Endogenous Non-Tradability and International Prices*

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April 13, 2007

PRELIMIARY AND INCOMPLETE.

Abstract

Recent trade models emphasizing firm-level selection into exporting and endogenous non-tradability – typified by Melitz (2003) – make strong predictions regarding the behavior of traded goods prices. Specifically, they imply that as the productivity cutoff for exporting to a given market rises, the price of exports to that market should fall. This paper studies whether this mechanism helps us understand the behavior of export prices across destinations and source countries, as well as through time. The key innovation is to use disaggregated sector-level, bilateral data on participation in trading relationships to infer destination-specific export productivity cutoffs using model-based restrictions. We then study the joint behavior of sector-level prices and estimated thresholds across sectors and countries. Results suggest that the baseline model must be modified to include heterogeneous product quality both across countries and within sectors to rationalize the data.

*I am grateful to Pierre-Olivier Gourinchas for many productive (and on-going) discussions regarding this work. I also thank Marc Melitz for providing data on trade costs.

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Traded goods prices play a central role in both international trade and international macroeconomics. Prices provide important evidence on patterns of vertical specialization across countries and help differentiate between competing theories of trade. Prices also feature prominently in theories of the real exchange rate, economic growth, and external adjustment. Yet, canonical macroeconomic approaches to understanding these prices mostly ignore microeconomic theories of international trade, perhaps because traditional microeconomic trade theories provide only weak predictions regarding prices. In contrast, more recent work in both fields draws on new theories of international trade incorporating endogenous product variety, producer heterogeneity, fixed costs of exporting, and endogenous non-tradability to attempt to reinterpret traditional facts and puzzles regarding international prices, including the Balassa-Samuelson effect, the behavior of the terms of trade, and fluctuations in real exchange rates.

There are several channels via which these new trade theories – typified Melitz (2003) – make novel predictions regarding traded goods prices. First, endogenous product variety leads to a "home market effect" that may break the intuitive link between aggregate productivity-adjusted factor prices – and hence export prices – and the aggregate supply of home goods on world markets. Specifically, a country's export prices may rise following increases in relative supply of its goods when the home market effect is operative.[1] Second, and more important for this paper, fixed costs of exporting lead firms to select into exporting based on productivity, hence exporting firms will tend to have lower prices on average than non-exporting firms within disaggregated sectors. As a result, aggregate observed export prices will depend not only on productivity-adjusted wages, but also on the endogenous productivity-cutoff for exporting. This cutoff, in turn, will depend on access to foreign markets (including both variable and fixed costs of exporting), the size and competitiveness of those markets, and own country productivity-adjusted factor prices. In addition to these

[1]Redding and Venables (2004) point out that improvements in foreign market access has a similar effect even holding the number of firms fixed.

two channels emphasized in recent work, a third force – namely, variation in product quality (vertical differentiation) across countries and/or within sectors – provides a further reason why export prices may vary across countries and destinations.

That export prices do in fact vary across countries in seemingly systematic ways is largely uncontroversial. Schott (2004) and Hummels and Klenow (2005) document the stylized fact that export prices are positively correlated with source country variables such as income per capita, capital/skill intensity of production, and other factors.[2] However, these correlations alone are not enough to identify the underlying sources of variation. For example, while a richer countries may export at higher prices due to higher product quality or productivity-adjusted factor prices, they may also have higher unit value prices simply because they face lower fixed and variable costs of accessing foreign markets. These lower costs will translate into a lower productivity threshold for exporting and higher export prices. To properly decompose the sources of variation in export prices in the cross section or through time, one must account for this channel.[3]

With this in mind, this paper attempts to quantitatively assess the influence of endogenous non-tradability on international prices. In the empirical work, we exploit binary, sector-level data on participation in trading relationships to estimate thresholds for selection into exporting using a procedure suggested by Helpman, Melitz, and Rubinstein (2007). We then combine these estimates with bilateral, sector-level export prices to study the role of endogenous non-tradability in explaining variation in export prices for a given country across destination markets, multiple source countries to a given destination, and at the aggregated sector-level across countries.

[2]Whereas Schott points to large price differences for US imports across source countries within narrowly defined sectors, Hummels and Klenow focus on aggregated export prices on the intensive margin of international trade.

