a representative consumer with nested constant-elasticity-of-substitution (CES) preferences. The upper nest is given by:

$$U_k = \left[\int_{s \in S_k} (X_{sk})^{\frac{\eta-1}{\eta}} \, ds \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

where X_{sk} is a sector-level aggregate that depends in part on product quality:

$$X_{sk} = \left[\sum_{i \in I_{sk}} \left(q_{ik}{}^{\zeta(y_k)} x_{ik} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{2}$$

Here I_{sk} is the set of firms selling in sector s in country k; q_{ik} is product quality; x_{ik} is consumption; $\zeta(y_k)$ captures the representative consumer's valuation of quality, which we assume is strictly increasing in the country's income level, y_k, which we take as exogenous. To reduce clutter, we will write $\zeta_k = \zeta(y_k)$. We assume that $\zeta_k > \frac{1}{2}$ for all k, which will ensure an interior solution for the choice of quality. Following Atkeson and Burstein (2008), we assume that goods are more substitutable within sectors than across sectors, and that both are greater than one: $\rho > \eta > 1$.

We adopt the convention of reporting monetary values principally in destination-market currency; values in producer currency are indicated by an asterisk. The aggregate price index in market k is:

$$P_k = \left[\int_{s \in S_k} (P_{sk})^{1-\eta} \, ds \right]^{\frac{1}{1-\eta}} \tag{3}$$

where P_{sk} is a sector-level quality-adjusted price index:

$$P_{sk} = \left[\sum_{i \in I_{sk}} \left(\frac{p_{ik}}{q_{ik}{}^{\zeta_k}} \right)^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{4}$$

where p_{ik} is the output price charged by firm i in market k.

Given the preferences of the representative consumer, demand for the output of firm i in sector s in market k can be written:

$$x_{ik} = \left(U_k {P_k}^{\eta}\right) {P_{sk}}^{\rho-\eta} {p_{ik}}^{-\rho} {q_{ik}}^{\zeta_k(\rho-1)} \tag{5}$$

The corresponding market share is:

$$S_{ik} \equiv \frac{p_{ik} x_{ik}}{\sum_{i' \in I_{sk}} p_{i'k} x_{i'k}} = \left[\frac{\left(\frac{p_{ik}}{{q_{ik}}^{\zeta_k}} \right)}{P_{sk}} \right]^{1-\rho} \tag{6}$$

The price elasticity of demand is:

$$\sigma_{ik} \equiv -\frac{p_{ik}}{x_{ik}} \frac{dx_{ik}}{dp_{ik}} = \rho(1 - S_{ik}) + \eta S_{ik} \tag{7}$$

A key difference between this Atkeson-Burstein-type framework and the Melitz (2003) model is that firms are not assumed to be vanishingly small relative to their sector. The greater a firm's market share in a sector, the greater is the weight is placed on the between-sector elasticity of demand, η, as opposed to the within-sector elasticity, ρ. Since $\rho > \eta$ by assumption, firms with greater market share face a lower elasticity of demand. Each sector is small relative to the economy as a whole, and firms will ignore the effect of their pricing decisions on the economy-level aggregate $U_k {P_k}^{\eta}$ in (5).

2.2 Production

As in Kugler and Verhoogen (2012), we assume that there is a perfectly competitive constant-returns-to-scale intermediate-input sector with quality differences. The intermediate sector transforms homogeneous units of labor into intermediate inputs of different qualities.[7] The production function in this sector (in all countries) is assumed to be simply:

$$F(\ell, c) = \frac{\ell}{c}$$

[7] The intermediate-inputs sector can also be thought of an education sector, which transforms homogeneous unskilled labor into skilled labor.

where c is the quality of the input produced and ℓ is units of labor. Let the wage level be w_j^* in production location j, denominated in units of producer currency (indicated by the asterisk). The production cost of an intermediate input of quality c in country j will then be $w_j^* c$.

It is convenient to think of firms as producing on a separate production line for each destination, indexed by ik. (Here we are focusing on firms in "home" and dropping the index for production location.) Output price (in destination currency) on the ik production line is p_{ik}; input quality is c_{ik}. Let v_{ik}^* be the price paid for inputs on the ik production line, in destination currency. Given perfect competition in the intermediate-input sector, the input price will be equal to the cost of producing the input: $v_{ik}^* = w_j^* c_{ik}$. Given the definition of the nominal exchange rate, ϵ_{jk}, $w_j = \frac{w_j^*}{\epsilon_{jk}}$ and $v_{ik} = \frac{v_{ik}^*}{\epsilon_{jk}} = \frac{w_j^* c_{ik}}{\epsilon_{jk}} = w_j c_{ik}$.

Final-good producers have a "capability" λ_i.[8] Here we do not model how firms draw λ_i; we take it as given, along with entry decisions. There is a fixed cost every period to sell in any destination market, f_{ik}.[9] There is an iceberg trade cost for shipping to another country: $\tau_{jk} > 1$ for $j \neq k$ and $\tau_{jj} = 1$. In each country, production of physical units in the final-good sector is given by $F(n) = n{\lambda_i}^a$, where n is the number of units of inputs used and $a > 0$ is a parameter reflecting the extent to which capability lowers unit costs. The marginal cost of each unit of output delivered to the destination (in destination currency) is then: $mc_{ik} = \frac{v_{ik}\tau_{jk}}{{\lambda_i}^a}$.

Following the first variant of Kugler and Verhoogen (2012), the production of quality in the final-good sector is assumed to be governed by a CES combination of firm capability and input quality:[10]

$$q_{ik} = \left[\frac{1}{2} \left({\lambda_i}^b \right)^\theta + \frac{1}{2} \left({c_{ik}}^2 \right)^\theta \right]^{\frac{1}{\theta}} \tag{8}$$

We assume $\theta < 0$, which guarantees that firm capability, λ, and input quality, c, are complements in generating output quality. The parameter b can be interpreted as capturing the technological potential for improving quality with increased capability, which we refer to as the scope for quality differentiation. We assume that producing quality does not require fixed investments.

[8] Following Sutton (2007) and Kugler and Verhoogen (2012), we use the term "capability" to refer to the Melitz productivity draw in order to avoid confusion below, where we allow the parameter to affect both production costs and quality.

[9] We think of the fixed cost of selling in the firm's home market as including any fixed cost of being in business at all; we assume that all firms enter the domestic market.

[10] The multiplicative factor $\frac{1}{2}$ and the 2 in the exponent on c are convenient but not crucial. See Kugler and Verhoogen (2012, fn 30).

2.3 Firms' Optimization

A firm's profit on a given production line can be written as:

$$\pi_{ik}(p_{ik}, c_{ik}; \lambda_i) = \left(p_{ik} - \frac{w_j c_{ik} \tau_{jk}}{\lambda_i{}^a}\right) \epsilon_{jk} x_{ik} - f_{ik} \tag{9}$$

Optimizing over the choice of p_{ik} and c_{ik} on each line, we have:

$$c_{ik} = (2\zeta_k - 1)^{-\frac{1}{2\theta}} \lambda_i^{\frac{b}{2}} \tag{10a}$$

$$v_{ik} = w_j (2\zeta_k - 1)^{-\frac{1}{2\theta}} \lambda_i^{\frac{b}{2}} \tag{10b}$$

$$q_{ik} = \left(2 - \frac{1}{\zeta_k}\right)^{-\frac{1}{\theta}} \lambda_i^b \tag{10c}$$

$$\mu_{ik} = \frac{\sigma_{ik}}{\sigma_{ik} - 1} \tag{10d}$$

$$p_{ik} = \mu_{ik} mc_{ik} = \mu_{ik} w_j \tau_{jk} (2\zeta_k - 1)^{-\frac{1}{2\theta}} \lambda_i^{\frac{b}{2} - a} \tag{10e}$$

$$x_{ik} = \Gamma_k P_{sk}^{\rho - \eta} (2\zeta_k - 1)^{\frac{1}{2\theta}} \left(\mu_{ik} w_j \tau_{jk}\right)^{-\rho} \lambda_i{}^{(\rho-1)\left[b\left(\zeta_k - \frac{1}{2}\right) + a\right] - \left(\frac{b}{2} - a\right)} \tag{10f}$$

$$r_{ik} = p_{ik} x_{ik} = \Gamma_k P_{sk}^{\rho - \eta} \left(\mu_{ik} w_j \tau_{jk}\right)^{1-\rho} \lambda_i{}^{(\rho-1)\left[b\left(\zeta_k - \frac{1}{2}\right) + a\right]} \tag{10g}$$

where μ_{ik} is the (multiplicative) mark-up; σ_{ik} is the firm-specific elasticity of demand, defined in (7); mc_{ik} is marginal cost, defined above; r_{ik} is revenues; and $\Gamma_k \equiv U_k P_k^{\eta} \zeta_k^{\frac{\zeta_k(\rho-1)}{\theta}} (2\zeta_k - 1)^{-\frac{(2\zeta_k - 1)(\rho - 1)}{2\theta}}$, which varies only at the destination level.

Consider first how these choices vary in cross-section, among firms from a given production location selling in destination market k. It follows from (10a)-(10c) that more-capable firms purchase higher-quality inputs, pay higher input prices, and produce higher-quality outputs. Using (10d) and (10g), it is straightforward to show that revenues, r_{ik}, and mark-ups, μ_{ik}, also increase in capability, λ.[11] As in Kugler and Verhoogen (2012), whether output prices are increasing or decreasing in capability (or revenues) depends on the parameters characterizing how capability reduces costs per unit and increases product quality, a and b; if the scope-for-quality-differentiation parameter, b, is sufficiently large then output prices also increase in λ.

Now consider how the choices vary within firms, across production lines producing for different

[11] To see this, rewrite (10g):

$$r_{ik} \mu^{\rho - 1} = \Gamma_k P_{sk}^{\rho - \eta} \left(w_j \tau_{jk}\right)^{1-\rho} \lambda_i{}^{(\rho-1)\left[b\left(\zeta_k - \frac{1}{2}\right) + a\right]} \tag{11}$$

Note from (7) that σ_{ik} is decreasing in S_{ik} and hence r_{ik}. Hence, from (10d), μ_{ik} is increasing in r_{ik} and the left-hand side of (11) is strictly increasing in r_{ik}. Since $\zeta_k > \frac{1}{2}$ by assumption, the right-hand side of (11) is increasing in λ. It follows that r_{ik} and hence μ_{ik} are increasing in λ.

markets. It follows from (10a)-(10c) (recalling that $\theta < 0$) that firms use higher-quality inputs, pay higher input prices, and produce higher-quality outputs for goods destined for richer markets, with higher values of the willingness-to-pay parameter, ζ_k. We have not taken a stand on which firms are active in which markets and hence we cannot draw conclusions about how market shares, mark-ups and output prices vary across destinations within firms. We can say, however, that in the limit as market shares go to zero ($S_{ik} \to 0$ and hence $\mu_{ik} \to \frac{\rho}{\rho-1}$ for all k) the model predicts that output prices are higher in richer markets (with higher ζ_k), holding trade costs (τ_{jk}) equal.

