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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 as a source of variation in export destinations and find that exporting to richer countries leads firms to charge more for outputs and pay higher prices for inputs, other things equal. The results are supportive of the hypothesis that an exogenous increase in average destination income leads firms to raise the average quality of goods they produce and to purchase higher-quality inputs.

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1 Introduction

A growing body of literature suggests that exporting has significant effects on firm behavior. Although results for 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, and Verhoogen (2008) finds effects on wages and ISO 9000 certification (an international production standard) in Mexico.

A number of potential 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 for production 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 often referred to 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, what matters is the income level of consumers in the destination.[3]

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

[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-firm model.

[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. As stated by Matsuyama, this model suggests that the volume of exports not destination characteristics should matter for firms' decisions. A number of authors have suggested that learning-by-exporting effects are important, although it is common not to specify the extent to which such effects depend on characteristics of destination markets. An argument that learning-by-

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] The within-firm-product correlation between export prices and destination-country income appears to be quite robust across countries: 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 "price to market": they 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, forthcoming; Simonovska, 2013). 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 short 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. Our empirical approach is motivated by two theoretical ideas. First, as mentioned above, countries are asymmetric in income and in their 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 and firms use higher-quality inputs to produce higher-quality products, as in Verhoogen (2008) and Kugler and Verhoogen (2012). We develop a Melitz (2003)-type model that embeds both ideas (which appears in the appendix to save space); although the basic ingredients are familiar from the literature, we are not aware of a paper that combines them in a general-equilibrium setting. The key theoretical implication is that an exogenous shift in the

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.

destination of exports toward a richer market will lead a firm not only to charge a higher output price on average, but also to pay higher *input prices* on average. Empirically, using detailed information on output and input prices at the firm level and real-exchange-rate changes as a source of exogenous variation in the composition of destination markets, we show that increases in the average income level of export destinations lead Portuguese firms to charge more for outputs and pay higher prices for material inputs, controlling for export share, average destination distance, and total sales. We argue that although differences in mark-ups across countries may explain the output price patterns, it is difficult to reconcile the effects on input prices with models that do not allow a role for quality choice. We interpret the results as supportive of the hypothesis that increased exporting to rich countries leads firms to raise the average quality of goods they produce and to purchase higher-quality inputs.

This paper is 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. The authors interpret the results as supportive of the argument that firms sell higher-quality, skill-intensive varieties in richer countries to appeal to richer consumers there. Relative to the Brambilla et al. paper, the current study makes three main contributions. First, we have access to output price data, including prices of products sold domestically, and we can show how average output prices at the firm level respond to exogenous shifts in destinations. Second, we have access to input price data, and we can show that average material input prices respond similarly. This is a particular advantage because labor may be a special input: there are a number of mechanisms that might lead to rent-sharing within a firm — e.g. collective bargaining, fair/efficiency wages — and these might generate a relationship between wages and mark-ups (and hence destination markets), even in the absence of quality effects. This concern is arguably less salient for material input prices, since arm's-length supplier-purchaser relationships are less subject to the social pressures and institutional idiosyncrasies that characterize employment relationships in Argentina and elsewhere.[5] Third, we are able to distinguish between the "Washington apples" and income-

[5]Kugler and Verhoogen (2012) consider at some length the possibility that material input suppliers bargain for higher input prices when output prices are higher, but find little evidence for such a mechanism in cross-sectional data in Colombia.

based quality-choice channels. In the Argentinian case, richer destinations (primarily the U.S. and Europe) also tend to be further away than poorer destinations (primarily Brazil and other countries in South America). In the Portuguese case, the correlation is reversed: richer destinations (e.g. U.K, Sweden) tend be closer, and poorer destinations (e.g. Brazil, Angola) further away. This provides a stronger basis for separate identification of the effects of income and distance. These contributions strengthen the income-based quality-choice interpretation, 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 (2011), Crozet, Head, and Mayer (2012), Johnson (2012), Hallak and Sivadasan (2013), Amiti and Khandelwal (2013), Markusen (2013), Caron, Fally, and Markusen (forthcoming), Di Comite, Thisse, and Vandenbussche (forthcoming), Iacovone and Javorcik (2012), Harrigan, Ma, and Shlychkov (2012), Kneller and Yu (2008), and Gervais (2013).

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 raising the quality of outputs requires raising the quality of inputs (Verhoogen, 2008; Kugler and Verhoogen, 2012). This in turn suggests that increasing exports to high income destinations may require the upgrading of entire complexes of suppliers and downstream producers, not just of exporters. 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 Data

The analysis in this paper draws on two main datasets, both collected by the *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]).[6]

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 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.[7] To provide summary statistics, we supplemented this survey with additional information on manufacturing firms' attributes from the *Sistema de Contas Integradas das Empresas (SCIE)* [Enterprise Integrated Accounts System], which provides a census of firms in 2005.[8]

We supplement these data with information on country characteristics from the World Bank's World Development Indicators and CPI and nominal exchange rate information from the IMF's International Financial Statistics.

Our firm-level estimation sample consists of manufacturing firms in the IAPI survey with information on input purchases and physical 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 de-

[6] 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.

[7] From 1997-2001 the IAPI was intended to include manufacturing firms to cover 90% of total manufacturing sales. Firms were ranked in descending order of sales and included until the 90% threshold was reached, 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.

[8] 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.

scriptive statistics on our estimation sample and the 2005 census of firms. 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, 2012).[9]

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.[10] 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.

3 Empirical Methodology

We are interested in examining the effect of the income level of export destinations on output and 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 output and input prices at the firm level to average destination income at the firm level. We describe the steps we follow to calculate average output and input prices at the firm level at the end of this section. We are

[9] By the same token, the data are not particularly well suited to cross-sectional comparisons between small and large firms, which require information on something closer to a full census of firms.

[10] 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, Guyana.

ultimately interested in estimating a model of the following form:

$$p_{it} = \log(inc)_{it}\beta + X_{it}\alpha + a_i + b_t + \varepsilon_{it} \quad (1)$$

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

A general concern with estimating (1) by OLS is that there may be unobserved differences among firms that affect both the composition of export destinations and prices at the firm level. One relevant possibility is that there are input-cost shocks at the firm level. We would expect firms to pass increases in input costs at least partly into increases in output prices.[11] The direction of bias in the OLS estimates of β for output and input prices will then depend on how the composition of destination countries responds to the increase in output prices. In the single-sector model that appears in the appendix, the price elasticity of demand is constant across countries (refer to equation (A2) in the appendix). But in plausible alternative models, for instance the multi-sector model with additively separable utility recently explored by Caron, Fally, and Markusen (forthcoming), price elasticities are higher for more income-elastic goods, and richer countries tend to consume more income-elastic goods, with the consequence that a given increase in output prices may lead to a greater decline in sales in richer countries (and hence a negative correlation between $\log(inc)_{it}$ and the error term). On the other hand, if for a given product rich-country consumers are less price-sensitive than poor-country consumers, then the response to a given output-price increase may be smaller in richer countries. 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 an output-price increase will be greater. If sales are more responsive rich countries, then we would expect negative biases in the OLS estimates of β in (1) for both the output-price and input-price regressions; if sales are less responsive in rich countries, we would expect positive biases. Additionally, measurement

[11] 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.

error in average destination income would be expected to lead to attenuation in OLS estimates for both output and input prices. Other forms of bias are also possible.[12] In short, 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 (a simple transformation of) 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.[13]

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

$$s_{ijt} = \mu_{ij} + rpl_{jt}\gamma_j + (rpl_{jt} * C_{ij,1997})\,\delta_j + u_{ijt} \tag{2}$$

where i, j, and t index firms, destinations and years; s_{ijt} denotes the share of firm i's total sales in year t that are due to exports to destination j;[14] μ_{ij} is a firm-destination fixed effect; $C_{ij,1997}$ is an indicator for whether firm i had any exports to destination j in the initial year of our sample, 1997; and rpl_{jt} is the "relative price level" of destination j in year t, defined as the log of the

[12] Related to the input-cost-shock argument above, if firms pass on increases in input costs more in rich countries than in poor countries, then (with similar sensitivities of sales to price across countries) we would expect a positive bias in OLS. Another relevant possibility is that there are productivity shocks at the firm level. In the model developed in the appendix, as in Kugler and Verhoogen (2012), productivity matters in two ways: it reduces input requirements per unit of output and it raises output quality for a given set of inputs. If the former effect is stronger than the latter, then output price will decrease with a positive productivity shock. At the same time, higher productivity will lead firms to purchase higher-quality inputs, produce higher-quality outputs, and expand sales relatively more in richer countries. In this case, there will be a negative bias for output prices in OLS, and a positive bias for input prices. In the model in the appendix, this case occurs when $b < 2a$. See equation (A5d). In the case where $b > 2a$, and hence where productivity increases lead to output price increases and quality increases, firm-level productivity shocks would be expected to lead to a positive bias to OLS in both the output price and input price regressions.

[13] 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 (forthcoming) among others.

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

reciprocal of the real exchange rate as conventionally written:

$$rpl_{jt} = \log\left[\left(\frac{CPI_{jt}}{CPI_{ht}}\right)/e_{jt}\right] \tag{3}$$

where e_{jt} is the nominal exchange rate. Here h indicates Home (Portugal). Using the reciprocal of the real exchange rate rather than the real exchange rate itself is purely a matter of convenience: it facilitates the exposition that δ_j 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.[15] Average destination income for firm i in year t can then be written:

$$inc_{it} = \sum_{j \in J} s_{ijt} \cdot gdppc_{j,1996} \tag{4}$$

One strategy for constructing an instrument for inc_{it} would be to estimate (2), recover the predicted values $\widehat{s}_{ijt}$, and plug them into the expression (4). But estimating (2) by OLS would generate negative values, especially given the large number of firm-destination pairs with zero exports. Estimating a non-linear model such as a tobit would be challenging because of the presence of the large number of incidental parameters, μ_{ij}. Instead we take a more "reduced form" approach that avoids the need to estimate (2) in a preliminary step. Combining (2) and (4), we can write:

$$inc_{it} = \psi_i + \lambda_t + \sum_{j \in J} (rpl_{jt} \cdot C_{ij,1997})\, \phi_j + v_{it} \tag{5}$$

where $\psi_i = \sum_{j \in J} \mu_{ij}\, gdppc_{j,1996}$, $\lambda_t = \sum_{j \in J} rpl_{jt}\, gdppc_{j,1996}$, $\phi_j = \delta_j\, gdppc_{j,1996}$, and $v_{it} = \sum_{j \in J} u_{ijt}\, gdppc_{j,1996}$.