[3]This channel is featured prominently in recent work by Ghironi and Melitz (2005), among others, in studying aggregate tradable international prices. Though they highlight the implications of movements in the endogenous productivity cutoff for the relative price of non-traded to traded goods, in fact (as shown by Johnson (2006)), this channel plays a relatively minor role empirically in their paper.

We focus on documenting and explaining four main facts: (1) rich countries export at higher average prices than poor countries; (2) rich countries export at lower average export thresholds than do poor countries; (3) within a given sector, export prices for a given exporter across destinations are (roughly speaking) uncorrelated with the threshold at which it serves the market; (4) export prices to a common destination market are (roughly speaking) uncorrelated with the threshold at which exporters serve the market. While facts (1) and (2) seem to suggest that price and export thresholds may be causally related as in the model, fact (3) is inconsistent with the model. In addition, fact (4) implies that productivity adjusted wages must be higher in poor countries than rich countries to make sense of the data. The model predicts that just the opposite should be the case. In light of these conflicts, we argue that the model must be modified to include heterogeneous product quality both across countries and within sectors in order to rationalize the data. This extended framework is then capable of accounting for all four facts simultaneously.[4]

Previous empirical work on models with endogenous non-tradability has mostly been targeting at studying trade flows and export participation decisions. Recent papers have documented selection into exporting based on firm productivity, studied the response of trade flows and aggregate industry productivity following trade liberalization or other market access shocks, and attempted to match observed firm-level and aggregate export volumes and dynamics. Bernard, Jensen, Redding, and Schott (2006) provide a survey of a selection of this rapidly growing volume of work. Several other papers, including Ruhl (2005) and Alessandria and Choi (2007), have studied the effects of sunk export costs and hysteresis on trade dynamics.

In contrast to the substantial amount of evidence on the importance of endogenous non-tradability for participation in exporting and trade flows, relatively less work has been

[4]While the present work advances this point by appealing to correlations, future work will attempt to produce a more structural account of how these pieces fit together quantitatively, as well as consider alternative explanations.

dedicated to the price implications of these models. Melitz and Ghironi (2005), Bergin and Glick (2006), and Bergin, Glick, and Taylor (2006) study the behavior of the real exchange rate in a model with both endogenous non-tradability.[5] Atkeson and Burstein (2006) use a model with endogenous non-tradability, imperfect competition, and pricing to market to study short run fluctuations of cross-country consumer and producer prices. Importantly, virtually all of these contributions have focused primarily on calibration and simulation to study aggregate empirical predictions of this class of models. This paper is among the first to exploit disaggregated unit value price data to assess the empirical plausibility of the price predictions of these models.

Most closely related to this paper, contemporaneous independent work by Baldwin and Harrigan (2007) explores how one can use information contained in the incidence of export zeros and export prices in US bilateral data to distinguish between alternative models of international trade. In contrast to that paper, we use world trade flows to estimate productivity cutoffs based on a reduced form implied by a structural model and seek to explain the behavior of prices and selection rules across countries and markets. Also related to this paper is work in progress by Hallak and Sivadasan (2006) that incorporates endogenous quality choices into a Melitz style model of trade with minimum quality requirements for exporting in order to study microdata on the characteristics of exporting versus non-exporting firms. Unlike this complementary micro-based work on selection into exporting, our focus is primarily on studying the behavior of aggregated prices in a multi-sector, multi-country world.

The structure of the paper is as follows. To build intuition regarding the determinants of international prices in models with endogenous non-tradability, I begin by discussing a simplified one sector version of a multilateral Melitz-style model in Section One in which

[5] An important difference between these papers is that Melitz and Ghironi focus on an environment with endogenous variety, whereas the others do not. Corsetti, Martin, and Pesenti (forthcoming) also study international relative prices with endogenous variety, but in a model with traded goods only.

each country exports to all destination countries. In Section Two, I extend this multilateral framework to allow for multiple sectors and zero bilateral trade flows. In Section Three, I discuss how we can take the model to the data, implement the procedure, and discuss results. Section Four presents extensions of the baseline model that help us interpret the results.