2.4 Production-Line Responses to Real-Exchange-Rate Movements

Now consider an increase in the nominal exchange rate, ϵ_{hk}, holding wages in producer currency unchanged, where h indicates home. We re-introduce the time subscript. Define the real exchange rate (RER) between j and k as:

$$RER_{jkt} = \frac{\epsilon_{jkt}}{w^*_{jt}/w^*_{kt}} \tag{12}$$

An increase in ϵ_{hkt}, holding w^*_{ht} and w^*_{kt} constant, generates an increase in the real exchange rate between home and destination k, RER_{hkt}, reflecting a real appreciation in country k relative to home.

What effect does this real-exchange-rate change have on prices and mark-ups on the production lines of home firms destined for k? Consider a production line in continuous operation before and after the RER change (i.e. no change on the extensive margin). Note that (10b) implies $v^*_{ikt} = \epsilon_{hkt} v_{ikt} = \epsilon_{hkt} w_{jt} (2\zeta_k - 1)^{-\frac{1}{2\theta}} \lambda_i^{\frac{b}{2}} = w^*_{jt} (2\zeta_k - 1)^{-\frac{1}{2\theta}} \lambda_i^{\frac{b}{2}}$ and hence that, conditional on w^*_{ht}, the nominal exchange rate does not enter the producer-currency input price. That is, conditional on the domestic wage level (which is constant across firms in a given location), the producer-currency input price on a given production line, v^*_{ikt}, is unaffected by the RER movement.

In contrast, we see in (10e) that the producer-currency output price, p^*_{ikt}, is affected through the mark-up term, μ_{ikt}. Using (6) and (7), we can derive the elasticities of the mark-up and prices with respect to the nominal exchange-rate change (holding wage rates constant in producer currency terms). Following Amiti, Itskhoki, and Konings (2014), we hold the sector-level price indices, P_{sk}, constant when calculating these elasticities.[12] Under this assumption,

$$\frac{d\ln p^*_{ikt}}{d\ln \epsilon_{hkt}} = \frac{d\ln \mu_{ikt}}{d\ln \epsilon_{hkt}} = \frac{S_{ikt}}{\left(\frac{\rho}{\rho-\eta} - S_{ikt}\right)\left(1 - \frac{\rho-\eta}{\rho-1}S_{ikt}\right) + S_{ikt}} \tag{13a}$$

$$\frac{d\ln p_{ikt}}{d\ln \epsilon_{hkt}} = -\frac{\left(\frac{\rho}{\rho-\eta} - S_{ikt}\right)\left(1 - \frac{\rho-\eta}{\rho-1}S_{ikt}\right)}{\left(\frac{\rho}{\rho-\eta} - S_{ikt}\right)\left(1 - \frac{\rho-\eta}{\rho-1}S_{ikt}\right) + S_{ikt}} \tag{13b}$$

where the first equality in (13a) follows from the facts that $p^*_{ikt} = \mu_{ikt}v^*_{ikt}$ and that v^*_{ikt} is unaffected by ϵ_{hkt}. Note that $0 < \frac{d\ln p^*_{ikt}}{d\ln \epsilon_{hkt}} = \frac{d\ln \mu_{ikt}}{d\ln \epsilon_{hkt}} < 1$ and that $-1 < \frac{d\ln p_{ikt}}{d\ln \epsilon_{jkt}} < 0$ for positive market shares. The mark-up rises and in producer-currency terms the price rises but by proportionally less than the RER appreciation in the destination. In destination-currency terms, the producer-country wage falls but pass-through is incomplete.[13]

2.5 Implications for Firm-level Average Prices

Although it is convenient to think in terms of destination-specific production lines, we do not observe input prices at the production-line level, even in the uncommonly detailed Portuguese data. What we can observe is an output-weighted average of input prices across all product lines. In the model, the output-weighted average input price in producer-currency terms can be expressed as:

$$\overline{v}^*_{it} = \sum_{k\in K} \omega_{ikt}\, v^*_{ikt} \tag{14}$$

where the weights are defined as $\omega_{ikt} = \frac{x_{ikt}}{\sum_{k\in K} x_{ikt}}$. Plugging in (10b), recalling that $v_{ikt} = \frac{v^*_{ikt}}{\epsilon_{hkt}}$ and $\zeta_k = \zeta(y_k)$, and letting $g(y_k) = [2\zeta(y_k) - 1]^{-\frac{1}{2\theta}}$, we have:

$$\overline{v}^*_{it} = w^*_{ht}\lambda_i^{\frac{b}{2}} \sum_{k\in K} \omega_{ikt}\, g(y_k) \tag{15}$$

[12] As in Amiti, Itskhoki, and Konings (2014), these partial elasticities are the empirically relevant measures, since our empirical estimates are based on comparisons within sectors of firms facing the same set of sector-level elasticities across destination markets. See footnote 11 of Amiti, Itskhoki, and Konings (2014).

[13] Note in addition that as $S_{ikt} \to 0$, $\frac{d\ln p^*_{ikt}}{d\ln \epsilon_{hkt}}$ and $\frac{d\ln \mu_{ikt}}{d\ln \epsilon_{hkt}}$ approach zero, and $\frac{d\ln p_{ikt}}{d\ln \epsilon_{hkt}}$ approaches -1. That is, in the limit as market shares go to zero, mark-ups are constant and pass-through is complete (as it would be, for instance, in the standard Melitz (2003) setting). Note also from (13a) that $\frac{d\ln p^*_{ikt}}{d\ln \epsilon_{hkt}}$ and $\frac{d\ln \mu_{ikt}}{d\ln \epsilon_{hkt}}$ are increasing in S_{ikt} and hence that product prices (in producer currency) and mark-ups respond more to a given RER change for product lines with greater market share. This is consistent with the findings of Berman, Martin, and Mayer (2012) that higher-performance firms raise mark-ups more than lower-performance ones in response to a domestic real depreciation, and of Chatterjee, Dix-Carneiro, and Vichyanond (2013) that, within multi-product firms, firms do the same for products closer to the their core competence.

Note that $g(y_k)$ is monotonically increasing in $\zeta(y_k)$, which we have assumed is monotonically increasing in y_k. Hence average input prices vary with the domestic wage level (which does not vary across firms), firm capability (which does not vary over time), and a firm-specific weighted average of a monotonic non-linear transformation of destination income. Importantly, conditional on the domestic wage level, firm capability, and the average $g(y_k)$ term, *average input prices do not depend on a firm's mark-up in any market.* Nor do they depend on trade costs. The only mechanism linking RER changes and input prices in our model is shifts among production lines producing different quality products for different destinations. Equation (15) implies that, in response to a real-exchange-rate change, *average input prices will move, to a first-order approximation, proportionally to the average income of its destination markets.* If we were to "turn off" the income-based quality channel in our model — if, for instance, we set $\zeta_k = \zeta$ for all k, regardless of income — then there would be no systematic relationship between destination income and input prices.

In Section 2.4 above, we focused on production lines assumed to be in continuous operation. But here the insight that average input prices should move approximately in the same way as average destination income allows for changes on the extensive margin as well. A shift toward richer destinations on average, whether because of intensive-margin or extensive-margin shifts, generates an increase in average input price.

Although in the Portuguese customs data we observe output prices at the firm-destination level, in many cases output prices are not available separately by destination market. A firm's output-weighted average output price is a function of mark-ups, destination income, and trade costs. Using (10e):

$$\overline{p}_{it}^* = \sum_{k \in K} \omega_{ikt}\, p_{ikt}^* = w_{ht}^* \lambda_i^{\frac{b}{2}-a} \sum_{k \in K} \left[\omega_{ikt} \mu_{ikt} \tau_{hk} g(y_k)\right] \tag{16}$$

where ω_{ikt} and $g(y_k)$ are as defined above. Equation (16) highlights the difficulties of drawing inferences about product quality from firm-level output prices. There are a number of channels through which an exchange-rate change of the sort we have considered will affect average output prices. The mark-up, μ_{ikt}, will change within destination, as discussed in Section 2.4 above. In addition, the weights, ω_{ikt} will shift across destination markets with different levels of mark-ups, transport costs, τ_{hk}, and incomes (and hence valuation of quality), y_k. If we observe a movement in average output prices, we cannot attribute the movement to only one of these channels.

2.6 Discussion

The theoretical framework developed in this section formalizes the claim that while variable mark-ups may confound attempts to draw inferences about product quality from output prices, they do not confound inferences based on *input* prices in the same way. Clearly, our model has imposed a number of restrictive assumptions, on preferences, production functions, and the nature of competition. But we believe that the basic insight that endogenous mark-ups influence output prices but not input prices would hold under a wide variety of models with different demand systems and different production functions, as long as they share the (in our view, natural) feature that producing higher-quality outputs requires higher-quality inputs.

A potential concern with our argument is that firms or their suppliers may enjoy market power in input markets. For instance, Halpern and Koren (2007) develop a model in which suppliers charge higher mark-ups to firms that face lower elasticities of demand (and themselves charge higher mark-ups), a phenomenon they call "pricing to firm". Another possibility is that downstream firms have monopsony power in input markets and face upward-sloping supply curves for inputs. While developing a formal model with these features is beyond the scope of the current paper, we consider these possibilities at some length in the empirical analysis below.

3 Data

The analysis in this paper draws on two main datasets, both collected by *Instituto Nacional de Estatística (INE)*, the Portuguese national statistical agency:

1. Customs data on firm-level international trade transactions, which are collected separately for European Union (EU) partner countries (*Estatísticas Correntes do Comércio Intracomunitário* [Current Statistics on Intra-community Trade]) and non-EU partners (*Estatísticas Correntes do Comércio Extracomunitário* [Current Statistics on Extra-community Trade]).[14]

2. *Inquérito Anual à Produção Industrial (IAPI)* [Annual Survey of Industrial Production], a special survey that solicits information on values and physical quantities of outputs, material inputs, and energy sources of firms. The product-level information is reported using a

[14] The extra-community trade statistics capture the universe of external trade transactions. The intra-community statistics capture shipments from firms registered in the value-added tax system whose value of annual shipments exceed a cut-off that has changed over time. In 2005, for instance, the cut-off was 85,000 Euros. See Bastos and Silva (2010) for further details.