Equation (5) suggests that the full set of relative-price-level interaction terms, $rpl_{jt} \cdot C_{ij,1997}$ for available destinations j, could serve as instruments for inc_{it} in an IV estimation of (1). But it is important to note that the movements of relative price levels may have a direct effect on input prices, and hence on output prices.[16] If such movements matter for input prices especially

[15] 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.

[16] 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

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 (1) will be violated. This concern has not always been taken into account in the literature using exchange rates as instruments for exports. To absorb these direct effects, we construct interactions of the relative price levels with indicators for whether a firm has positive imports from a particular source country, $rpl_{jt} \cdot D_{ij,1997}$, where $D_{ij,1997} = 1$ if firm i has positive imports from country j in 1997, and equals zero otherwise. We include these relative price level/initial importer interactions directly as covariates in the main outcome equation. Thus our main estimating equation is:

$$p_{it} = \log(inc)_{it}\beta + X_{it}\alpha + a_i + b_t + \sum_{j\in J}(rpl_{jt} \cdot D_{ij,1997})\,\chi_j + \varepsilon_{it} \tag{6}$$

where inc_{it} is instrumented by the terms $rpl_{jt} * C_{ij,1997}$. In the cases of firms that initially import from and export to the same set of countries, the effect of the relative-price-level movements will be captured by the relative price level/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 relative price level movements that result from them.

In constructing the average destination income (and average destination distance), we calculate a weighted average over all destinations, including the domestic market, using sales to the destination as weights.[17] However, 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 relative price level 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 (as well as from the set of relative price level/importer interactions). The qualitative results are not affected when we include the Euro-zone countries in the instrument set. We also limit the number of countries in the instrument set to 100, by descending order of export share. The qualitative results are robust to including 50, 75 or 125

(forthcoming).

[17]Domestic sales are not observed in the customs data, but we observe domestic sales, as well as domestic purchases, in the IAPI data.

destinations instead.

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 1km 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 relative price level interactions are also plausible instruments for these two covariates. That is, because the relative price 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 output and input prices, represented by p_{it} in (1) and (6). We first run the following regression:

$$\log uv_{ikt} = \theta_{it} + \xi_{kt} + u_{ikt} \tag{7}$$

where i indexes firms, k indexes products, t indexes years; uv_{it} is the unit value for product k in firm i in year t, calculated as total output sales (or input purchases) divided by units of physical quantity; θ_{it} is a firm-year fixed effect and ξ_{kt} is a product-year fixed effect. We use information only on manufactured outputs or inputs. Note that the product-year effects capture all common factors that affect the price of a particular output or 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 average output and input prices to be equal to these OLS estimates (setting $p_{it} = \widehat{\theta}_{it}$), estimated separately for output unit values and input unit values.[18]

[18] An alternative approach would be to regress the output or input unit values ($\log(uv_{ikt})$ in (7)) directly on the covariates in (6), 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 (7) and then estimating (6)) (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.

4 Results

4.1 Descriptive Analysis

Before turning to our IV estimates, we present a descriptive analysis of two 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). The "richer than Portugal" variable is an indicator for whether the country's GDP per capita is above Portugal's, and log GDP/cap refers to income in the destination country. 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.[19]

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 relative price levels (reciprocals of real exchange rates) of Portugal's principal non-euro-zone trading partners, for countries richer and poorer than Portugal, respectively. Prima facie, the swings in relative price levels appear large enough to have been economically significant, especially in poorer countries such as Brazil, Angola, Turkey, and Russia, Portugal's 13th, 17th, 21st and 27th most important export destinations.

Table 4 analyzes the response of Portuguese firms' sales to the relative price level movements. Panel A of Table 4 uses data at the firm-destination-product-year level. We see that increases in the relative price level in a destination are associated with an increase in the share of a firm's total sales derived from each product sold in that destination, even when including firm-destination-product effects (Column 2). Column 3 includes an interaction of the relative price level with an indicator for whether the firm had positive initial exports to the destination. We see that the response to relative price movements is much larger for firms with initial positive exports to the destination. The message is similar whether we interact the relative price movements with an indicator for any exports to the destination in the initial year (Column 3) or with the firm's initial share of sales in the destination (Column 4). Using data aggregated to the firm-destination level

[19] Table A3 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).

(and hence corresponding to equation (2), again constraining the δ coefficient across destinations), Panel B of Table 4 conveys the same basic message. It appears, in other words, that although relative price movements in destination countries potentially affect all firms, they especially affect firms with initial attachment to the destination.

4.2 Main Results

We now turn to the estimation of the relationships between average output and input prices and destination income. Columns 1-4 of Table 5 present simple OLS estimates of equation (6) for average output prices, successively adding more covariates. In OLS, there appears to be no statistically significant relationship between destination income and output 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. Columns 5-8 present IV estimates of the same equation, using the interactions of relative price level movements and indicators for initial positive sales in a destination as excluded instruments. Column 5 treats only log avg. destination income as endogenous; Column 6 adds the share of sales from exports and Column 7 log avg. destination distance to the set of endogenous covariates. The first stage of the IV estimation is reported in Appendix Table A4.[20] Table 6 is organized in the same way as Table 5, but with average input prices as the outcome variable.

Before discussing the IV estimates, it is important to consider two possible concerns about the IV strategy. First, although including the (initial exporter * relative price level) interaction terms directly avoids the difficulties of estimating a non-linear relationship between sales share and relative price levels 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 relative price level 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 relative price movements than initial exporters, for idiosyncratic reasons.

Second, there is reason to be concerned that the instruments are weakly correlated with average

[20]Column 5 of Table 5 corresponds to Column 1 in Table A4; Column 6 to Columns 2 and 4; and Column 7 to Columns 3, 5, and 6.

destination income and the other potentially endogenous covariates. Tables 5 and 6 report a number of diagnostic statistics for the first stage, which is common between them. 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 5. The IV estimates of the coefficient on the destination-income term are significantly positive and significantly greater than the OLS estimates. Given the positive cross-sectional correlation of export prices and destination income in cross section (Table 3), this result is perhaps not surprising, but it is nonetheless reassuring for our strategy. Because of the weak-instruments concern, we also report a Anderson-Rubin (1949) Wald test, which is robust to weak 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 specification of Column 5, 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 6 and 7, where there are multiple endogenous covariates, the Anderson-Rubin test corresponds to the hypothesis that the coefficients on the endogenous covariates are jointly zero. Tests for subsets of endogenous regressors in weakly identified IV models is 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 is significantly smaller than than the IV estimates in Columns 5-7, this suggests that the IV estimates are likely to be underestimates of the true relationships.

We now turn to the results for input prices in Table 6. The OLS estimates for the relationship between destination income and input prices are positive and significant, although these should be interpreted with caution because of the omitted-variables concerns discussed above. The key point of the table — indeed, of this paper — is that the IV estimates are positive and highly significant in Columns 5-7. As above, weak instruments are a concern. In Column 5, the Anderson-Rubin F-test indicates that we can reject the null that the coefficient on the destination-income term is zero with a high level of confidence. Regarding Columns 6 and 7, we again note that the IV estimates for the destination-income term are robust across specifications and that, if anything, since we expect IV to be biased towards OLS in the weak-instruments case, the reported coefficients are likely to be underestimates. 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 Table A5 and correspond to Columns 5-7 of Table 6. 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. In unreported results, we have found that the basic patterns in Tables 5 and 6 survive a number of robustness checks: (1) using 50, 75 or 125 instruments instead of 100; (2) not winsorizing prices, or winsorizing by year; (3) including non-manufacturing outputs or inputs in the calculation of firm-level average prices; and (4) including Euro-zone destinations in the instrument set.

Considering Tables 5 and 6 together, a number of points are worth noting. First, and most obviously, the positive significant IV coefficients for both output and input prices are consistent with the hypothesis that exogenous shifts in exporting toward richer destinations are associated with an increase in average output and input quality within firms. Second, the magnitudes appear to be economically significant: our baseline estimates in Column 5 of each table suggest that a 10% increase in average destination income leads to a 20% increase in average output prices and a 7% increase in average input prices. Third, the fact that the estimates are larger for output prices than for input prices suggests that both mark-ups and product quality increase when firms sell to richer destinations. That is, the results provide evidence for both the pricing-to-market and the income-based quality-choice stories discussed in the introduction. Our key contention is that pricing-to-market alone cannot entirely explain the empirical patterns, in particular the response of input prices; quality-choice also appears to be playing an important role. Fourth, although there is some evidence that exogenous increases in average distance are associated with higher average input prices (Column 7 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 Conclusion

This paper has 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. There is reason to be concerned that the instruments are only weakly correlated with the endogenous covariates, but weak-instrument-robust statistical tests indicate that there is a positive, statistically significant relationship between average destination income and both output and material input prices within firms. The fact that the pattern holds for input prices as well as output prices suggests that it is not simply due to pricing-to-market behavior by firms. The income-price relationships hold when controlling for the export share of sales, average destination distance, and total sales at the firm level, suggesting that scale effects and the "Washington apples" effect — two leading alternative hypotheses to explain the effect of exporting on firm behavior — cannot provide a full explanation for the empirical patterns. Our findings are supportive of what we have called the income-based quality-choice channel: exporting to richer countries leads firms to upgrade the quality of outputs, which requires purchasing higher-quality inputs. Although we do not observe quality directly, 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.