1 A Simple Multi-Country Model

The basic setup of the one sector model follows Melitz (2003) and Ghironi and Melitz (2005) closely. As a result, I relegate details of the model to the appendix [**TO BE COMPLETED**].

To begin, we assume that there is one tradable sector (e.g., aggregate manufacturing) in each country comprised of a continuum of differentiated goods. Consumers have CES, Love-of-Variety preferences over these differentiated goods, with elasticity of substitution θ.[6] Preferences are identical across countries.

Each variety of the differentiated good is produced by an individual firm, and these firms are heterogeneous with respect to productivity. Specifically, after paying a sunk cost of entry, firms draw their individual productivity z from a Pareto distribution given by $G(z) = 1 - \left(\frac{z_{min}}{z}\right)^k$ with support $[z_{min}, \infty)$. For simplicity, assume this distribution is the same in all countries. Firms in country c then produce with marginal cost $\frac{w_c}{Z_c z}$ where Z_c is aggregate productivity and w_c is the price of one unit of the composite factor of production. Prices for each variety are then set as a constant markup $(\frac{\theta}{\theta-1})$ over this marginal cost.[7] In addition to the fixed entry cost and variable production cost, firms pay additional costs to export their output. In particular, they face both a fixed cost to enter each specific export

[6] Implicitly, we assume for now that consumers have identical "tastes" for each variety and that all varieties are of identical quality. These assumptions are to be partially relaxed later.

[7] Note that all firms that choose to enter and draw a productivity level actually produce ex post. Thus, the minimum productivity cutoff in the model is exogenous, unlike in Melitz (2003). This may be relaxed without changing the main implications of the model for export prices.

market and a variable iceberg trade cost to serve that market.[8] Specifically, for a firm from country c to export to country d it must pay a fixed cost equal to $\frac{w_c}{Z_c} f_{xcd}$ and must ship τ_{cd} units of the good for one unit to arrive in d. Firms then select into exporting to market d if they earn positive profits from exporting. For each market, there is then a bilateral productivity cutoff for exporting z_{xcd} that satisfies:

$$\pi_{xcd}(z_{xcd}) = \frac{1}{\theta} \left(\frac{p_{xcd}\tau_{cd}}{P_d} \right)^{1-\theta} E_d - \frac{w_c f_{xcd}}{Z_c} = 0, \tag{1}$$

where $p_{xcd} = \frac{\theta}{\theta-1} \frac{w_c}{Z_c z_{xcd}}$ is the fob export price of the marginal exporter to country d, and P_d, E_d are the destination country price level and expenditure.[9]

Because the productivity distribution is not bounded above, there will always be some firm with productivity high enough to ensure that it earns strictly positive profits from exporting. Therefore, in the aggregate, this simple model (counterfactually) implies that each country will export to all destinations.[10] Further, note that variation in the fixed costs of exporting across destinations implies that the productivity cutoff for exporting will also vary across destinations. This, in turn, gives rise to variation in export prices across markets for a given country. Using the zero profit condition for the marginal exporter, we can solve

[8] Note that the treatment of iceberg trade costs in this framework (though conventional in the literature) may require some discussion. In particular, while the trade cost drives a wedge between the price of the good in the home and foreign market, goods do not actually "melt away" as the iceberg analogy suggests. That is, the total value of goods is conserved. To extend the iceberg analogy, we suppose that the iceberg melts in transit so that the quantity of goods that arrive for consumption exceeds the quantity of goods that is shipped, but that the firm collects the water that melts off the iceberg in transit and charges the foreign consumer for this service. Thus, whereas the quantity of goods is diminished in transit, the volume (and value) of the total amount of water trapped in the iceberg leaving the home home country is preserved. Translated into more standard terms, this means the foreign consumer pays the firm directly for the cost of delivering the good to the foreign market.

[9] One assumption here worth noting is that I have assumed that costs of exporting depend on economy-wide productivity adjusted wages. Thus, sectoral variation in fixed costs of exporting comes entirely from variation in f_{cd}. This can be relaxed to allow sectoral productivity to influence the fixed cost of exporting, but ultimately this is isomorphic to variation in f_{cd} alone.