12-digit PRODCOM classification, with approximately 5,300 different products, 3,300 different material inputs, and 17 different energy sources appearing in the data. The IAPI data are available for the period 1997-2005, with 6,800-8,300 manufacturing firms covered during 1997-2001 and a reduced number (2,300-3,900 manufacturing firms) covered in 2002-2005.[15,16]

We supplement these data with additional information on manufacturing firms' attributes from the *Sistema de Contas Integradas das Empresas (SCIE)* [Enterprise Integrated Accounts System], a census of firms in 2005, and with information on country characteristics from the World Bank's World Development Indicators, as well as with CPI and nominal exchange rate information from the IMF's International Financial Statistics.

Our firm-level baseline estimation sample consists of manufacturing firms in the IAPI survey with information on input purchases and quantities and output sales and quantities at the product level. If a firm appears in the IAPI survey but not in the export or import customs data, we assume that it had zero exports or imports. Table 1 reports summary statistics on our estimation sample and the full set of exporters and importers in the customs data in 1997. Firms in our estimation sample tend to have larger export revenues per year, serve more destinations, export in more different product categories, source inputs from more countries, and source more different types of inputs than firms in the full customs data set. Table 2 displays further descriptive statistics on our estimation sample for 2005 and the census of firms for the same year. We see that firms in our estimation sample tend to be larger, older and pay higher average wages than the typical manufacturing firm. They are also considerably more likely to be an exporter or importer. Our empirical analysis is therefore best suited to shed light on the behavior of large manufacturing firms, which typically account for the bulk of trade flows in each country (Bernard and Jensen, 1999; Bernard, Jensen, Redding, and Schott, 2007; Freund and Pierola, 2015).

[15]From 1997-2001, the IAPI sampling procedure ranked firms in descending order of sales and included them until 90% of total sales were covered, with some minor qualifications: all firms with 20 or more employees were included, all firms in sectors with fewer than 5 firms were included, and once included in the sample firms were followed in subsequent years. In 2002-2005, for budgetary reasons, the set of sectors covered by the survey was reduced. These sampling procedures make it difficult to make cross-sectional comparisons by firm size (in contrast to Kugler and Verhoogen (2012) who had access to data with wider and more consistent coverage). Our main focus in this paper is on within-firm changes over time, conditional on a firm being sampled.

[16]To reduce the influence of outliers in the IAPI unit values data, we followed a suggestion of Angrist and Krueger (1999) and "winsorized" the unit values within product category, pooling across years, mapping observations below the 1^{st} percentile of the distribution of real unit values to the 1^{st} percentile and observations above the 99^{th} percentile to the 99^{th}. The results reported below are robust to not winsorizing, or winsorizing by product-year.

Appendix Table A1 presents descriptive statistics on export destinations and source markets for input purchases of Portuguese firms in 1997, both in the full customs data and in our estimation sample, excluding petroleum trade. The leading destinations and source countries include several richer nations that adopted the Euro during our study period (Germany, Spain, France, Netherlands, Belgium and Italy) but also include non-Euro-zone countries such as the UK, US, Sweden, and Switzerland.[17] Among the main destination and source countries are several lower income nations such as Angola, Brazil, Cape Verde, Turkey, Morocco and Russia. We see that, for the vast majority of export destinations and source countries, bilateral export and import shares in the estimation sample are relatively similar to those in the full customs data. Appendix Table A2 provides summary statistics on firms in the estimation sample for each year of the period under analysis. We see that, for most indicators of interest, averages across firms remain fairly stable over time, despite the reduction in sample size observed after 2001.

4 Empirical Methodology

We are interested in examining the effect of the income level of export destinations on input prices. Although the Portuguese data are among the most detailed available in the world, we do not observe input prices at the production-line level (corresponding to firm-destination-products or firm-destinations). Our strategy instead is to relate average input prices at the firm level to average destination income at the firm level. We describe the steps we follow to calculate average input prices at the firm level at the end of this section. Motivated by the theoretical relationship in equation (15), we are interested in estimating a model of the following form:

$$\ln \overline{v}_{it} = log(inc_{it})\beta + A_i + B_t + X_{it}\alpha + \varepsilon_{it} \tag{17}$$

where i and t index firms and years, respectively; p_{it} is a firm-level average input price; inc_{it} is the average GDP per capita of firm i's export destinations in year t; A_i is a firm fixed effect; B_t is a year effect; X_{it} are other time-varying firm characteristics, including export share of sales, log average destination distance, and log total sales; and ε_{it} is a conditional-mean-zero error term.

[17] The currencies of the initial set of countries in the Euro-zone were fixed in relation to one another on Jan. 1, 1999, and the Euro bills and coins were introduced on Jan. 1, 2002. The original members of the Euro-zone are France, Belgium, Luxembourg, Netherlands, Germany, Italy, Ireland, Spain, Finland, and Austria. Greece and Denmark joined the European Exchange Rate Mechanism (ERM II) in 1999, and Greece adopted the Euro in 2001. The Danish Krone remained pegged to the Euro thereafter. We treat Greece and Denmark as part of the Euro-zone for our purposes. We also include several smaller countries (or administrative regions) that use the Euro as their currency: Andorra, Malta, San Marino, Slovenia, Réunion, Mayotte, Guadalupe, and Guyana.

A general concern with estimating (17) by OLS is that there may be unobserved differences among firms that affect both the composition of export destinations and input prices at the firm level. One relevant possibility is input-cost shocks at the firm level. As suggested by our theoretical model, we would expect firms to pass increases in input costs at least partly into increases in output prices.[18] The direction of bias in the OLS estimates of β would then depend on how demand in the destination countries responds to the increase in output prices. In our theoretical model, the price elasticity of demand in a given destination depends on a firm's market share in that destination (refer to (7)), which we have not specified. It could be that price elasticities are higher in richer destinations, with the result that a positive shock to input prices and hence output prices would generate a decline in average destination income and a negative correlation between $log(inc_{it})$ and the error term in (17), biasing the OLS estimate of β downward.[19] The bias could also go the other way, if price elasticities for Portuguese firms are lower in richer countries. Other forms of bias are also possible.[20] It is not clear theoretically whether we would expect the OLS estimates to be understated or overstated.

To deal with the omitted-variables concerns, we use real-exchange-rate movements to construct instruments for average destination income. A key challenge in constructing the instruments is to identify a source of variation at the firm level. Our strategy relies on the observation that a real-exchange-rate movement in a particular destination market does not matter equally for all Portuguese firms; it matters particularly for Portuguese firms that have already developed relationships with buyers in that destination. Motivated by this observation, we construct instruments by interacting the real exchange rate in a destination with an indicator for whether a firm had positive exports to the destination in the initial year of our sample.[21]

[18] Such pass-through of input cost shocks is a reason to be cautious in interpreting cross-sectional correlations between input prices and output prices at the firm level as evidence that high-quality inputs are used to produce high-quality outputs, as in Manova and Zhang (2012). As Khandelwal (2010), Kugler and Verhoogen (2012) and others have argued, one needs additional information on sales (and ideally measures of market power in input markets) to justify inferences about product quality in cross-sectional data.

[19] In our model, such an effect might arise if Portuguese firms have smaller market shares in richer countries. Similarly, in the multi-sector model with additively separable utility recently explored by Caron, Fally, and Markusen (2014), price elasticities are higher for more income-elastic goods, and richer countries tend to consume more income-elastic goods, which again would generate a negative bias in the OLS estimate of β.

[20] There may also be responses on the extensive margin of products; these will depend on the fixed costs of selling to different markets, and it is not clear theoretically where the extensive-margin response to, for instance, a given cost shock will be greater. Measurement error in average destination income would be expected to lead to attenuation in OLS estimates for both output and input prices. Additionally, our theoretical model suggests that a positive productivity shock will lead firms to purchase higher-quality inputs, produce higher-quality outputs, and expand sales relatively more in richer countries. This in turn will generate a positive bias in $\widehat{\beta}_{OLS}$.

[21] Similar instruments based on real exchange rates have been used at the sector level by Revenga (1992) and Bertrand (2004), and at the firm level by Park, Yang, Shi, and Jiang (2010), Brambilla, Lederman, and Porto (2012), and Hummels, Jørgensen, Munch, and Xiang (2014) among others.

As a first step in explaining the IV strategy, consider the following empirical model for sales of Portuguese firms in each destination:

$$s_{ikt} = F_{ik} + log(RER_{kt})\gamma_k + (log(RER_{kt}) * C_{ik,1997})\,\delta_k + u_{ikt} \tag{18}$$

where i, k, and t index firms, destinations and years; s_{ikt} denotes the share of firm i's total sales in year t that are due to exports to destination k;[22] F_{ik} is a firm-destination fixed effect; $C_{ik,1997}$ is an indicator for whether firm i had any exports to destination k in the initial year of our sample, 1997; and $log(RER_{kt})$ is the log real exchange rate of destination k in year t, defined (following (12)) as:

$$log(RER_{kt}) = log\left[\frac{\epsilon_{hkt}}{CPI_{ht}/CPI_{kt}}\right] \tag{19}$$

where h indicates Home (Portugal) and ϵ_{hkt} is the nominal exchange rate, defined as units of home currency per unit of k currency. Note that, given this definition, a real appreciation of, for instance, the British pound will be reflected in an increase of $log(RER_{kt})$ for the UK. Given this definition, δ_k in (18) is expected to be positive.

As a measure of the income level of each destination market, we use GDP per capita in the year prior to the beginning of our sample, 1996, to avoid possible endogeneity issues with contemporaneous income.[23] Average destination income for firm i in year t can then be written:

$$inc_{it} = \sum_{k \in K} s_{ikt} \cdot gdppc_{k,1996} \tag{20}$$

where the set of all destinations, K, includes the home market.[24] In principle, a valid IV strategy would be to estimate (18), recover the predicted values $\widehat{s}_{ikt}$, and plug them into the expression (20) to generate predicted values of inc_{it} to use as an instrument for inc_{it}. But estimating (18) by OLS would generate many negative values, especially given the large number of firm-destination pairs with zero exports, and the generated instrument would be a poor predictor of inc_{it}, exacerbating the weak-instrument problem we discuss below. Estimating a non-linear model such as a tobit would be challenging because of the presence of the large number of incidental parameters, F_{ik}.

[22] We use the share of the firm's total sales rather than log(sales) so that we do not lose destinations with zero exports.

[23] In a small number of destinations, GDP per capita is not observed in 1996. In these cases, we use GDP per capita in the first subsequent year in which it is observed.

[24] Domestic sales are not observed in the customs data, but we observe domestic sales in the IAPI data.

Instead we take a more "reduced form" approach that avoids the need to estimate (18) in a preliminary step. Combining (18) and (20), we can write:

$$inc_{it} = G_t + H_i + \sum_{k \in K} (log(RER_{kt}) \cdot C_{ik,1997})\, \phi_k + v_{it} \tag{21}$$

where $G_t = \sum_{k \in K} log(RER_{kt})\, gdppc_{k,1996}$, $H_i = \sum_{k \in K} F_{ik}\, gdppc_{k,1996}$, $\phi_k = \delta_k\, gdppc_{k,1996}$, and $v_{it} = \sum_{k \in K} u_{ikt}\, gdppc_{k,1996}$.