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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, weighting firms equally. First four rows are conditional on being an exporter (i.e. having positive exports), and second 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, weighting firms equally. Values of revenues (sales plus income from provision of subcontracting and other services) are in millions of 2000 euros. Average annual earning per worker are in thousands of 2000 euros. Standard errors of means in parentheses. Estimation sample contains 2639 firms in 2005; a small number of firms could not be linked to the manufacturing census.

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***	0.11***		
	(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)	(0.00)	(0.01)	(0.01)
European Union	0.06**	0.03	0.07***	0.04
	(0.03)	(0.02)	(0.03)	(0.03)
landlocked	-0.02	0.03	-0.05	0.01
	(0.04)	(0.05)	(0.04)	(0.06)
log distance	0.05***	0.04***	0.06***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
product effects	Y	N	Y	N
firm-product effects	N	Y	N	Y
R2	0.73	0.94	0.73	0.94
N	35438	35438	35438	35438

Notes: Sample is all firm-product-destination observations for firms in estimation sample. Petroleum exports excluded. Robust standard errors, clustered by destination, in parentheses. *10% level, **5% level, ***1% level.

Table 4. Sales Response to Relative Price Level Movements

	dep. var.: % firm's sales			
	(1)	(2)	(3)	(4)
A. Data at firm-destination-product-year level				
log(rel. price level)	0.092***	0.100***	0.022**	0.031***
	(0.012)	(0.010)	(0.010)	(0.012)
log(rel. price level)*1(any exports in 1997)			0.430***	
			(0.041)	
log(rel. price level)*(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(rel. price level)	0.563***	0.579***	0.236***	0.298***
	(0.076)	(0.056)	(0.055)	(0.054)
log(rel. price level)*1(any exports in 1997)			1.134***	
			(0.134)	
log(rel. price level)*(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: Relative price level defined as in (3) 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 output prices

	dep. var.: firm-average log real output price						
	OLS				IV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log avg. destination gdp/cap	0.08	0.04	0.04	0.03	2.06***	1.76***	1.75***
	(0.06)	(0.08)	(0.08)	(0.08)	(0.64)	(0.66)	(0.66)
export share of sales		0.08	0.09	0.09	-0.95***	0.63	0.63
		(0.07)	(0.08)	(0.08)	(0.34)	(0.91)	(0.91)
log avg. destination distance			-0.00	-0.00	0.00	-0.06*	0.01
			(0.01)	(0.01)	(0.01)	(0.03)	(0.07)
log sales				0.04***	0.03**	0.03**	0.02
				(0.01)	(0.01)	(0.01)	(0.02)
initial source interactions	Y	Y	Y	Y	Y	Y	Y
firm effects	Y	Y	Y	Y	Y	Y	Y
year effects	Y	Y	Y	Y	Y	Y	Y
N	45659	45659	45659	45659	45659	45659	45659
Kleibergen-Paap LM statistic (under-identification)					248.92	192.30	232.20
Kleibergen-Paap LM p-value					0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)					2.65	2.09	2.32
Anderson-Rubin Wald test F-stat					2.98	2.99	2.99
Anderson-Rubin Wald test p-value					0.00	0.00	0.00

Notes: Instruments are interactions of indicators for positive exports to destination in 1997 and log relative price level (reciprocal of real-exchange rate) for Portugal's top 100 non-Euro-zone export destinations; see first-stage results in Table A4. Initial source interactions, included directly as covariates, are defined analogously to the instruments, using indicators for initial imports. Columns 5 treats only log avg. destination GDP/cap as endogenous; Column 6 adds export share of sales, and Column 7 adds log avg. destination distance to endogenous set. Petroleum exports and imports excluded. Euro-zone countries not included in instrument set. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table 6. Destination income and firm average input prices

	dep. var.: firm-average log real input price						
	OLS				IV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log avg. destination gdp/cap	0.07***	0.08***	0.08***	0.07**	0.71***	0.69***	0.68***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.25)	(0.26)	(0.26)
export share of sales		-0.02	-0.00	-0.00	-0.33**	-0.22	-0.22
		(0.03)	(0.03)	(0.03)	(0.13)	(0.31)	(0.32)
log avg. destination distance			-0.00	-0.00	-0.00	-0.01	0.06**
			(0.00)	(0.00)	(0.00)	(0.01)	(0.03)
log sales				0.02***	0.02***	0.02***	0.01
				(0.01)	(0.01)	(0.01)	(0.01)
initial source interactions	Y	Y	Y	Y	Y	Y	Y
firm effects	Y	Y	Y	Y	Y	Y	Y
year effects	Y	Y	Y	Y	Y	Y	Y
N	45659	45659	45659	45659	45659	45659	45659
Kleibergen-Paap LM statistic (under-identification)					248.92	192.30	232.20
Kleibergen-Paap LM p-value					0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat (weak insts.)					2.65	2.09	2.32
Anderson-Rubin Wald test F-stat					2.17	2.18	2.18
Anderson-Rubin Wald test p-value					0.00	0.00	0.00

Notes: Instruments are interactions of indicators for positive exports to destination in 1997 and log relative price level (reciprocal of real-exchange rate) for Portugal's top 100 non-Euro-zone export destinations; see first-stage results in Table A4. Initial source interactions, included directly as covariates, are defined analogously to the instruments, using indicators for initial imports. Columns 5 treats only log avg. destination GDP/cap as endogenous; Column 6 adds export share of sales, and Column 7 adds log avg. destination distance to endogenous set. Petroleum exports and imports excluded. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Export Destinations and Input Prices

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May 2014

Appendix

A Theory Appendix

This section develops a model of endogenous input and output quality choices by heterogeneous firms in asymmetric countries in which consumers differ in their willingness to pay for product quality, building on the Melitz (2003) framework. It can be understood as a general-equilibrium formulation of the model in Verhoogen (2008), which employed a logit-based demand system in a partial-equilibrium setting. The model provides a framework for thinking about how exchange-rate movements will affect average output and input prices at the firm level.[1]

A.1 Set-up

Consider three countries, Home (h), North (n) and South (s), where we think of North as richer than Home and South as poorer than Home in a manner which will be discussed below. Let i index the location of production and j index the location of consumer purchases. In each country, there are three sectors: (1) a homogeneous-good "outside" sector producing for consumption; (2) a differentiated manufacturing sector producing final goods for consumption; (3) a perfectly competitive, non-traded intermediate-input sector, supplying the final-good manufacturers. Both the final-good manufacturing sector and the intermediate-input sector may have quality differences, as will be discussed below.

As in Helpman, Melitz, and Yeaple (2004), Chaney (2008), and other papers, we assume that the outside-good sector is perfectly competitive, produces under constant returns to scale, and is costlessly traded, and that countries' endowments of effective units of labor, L_i, are sufficiently similar that in equilibrium all countries produce the homogeneous good. We take the homogeneous good to be the numeraire. We denote labor productivity in the sector by w_i, i.e. one unit of effective labor can produce w_i units of the homogeneous good. As a consequence, the wage rate in country i will be pinned down at w_i. We will focus on an initial equilibrium in which countries' productivities in the outside-good sector are the same: $w_h = w_n = w_s = 1$. This assumption is not quite as restrictive as it may initially appear, since we can be agnostic about how units of effective labor are bundled into each person; individuals in North can be thought of as embodying more units of effective labor (and hence earning higher wages) than individuals in Home or South, even though the wage per unit of effective labor is initially equal across the countries. Below we consider the comparative-static consequences of shocks to w_i in particular countries.

In each country, there is a representative consumer with the following utility function over final goods:

$$U_j = \left\{ \left[\int_{\omega \in \Omega_j} \left(q(\omega)^{\mu_j} x(\omega) \right)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \right\}^{\beta} Z^{1-\beta} \tag{A1}$$

Z is the quantity of the homogeneous good consumed; $\beta > 0$ will be the budget share spent on differentiated goods; ω indexes varieties in the final-good sector; Ω_j is the set of all differentiated

[1] A number of recent papers have developed heterogeneous-firm models in which more-productive firms (under some circumstances) produce higher quality goods: see e.g. Baldwin and Harrigan (2011), Johnson (2012) , Hallak and Sivadasan (2013), Crozet, Head, and Mayer (2012), Eckel, Iacovone, Javorcik, and Neary (2011), and Gervais (2013). The Melitz (2003) model can also be interpreted in terms of quality-differentiated outputs; see Kugler and Verhoogen (2012, appendix D) for further discussion. This model differs both in the heterogeneity in willingness to pay for quality across countries and in the treatment of inputs. The model is also related to papers by Ghironi and Melitz (2005), Arkolakis, Demidova, Klenow, and Rodriguez-Clare (2008) and Hsieh and Ossa (2011), which extend the Melitz (2003) framework to allow for differences in wages across countries without explicitly considering quality choices or differences in willingness to pay for quality across countries.

varieties available in country j; σ is the elasticity of substitution between varieties, where we make the standard assumption that $\sigma > 1$; and $x(\omega)$ is the quantity of variety ω consumed. Here $q(\omega)$ represents the quality of variety ω, which we assume is chosen by firms, and μ_j represents the valuation that consumers place on quality, which we take as exogenous.[2] To guarantee an interior solution to the optimization problem below, we assume that $\mu_j > \frac{1}{2}$ for all j. We assume that willingness to pay for quality is greater in richer countries, such that $\mu_n > \mu_h > \mu_s$.[3]

If all units of effective labor are employed at wage w_i, as will be true in equilibrium, then the demand in country j for each variety will be:

$$x_j(\omega) = \beta w_j L_j P_j^{\sigma-1} q(\omega)^{\mu_j(\sigma-1)} p(\omega)^{-\sigma} \tag{A2}$$

where $p(\omega)$ is the price of variety ω, P_j is a quality-adjusted ideal price index,[4] and $w_j L_j$ is total income in country j.