[10] While the unbounded productivity assumption is useful for the moment, the problems it generates are rectified in the following section.

for the fob equilibrium price of the marginal exporter to country d as:

$$p_{xcd} = \left[\frac{\theta w_c}{Z_c} \frac{f_{xcd}}{\tau_{cd}^{1-\theta} P_d^{\theta-1} E_d} \right]^{1/(1-\theta)} . \tag{2}$$

Put differently, the productivity cutoff for exporting to d is:

$$z_{xcd} = \frac{\theta}{\theta - 1} \left[\theta \left(\frac{w_c}{Z_c} \right)^{\theta} \frac{f_{xcd}}{\tau_{cd}^{1-\theta} P_d^{\theta-1} E_d} \right]^{1/(\theta-1)} \tag{3}$$

Then we see that the productivity cutoff is rising – and hence the equilibrium cutoff price is falling – in productivity adjusted factor prices, fixed costs of exporting, and iceberg trade costs. The cutoff is falling, and hence the price is rising, in the competitiveness of the destination market (which is a function of $P_d^{\theta-1}$)[11] and the size of the destination market (E_d).

In the data, we do not observe the export price of the marginal firm. Nor do we observe prices of individual firms, or even a "representative exporting firm" as defined in Melitz (2003). Rather, we observe aggregate unit values – aggregate values divided by aggregate quantities. Fortunately, we are able to construct aggregate unit values in the model.[12] To derive the unit value export price, we begin by defining fob prices and quantities for the representative exporter as $\tilde{p}_{xcd}$ and $\tilde{q}_{xcd}$.[13] Then, $\tilde{q}_{xcd}$ can be defined as aggregate exports

[11] $P_d^{\theta-1}$ is a measure of the competitiveness of the market in the sense that, for any given level of prices at which country c exports to country d, its market share is higher when $P_d^{\theta-1}$ is higher.

[12] Interestingly, they are proportional to the the prices of the "representative exporting firm" emphasized in the work of Melitz (2003) and Ghironi and Melitz (2005).

[13] For completeness, $\tilde{p}_{xcd} = \left(\frac{1}{1-G(z_{xcd})} \int_{z_{xcd}}^{\infty} p_{xcd}(z)^{1-\theta} dG(z) \right)^{1/(1-\theta)}$.

divided by $N_{xcd}\tilde{p}_{xcd}$. Using these definitions, we can write aggregate exports from c to d as:

$$\begin{aligned} EX_{cd} &= \int_{z_{xcd}}^{\infty} p_{xcd}(z)\tau_{cd} q_{xcd}(z) N dG(z) \\ &= N_{xcd}\tilde{p}_{xcd}\tau_{cd}\tilde{q}_{xcd} \\ &= N_{xcd}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c\tilde{z}_{xcd}}\tau_{cd}\right)^{1-\theta} P_d^{\theta-1}E_d, \end{aligned} \tag{4}$$

where N_{xcd} is the number of exporting firms and $\tilde{z}_{xcd} = \left(\frac{k}{k-(\theta-1)}\right)^{1/(\theta-1)} z_{xcd}$ is the productivity of the "representative exporting firm."

Further, define the aggregate quantity of exports as:

$$\begin{aligned} Q_{cd} &= \int_{z_{xcd}}^{\infty} q_{xcd}(z) N dG(z) \\ &= N_{xcd}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c\bar{z}_{xcd}}\tau_{cd}\right)^{-\theta} P_d^{\theta-1}E_d, \end{aligned} \tag{5}$$

where $q_{xcd}(z)$ is the demand in market d for output from a firm with productivity z and $\bar{z}_{xcd} = \left(\frac{k}{k-\theta}\right)^{1/\theta} z_x$ is the productivity of the "average exporter" – namely, a hypothetical firm that exports the average quantity of goods (total quantity divided by the number of firms).