Equation (21) suggests that the full set of RER interaction terms, $log(RER_{kt}) \cdot C_{ik,1997}$, could serve as instruments for inc_{it} in an IV estimation of (17). But it is important to note that the movements of real exchange rates may have an effect not only on the destination of exports of Portuguese firms but also on the prices that Portuguese firms pay for imported inputs.[25] If such movements matter for input prices especially for firms that have initial *importing* relationships with the relevant *source* country, and initial importing relationships are correlated with initial exporting relationships, then the IV exclusion restriction for a model of the form of (17) will be violated. To absorb these direct effects, we construct interactions of (the log of) real exchange rates with indicators for whether a firm has positive imports from a particular source country, $log(RER_{kt}) \cdot D_{ik,1997}$, where $D_{ik,1997} = 1$ if firm i has positive imports from country k in 1997, and equals zero otherwise. We include these RER-initial importer interactions directly as covariates in the main outcome equation. Thus our main estimating equation is:

$$\overline{v}_{it} = log(inc_{it})\beta + X_{it}\alpha + a_i + b_t + \sum_{k \in K} (log(RER_{kt}) \cdot D_{ik,1997})\, \chi_k + \varepsilon_{it} \tag{22}$$

where $log(inc_{it})$ is instrumented by the terms $log(RER_{kt}) * C_{ik,1997}$. In the cases of firms that initially import from and export to the same set of countries, the effect of the RER movements will be captured by the RER-importer interactions. The coefficient on average destination income will be identified by differences between the initial sets of import sources and export destinations, and the differential response to RER movements that result from them. To be clear, the exclusion restriction we need for the model to be identified is that the interaction terms $log(RER_{kt}) \cdot C_{ik,1997}$ are uncorrelated with the error term ε_{it} in (22), conditional on the other covariates. Intuitively,

[25] A large literature on exchange-rate pass-through investigates the relationship between exchange-rate-driven movements in input prices and output prices at the firm level. Although pass-through is typically found to be less than complete, it is also typically found to be greater than zero. See Goldberg and Knetter (1997) and more recent work by Nakamura and Zerom (2010), Goldberg and Hellerstein (2008, 2013) and Amiti, Itskhoki, and Konings (2014).

the assumption is that the $log(RER_{kt}) \cdot C_{ik,1997}$ term affect the input prices paid by Portuguese firms only through their effect on average destination income, captured by $\log(inc_{it})$.

For completeness, we will also estimate a model similar to (22) with firm-level average *output* prices on the left-hand side. As noted above, however, any effects on output prices may reflect mark-ups as well as quality, and the estimates are more difficult to interpret.

In our baseline specification, we drop some destinations from the instrument set. Portugal is a member of the Euro-zone, and since 1999 has shared the Euro with a number of its main trading partners. For these partners, the only changes in the real exchange rate over the 1999-2005 period were due to differential rates of inflation. One might worry that omitted variables such as firm-level productivity shocks in Portuguese firms might contribute to inflation rates in the Euro-zone. For this reason, in our baseline specification we omit the Euro-zone states from our set of instruments. We also limit the number of countries in the instrument set to 100, by descending order of export share. (As mentioned below, the qualitative results are robust to including the Euro-zone countries in the instrument set and to including 50, 75 or 125 destinations instead of 100.)

As noted above, in the set of covariates represented by X_{it} we include the export share of sales at the firm level, log average destination distance (assigning a value of 1 km to domestic sales), and log total sales. One might worry that export share and average distance are also endogenous, for reasons similar to those discussed in connection to average destination income. Conveniently, the same set of RER interactions are also plausible instruments for these two covariates. That is, because the RER movements interacted with the initial export indicator affect sales to each destination, they also affect the export share of sales and average destination distance. Below we present IV specifications in which we treat these covariates as endogenous.

It remains to explain how we construct the firm-level average input prices, represented by $\overline{v}_{it}$ in (17) and (22) (and the firm-level average output prices for when we run the output analogue of (22).) We first run the following regression:

$$log(uv_{i\ell t}) = \theta_{it} + \kappa_{\ell t} + \xi_{i\ell t} \tag{23}$$

where i indexes firms, ℓ indexes products, t indexes years; $uv_{i\ell t}$ is the unit value for product ℓ in firm i in year t, calculated as total input purchases (or output sales) divided by units of physical quantity; θ_{it} is a firm-year fixed effect; $\kappa_{\ell t}$ is a product-year fixed effect; and $\xi_{i\ell t}$ is a mean-zero error term. We use information only on manufactured outputs or inputs. Note that the product-year effects, $\kappa_{\ell t}$, capture all common factors that affect the price of a particular input across firms; the firm-year effects, θ_{it}, are thus identified by comparisons with other firms producing the same product or purchasing the same input in the same year. The OLS estimates, $\widehat{\theta}_{it}$, reflect average prices at the firm level purged of effects due to the composition of products. We define the firm-level average input prices to be equal to these OLS estimates (setting $\overline{v}_{it} = \widehat{\theta}_{it}$). We estimate the firm-level average output prices similarly.[26]

5 Results

5.1 Preliminaries

Before turning to our main estimates, we present a descriptive analysis of several key empirical relationships underlying our approach. We first confirm the cross-sectional finding from Bastos and Silva (2010) that firms charge higher prices to richer destinations in the same narrow product category in the same year. Table 3 presents regressions of log export unit values at the firm-product level on indicators of destination income per capita and a number of other destination characteristics (standard in gravity regressions), for firms in our estimation sample in the initial year (1997). Consistent with Bastos and Silva (2010), the results indicate that individual firms charge higher prices in richer countries, on average, even controlling for firm-product fixed effects.[27]

We now consider the effects of real exchange rate movements on sales of Portuguese firms. To provide a visual sense of the variation underlying the fluctuations in the firm-specific exchange rates, Appendix Figures A1 and A2 illustrate the movements in the real exchange rates of Portugal's principal non-Euro-zone trading partners, for countries richer and poorer than Portugal, respectively. At first blush, the swings in real exchange rates appear large enough to have been economically significant, especially in poorer countries such as Brazil, Angola, Turkey, and Russia, Portugal's 5th, 8th, 11st and 16th most important non-Euro-zone export destinations.

[26] An alternative approach would be to regress the firm-product level output or input unit values ($log(uv_{ikt})$ in (23)) directly on the covariates in (22), using the same instruments as described above. Using a particular choice of weights, such a "one-step" approach would be numerically equivalent to the "two-step" approach that we employ (first estimating the $\widehat{\theta}_{it}$ from (23) and then estimating (22)) (Amemiya, 1978; Donald and Lang, 2007). Using different weights, Kugler and Verhoogen (2012) report both one-step and two-step estimates and show that they are similar. Here we focus on the two-step estimates to reduce the computational burden of the estimation.

[27] Appendix Table A4 shows that an analogous pattern holds for imports: within narrow product categories, imports from richer nations tend carry higher prices, in line with prior findings in the literature (Schott, 2004; Hummels and Klenow, 2005; Kugler and Verhoogen, 2009; Hallak and Schott, 2011).

Table 4 analyzes the response of Portuguese firms' sales to the RER movements at the firm-destination-product or firm-destination level. In Panel A, we see that an increase in the real exchange rate in a destination is associated with an increase in the share of a firm's total sales for product sold in that destination, controlling for firm-destination-product fixed effects (Columns 2-4). Column 3 includes an interaction of the RER with an indicator for whether the firm had positive initial exports of the corresponding product to the destination. We see that the response to RER movements is much larger for firms with initial positive exports to the destination. The message is similar when we interact the RER movements with the firm's initial share of sales in the destination (Column 4). Panel B uses data aggregated to the firm-destination level, corresponding to equation (18) constraining the δ coefficient to be equal across destinations. The message is the same: although RER movements in destination countries potentially affect all firms, they especially affect firms with initial attachment to the destination.

As discussed in Section 4, our baseline IV specification (see equation (22)) requires differences between the initial sets of import sources and export destinations at the firm level in order to identify the coefficients of interest. Considering firms in our estimation sample that export to one or more of the top 100 non-Euro-zone export destinations in 1997, the top panel of Appendix Figure A3 plots the average number of non-Euro-zone source countries (hollow bars) and the average number of non-Euro-zone source countries that are also destinations (gray bars) against the number of non-Euro-zone export destinations in 1997. The bottom panel presents a simple histogram of firms' number of non-Euro-zone destinations. The figure reveals that the overlap between destinations and source countries is modest. Averaging over all firms in 1997, 18 percent of export destinations were also source countries for imports. In short, the overlap between export destinations and import sources does not appear to be prohibitively large in our setting.

5.2 Main Results: Average Destination Income and Input Prices

We now turn to the relationship between average destination income and firm-level average input prices. Table 5 presents simple OLS estimates of equation (22), successively adding more covariates. There is a positive and significant relationship between destination income and input prices. As noted above, however, there are plausible reasons why the OLS coefficient on average destination income could be biased in either a positive or a negative direction.

Table 6 presents IV estimates of equation (22), using the interactions of RER movements and indicators for positive initial sales in a destination as excluded instruments. Columns 1-4 treat only log average destination income as endogenous; Column 5 adds the share of sales from exports and Column 6 log average destination distance to the set of endogenous covariates.[28] The first stage of the IV estimation is reported in Appendix Table B1.[29]

It is important to consider two possible concerns about the first stage of the IV estimation. First, although including the (initial exporter * log(RER)) interaction terms directly avoids the difficulties of estimating a non-linear relationship between sales share and real exchange rates discussed above, it also makes the first-stage coefficients more difficult to interpret. Based on the fact that increases in firm-level sales shares are on average positively associated with the interaction of the initial export indicator and RER for a destination (Table 4), we would expect to see a positive effect of the instrument on average destination income for richer destinations and a negative effect for poorer destinations. The estimates largely conform to this pattern but there are many exceptions. These exceptions appear to be driven by the fact that in several destinations initial non-exporters reacted more to the RER movements than initial exporters, for apparently idiosyncratic reasons.