As in Kugler and Verhoogen (2012), the intermediate sector transforms units of effective labor into intermediate inputs of different qualities, under constant returns to scale. The production function in this sector (the same in all countries) is $F_I(\ell, c) = \frac{\ell}{c}$, where c is the quality of the input produced and ℓ is units of effective labor. The production cost of an intermediate input of quality c in country i will be $w_i c$. In the simplest interpretation, which we adopt hereafter, the final-good sector only uses material inputs. But the intermediate-input sector could also be thought of as an education sector, which converts units of effective labor into workers of different skill levels, who are subsequently employed in the final-good sector.

As in Melitz (2003), potential final-good entrepreneurs in each country must make an investment of f_e effective labor units in their home country (at cost $w_i f_e$, given the wage rate), to enter the final-good sector and receive a capability draw, λ.[5] We assume that in all countries capability is drawn from a Pareto distribution with c.d.f. $G(\lambda) = 1 - \left(\frac{\lambda_m}{\lambda}\right)^k$, with $0 < \lambda_m \leq \lambda$. (We will impose a positive lower bound on k, as explained below.) Each period a fraction δ of firms dies for exogenous reasons; we focus on a steady-state in which an equal mass of new entrants replaces the exiters. We assume that there is a fixed cost for a firm located in country i to produce for market j of f_{ij} effective labor units (paid to labor in their home country, at cost $w_i f_{ij}$), that there is an iceberg variable cost of trade of τ_{ij}, and that these costs are symmetric across countries in the sense that $f_{ij} = f_x$ and $\tau_{ij} = \tau > 1$ for $i \neq j$, and $f_{ij} = f$ and $\tau_{ij} = 1$ for $i = j$. We will also assume that f_x is sufficiently larger than f that only a subset of firms in the domestic market will export.

[2]Here product quality, $q(\omega)$, may reflect consumer perceptions (for instance, due to advertising) rather than inherent physical characteristics. The key point is that $q(\omega)$ is perceived to be the same by all consumers. Consumer heterogeneity in the perception of quality is best thought of as being captured by μ_j. In this model, we assume that μ_j varies only across countries, not within. This is clearly a drastic simplification, but given that in the empirical analysis we observe only which country a good is sold in, not the characteristics of consumers it is sold to, the assumption is suitable for our purposes in this paper.

[3]Ideally, one would be able to derive differences in willingness to pay for quality from income differences, as in the logit specification of Verhoogen (2008). But here, in the interests of tractability, we follow the literature in assuming exogenous differences in preferences for quality across countries in a constant-elasticity-of-substitution (CES) framework (Hallak, 2006; Hallak and Schott, 2011).

[4]P_j is defined as:

$$P_j = \left[\int_{\omega \in \Omega_j} \left(\frac{p_O(\omega)}{q(\omega)^{\mu_j}}\right)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}} \tag{A3}$$

[5]Following Sutton (2007), 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.

In each country, production of physical units in the final-good sector is given by $F(n) = n\lambda^a$, where n is the number of units of inputs used and the constant $a > 0$ reflects the extent to which capability lowers unit costs. Given this assumption, the marginal cost of each unit of output is $\frac{p_{Ii}(c)}{\lambda^a}$. 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:[6]

$$q(\lambda) = \left[\frac{1}{2}\left(\lambda^b\right)^\theta + \frac{1}{2}\left(c^2\right)^\theta\right]^{\frac{1}{\theta}} \tag{A4}$$

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 scope for improving quality with increased know-how, or what might be termed the scope for quality differentiation. We assume that producing quality does not require fixed investments. We assume that there is no cost of differentiation and that each firm produces a single, distinct variety for each market that it enters. It is convenient to think of firms as producing on up to three separate production lines, corresponding to the three possible destinations, Home, North and South. To ensure that the distribution of revenues has finite variance in all countries, we assume that $k > (\sigma - 1)\left[b\left(\mu_n - \frac{1}{2}\right) + a\right]$, where the right-hand side is strictly positive.[7]

A.2 Equilibrium

In the perfectly competitive intermediate-input sector, the equilibrium price of inputs produced is simply $p_{Ii}(c) = w_i c$. In the final-good sector, firms choose which markets to enter, input quality and output price (p_O). The choice of input quality determines input price and, together with the firm's capability draw, output quality. The optimal output price is a fixed multiplicative mark-up over costs, as is standard in Dixit-Stiglitz-type demand systems. Because there are no fixed costs of quality, firms' choices can be considered separately for each product line, indexed by ij. The first-order conditions for each firm's optimization problem for each production line imply the following:

$$c^*_{ij}(\lambda) = (2\mu_j - 1)^{-\frac{1}{2\theta}} \lambda^{\frac{b}{2}} \tag{A5a}$$

$$p^*_{Iij}(\lambda) = w_i(2\mu_j - 1)^{-\frac{1}{2\theta}} \lambda^{\frac{b}{2}} \tag{A5b}$$

$$q^*_{ij}(\lambda) = \left(2 - \frac{1}{\mu_j}\right)^{-\frac{1}{\theta}} \lambda^b \tag{A5c}$$

$$p^*_{Oij}(\lambda) = \left(\frac{\sigma}{\sigma - 1}\right) w_i \tau_{ij} (2\mu_j - 1)^{-\frac{1}{2\theta}} \lambda^{\frac{b}{2} - a} \tag{A5d}$$

$$r^*_{ij}(\lambda) = \beta w_j L_j \Phi_j \left(\frac{P_j}{w_i \tau_{ij}}\right)^{\sigma - 1} \lambda^{\zeta_j} \tag{A5e}$$

where $\zeta_j = (\sigma - 1)\left[b\left(\mu_j - \frac{1}{2}\right) + a\right] > 0$, and $\Phi_j = \left[\left(\frac{\sigma - 1}{\sigma}\right) \mu_j^{\frac{\mu_j}{\theta}} (2\mu_j - 1)^{-\frac{2\mu_j - 1}{2\theta}}\right]^{\sigma - 1} > 0$. Noting that $\theta < 0$, these conditions imply that on a product line selling to a richer country a given firm

[6] 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).

[7] Helpman, Melitz, and Yeaple (2004) and Chaney (2008) place an analogous lower bound on the shape parameter for the Pareto distribution to ensure finite variance of the distribution of sales.

will (1) purchase a higher level of input quality; (2) pay a higher input price; (3) produce higher output quality; and (4) charge a higher output price.

The cut-offs for entry into each market, given the wage levels, w_i, are pinned down by two sets of conditions, similar to conditions in Melitz (2003). First, in each country firms on the margin of entry into each of the three destination markets earns zero profit from entry into that market:

$$\begin{aligned}\pi^*_{ij}(\lambda^*_{ij}) &= \left[p^*_{Oij}(\lambda^*_{ij}) - \frac{p^*_{Iij}(\lambda^*_{ij})}{\lambda^{*\,a}_{ij}}\right] x^*_{ij}(\lambda^*_{ij}) - w_i f_{ij} \\ &= \frac{r^*_{ij}(\lambda^*_{ij})}{\sigma} - w_i f_{ij} = 0, \quad i,j \in h,n,s \end{aligned} \tag{A6}$$

where the second equality uses (A5b) and (A5d). Second, in each country there is free entry and the ex ante expected future profit of paying the investment cost to get a capability draw is zero:

$$\sum_{j\in h,n,s} \left\{ \left(1 - G(\lambda^*_{ij})\right) \sum_{t=0}^{\infty} (1-\delta)^t \left[\frac{E(r^*_{ij}(\lambda))}{\sigma} - w_i f_{ij}\right] \right\} - w_i f_e = 0, \quad i \in h,n,s \tag{A7}$$

where the term in square brackets is the expected per-period profit on the ij production line and $1 - G(\lambda^*_{ij})$ is the ex ante probability that a firm's capability draw is sufficiently high to be worth producing for market j.

The cut-off conditions (A6) and the fact (from (A5e)) that $\frac{r^*_{ij}(\lambda)}{r^*_{ij}(\lambda^*_{ij})} = \left(\frac{\lambda}{\lambda^*_{ij}}\right)^{\zeta_j}$ imply that, conditional on entering market j,

$$E(r^*_{ij}(\lambda)) = \frac{\sigma k f_{ij} w_i}{k - \zeta_j} \tag{A8}$$

and in each location the export cut-offs can be expressed in terms of the domestic cut-offs in the destination market:

$$\lambda^*_{ij} = \left[\left(\frac{f_x}{f}\right)\left(\frac{w_i}{w_j}\right)^{\sigma} \tau^{\sigma-1}\right]^{\frac{1}{\zeta_j}} \lambda^*_{jj}, \quad i \neq j \tag{A9}$$

Using (A8) and (A9), the free-entry conditions (A7) can be rewritten in matrix form as:

$$A\Lambda = \left(\frac{\delta f_e}{\lambda^k_m f}\right) I \tag{A10}$$

where A is a 3x3 matrix with ij element $a_{ij} = \left(\frac{\zeta_j}{k-\zeta_j}\right)\left(\frac{f}{f_{ij}}\right)^{\frac{k-\zeta_j}{\zeta_j}} \tau_{ij}^{\frac{(1-\sigma)k}{\zeta_j}} \left(\frac{w_j}{w_i}\right)^{\frac{\sigma k}{\zeta_j}}$, Λ is a 3x1 vector with elements $\Lambda_j = \frac{1}{(\lambda^*_{jj})^k}$ (ordered h,n,s), and I is a 3x1 vector of ones.