Then defining the fob unit value export price as $\bar{p}_{xcd} = \frac{EX_{cd}}{\tau_{cd}Q_{cd}}$, we combine the previous results to show that:

$$\begin{aligned} \bar{p}_{xcd} = \frac{EX_{cd}}{\tau_{cd}Q_{cd}} &= \frac{N_{xcd}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c\tilde{z}_{xcd}}\tau_{cd}\right)^{1-\theta} P_d^{\theta-1}E_d}{N_{xcd}\tau_{cd}^{1-\theta}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c\bar{z}_{xcd}}\right)^{-\theta} P_d^{\theta-1}E_d} \\ &= \frac{\tilde{z}_{xcd}^{\theta-1}}{\bar{z}_{xcd}^{\theta}} = \frac{k-\theta}{k-(\theta-1)}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c z_{xcd}}\right). \end{aligned} \tag{6}$$

And note that $\frac{k-\theta}{k-(\theta-1)} < 1$ naturally implies that the average export price lies below the export price of the marginal firm.[14]

Looking at disaggregated export prices within a sector across destination markets provides insight into possible sources of variation in the data. The relative unit value export price of country c to markets d and d' is a function of the productivity cutoffs alone:

$$\frac{\bar{p}_{xcd}}{\bar{p}_{xcd'}} = \left(\frac{z_{xcd'}}{z_{xcd}}\right) \tag{7}$$

Thus, in this simple model, data on relative export prices across destination markets allows one to directly infer relative export productivity cutoffs. Moreover, these relative cutoffs are determined at a fundamental level by relative trade costs (both fixed and variable) and relative partner market size and competitiveness:

$$\frac{z_{xcd}}{z_{xcd'}} = \left[\frac{f_{xcd}}{f_{xcd'}}\frac{\tau_{cd'}^{1-\theta}P_{d'}^{\theta-1}E_{d'}}{\tau_{cd}^{1-\theta}P_{d}^{\theta-1}E_{d}}\right]^{1/(\theta-1)}. \tag{8}$$

Next, consider the price at which country c exports to a given destination d relative to the price at which another country c exports to the same destination. This price is given by:

$$\frac{\bar{p}_{xcd}}{\bar{p}_{xc'd}} = \left(\frac{w_c/Z_c}{w_{c'}/Z_{c'}}\right)\left(\frac{z_{xc'd}}{z_{xcd}}\right). \tag{9}$$

Thus, we can decompose this price into a term accounting for differences in the relative productivity adjusted wage between two countries and a term due to differences in the productivity cutoff across countries.

Then, to aggregate up to sector level unit value export prices (denoted by a double bar) across destination countries, simply take a quantity-weighted average of these prices

[14] To interpret this result, denote the export quantity of the average exporter as $\bar{q}_{xcd}$. Note that by construction: $EX_{cd} = N_{xcd}\tilde{p}_{xcd}\tilde{q}_{xcd} = N_{xcd}\bar{p}_{xcd}\bar{q}_{xcd}$, so that $\bar{p}_{xcd} = \tilde{p}_{xcd}\left(\frac{\tilde{q}_{xcd}}{\bar{q}_{xcd}}\right)$. Hence, the unit value price is proportional to the export price of the "representative firm", where the constant of proportionality reflects differences in the quantity exported by the "average firm" and the "representative firm."

using quantity shares $\delta_d = \frac{q_{xcd}}{Q_{cd}}$ as weights.

$$\begin{aligned} \bar{\bar{p}}_{xi}(c) &= \sum_d \delta_d \bar{p}_{xcd} \\ &= \frac{k-\theta)}{k-(\theta-1)} \left(\frac{\theta}{\theta-1} \frac{w_c}{Z_c} \right) \sum_d \delta_d z_{xcd}^{-1} \end{aligned} \tag{10}$$

Then, comparing aggregate prices across countries c and c' we see that:[15]

$$\frac{\bar{\bar{p}}_{xi}(c)}{\bar{\bar{p}}_{xi}(c')} = \frac{w_c/Z_c}{w_{c'}/Z_{c'}} \frac{\sum_d \delta_d z_{xcd}^{-1}}{\sum_d \delta_d z_{xc'd}^{-1}}. \tag{11}$$

There are now three principal sources of variation in aggregate prices: (1) differences in productivity adjusted factor prices; (2) differences in productivity cutoffs to common markets; and (3) differences the set of countries to which each country exports.[16] To isolate the role of productivity adjusted wages in explaining factor prices, one would need to remove the effects of variation in z_{xcd} across countries and destinations, as well as harmonize the set of export destinations across countries.