Second, there is reason to be concerned that the instruments are weakly correlated with average destination income and the other potentially endogenous covariates. Table 6 reports a number of diagnostic statistics for the first stage. Because we have no particular reason to believe that errors are homoskedastic, we use the heteroskedasticity-robust Kleibergen and Paap (2006) test statistics for under-identification and weak instruments. The Kleibergen-Paap LM statistic indicates that we can reject the null hypothesis that the endogenous regressors are unidentified. This leaves open the possibility that the instruments are only weakly correlated with the endogenous regressors, however. Stock and Yogo (2005) tabulate critical values for the Cragg-Donald (1993) F-statistic to use in testing the null that instruments are weak in the homoskedastic case. Because we are reluctant to assume homoskedasticity, we instead report the heteroskedasticity-robust Kleibergen-Paap (2006) Wald rk F-statistic. Although the appropriate critical values in the heteroskedastic case have not been tabulated in the literature (Mikusheva, 2013), common practice is to compare this statistic to the Stock-Yogo critical values. This comparison suggests that we *cannot* reject the null of weak instruments. For this reason, below we report weak-instrument-robust test statistics and consider further the consequences of weakness of the instruments.

Keeping these caveats in mind, we now turn back to the IV estimates in Table 6. The estimates

[28] Results are similar when log sales is also treated as an endogenous covariate.

[29] Column 4 of Table 6 corresponds to Column 1 of Appendix Table B1; Column 5 to Columns 2 and 4; and Column 6 to Columns 3, 5, and 6.

of the coefficient on the destination-income term are significantly positive and significantly greater than the OLS estimates in Table 5. Because of the weak-instruments concern, we also report a Anderson-Rubin (1949) Wald test, which is robust to weakness of the instruments. This is a test of the null that the coefficients on the excluded instruments are jointly zero when they are included in place of the endogenous covariates in the outcome equation. In the specifications of Columns 1 to 4, this is equivalent to a test of the hypothesis that the coefficient on the destination-income term is zero. The test decisively rejects the null. In Columns 5 and 6, where there are multiple endogenous covariates, the Anderson-Rubin test corresponds to the null hypothesis that the coefficients on the endogenous covariates are jointly zero. Tests for subsets of endogenous regressors in weakly identified IV models are a frontier of research in econometric theory (Mikusheva, 2013), and the literature has not converged on a standard test in this setting. Here we satisfy ourselves with two simple observations. First, it is reassuring that the IV estimates of the destination-income coefficient are reasonably robust across specifications. Second, in settings with weak instruments, IV estimates are "biased towards" the corresponding OLS estimates (see e.g. Angrist and Pischke (2009, ch. 4) for discussion). Given that the corresponding OLS estimate in Column 4 of Table 5 is significantly smaller than than the IV estimates in Columns 4-6, this suggests that the IV estimates are likely to be *underestimates* of the true relationships. As an additional check, we also follow a suggestion of Angrist and Pischke (2009, Section 4.6.4) and report limited-information maximum likelihood (LIML) estimates of the same model, since LIML estimates tend to be more robust to weakness of the instruments than IV. These appear in Appendix Table A5. Reassuringly, the results are similar to those for IV, and are a bit larger, consistent with the idea that the IV estimates are more biased towards OLS than the LIML estimates.

Considering the results in Table 6, a number of points are worth noting. First, and most obviously, the positive significant IV coefficients for input prices are consistent with the hypothesis that exogenous shifts in exporting toward richer destinations lead to an increase in average output and input quality within firms. Second, the magnitudes appear to be economically significant: our baseline estimates in Column 4 of this table suggest that a 10% increase in average destination income leads to a 7% increase in average input prices. Third, although there is some evidence that exogenous increases in average distance are associated with higher average input prices (Column 6 of Table 6), the relationships between within-firm changes in prices and within-firm changes in export share, average distance and total sales do not appear to be robust. This is not to argue that there is no relationship between these variables and firm-level prices; the standard errors are large enough that it is not possible to rule out economically significant positive effects.

5.3 Average Destination Income and Output Prices

We now briefly turn to the relationship between average destination income and firm-level average *output* prices. As discussed above, this relationship, even if causal, is difficult to interpret, since output prices are expected to reflect mark-ups and distance as well as product quality. Table 7 presents OLS estimates of equation (22) for average output prices, analogous to Table 5. The OLS estimates indicate a positive but statistically insignificant relationship between destination income and average output price. Again, as discussed above, there are plausible reasons why the OLS coefficient on average destination income may be biased in either a positive or a negative direction.

Table 8 reports the IV results for output prices, analogous to Table 6. Qualitatively the results are similar to the results for input prices: we see a significant, robust positive relationship between average destination income and average output prices at the firm level, and no robust relationship between either the export share of sales or average destination distance and average firm-level prices. In terms of magnitudes, the point estimates are significant larger, indicating that a 10% increase in average destination income is associated with a 17-21% increase in average output prices at the firm level. But once again it is important to recognize that the price response includes both changes in mark-ups and changes in product quality, and that we have no exogenous variation to use to separate these two effects.

5.4 Robustness

In this subsection, we conduct a number of checks of the robustness of the IV estimates. Since each non-Euro-zone destination is entering the instrument set individually, our estimates might potentially be driven by RER movements in a relatively small subset of rich or poor destinations. To address this concern, Appendix Tables A6 and A7 examine the extent to which the estimates are sensitive to the exclusion from the instrument set of progressively larger subsets of the richest and poorest destinations, ranked on the basis of their income per capita in 1996. Reassuringly, the tables reveal that the magnitude and precision of the IV estimates are quite similar when excluding from the instrument set the richest 5, 10, 15, 20 or 25 non-Euro-zone export destinations or the the poorest 5, 10, 15, 20 or 25 non-Euro-zone export destinations.[30]

[30] The first-stage tables corresponding to each column of Appendix Tables A6 and A7 are available upon request.

Appendix Table A8 presents estimates of our IV model excluding the initial source interactions (the $(log(RER_{kt}) \cdot D_{ik,1997})$ terms in (22)) from the set of covariates. Consistent with our observation in Section 5.1 above that there is relatively little overlap between initial export destinations and import sources, the point estimates on average destination income remain positive and significant and are of similar magnitude to those in Table 6.

Another potential concern about the IV estimates in Table 6 is that the two-step estimation procedure we adopt might introduce or increase heteroskedasticity in the second step. To address this concern, in Appendix Table A9 we report estimates weighted for efficiency to correct for arbitrary heteroskedasticity, using a two-step feasible efficient GMM estimator (EGMM). The results remain qualitatively similar.

In unreported results (available from the authors), we have found that the basic patterns in Table 6 survive a number of additional robustness checks: (1) using 50, 75 or 125 instruments instead of 100; (2) not winsorizing prices, or winsorizing by year; (3) including non-manufacturing inputs in the calculation of firm-level average prices; (4) including Euro-zone destinations in the instrument set; and (5) instrumenting for log sales as well as average destination income, export share and average destination distance.

5.5 Alternative Explanations

Although the income-based quality-choice channel discussed in the introduction is, in our view, the most plausible explanation for the empirical results reported above, it is not the only possible one. As discussed in Kugler and Verhoogen (2012), models with imperfect competition in input markets offer plausible alternative mechanisms linking firm-level outcomes to input prices. First, real-exchange-rate movements leading to a shift in exports towards richer destinations may lower the price-elasticity of output demand (for instance because consumers in the richer countries are less price-sensitive, or because because a firm's market shares in its main export destinations increase) and this in turn may make producers less sensitive to input prices. To the extent that input suppliers have market power, they may optimally charge higher prices to firms facing a lower elasticity of demand, a phenomenon that Halpern and Koren (2007) call "pricing to firm." Second, and relatedly, if input suppliers have bargaining power and the real-exchange-rate movements lead firms to charge higher mark-ups, input suppliers may be able to bargain for higher input prices, capturing part of these increased mark-ups. Third, if a producer has monopsony power in input markets and faces upward sloping supply curves for inputs, any firm-specific positive demand shock will increase derived demand for inputs, which may in turn make firms move up in the supply curve and pay a higher input price.

Following a similar analysis in Kugler and Verhoogen (2012), we proceed by constructing measures of market power in intermediate-input markets, and examining the extent to which the relationship between average destination income on average input prices is stronger when input suppliers or purchasers have more market power. To measure market power of input suppliers, we construct a Herfindahl index for suppliers of each input category, defined as the sum of squared market shares of producers of the input. To account for potential monopsony power of downstream producers in input markets, we construct two measures: (1) a Herfindahl index for purchasers of each input category, defined as the sum of squares of expenditures on the input by downstream producers; and (2) the "purchaser share", defined as the share of each firm in total domestic expenditures on a given input. The Herfindahl indices are defined at the input-year level, while the purchaser share is defined at firm-input-year level. To construct firm-year averages of these measures, we run regressions analogous to that defined in equation (23). Since the input mix used in production varies across firms and over time, the relevant concentration measures also vary across firms in each year and over time. The resulting firm-year averages can therefore be interpreted as time-varying measures of firm-specific exposure to market power in input markets.[31]

In Table 9, we examine whether the correlation between average destination income and input prices is stronger among firms with greater values of these market-power measures. In Columns 1-3, we add to our baseline specification interactions of each of these measures with average destination income, using the RER-exporter interactions from above and their interaction with the market-power measures as instruments in the first stage. In Column 1, we observe that the interaction of the Herfindahl supplier index with average destination income is statistically insignificant, while the uninteracted coefficient on average destination income remains positive and significant. This suggests that the relationship of interest is not being driven by the market power of input suppliers. Columns 2 and 3 include interactions of average destination income with the measures of monopsony power of downstream producers. As in Kugler and Verhoogen (2012), there is some evidence that downstream firms with larger purchaser shares in input markets pay higher input prices on average (Column 3). But the interaction with the average destination income is negative (although insignificant in Column 3), suggesting that the monopsony story is unlikely to explain the positive relationship between destination income and input price. Including

[31] Because some firms only use inputs for which no producers were sampled in the IAPI data, there are a few firms in our baseline estimation sample for which the firm-specific Herfindahl index for suppliers could not be constructed.

all three interactions together in Column 4 yields similar results.[32] Overall, we interpret these results as suggesting that the effect of average destination income on input prices is not driven by observable measures of market power in inputs markets.

To provide additional evidence for the income-based quality channel and against alternative hypotheses based on market power in input markets, we consider how the relationship between destination income and input prices varies across sectors with different scopes for quality differentiation. Following Sutton (1998) and Kugler and Verhoogen (2012), we use the ratio of industry-level R&D and advertising expenditures to sales as a proxy for the scope for vertical differentiation.[33] In Table 10, we add to our baseline IV specification an interaction term between this measure and average destination income, using the RER-exporter terms and and their interaction with the R&D and advertising intensity measure as instruments in the first stage. We observe that the effect of average destination income on input prices is significantly greater among firms operating in industries with greater scope for quality differentiation, providing further support for the income-based quality-choice channel.