As mentioned above, we focus on an equilibrium in which $w_h = w_n = w_s = 1$. In this case, we have:

$$\det A = \left(\prod_{j\in h,n,s} \frac{\zeta_j}{k-\zeta_j}\right) [d_h(1-d_n)(1-d_s) + (1-d_h)(1-d_n d_s)] \tag{A11}$$

where $d_j = \left(\frac{f}{f_x}\right)^{\frac{k-\zeta_j}{\zeta_j}} \left(\frac{1}{\tau}\right)^{\frac{(\sigma-1)k}{\zeta_j}}$. Since $d_j < 1$, $\det A > 0$ and hence A is invertible.[8] We thus have

[8]Note that the expression in brackets on the right-hand side of (A11) can be written $1 - d_h d_n - d_h d_s - d_n d_s +$

an explicit solution for the domestic entry cut-offs in terms of wage levels and other parameters:

$$\Lambda = \left(\frac{\delta f_e}{\lambda_m^k f}\right) A^{-1} I \tag{A12}$$

Simplifying,

$$\lambda_{jj}^* = \lambda_m \left\{ \frac{d_j f}{\delta f_e} \left(\frac{\zeta_j}{k - \zeta_j} \right) \left[1 + \frac{(1-d_j)(1-\prod_{i \neq j} d_i)}{d_j \prod_{i \neq j}(1-d_i)} \right] \right\}^{\frac{1}{k}} \tag{A13}$$

The export cut-offs in each country follow immediately using (A9). As in Melitz (2003), a convenient feature of this model is that the entry cutoffs do not depend on the scale of the economies.

The scale of the economies are pinned down by the requirements that the goods markets and labor markets clear. Let M_{ij} be the mass of firms from location i producing for destination j. Given that all firms enter the domestic market, we can write:

$$M_{ij} = \left[\frac{1 - G(\lambda_{ij}^*)}{1 - G(\lambda_{ii}^*)} \right] M_{ii} = \left(\frac{\lambda_{ii}^*}{\lambda_{ij}^*} \right)^k M_{ii} \tag{A14}$$

It must be the case that expenditures on manufactures in each country is equal to the revenues for manufacturing firms selling in that location:

$$\begin{aligned} \beta w_j L_j &= \sum_{i \in h,n,s} M_{ij} E(r_{ij}^*(\lambda)) \\ &= \frac{\sigma k}{k - \zeta_j} \left\{ f w_j M_{jj} + \sum_{i \neq j} f_x w_i M_{ii} \left(\frac{\lambda_{ii}^*}{\lambda_{ij}^*} \right)^k \right\}, \qquad j \in h,n,s \end{aligned} \tag{A15}$$

where the second equality uses (A8) and (A14).

Let α_i be the share of the labor force in location i employed in the intermediate-input sector, with the remainder in the outside sector. Total payments by final-good producers for material inputs are equal to total payments by intermediate-input producers for labor. The per-period fixed costs, f and f_x, and the investment cost, f_e, are also paid to workers. Let M_i^e be the mass of entrepreneurs who pay the investment cost in location i. It must be the case that income of workers in i must be equal to total effective payments to workers by firms operating in i:

$$\alpha_i w_i L_i = \left\{ \sum_{j \in h,n,s} \left[M_{ij} E(r_{ij}^*(\lambda) \right] - \Pi_i \right\} + M_i^e w_i f_e, \qquad i \in h,n,s \tag{A16}$$

where Π_i denotes total profits of final-good producers. Total profits can be written:

$$\Pi_i = \sum_{j \in h,n,s} M_{ij} \left[\frac{E(r_{ij}^*(\lambda))}{\sigma} - w_i f_{ij} \right], \qquad i \in h,n,s \tag{A17}$$

In steady state, the mass of new entrants in each country is equal to the mass of plants that die:

$$M_i^e \left(1 - G(\lambda^*)\right) = \delta M_{ii}, \qquad i \in h,n,s \tag{A18}$$

$2 d_h d_n d_s$ and is invariant to the ordering of countries. We have written the expression in the form of (A11) to make clear that is it positive.

Combining (A7), (A14), (A17), and (A18), we have that $\Pi_i = M_i^e w_i f_e$ and hence (A16) becomes:

$$\alpha_i w_i L_i = \sum_{j \in h,n,s} M_{ij} E(r_{ij}^*(\lambda)), \quad i \in h,n,s \tag{A19}$$

Using (A8) and (A14), we can solve for the mass of firms active in location i as a function of the share of labor in manufacturing, α_i:

$$M_{ii} = \frac{\alpha_i L_i}{\sigma k} \left\{ \frac{1}{\frac{f}{k-\zeta_i} + \sum_{j \neq i} \frac{f_x}{k-\zeta_j} \left(\frac{\lambda_{ii}^*}{\lambda_{ij}^*}\right)^k} \right\}, \quad i \in h,n,s \tag{A20}$$

Substituting the equations (A20) into (A15), we have three equations in the three unknowns, α_h, α_n, α_s. These pin down the share of the labor force in manufacturing and hence the scale of each economy.

A.3 Response to Exchange-Rate Shocks

In this setting, we can think of changes in real exchange rates as deriving from shocks to productivity in the homogeneous, "outside" sectors, represented by w_i for $i \in h,n,s$. These affect the wage level in each economy, and in turn affect the prices of all goods in manufacturing. As noted above, we consider deviations from an equilibrium in which $w_h = w_n = w_s = 1$.

Consider an increase in w_n, which we can think of as an appreciation in North. We begin by deriving predictions for the response of the various entry cutoffs. Partially differentiating (A10) or (A12), we have:

$$\begin{aligned} \frac{\partial \Lambda}{\partial w_n} &= -A^{-1}\left(\frac{\partial A}{\partial w_n}\right)\Lambda \qquad \text{(A21)} \\ &= -\frac{\sigma k}{w_n(\det A)} \begin{pmatrix} \left(\frac{\zeta_n}{k-\zeta_n}\right)\left(\frac{\zeta_s}{k-\zeta_s}\right) d_n(1-d_s)\left(\frac{\Lambda_n}{k-\zeta_n} + \frac{d_h\Lambda_h}{k-\zeta_h} + \frac{d_s\Lambda_s}{k-\zeta_s}\right) \\ -\left(\frac{\zeta_h}{k-\zeta_h}\right)\left(\frac{\zeta_s}{k-\zeta_s}\right)\left\{[d_h(1-d_s)+d_s(1-d_h)]\frac{d_n\Lambda_n}{k-\zeta_n} + (1-d_s d_h)\left[\sum_{j\in h,s}\frac{d_j\Lambda_j}{k-\zeta_j}\right]\right\} \\ \left(\frac{\zeta_n}{k-\zeta_n}\right)\left(\frac{\zeta_h}{k-\zeta_h}\right) d_n(1-d_h)\left(\frac{\Lambda_n}{k-\zeta_n} + \frac{d_h\Lambda_h}{k-\zeta_h} + \frac{d_s\Lambda_s}{k-\zeta_s}\right) \end{pmatrix} \end{aligned}$$

Using the definition of Λ, the fact that $d_j < 1 \ \forall j$, (A9) and (A11), the comparative-static predictions for changes in the entry cutoffs are:

$$\begin{aligned} &\frac{\partial \lambda_{nh}^*}{\partial w_n} > 0 \qquad \frac{\partial \lambda_{ns}^*}{\partial w_n} > 0 \\ &\frac{\partial \lambda_{hn}^*}{\partial w_n} < 0 \qquad \frac{\partial \lambda_{sn}^*}{\partial w_n} < 0 \end{aligned} \tag{A22a}$$

$$\begin{aligned} &\frac{\partial \lambda_{ss}^*}{\partial w_n} > 0 \qquad \frac{\partial \lambda_{hh}^*}{\partial w_n} > 0 \\ &\frac{\partial \lambda_{hs}^*}{\partial w_n} > 0 \qquad \frac{\partial \lambda_{sh}^*}{\partial w_n} > 0 \\ &\frac{\partial \lambda_{nn}^*}{\partial w_n} < 0 \end{aligned} \tag{A22b}$$

The intuition for the four results in (A22a) is straightforward. Northern exporters are put at a disadvantage by the increase in the Northern wage and the consequent increase in input prices in North, and marginal Northern exporters stop exporting to Home and South. Conversely, Home and Southern exporters benefit from their lower costs relative to Northern producers in the market in North, and firms previously below the cut-off for entering the Northern market can profitably enter.

The intuition for the results in (A22b) is more subtle. In Home and South, the expansion of profitable export opportunities induces a greater number of firms to pay the fixed investment cost to get a productivity draw, increasing the measure of firms in the domestic market. This in turn drives down the price index for differentiated goods and induces firms at the domestic cut-off margin to exit, leading the domestic cut-offs to rise. There is an offsetting effect, in that producers in Home and South face less competition in their domestic markets from Northern exporters, but given the assumptions of our model (in particular, the assumptions about the Pareto distribution of capabilities), the former effect always dominates the latter. Similar logic explains the increase in cut-offs for Home exporters to South and Southern exporters to Home. An analogous argument explains the fall in the cut-off in North: because export opportunities are less attractive, fewer firms enter, the price index rises, and firms at the domestic cut-off margin become more profitable.

A convenient feature of this model is that firm-level revenues and output can be expressed as functions of the entry cut-offs, without reference to the variables reflecting the scale of each of the economies. In particular, using (A5d) and (A5e) output on each production line can be expressed as:

$$x^*_{ij}(\lambda) = \frac{r^*_{ij}(\lambda)}{p^*_{Oij}(\lambda)} = \frac{(\sigma-1)f_{ij}}{\tau_{ij}(2\mu_j-1)^{-\frac{1}{2\theta}}} \frac{\lambda^{\zeta_j+a-\frac{b}{2}}}{\lambda^{*\,\zeta_j}_{ij}} \tag{A23}$$

That is, for a given firm with a given λ, output of each production line varies inversely with the entry cut-offs for each market.