Unfortunately, it is not possible to use the trade data alone to learn about the role of factor prices versus productivity in price movements – i.e., to separate $\frac{w_c}{w_{c'}}$ from $\frac{Z_{c'}}{Z_c}$ for each country pair. However, one can get a flavor of the determinants of wage differences from a theoretical perspective by looking at the sector-level aggregate output-income identity. [**DETAILS TO BE ADDED.**] This serves to build intuition about how productivity adjusted wages vary in the model that will be useful for qualitatively interpreting later empirical results. For a sector with in which some firms export, one can combine a labor

[15] Note that this comparison assumes that parameters θ and k are identical across countries.

[16] Of course, this third channel is weak in this artificial setting in which each country exports to all destinations, but it is still operative. Namely, even though each country exports to all possible destinations, countries do not export to themselves. In the more general model specified in the following section, this channel is relatively more important as endogenous zeros in the trade data will in general lead the set of countries over which the weighted average cutoffs are constructed to vary.

market clearing condition and an expected zero profit condition for firm entry to show:

$$w_c L_c = N_c p_c(\tilde{z}_c) q_c(\tilde{z}_c) + \sum_d N_{xcd} p_{xcd}(\tilde{z}_{xcd}) \tau_{cd} q_{xcd}(\tilde{z}_{xcd}), \tag{12}$$

where $\tilde{z}_c$ is productivity of the "representative firm" in the economy as a whole and $\tilde{z}_{xcd}$ is productivity of the "representative firm" exporting to country d. This equation simply says that total payments to factors employed equal total firm revenue from domestic and foreign sales. Then, one can manipulate this condition using familiar facts from other parts of the model to show that:

$$\begin{aligned} w_c = {} & \left(\frac{\theta-1}{\theta}\right)^{1/\theta} \left(\frac{N_c}{L_c}\right)^{1/\theta} (Z_c \tilde{z}_c)^{(\theta-1)/\theta} \\ & \times \left[P_c^{\theta-1} E_c + \sum_d (1 - G(z_{xcd})) \left(\frac{\tilde{z}_c}{\tilde{z}_{xcd}}\right)^{1-\theta} \tau_{cd}^{1-\theta} P_d^{\theta-1} E_d \right]^{1/\theta}. \end{aligned} \tag{13}$$

This expression (while somewhat unwieldy) provides intuition about how wages depend on the number of firms in the economy, productivity, home market size, access to foreign markets, productivity cutoffs, etc. Of course, this intuition is only partial, because many of these factors are *endogenous*. Yet, under general conditions, productivity adjusted wages $\frac{w_c}{Z_c}$ will be on net increasing with Z_c. The key intuition for this result is that an increase in productivity Z_c triggers the entry of new firms. This induces upward pressure on wages in the labor market. In fact, wages rise *more than* productivity. Thus, to the extent that productivity differences are an important source of income differences across countries, we would expect the productivity adjusted wage to be higher in rich countries.[17]

[17]For a proof of these propositions, see Johnson (2006) or Corsetti, Martin, and Pesenti (forthcoming).

2 A Multi-Sector, Multi-Country Model

In laying out the simple model above to build intuition, I have completely ignored several prominent features of the data: (1) as a practical matter, the units in which quantities are measured varies across sectors in actual trade data, (2) in some countries, entire sectors are non-traded; (3) within sectors with positive exports, countries typically export to only a subset of available markets. Following Helpman, Melitz, and Rubinstein (2007), we extend the simple model to include multiple sectors with bounded productivity in each sector allows us to capture these features.[18] Not only is this extended framework useful from an accounting perspective, but more importantly, as argued by Helpman et al., zeros are prominent features of the data that encode potentially useful information about fixed costs of international trade that help us estimate the model.

