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:

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

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:

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

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:

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

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:

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

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

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

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

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

$2d_h d_n d_s$ 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:

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

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:

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

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:

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

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:

$$x_{ij}^*(\lambda) = \frac{r_{ij}^*(\lambda)}{p_{Oij}^*(\lambda)} = \frac{(\sigma-1)f_{ij}}{\tau_{ij}(2\mu_j-1)^{-\frac{1}{2\theta}}} \frac{\lambda^{\zeta_j+a-\frac{b}{2}}}{\lambda_{ij}^{*\,\zeta_j}} \tag{A23}$$

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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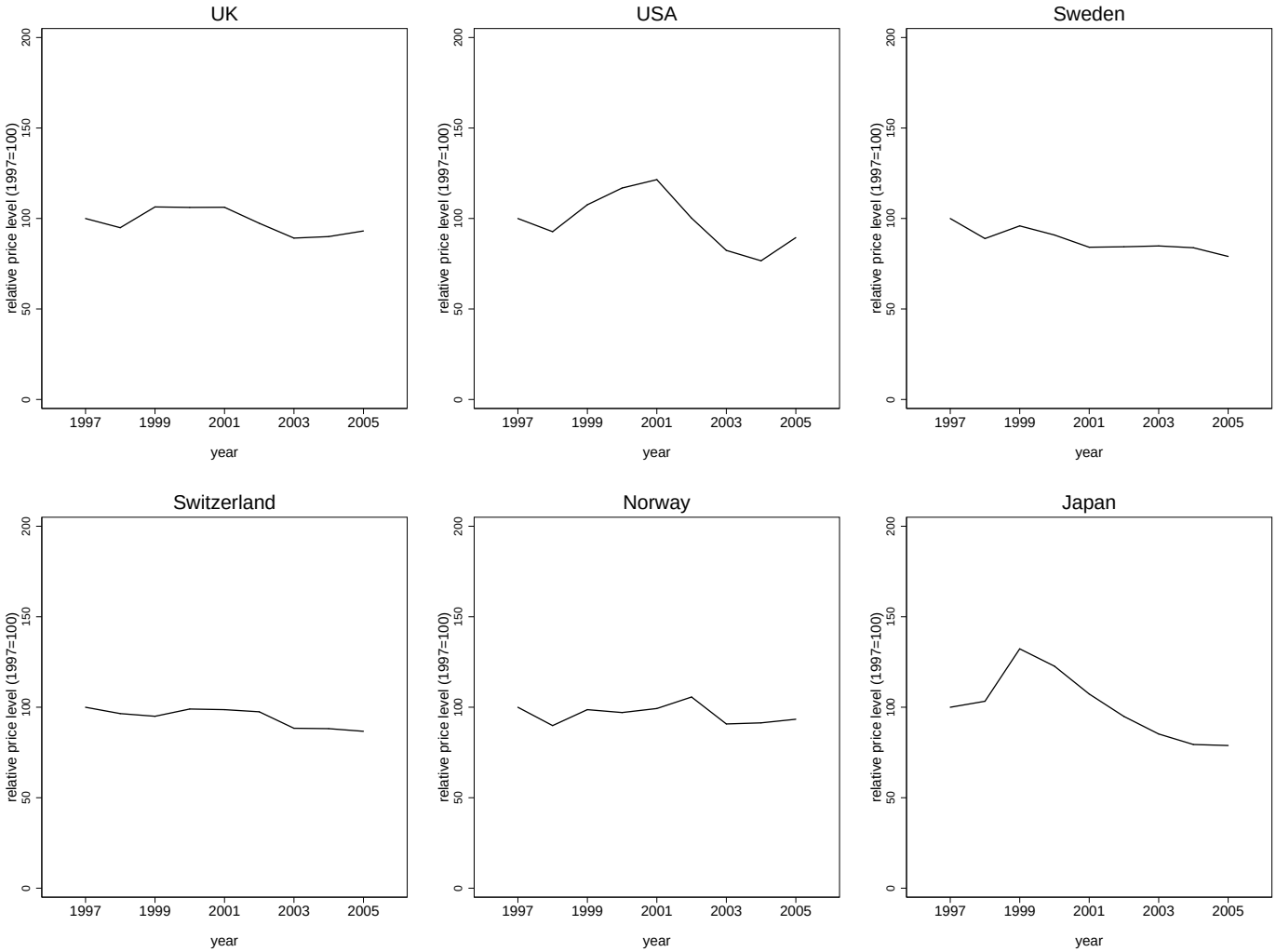
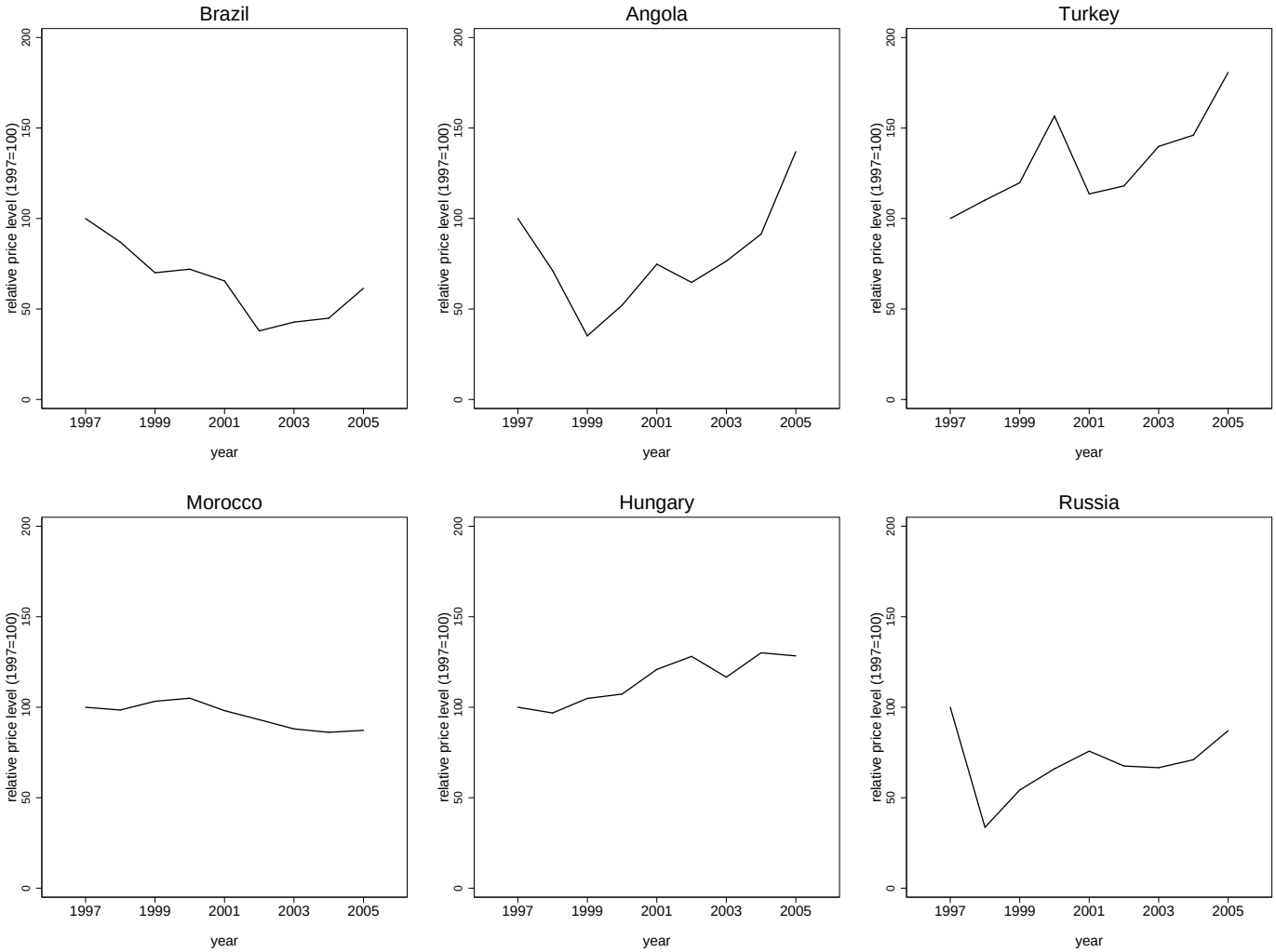
Figure A1. Relative Price Level, Selected Richer Export Destinations



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.