As in other firm-level datasets, in our data it is not possible to observe input prices at the level of product lines. What is observable is an average of input prices across all product lines. In the model, average input price can be represented as:

$$\overline{p}^*_{Ih}(\lambda) = \sum_{j\in h,n,s} \left[\frac{x^*_{hj}(\lambda)}{x^*_{hh}(\lambda)+x^*_{hn}(\lambda)+x^*_{hs}(\lambda)}\right] p^*_{I_{hj}}(\lambda) \tag{A24}$$

Average output price can be defined analogously:

$$\overline{p}^*_{Oh}(\lambda) = \sum_{j\in h,n,s} \left[\frac{x^*_{hj}(\lambda)}{x^*_{hh}(\lambda)+x^*_{hn}(\lambda)+x^*_{hs}(\lambda)}\right] p^*_{O_{hj}}(\lambda) \tag{A25}$$

Now consider the effect of an increase in the Northern wage on average firm-level output and input prices for Home firms. The Northern wage, w_n, does not enter the expressions for output or input prices on a particular production line (refer to (A5b) and (A5d)). Hence any changes in $\overline{p}^*_O(\lambda)$ or $\overline{p}^*_I(\lambda)$ in response to a change in w_n must arise through changes in the output shares destined for each market. For a Home firm that initially exports to both North and South, it follows from (A22a)-(A22b) that its output share to North will increase and its output share to Home and South will decrease. Given that output and input prices on the Northern production line are greater than on either of the other lines (refer to (A5d) and (A5b)), this implies that average output and input prices, $\overline{p}^*_{Oh}(\lambda)$ and $\overline{p}^*_{Ih}(\lambda)$ will both increase. In the case of Home firms that initially do not export to one or both markets, the results go weakly in the same direction. Hence:

$$\frac{\partial \overline{p}^*_{Oh}(\lambda)}{\partial w_n} \geq 0 \tag{A26}$$

$$\frac{\partial \overline{p}^*_{Ih}(\lambda)}{\partial w_n} \geq 0 \tag{A27}$$

Analogously, it is straightforward to show that an increase in the Southern wage has the opposite effect on average output and input prices, since output and input prices are lower on the production line destined for South:

$$\frac{\partial \overline{p}^*_{Oh}(\lambda)}{\partial w_s} \leq 0 \tag{A28}$$

$$\frac{\partial \overline{p}^*_{Ih}(\lambda)}{\partial w_s} \leq 0 \tag{A29}$$

To summarize, (A26)-(A29) indicate that an increase in the wage level in North (which can be interpreted as a real-exchange-rate appreciation in North) all else equal will lead to an increase in firm-average output and input prices among Home firms, and an increase in the wage level in South will lead to a decrease in both firm-average output and input prices. These are the testable implications that we take to the data in the main text.

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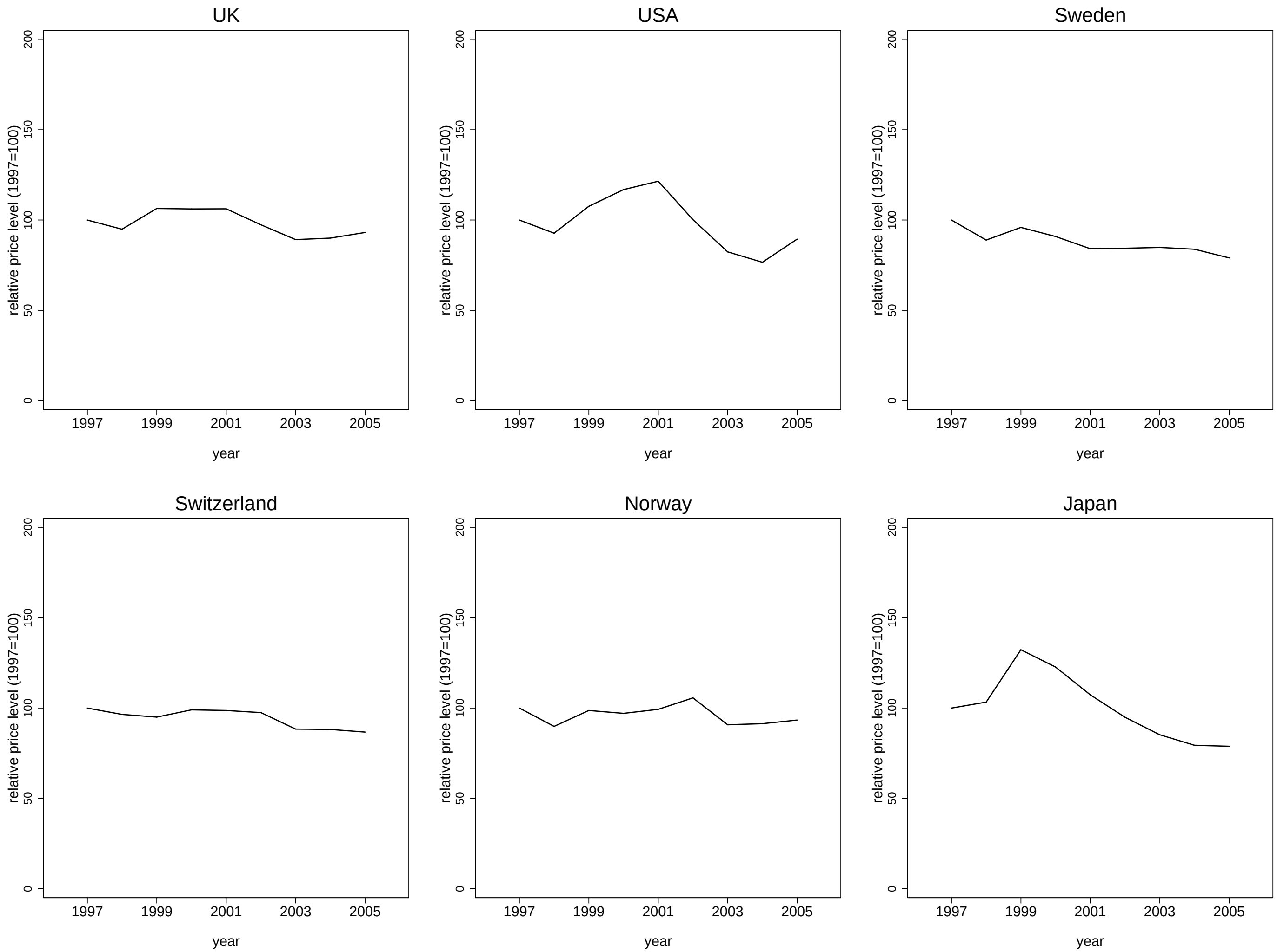
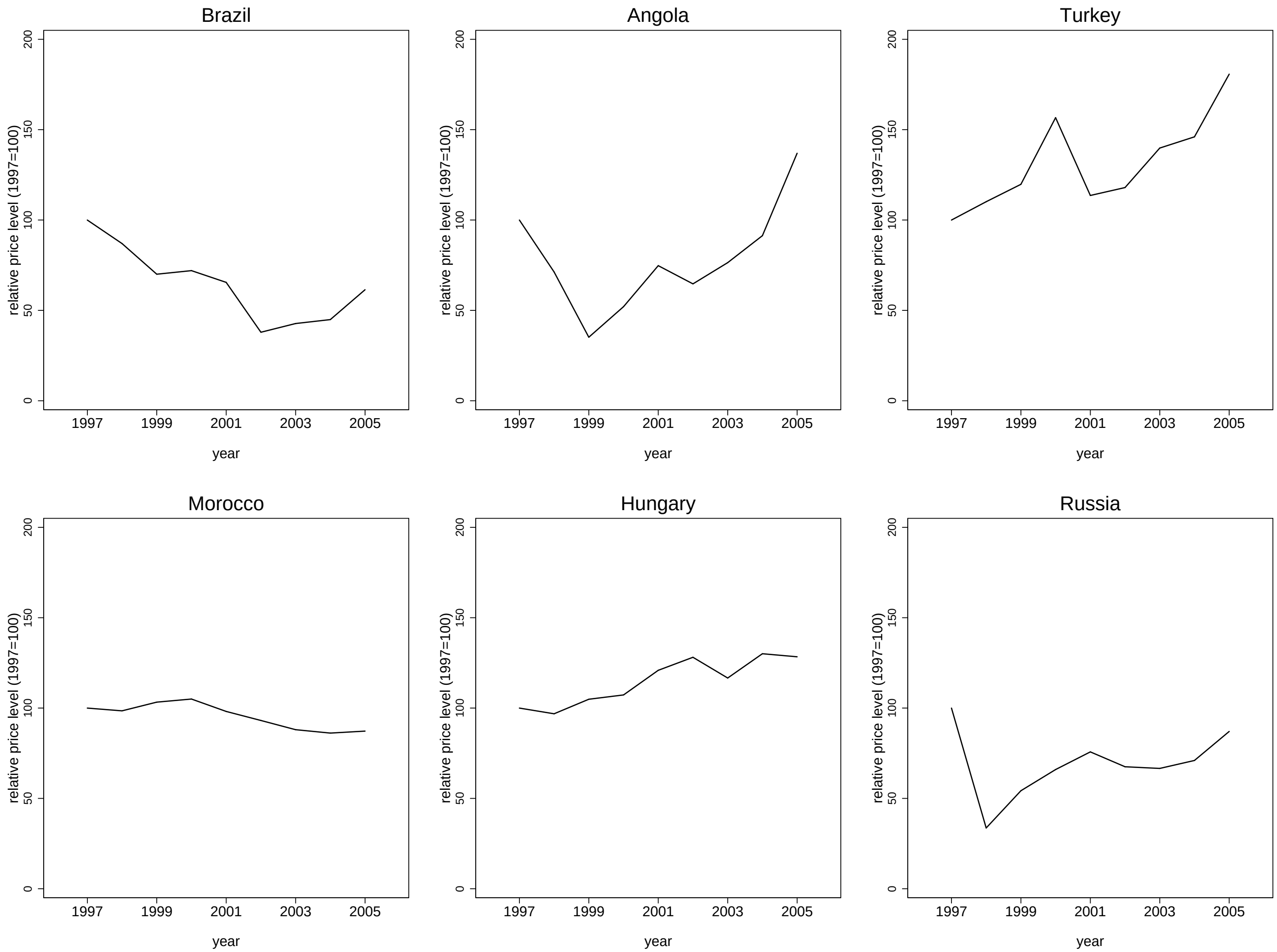
Figure A1. Relative Price Level, Selected Richer Export Destinations



Notes: Relative price level calculated as $(1/e) * \frac{CPI_{portugal,t}}{CPI_{jt}}$ where e is the nominal exchange rate; this is the reciprocal of the real exchange rate as conventionally defined. Relative price level normalized to 100 in 1997.