In the same spirit, we conduct a placebo test using a set of inputs for which we are confident that there is no scope for quality differentiation: energy inputs. There are 17 different energy inputs in the IAPI data, including categories such as electricity, fuel, natural gas, propane gas, charcoal, hydrogen and acetylene. In contrast to manufactured inputs, energy inputs do not exhibit meaningful quality differences, but their prices might plausibly reflect the alternative mechanisms discussed above, notably market power of input suppliers or monopsony power of downstream producers. A positive and significant effect of average destination income on energy input prices would suggest that forces other than quality differences would be driving this relationship. Table 11 reports OLS and IV estimates on the effect of average destination income on average energy input prices. The estimate of the destination-income coefficient is statistically insignificant and close to zero, consistent with the hypothesis that in the absence of quality differences we would not observe a positive and significant effect of average destination income on

[32] In Appendix Table A10 we report results from analogous regressions using market power measures for input sectors that are averaged over the sample period. In this case, the Herfindahl indices are defined by input and the "purchaser share" is defined by firm-input, and do not vary over time. These alternative definitions seek to account for potential measurement error in these variables due to changes in sample coverage over time. As before, to construct firm-year averages of these measures, we run a regression analogous to that defined in equation (23). Since the mix of inputs used in production varies across firms and over time, the relevant concentration measures also vary across firms in each year and over time. Reassuringly, we observe that the results in Table 9 remain qualitatively similar when using these alternative measures.

[33] These data come from the U.S. Federal Trade Commission (FTC) Line of Business Survey and have been widely used by researchers, including Cohen and Klepper (1992), Brainard (1997), Antràs (2003) and Kugler and Verhoogen (2012), in addition to Sutton (1998)

input prices paid by firms.

6 Conclusion

This paper has developed an approach to estimating the importance of the income-based quality-choice channel — the idea that firms sell higher-quality products to richer consumers, and that doing so requires purchasing higher-quality inputs — in shaping firms' behavior in the international economy. Direct measures of product quality are not available, and following a growing literature we seek to draw inferences about product quality from information about prices. But such inferences are confounded by the well-known fact that prices may reflect mark-ups as well as product quality. Our proposed solution to this problem is to focus on how *input* prices paid at the firm level respond to exogenous variation in the income level of a firm's export destinations. While output prices may clearly reflect various forms of pricing-to-market, input prices arguably do not.

Using this insight, and detailed customs and firm-product-level data from Portugal, we have examined the effects of export shocks to different destinations on the input prices paid by Portuguese manufacturing firms. We have used real-exchange-rate movements, interacted with indicators for firms' initial export presence in particular destinations, as instruments for the average income of destination markets (and other endogenous covariates) at the firm level. Weak-instrument-robust statistical tests indicate that there is a positive, robust, statistically and economically significant relationship between average destination income and input prices within firms. The destination income-input price relationship holds when controlling for the export share of sales, average destination distance, and total sales at the firm level.

Alternative candidate explanations of the effects of exporting on firm behavior are difficult to reconcile with the observed patterns. Models based on scale effects suggest that destination income should not matter once we have controlled for the scale of exports and total sales. Models of the "Washington apples" effect suggest that destination income should not matter once we have controlled for distance. We have considered alternative possible explanations for the input-price results based on market power in input markets, but have found little evidence to support them.

Overall, we interpret our findings as supportive of the hypothesis that firms choose to sell higher-quality products in richer countries, that doing so requires purchasing higher-quality inputs, and that this mechanism is part of the explanation for the effects of exporting on firm behavior that have been documented by a number of authors. Although we do not observe quality directly, and caution needs to be exercised in interpreting the results, the empirical patterns documented here add to the accumulation of evidence in the literature that quality choice of both outputs and inputs is an important component of firms' behavior in the international economy.

References

Alchian, A. A., and W. R. Allen (1964): *University Economics*. Wadsworth, Belmont, CA.

Alessandria, G., and J. P. Kaboski (2011): "Pricing-to-Market and the Failure of Absolute PPP," *American Economic Journal: Macroeconomics*, 3(1), 91–127.

Alvarez, R., and R. A. López (2005): "Exporting and Performance: Evidence from Chilean Plants," *Canadian Journal of Economics*, 38(4).

Amemiya, T. (1978): "A Note on a Random Coefficients Model," *International Economic Review*, 19(3), pp. 793–796.

Amiti, M., O. Itskhoki, and J. Konings (2014): "Importers, Exporters, and Exchange Rate Disconnect," *American Economic Review*, 104(7), 1942–1978.

Amiti, M., and A. Khandelwal (2013): "Import Competition and Quality Upgrading," *Review of Economics and Statistics*, 95(2), 476–490.

Anderson, T. W., and H. Rubin (1949): "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations," *The Annals of Mathematical Statistics*, 20(1), 46–63.

Angrist, J. D., and A. B. Krueger (1999): "Empirical Strategies in Labor Economics," in *Handbook of Labor Economics*, ed. by O. C. Ashenfelter, and D. Card, vol. 3A. Elsevier Science.

Angrist, J. D., and J. Pischke (2009): *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press.

Antràs, P. (2003): "Firms, Contracts, and Trade Structure," *Quarterly Journal of Economics*, 4(118), 1375–1418.

Atkeson, A., and A. Burstein (2008): "Pricing-to-Market, Trade Costs, and International Relative Prices," *American Economic Review*, 98(5), 1998–2031.

Atkin, D., A. K. Khandelwal, and A. Osman (2014): "Exporting and Firm Performance: Evidence from a Randomized Trial," NBER working paper no. 20690.

Baldwin, R., and J. Harrigan (2011): "Zeros, Quality and Space: Trade Theory and Trade Evidence," *American Economic Journal: Microeconomics*, 3(2), 60–88.

Bastos, P., and J. Silva (2008): "The Quality of a Firm's Exports: Where You Export to Matters," GEP Research Paper 2008/18, University of Nottingham.

——— (2010): "The Quality of a Firm's Exports: Where You Export to Matters," *Journal of International Economics*, 82(2), 99–111.

Berman, N., P. Martin, and T. Mayer (2012): "How Do Different Exporters React to Exchange Rate Changes?.," *Quarterly Journal of Economics*, 127(1), 437 – 492.

Bernard, A. B., and J. B. Jensen (1999): "Exceptional Exporter Performance: Cause, Effect, or Both?," *Journal of International Economics*, 47, 1–25.

Bernard, A. B., J. B. Jensen, S. J. Redding, and P. K. Schott (2007): "Firms in International Trade," *Journal of Economic Perspectives*, 21(3), 105–130.

Bertrand, M. (2004): "From the Invisible Handshake to the Invisible Hand? How Import Competition-Changes the Employment Relationship," *Journal of Labor Economics*, 22(4), 723–765.

Brainard, S. L. (1997): "An Empirical Assessment of the Proximity-Concentration Trade-off between Multinational Sales and Trade," *American Economic Review*, 4(87), 520–544.

Brambilla, I., D. Lederman, and G. Porto (2012): "Exports, Export Destinations and Skills," *American Economic Review*, 102(7), 3406–3488.

Bustos, P. (2011): "Trade Liberalization, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms," *American Economic Review*, 101(1), 304–340.

Caron, J., T. Fally, and J. R. Markusen (2014): "International Trade Puzzles: A Solution Linking Production and Preferences," *Quarterly Journal of Economics*, 3(129), 1501 – 1552.

Chatterjee, A., R. Dix-Carneiro, and J. Vichyanond (2013): "Multi-product Firms and Exchange Rate Fluctuations.," *American Economic Journal: Economic Policy*, 5(2), 77 – 110.

Choi, Y. C., D. Hummels, and C. Xiang (2009): "Explaining Import Quality: The Role of the Income Distribution," *Journal of International Economics*, 77(2), 265 – 275.

Clerides, S., S. Lach, and J. Tybout (1998): "Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco," *Quarterly Journal of Economics*, 113, 903–947.

Cohen, W. M., and S. Klepper (1992): "An Anatomy of Industry R&D Intensity Distributions," *American Economic Review*, 4(82), 773–799.

Cragg, J. G., and S. G. Donald (1993): "Testing Identifiability and Specification in Instrumental Variable Models," *Econometric Theory*, 9(2), 222–240.

Crozet, M., K. Head, and T. Mayer (2012): "Quality Sorting and Trade: Firm-Level Evidence for French Wine," *Review of Economic Studies*, 79, 609–644.

De Loecker, J. (2007): "Do Exports Generate Higher Productivity? Evidence from Slovenia," *Journal of International Economics*, 73, 69–98.

Di Comite, F., J.-F. Thisse, and H. Vandenbussche (2014): "Verti-zontal Differentiation in Export Markets," *Journal of International Economics*, 93, 50–66.

Donald, S. G., and K. Lang (2007): "Inference with Difference-in-Differences and Other Panel Data," *Review of Economics and Statistics*, 89(2), 221–233.

Eckel, C., L. Iacovone, B. Javorcik, and J. P. Neary (2015): "Multi-Product Firms at Home and Away: Cost versus Quality-Based Competence," *Journal of International Economics*, 95(2), 216–232.

Fajgelbaum, P., G. Grossman, and E. Helpman (2011): "Income Distribution, Product Quality, and International Trade," *Journal of Political Economy*, 119(4), 721–765.

Feenstra, R. C. (1988): "Quality Change under Trade Restraints in Japanese Autos," *Quarterly Journal of Economics*, 103(1), 131–146.

Feenstra, R. C., and J. Romalis (2014): "International Prices and Endogenous Quality," *Quarterly Journal of Economics*, 129(2), 477–527.

Fitzgerald, D., and S. Haller (2013): "Pricing-to-Market: Evidence from Plant-Level Prices," *Review of Economic Studies*, 81(2), 761–786.

Flam, H., and E. Helpman (1987): "Vertical Product Differentiation and North-South Trade," *American Economic Review*, 77(5), 810–822.

Freund, C., and M. D. Pierola (2015): "Export Superstars," *Review of Economics and Statistics*, 97(5), 1023–1032.

Gervais, A. (forthcoming): "Product Quality and Firm Heterogeneity in International Trade," Forthcoming, *Canadian Journal of Economics*.

Goldberg, P. K., and R. Hellerstein (2008): "A Structural Approach to Explaining Incomplete Exchange-Rate Pass-Through and Pricing-to-Market," *American Economic Review*, 98(2), 423 – 429.

——— (2013): "A Structural Approach to Identifying the Sources of Local Currency Price Stability," *Review of Economic Studies*, 80(1), 175–210.

Goldberg, P. K., and M. M. Knetter (1997): "Goods Prices and Exchange Rates: What Have We Learned?," *Journal of Economic Literature*, 35(3), 1243–1272.

Görg, H., L. Halpern, and B. Muraközy (2010): "Why Do Within Firm-Product Export Prices Differ Across Markets?," Kiel Institute for the World Economy working paper no. 1596.

Hallak, J. C. (2006): "Product Quality and the Direction of Trade," *Journal of International Economics*, 68, 238–265.

Hallak, J. C., and P. Schott (2011): "Estimating Cross-Country Differences in Product Quality," *Quarterly Journal of Economics*, 126(1), 417–474.

Hallak, J. C., and J. Sivadasan (2013): "Product and Process Productivity: Implications for Quality Choice and Conditional Exporter Premia," *Journal of International Economics*, 91, 53–67.

Halpern, L., and M. Koren (2007): "Pricing to Firm: An Analysis of Firm- and Product-Level Import Prices," *Review of International Economics*, 3(15), 574–591.

Harrigan, J., X. Ma, and V. Shlychkov (2015): "Export Prices of U.S. Firms," *Journal of International Economics*, 97.

Helpman, E., O. Itskhoki, and S. Redding (2010): "Inequality and Unemployment in a Global Economy," *Econometrica*, 78(4), 1239–1283.

Hummels, D., R. Jørgensen, J. R. Munch, and C. Xiang (2014): "The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data," *American Economic Review*, 104(6), 1597–1629.

Hummels, D., and P. J. Klenow (2005): "The Variety and Quality of a Nation's Exports," *American Economic Review*, 95(3), 704–723.

Hummels, D., and A. Skiba (2004): "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture," *Journal of Political Economy*, 112(6), 1384–1402.

Iacovone, L., and B. Javorcik (2012): "Getting Ready: Preparing to Export," CEPR discussion paper no. 8926.

Johnson, R. C. (2012): "Trade and Prices with Heterogeneous Firms," *Journal of International Economics*, 86(1).

Khandelwal, A. (2010): "The Long and Short (of) Quality Ladders," *Review of Economic Studies*, 77(4), 1450–1476.

Kleibergen, F., and R. Paap (2006): "Generalized Reduced Rank Tests using the Singular Value Decomposition," *Journal of Econometrics*, 133(1), 97 – 126.

Krugman, P. (1987): "Pricing to Market when the Exchange Rate Changes," in *Real Financial Linkages Among Open Economies*, ed. by S. Arndt, and J. D. Richardson, pp. 49–70. Cambridge, MA: MIT Press.

Kugler, M., and E. Verhoogen (2009): "Plants and Imported Inputs: New Facts and an Interpretation," *American Economic Review Papers and Proceedings*, 99(2), 501–507.

——— (2012): "Prices, Plant Size and Product Quality," *Review of Economic Studies*, 79(1), 307–339.

Lileeva, A., and D. Trefler (2010): "Improved Access to Foreign Markets Raises Plant-Level Productivity ... For Some Plants," *Quarterly Journal of Economics*, 125(3), 1051–1099.

Linder, S. B. (1961): *An Essay on Trade and Transformation.* Wiley & Sons, New York NY.

Manova, K., and Z. Zhang (2012): "Export Prices Across Firms and Destinations," *Quarterly Journal of Economics*, 127(1), 379–436.

Markusen, J. (1986): "Explaining the Volume of Trade: An Eclectic Approach," *American Economic Review*, 76(5), 1002–1011.

Markusen, J. R. (2013): "Putting Per-Capita Income Back into Trade Theory," *Journal of International Economics*, 90, 255–265.

Martin, J. (2012): "Mark-Ups, Quality and Transport Costs," *European Economic Review*, 56(4), 777 – 791.

Matsuyama, K. (2007): "Beyond Icebergs: Towards a Theory of Biased Globalization," *Review of Economic Studies*, 74(1), 23753.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

Mikusheva, A. (2013): "Survey on Statistical Inferences in Weakly Identified Instrumental Variable Models," *Applied Econometrics*, 29(1), 117–131.

Nakamura, E., and D. Zerom (2010): "Accounting for Incomplete Pass-Through," *Review of Economic Studies*, 77, 1192–1230.

Park, A., D. Yang, X. Shi, and Y. Jiang (2010): "Exporting and Firm Performance: Chinese Exporters and the Asian Financial Crisis," *Review of Economics and Statistics*, 92(4), 822–842.

Revenga, A. (1992): "Exporting Jobs? The Impact of Import Competition on Employment and Wages in U.S. Manufacturing," *Quarterly Journal of Economics*, 107, 255–284.

Schott, P. (2004): "Across-Product versus Within-Product Specialization in International Trade," *Quarterly Journal of Economics*, 119(2), 647–678.

Simonovska, I. (2015): "Income Differences and Prices of Tradables: Insights from an Online Retailer," *Review of Economic Studies*, 82(4), 1612–1656.

Stock, J. H., and M. Yogo (2005): "Testing for Weak Instruments in Linear IV Regression," in *Identification and Inference for Econometric Models: A Festschrift in Honor of Thomas J. Rothenberg*. Cambridge UK: Cambridge University Press.

Sutton, J. (1998): *Technology and Market Structure: Theory and History*. MIT Press, Cambridge.

——— (2007): "Quality, Trade and the Moving Window: The Globalization Process," *Economic Journal*, 117, F469–F498.

Tanaka, M. (2015): "Exporting Sweatshops? Evidence from Myanmar," Unpub. paper, Stanford University, Dec.

Van Biesebroeck, J. (2005): "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms," *Journal of International Economics*, 67(2), 373–391.

Verhoogen, E. (2008): "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector," *Quarterly Journal of Economics*, 123(2), 489–530.

Yeaple, S. R. (2005): "A Simple Model of Firm Heterogeneity, International Trade, and Wages," *Journal of International Economics*, 65(1), 1–20.

Table 1. Summary statistics, international transactions, firm level, 1997

	all exporters (1)	all importers (2)	estimation sample (3)
exports per firm	1.34		5.06
	(0.13)		(0.72)
share of exports to richer nations	0.61		0.79
	(0.00)		(0.01)
number of export destinations	3.78		7.71
	(0.05)		(0.15)
number of export categories	8.47		10.03
	(0.19)		(0.28)
imports per firm		1.29	3.44
		(0.06)	(0.37)
share of imports from richer nations		0.88	0.90
		(0.00)	(0.00)
number of import source countries		3.66	5.63
		(0.02)	(0.08)
number of import categories		16.92	21.74
		(0.23)	(0.65)
fraction exporter			0.45
fraction importer			0.49
fraction exporter and importer			0.35
N (firms)	12660	20280	6585

Notes: Table reports averages across firms using customs data from 1997, weighting firms equally. First four rows are conditional on being an exporter (i.e. having positive exports), and next four rows are conditional on being an importer (i.e. having positive imports). Values of exports and imports in millions of 2000 Euros. Petroleum exports and imports excluded in calculations. Standard errors of means in parentheses.

Table 2. Summary statistics, firm level, 2005

	all manufacturing (1)	estimation sample (2)
revenues	1.36	13.32
	(0.15)	(1.27)
avg. annual earnings/worker	7.06	10.01
	(0.14)	(0.09)
employment	17.38	108.59
	(0.29)	(7.51)
age of firm	15.74	25.08
	(0.32)	(0.86)
number of establishments in Portugal	1.17	1.83
	(0.01)	(0.11)
fraction exporter	0.15	0.62
fraction importer	0.14	0.61
N (firms)	45031	2522

Notes: Table reports averages across firms using the 2005 economic census (SCIE), weighting firms equally. Values of revenues (sales plus income from provision of subcontracting and other services) are in millions of 2000 Euros. Average annual earnings per worker are in thousands of 2000 Euros. Standard errors of means in parentheses. The estimation sample contains 2639 firms in 2005; a small number of firms could not be linked to the manufacturing census, and these are omitted in Column 2.

Table 3. Destination characteristics and export prices in cross section, 1997

	dep. var.: firm-product log export price			
	(1)	(2)	(3)	(4)
richer than Portugal	0.09***	0.09***		
	(0.03)	(0.03)		
log GDP/cap.			0.03***	0.03***
			(0.01)	(0.01)
log GDP	0.01*	0.00	0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)
European Union	0.05*	0.02	0.06**	0.03
	(0.03)	(0.02)	(0.03)	(0.02)
landlocked	0.02	0.03	0.01	0.02
	(0.03)	(0.02)	(0.03)	(0.02)
log distance	0.07***	0.06***	0.07***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
product effects	Y	N	Y	N
firm-product effects	N	Y	N	Y
R2	0.75	0.93	0.75	0.93
N	71519	71519	71519	71519

Notes: Sample is all firm-product-destination observations in 1997 for firms in estimation sample, inluding Euro-zone destinations, excluding petroleum exports. Results when including Euro-zone destinations are similar (see Appendix Table A3). "Richer than Portugal" defined using 1996 GDP/capita, consistent with our use of 1996 values elsewhere; log GDP/cap. variable is from 1997. Robust standard errors, clustered by destination, in parentheses. *10% level, **5% level, ***1% level.

Table 4. Sales response to real-exchange-rate movements

	dep. var.: % firm's sales			
	(1)	(2)	(3)	(4)
A. Data at firm-destination-product-year level				
log(RER)	0.092***	0.100***	0.022**	0.031***
	(0.012)	(0.010)	(0.010)	(0.012)
log(RER)*1(any exports in 1997)			0.430***	
			(0.041)	
log(RER)*(sales share in 1997)				0.353***
				(0.057)
firm effects	Y			
destination effects	Y			
firm-product-destination effects	N	Y	Y	Y
year effects	Y	Y	Y	Y
R2	0.15	0.70	0.70	0.70
N	954025	954025	954025	954025
B. Data at firm-destination-year level				
log(RER)	0.563***	0.579***	0.236***	0.298***
	(0.076)	(0.056)	(0.055)	(0.054)
log(RER)*1(any exports in 1997)			1.134***	
			(0.134)	
log(RER)*(sales share in 1997)				0.289***
				(0.050)
firm effects	Y			
destination effects	Y			
firm-destination effects	N	Y	Y	Y
year effects	Y	Y	Y	Y
R2	0.32	0.80	0.80	0.80
N	191793	191793	191793	191793

Notes: log real exchange rate (log(RER)) defined as in (19) in text. Variables 1(any exports in 1997) and sales share in 1997 defined at firm-destination-product level in Panel A and firm-destination level in Panel B. Robust standard errors, clustered at firm-year level, in parentheses. *10% level, **5% level, ***1% level.