Figure A2. Relative Price Level, Selected Poorer Export Destinations



Notes: Relative price level calculated as $(1/e) * \frac{CPI_{portugal,t}}{CPI_{jt}}$ where e is the nominal exchange rate; this is the reciprocal of the real exchange rate as conventionally defined. Relative price level normalized to 100 in 1997.

Table A1. Summary statistics, exports and imports, 1997

		export share			import share	
	export rank	all exports	estimation sample	import rank	all imports	estimation sample
Germany	1	0.217	0.211	2	0.208	0.210
Spain	2	0.145	0.150	1	0.219	0.226
France	3	0.144	0.151	3	0.116	0.121
United Kingdom	4	0.125	0.130	4	0.070	0.073
Netherlands	5	0.055	0.054	6	0.038	0.040
Belgium-Luxemburg	6	0.052	0.052	8	0.029	0.029
United States	7	0.044	0.038	9	0.029	0.025
Italy	8	0.039	0.039	5	0.061	0.063
Sweden	9	0.020	0.019	13	0.009	0.007
Denmark	10	0.017	0.018	17	0.008	0.007
Austria	11	0.013	0.013	15	0.008	0.008
Switzerland	12	0.011	0.011	16	0.008	0.008
Brazil	13	0.009	0.009	10	0.026	0.026
Norway	14	0.008	0.008	11	0.012	0.012
Japan	15	0.007	0.005	7	0.034	0.029
Finland	16	0.007	0.007	18	0.007	0.007
Angola	17	0.006	0.007	34	0.002	0.000
Greece	18	0.005	0.005	41	0.001	0.002
Singapore	19	0.005	0.002	28	0.003	0.001
Israel	20	0.005	0.005	43	0.001	0.001
Turkey	21	0.005	0.005	22	0.003	0.003
Ireland	22	0.004	0.004	20	0.004	0.004
Australia	23	0.004	0.004	83	0.000	0.000
Canada	24	0.004	0.004	31	0.003	0.003
Morocco	25	0.004	0.004	29	0.003	0.003
Hungary	26	0.003	0.003	94	0.000	0.000
Russia	27	0.003	0.004	14	0.008	0.009
South Africa	28	0.003	0.003	21	0.004	0.004
Chile	29	0.002	0.003	66	0.001	0.001
Hong Kong	30	0.002	0.002	65	0.001	0.001
Poland	31	0.002	0.002	52	0.001	0.001
Cape Verde	32	0.002	0.002	64	0.001	0.001
China	33	0.002	0.002	26	0.003	0.003
Saudi Arabia	34	0.002	0.001	91	0.000	0.000
Argentina	35	0.002	0.002	60	0.001	0.001
Tunisia	36	0.001	0.001	38	0.002	0.002
Korea	37	0.001	0.001	12	0.011	0.001
Czech Republic	38	0.001	0.001	56	0.001	0.001
Algeria	39	0.001	0.001	88	0.000	0.000
Mexico	40	0.001	0.001	68	0.001	0.001
Mozambique	41	0.001	0.001	50	0.001	0.001
Thailand	42	0.001	0.001	37	0.002	0.002
Guinea-Bissau	43	0.001	0.001	117	0.000	0.000
Panama	44	0.001	0.000	110	0.000	0.000
Venezuela	45	0.001	0.001	77	0.000	0.000
India	46	0.001	0.001	19	0.005	0.006
Egypt	47	0.001	0.001	44	0.001	0.001
Cyprus	48	0.001	0.001	120	0.000	0.000
New Zealand	49	0.001	0.001	78	0.000	0.000
Slovak Republic	50	0.001	0.001	105	0.000	0.000
Total (bil. euros)		16.05	14.86		11.89	11.03

Notes: Table reports export shares by destination for all exporters (Column 2) and our estimation sample (Column 3) and import share by source country for all importers (Column 5) and our estimation sample (Column 6). Final row reports total exports for all destinations and total imports from all sources. Countries poorer than Portugal (in 1996 GDP/capita) appear in italics. Export and import ranks based on all exports and all imports, respectively (i.e. not the estimation sample). Petroleum exports and imports excluded. Euro-zone countries included.

Table A2. Summary statistics, estimation sample, 1997-2005

	1997	1998	1999	2000	2001	2002	2003	2004	2005
sales	5.57	5.45	5.18	4.97	5.04	7.36	6.91	9.86	9.35
	(0.51)	(0.44)	(0.45)	(0.46)	(0.50)	(0.67)	(0.61)	(0.79)	(0.70)
number of output categories	4.51	4.52	4.51	4.53	4.47	5.93	6.04	3.89	3.82
	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.17)	(0.17)	(0.09)	(0.09)
export share of sales	0.21	0.21	0.21	0.20	0.19	0.14	0.14	0.24	0.24
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
share of exports to richer countries	0.79	0.80	0.81	0.80	0.79	0.76	0.75	0.79	0.78
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
number of destination countries	7.71	7.53	7.53	7.53	7.50	7.32	7.15	8.85	8.94
	(0.15)	(0.14)	(0.14)	(0.14)	(0.15)	(0.33)	(0.30)	(0.27)	(0.27)
number of export categories	10.03	9.89	9.88	9.86	10.02	9.76	9.39	13.04	13.77
	(0.28)	(0.26)	(0.26)	(0.25)	(0.27)	(0.72)	(0.61)	(0.56)	(0.59)
avg. income of destination	11.62	11.63	11.60	11.48	11.41	10.73	10.69	11.46	11.36
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.07)	(0.06)	(0.07)	(0.07)
purchases	3.24	3.09	2.91	2.87	2.92	4.19	3.70	5.49	5.12
	(0.43)	(0.35)	(0.36)	(0.43)	(0.42)	(0.37)	(0.32)	(0.55)	(0.47)
number of input categories	7.70	8.12	8.44	8.78	8.90	7.05	7.18	7.75	7.87
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.14)	(0.14)	(0.15)	(0.15)
import share of purchases	0.20	0.20	0.20	0.20	0.19	0.18	0.18	0.28	0.27
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
share of imports from richer countries	0.90	0.89	0.90	0.90	0.88	0.87	0.88	0.87	0.87
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
number of source countries	5.63	5.65	5.65	5.58	5.56	5.34	5.21	6.78	6.83
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.18)	(0.17)	(0.14)	(0.14)
number of import categories	21.74	21.70	21.94	22.00	21.61	20.06	20.60	29.41	31.04
	(0.65)	(0.64)	(0.61)	(0.59)	(0.59)	(1.19)	(1.51)	(1.28)	(1.33)
average income of source	10.87	10.88	10.89	10.81	10.68	10.55	10.51	11.17	11.07
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.06)	(0.05)	(0.06)	(0.06)
fraction exporter	0.49	0.49	0.49	0.47	0.45	0.45	0.46	0.59	0.60
fraction importer	0.50	0.52	0.51	0.49	0.48	0.45	0.45	0.60	0.59
N (firms)	6585	6873	7194	7713	7994	2046	2160	2455	2639

Notes: Table reports averages across firms, weighting firms equally. Average income of sales destination and purchase sources include the home market as possible destination or source, as described in Section 3 of the text. Sales and purchases are in millions of 2002 Euros, avg. incomes of destination and source in thousands of 2002 Euros.

Table A3. Source-country characteristics and import prices in cross section, 1997

	dep. var.: firm-product log import price			
	(1)	(2)	(3)	(4)
richer than Portugal	0.55***	0.27*		
	(0.11)	(0.15)		
log GDP/cap.			0.20***	0.10**
			(0.03)	(0.04)
log GDP	0.05**	0.03	0.04**	0.02
	(0.02)	(0.03)	(0.02)	(0.03)
European Union	-0.34***	-0.07	-0.29***	-0.07
	(0.08)	(0.16)	(0.07)	(0.15)
landlocked	0.18**	0.06	0.11	0.06
	(0.08)	(0.12)	(0.10)	(0.13)
log distance	-0.08	0.04	-0.07*	0.05
	(0.05)	(0.09)	(0.04)	(0.08)
product effects	Y	N	Y	N
firm-product effects	N	Y	N	Y
R2	0.75	0.97	0.75	0.97
N	21792	21792	21792	21792

Notes: Sample is all firm-product-source observations for firms in estimation sample. Petroleum imports excluded. Robust standard errors, clustered by source country, in parentheses. *10% level, **5% level, ***1% level.

Table A4. First stage for baseline regressions, export rank 1-25

	log avg. dest. income			export share		log avg. dest. distance
Instrument	(1)	(2)	(3)	(4)	(5)	(6)
export share of sales	0.51***					
log avg. distance of destination market	-0.00***	0.02***		0.04***		
log sales	0.01***	0.01***	0.01***	0.00	0.01***	0.11***
United Kingdom	-0.01	-0.06*	-0.07*	-0.10***	-0.11***	-0.39
United States	0.00	0.01	0.01	0.03	0.02	-0.18
Sweden	0.15***	0.22***	0.24***	0.14***	0.20***	1.31***
Switzerland	0.12**	0.11*	0.12*	-0.01	0.01	0.55
Brazil	-0.04***	-0.05***	-0.05***	-0.02**	-0.01	0.43***
Norway	-0.07*	-0.05	-0.04	0.04	0.06	0.52
Japan	0.04**	0.05**	0.05**	0.02	0.02	0.11
Angola	-0.02***	-0.03***	-0.02***	-0.01**	0.00	0.31***
Singapore	0.00	-0.07	-0.07	-0.14***	-0.14***	-0.21
Israel	0.01	-0.00	-0.00	-0.02	-0.02	0.07
Turkey	0.05***	0.07***	0.07***	0.03*	0.04*	0.15
Australia	0.00	-0.02	-0.02	-0.04	-0.04	-0.05
Canada	-0.01	-0.01	-0.01	-0.00	-0.02	-0.29
Morocco	0.02	-0.01	0.01	-0.06	-0.02	0.92*
Hungary	0.06	0.04	0.03	-0.05	-0.06	-0.08
Russia	-0.04**	-0.03*	-0.03*	0.02*	0.02	-0.04
South Africa	0.00	0.00	0.00	-0.00	0.00	0.14
Chile	-0.01	-0.01	-0.00	0.01	0.03	0.36
Hong Kong	0.05*	0.09***	0.10***	0.08***	0.10***	0.40**
Poland	0.05	0.06	0.06	0.02	0.04	0.42
Cape Verde	-0.01	-0.16**	-0.15**	-0.30***	-0.28***	0.37
China	0.07	0.08	0.08*	0.02	0.04	0.32
Saudi Arabia	-0.04	-0.03	-0.04	0.01	-0.00	-0.24
Argentina	0.02***	0.02**	0.02**	-0.00	0.00	0.10
Tunisia	0.01	-0.08	-0.09	-0.17***	-0.19***	-0.51
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
R2	0.95	0.94	0.94	0.97	0.96	0.93

Notes: Covariate corresponding to fourth row is (indicator for positive 1997 export revenues from UK)*(relative price level in UK, current year). Covariates in subsequent rows defined similarly. Table continued on following 3 pages. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

Table A4. (Continued) First stage for baseline regressions, export rank 26-50

	log avg. dest. income			export share		log avg. dest. distance
Instrument	(1)	(2)	(3)	(4)	(5)	(6)
Korea	-0.01	-0.03	-0.03	-0.02	-0.02	-0.04
Czech Republic	-0.10	-0.10	-0.10	-0.01	-0.01	-0.02
Algeria	-0.13**	-0.19***	-0.19***	-0.12*	-0.13*	-0.22
Mexico	-0.01	-0.03	-0.04	-0.04*	-0.06**	-0.33
Mozambique	0.02	0.01	0.03	-0.01	0.03	0.99***
Thailand	0.02	0.06*	0.05	0.06*	0.06	-0.18
Guinea-Bissau	0.05	0.11	0.05	0.12	-0.00	-3.07**
Panama	-0.10**	-0.08	-0.06	0.03	0.07	0.80**
Venezuela	-0.02	-0.01	-0.01	0.03	0.02	-0.03
India	-0.00	0.00	-0.00	0.01	0.01	-0.19
Egypt	0.01	0.00	0.00	-0.02	-0.02	0.06
Cyprus	-0.00	-0.01	-0.02	-0.01	-0.04	-0.91**
New Zealand	0.02	0.05	0.06	0.06	0.07	0.24
Slovak Republic	0.00	0.00	-0.01	0.00	-0.02	-0.46
Macao	-0.05***	-0.06***	-0.06***	-0.02	-0.01	0.07
Uruguay	0.01	0.02	0.02	0.03	0.02	-0.04
Bulgaria	0.13	0.14	0.17	0.04	0.08	1.12**
Iceland	-0.00	0.00	-0.01	0.01	-0.01	-0.41
Zimbabwe	0.02	0.01	0.01	-0.03**	-0.03*	0.01
Senegal	-0.25	-0.22	-0.23	0.06	0.04	-0.46
Colombia	-0.05	-0.02	-0.02	0.06	0.06	0.16
Jordan	0.04	0.08	0.08	0.09	0.09	0.01
Nigeria	0.00	-0.00	-0.00	-0.01	-0.02	-0.13
Pakistan	-0.29***	-0.29***	-0.30***	-0.00	-0.02	-0.39
Malaysia	-0.03	-0.03	-0.01	0.01	0.04	0.70**

Notes: See above.

Table A4. (Continued) First stage for baseline regressions, export rank 51-75

	log avg. dest. income			export share		log avg. dest. distance
Instrument	(1)	(2)	(3)	(4)	(5)	(6)
Ghana	0.04	0.10*	0.11*	0.11	0.13	0.54
Philippines	-0.00	0.02	0.02	0.04	0.03	-0.13
Kuwait	-0.01	-0.00	0.00	0.02	0.04	0.30
Romania	-0.17	-0.16	-0.16	0.01	0.02	0.11
Lithuania	-0.10*	-0.03	-0.03	0.15	0.13	-0.36
Moldova	-0.02	0.01	0.01	0.06	0.06	-0.11
Kenya	-0.12	-0.10	-0.12	0.04	-0.01	-1.26
Dominican Republic	0.02	0.02	0.02	0.01	-0.00	-0.24
Ukraine	-0.12	-0.14	-0.14	-0.02	-0.03	-0.11
Cote d'Ivoire	0.37	0.00	0.04	-0.72	-0.63	2.12
Libya	0.04***	0.03	0.03	-0.02	-0.02	-0.18
Syrian Arab Republic	-0.06	-0.12	-0.12	-0.12*	-0.13*	-0.33
Croatia	0.60	0.69	0.76	0.17	0.32	3.61
Guatemala	0.16	0.18	0.17	0.04	0.03	-0.12
Peru	0.12*	0.07	0.07	-0.10*	-0.11	-0.14
Estonia	-0.30*	-0.27	-0.28	0.06	0.04	-0.50
Vietnam	-0.11	-0.15*	-0.15*	-0.08	-0.08	0.06
Ethiopia	-0.28***	-0.34***	-0.32***	-0.12	-0.08	1.00
Mauritius	0.05	0.05	0.05	-0.02	-0.01	0.30
Latvia	-0.06	-0.16	-0.19	-0.20	-0.27	-1.68
Paraguay	-0.06**	-0.04	-0.05*	0.03	0.01	-0.40
Bahrain	0.01	0.10	0.11	0.17**	0.20**	0.77**
Sri Lanka	0.23*	0.18	0.18	-0.10	-0.10	0.05
Iran	0.02	0.03	0.03	0.02	0.02	-0.01
Netherlands Antilles	0.01	0.04	0.05	0.05	0.08*	0.92*

Notes: See above.

Table A4. (Continued) First stage for baseline regressions, export rank 76-100

	log avg. dest. income			export share		log avg. dest. distance
Instrument	(1)	(2)	(3)	(4)	(5)	(6)
El Salvador	-0.00	-0.06	-0.04	-0.10	-0.07	0.79*
Armenia	-0.08	-0.10	-0.12	-0.04	-0.07	-0.82
Malawi	0.01	0.04	0.04	0.05	0.07	0.34
Jamaica	0.02	0.02	0.03	0.00	0.01	0.31
Yemen	0.06	0.04	-0.04	-0.03	-0.21	-4.51
Gabon	-0.25**	-0.36***	-0.34**	-0.22*	-0.17	1.20
Cameroon	-0.89*	-1.47***	-1.45***	-1.14***	-1.10**	0.91
Tanzania	-0.09**	-0.10**	-0.10**	-0.03	-0.03	0.05
Costa Rica	0.03	0.06	0.05	0.05	0.04	-0.27
Qatar	0.09	0.06	0.06	-0.05	-0.05	-0.05
Indonesia	-0.06*	-0.05	-0.04	0.03	0.04	0.26
Honduras	-0.00	-0.03	-0.02	-0.05	-0.03	0.51*
Kazakhstan	0.02	0.02	0.03	-0.01	0.02	0.67
Zambia	-0.03	-0.05	-0.04	-0.05	-0.01	0.82
Burkina Faso	0.50*	1.12***	1.23***	1.22***	1.48***	6.38**
Bangladesh	0.05	0.03	0.01	-0.06	-0.10	-0.99*
Madagascar	0.01	0.08	0.07	0.12	0.11	-0.13
Georgia	0.08	0.02	0.00	-0.12	-0.16	-0.97
Albania	0.01	0.01	0.00	-0.00	-0.02	-0.39
Togo	0.37	0.32	0.39	-0.10	0.05	3.56
Benin	-0.60	-1.43*	-1.55**	-1.65**	-1.92**	-6.55
Dem. Rep. of Congo	0.06	0.06	0.06	-0.00	0.00	0.05
Rep. of Congo	-0.42***	-0.22	-0.22	0.38**	0.40*	0.50
Mauritania	-0.15**	-0.10	-0.11	0.11*	0.07	-0.80
Niger	0.96**	1.07**	1.01**	0.22	0.08	-3.55

Notes: See above.

Table A5. Destination income and firm average input prices, LIML estimates

	dep. var.: firm-average log real input price		
	(1)	(2)	(3)
log avg. destination gdp/cap	1.15***	1.16**	0.96**
	(0.44)	(0.51)	(0.48)
export share of sales	-0.56**	-0.58	-0.47
	(0.23)	(0.71)	(0.68)
log avg. destination distance	-0.00	0.00	0.25**
	(0.00)	(0.02)	(0.12)
log sales	0.02**	0.02**	-0.01
	(0.01)	(0.01)	(0.02)
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)	248.92	192.30	232.20
Kleibergen-Paap LM p-value	0.00	0.00	0.00
Kleibergen-Paap Wald rk F-stat	2.65	2.09	2.32
Anderson-Rubin Wald test F-stat	2.17	2.18	2.18
Anderson-Rubin Wald test p-value	0.00	0.00	0.00

Notes: Instruments are interactions of indicators for positive exports to destination in 1997 and log relative price level (reciprocal of real-exchange rate). Initial source interactions, included directly as covariates, are defined analogously to the instruments, using indicators for initial imports. Columns 5 treats only log avg. destination GDP/cap as endogenous; Column 6 adds export share of sales, and Column 7 adds log avg. destination distance to endogenous set. Petroleum exports and imports excluded. Euro-zone countries not included in instrument set. Robust standard errors in parentheses. *10% level, **5% level, ***1% level.

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