Table 5. Destination income and firm-average input prices, OLS estimates

	dep. var.: firm-average log real input price			
	(1)	(2)	(3)	(4)
log avg. destination gdp/cap	0.07***	0.08***	0.08***	0.07**
	(0.02)	(0.03)	(0.03)	(0.03)
export share of sales		-0.02	-0.00	-0.00
		(0.03)	(0.03)	(0.03)
log avg. destination distance			-0.00	-0.00
			(0.00)	(0.00)
log sales				0.02***
				(0.01)
initial source interactions	Y	Y	Y	Y
firm effects	Y	Y	Y	Y
year effects	Y	Y	Y	Y
R2	0.80	0.80	0.80	0.80
N	45659	45659	45659	45659

Notes: Table reports OLS estimates of equation (22) in text, using baseline estimation sample. Average destination GDP/capita defined as in equation (21). Price data have been winsorized as described in Section 3. Petroleum exports and imports excluded. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 6. Destination income and firm-average input prices, IV estimates

	dep. var.: firm-average log real input price					
	(1)	(2)	(3)	(4)	(5)	(6)
log avg. destination gdp/cap	0.66***	0.72***	0.73***	0.71***	0.69***	0.68***
	(0.21)	(0.25)	(0.25)	(0.25)	(0.26)	(0.26)
export share of sales		-0.34***	-0.34**	-0.33**	-0.22	-0.22
		(0.13)	(0.13)	(0.13)	(0.31)	(0.32)
log avg. destination distance			-0.00	-0.00	-0.01	0.06**
			(0.00)	(0.00)	(0.01)	(0.03)
log sales				0.02***	0.02***	0.01
				(0.01)	(0.01)	(0.01)
initial source interactions	Y	Y	Y	Y	Y	Y
firm effects	Y	Y	Y	Y	Y	Y
year effects	Y	Y	Y	Y	Y	Y
N	45659	45659	45659	45659	45659	45659
Kleibergen-Paap LM statistic (under-identification)	264.22	250.03	249.61	248.92	192.30	232.20
Kleibergen-Paap LM p-value	0.00	0.00	0.00	0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)	3.11	2.67	2.67	2.65	2.09	2.32
Anderson-Rubin Wald test F-stat	2.20	2.19	2.19	2.17	2.18	2.18
Anderson-Rubin Wald test p-value	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Table reports IV estimates of equation (22) in text, using baseline estimation sample. Instruments are interactions of indicators for positive exports to destination in 1997 and log real-exchange rates for Portugal's top 100 non-Euro-zone export destinations; first-stage results are in Appendix Table B1. Average destination GDP/capita defined as in equation (21). Price data have been winsorized as described in Section 3. Columns 1 to 4 treat only log avg. destination GDP/cap as endogenous; Column 5 adds export share of sales, and Column 6 adds log avg. destination distance to endogenous set. Petroleum exports and imports excluded. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 7. Destination income and firm-average output prices, OLS estimates

	dep. var.: firm-average log real output price			
	(1)	(2)	(3)	(4)
log avg. destination gdp/cap	0.08	0.04	0.04	0.03
	(0.06)	(0.08)	(0.08)	(0.08)
export share of sales		0.08	0.09	0.09
		(0.07)	(0.08)	(0.08)
log avg. destination distance			-0.00	-0.00
			(0.01)	(0.01)
log sales				0.04***
				(0.01)
initial source interactions	Y	Y	Y	Y
firm effects	Y	Y	Y	Y
year effects	Y	Y	Y	Y
R2	0.77	0.77	0.77	0.77
N	45659	45659	45659	45659

Notes: Table is similar to Table 5, but for output prices. Table reports OLS estimates of equation (22) in text for output prices, using baseline estimation sample. Average destination GDP/capita defined as in equation (21). Price data have been winsorized as described in Section 3. Petroleum exports and imports excluded. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 8. Destination income and firm-average output prices, IV estimates

	dep. var.: firm-average log real output price					
	(1)	(2)	(3)	(4)	(5)	(6)
log avg. destination gdp/cap	2.10***	2.09***	2.09***	2.06***	1.76***	1.75***
	(0.53)	(0.63)	(0.63)	(0.64)	(0.66)	(0.66)
export share of sales		-0.94***	-0.96***	-0.95***	0.63	0.63
		(0.32)	(0.34)	(0.34)	(0.91)	(0.91)
log avg. destination distance			0.00	0.00	-0.06*	0.01
			(0.01)	(0.01)	(0.03)	(0.07)
log sales				0.03**	0.03**	0.02
				(0.01)	(0.01)	(0.02)
initial source interactions	Y	Y	Y	Y	Y	Y
firm effects	Y	Y	Y	Y	Y	Y
year effects	Y	Y	Y	Y	Y	Y
N	45659	45659	45659	45659	45659	45659
Kleibergen-Paap LM statistic (under-identification)	264.22	250.03	249.61	248.92	192.30	232.20
Kleibergen-Paap LM p-value	0.00	0.00	0.00	0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)	3.11	2.67	2.67	2.65	2.09	2.32
Anderson-Rubin Wald test F-stat	3.01	2.99	2.99	2.98	2.99	2.99
Anderson-Rubin Wald test p-value	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Table similar to Table 6 but for output prices. Table reports IV estimates of equation (22) in text, using baseline estimation sample. Instruments are interactions of indicators for positive exports to destination in 1997 and log real-exchange rates for Portugal's top 100 non-Euro-zone export destinations; first-stage results are in Appendix Table B1. Average destination GDP/capita defined as in equation (21). Price data have been winsorized as described in Section 3. Columns 1 to 4 treat only log avg. destination GDP/cap as endogenous; Column 5 adds export share of sales, and Column 6 adds log avg. destination distance to endogenous set. Petroleum exports and imports excluded. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 9. Examining role of market power in input markets

	dep. var.: firm-average log real input price			
	(1)	(2)	(3)	(4)
log avg. destination gdp/cap	0.72***	0.40**	0.62***	0.75***
	(0.21)	(0.20)	(0.22)	(0.16)
export share of sales	-0.26	0.01	-0.36	-0.27
	(0.24)	(0.22)	(0.25)	(0.17)
log avg. destination distance	0.05**	0.03	0.03	0.03*
	(0.02)	(0.02)	(0.02)	(0.02)
log sales	0.01	0.02**	0.02**	0.01*
	(0.01)	(0.01)	(0.01)	(0.01)
herfindahl (suppliers)	1.18			-0.18
	(1.64)			(3.04)
herfindahl (purchasers)		5.64		1.50
		(4.25)		(8.87)
purchaser share			3.03***	7.24*
			(0.42)	(3.79)
log avg. destination gdp/cap *herfindahl (suppliers)	-0.02			-0.16
	(0.14)			(0.32)
log avg. destination gdp/cap *herfindahl (purchasers)		-0.30		0.48
		(0.44)		(0.96)
log avg. destination gdp/cap *purchaser share			-0.34	-0.77*
			(3.95)	(0.41)
initial source interactions	Y	Y	Y	Y
firm effects	Y	Y	Y	Y
year effects	Y	Y	Y	Y
N	42710	45659	45659	42710
Kleibergen-Paap LM statistic (under-identification)	325.69	409.68	370.58	585.28
Kleibergen-Paap LM p-value	0.00	0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)	1.55	1.93	2.29	1.72
Anderson-Rubin Wald test F-stat	1.56	1.89	3.92	9.53
Anderson-Rubin Wald test p-value	0.00	0.00	0.00	0.00

Notes: Specifications similar to Table 6 Column 6, but including market power measures and interactions. Instruments are the baseline instruments (interactions of indicators for positive exports to destination in 1997 and log real-exchange rates) and their interactions with the corresponding market power measures. Column 4 includes interactions of baseline instruments with all three market-power measures in instrument set; first-stage results are in Appendix Table B2. Because some firms only use inputs for which no producers were sampled in the IAPI data, there are a few firms in our baseline estimation sample for which the firm-specific Herfindahl index for suppliers could not be constructed, hence the smaller number of observations in Columns 1 and 4. See Section 5.5 for details of construction of market-power measures. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 10. Interaction with R&D and advertising intensity, IV estimates

	dep. var.: firm-average log real input price		
	(1)	(2)	(3)
log avg. destination gdp/cap	0.51**	0.47**	0.46**
	(0.21)	(0.21)	(0.21)
export share of sales	-0.20*	0.08	0.06
	(0.11)	(0.23)	(0.23)
log avg. destination distance	-0.04***	-0.05***	-0.02
	(0.02)	(0.02)	(0.03)
log sales	0.02***	0.02***	0.02**
	(0.01)	(0.01)	(0.01)
log avg. destination gdp/cap*R&D + adv. intensity	1.66**	1.61**	1.42**
	(0.66)	(0.66)	(0.69)
initial source interactions	Y	Y	Y
firm effects	Y	Y	Y
year effects	Y	Y	Y
N	45659	45659	45659
Kleibergen-Paap LM statistic (under-identification)	367.68	345.44	372.30
Kleibergen-Paap LM p-value	0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)	2.46	2.39	1.88
Anderson-Rubin Wald test F-stat	2.37	2.38	2.38
Anderson-Rubin Wald test p-value	0.00	0.00	0.00

Notes: Specifications similar to Table 6 Column 6, but including interaction of destination income and R&D and advertising intensity for the firm's output sector. Instruments are the baseline instruments (interactions of indicators for positive exports to destination in 1997 and log real-exchange rates) and their interactions with the R&D and advertising intensity measure; first-stage results are in Appendix Table B3. Data on advertising and R&D expenditures as a share of total industry sales are from the U.S. FTC 1975 Line of Business Survey, converted from FTC four-digit industry classification to CAE four-digit classification using verbal industry descriptions, then matched to firms' industries as reported in the firm-level data. Column 1 treats only log avg. destination GDP/cap and the interaction with the R&D and advertising intensity as endogenous; Column 2 adds export share of sales, and Column 3 adds log avg. destination distance to endogenous set. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 11. Destination income and firm-average energy input prices

	dep. var.: firm-average log real energy price			
	OLS	IV		
	(1)	(2)	(3)	(4)
log avg. destination gdp/cap	-0.00	-0.08	-0.02	-0.02
	(0.01)	(0.11)	(0.11)	(0.11)
export share of sales	-0.03**	0.01	-0.29**	-0.29**
	(0.01)	(0.06)	(0.13)	(0.13)
log avg. destination distance	0.00	0.00	0.01***	0.00
	(0.00)	(0.00)	(0.00)	(0.01)
log sales	-0.01***	-0.01***	-0.01***	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)
initial source interactions	Y	Y	Y	Y
firm effects	Y	Y	Y	Y
year effects	Y	Y	Y	Y
N	42043	42043	42043	42043
Kleibergen-Paap LM statistic (under-identification)		240.94	190.78	233.09
Kleibergen-Paap LM p-value		0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)		2.55	2.07	2.34
Anderson-Rubin Wald test F-stat		1.68	1.69	1.69
Anderson-Rubin Wald test p-value		0.00	0.00	0.00

Notes: Specifications similar to Table 5 Column 4 and Table 6 Columns 4-6, but using only energy inputs in calculating firm-level average input prices. See list of energy inputs in Section 5.5. First-stage results are in Appendix Table B4. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.