We now amend the basic structure of the model in Section One and assume that firms now draw productivity levels in each sector from a truncated Pareto distribution. Specifically, assume the CDF and PDF of the productivity distribution in each country c and sector i is now given by:

$$G_{ic}(z) = \frac{z^{-k} - z_{Lic}^{-k}}{z_{Hic}^{-k} - z_{Lic}^{-k}} \tag{14}$$

$$g_{ic}(z) = \frac{kz^{-k-1}}{z_{Lic}^{-k} - z_{Hic}^{-k}}, \tag{15}$$

with support $z \in [z_{Lic}, z_{Hic}]$. Note that this specification allows the bounds of the productivity distribution to be both country and sector specific. Productivity of an individual firm in sector i is then given as before by $Z_c z$, where z is drawn from $G_{ic}(z)$. In this specification,

[18] Extensions of the model on the consumer side are mostly not important for studying prices in the current framework, as differences in preferences across countries do not translate into differences in prices in the CES-monopolistic competition framework. The one exception to this statement would be if we allow the elasticity of substitution to vary across countries. Possible extensions of the model to allow for product quality differences and preferences for quality would reinstate a non-markup related link between preferences and prices, however.

we omit sector specific aggregate productivity levels becase variation in these is isomorphic to variation in the sector specific bounds.

With this specification, it is now possible for no firms in a given sector to export to a given destination. This occurs when the threshold productivity for exporting z_{xcd} in a sector exceed the upper bound of the productivity distribution. This is intuitive: when the most productive firm in a sector is unable to earn positive profits from exporting, then no firm exports.[19] Moreover, we need to modify the formulas for export prices from the previous section.

[SKIPPING DETAILS]

The unit value export price in sector i to country d is now:

$$\bar{p}_{xicd} = \frac{\theta_i}{\theta_i - 1} \frac{w_c}{Z_c z_{Hic}} \left(\frac{k_i - \theta_i}{k_i - (\theta_i - 1)} \right) \left(\frac{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i - k_i - 1} - 1}{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i - k_i} - 1} \right), \tag{16}$$

where θ_i and k_i are now sector specific (but common across countries). Thus, the unit price depends on both the level of the export productivity cutoff and the sector specific maximum level of productivity. Further note that within sectors, the relative price across destinations d and d' is a function of the ratios of the productivity cutoffs to maximum productivity:

$$\frac{\bar{p}_{xicd}}{\bar{p}_{xicd'}} = \left(\frac{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i - k_i - 1} - 1}{\left(\frac{z_{xicd'}}{z_{Hic}}\right)^{\theta_i - k_i - 1} - 1} \right) \left(\frac{\left(\frac{z_{xicd'}}{z_{Hic}}\right)^{\theta_i - k_i} - 1}{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i - k_i} - 1} \right). \tag{17}$$

And the productivity cutoff in a given sector relative to maximum productivity can be

[19] In the analysis below, I follow Helpman, Melitz, and Rubinstein (2007) and choose to ignore the case in which all firms in any given sector export to a given market. In principle this is possible and greatly complicates the analysis, but in practice is is highly unlikely given pervasive evidence that only a small minority of firms engage in exporting.

written as:

$$\frac{z_{xicd}}{z_{Hic}} = \frac{\theta_i}{\theta_i - 1}\frac{1}{z_{Hic}}\left[\theta_i\left(\frac{w_c}{Z_c}\right)^{\theta_i}\frac{f_{xicd}}{\tau_{icd}^{1-\theta}P_{id}^{\theta_i-1}E_{id}}\right]^{1/(\theta_i-1)} \tag{18}$$

Then, relative productivity cutoffs across destinations within a sector behave as in the simple model [Equation (8)].

Looking at export prices for countries c and c' to common market d, we get an analog to Equation (9):

$$\frac{\bar{p}_{xicd}}{\bar{p}_{xic'd}} = \frac{w_c}{w_{c'}}\frac{Z_{c'}z_{Hic'}}{Z_c z_{Hic}}\left(\frac{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i-k_i-1}-1}{\left(\frac{z_{xicd}}{z_{Hic}}\right)^{\theta_i-k_i}-1}\right)\left(\frac{\left(\frac{z_{xic'd}}{z_{Hic'}}\right)^{\theta_i-k_i}-1}{\left(\frac{z_{xic'd}}{z_{Hic'}}\right)^{\theta_i-k_i-1}-1}\right). \tag{19}$$

Furthermore, we can aggregate up bilateral export prices to the sector level as in the simple model. In comparing prices across countries, however, we need to recognize that bounded productivities and variation in market access will mean that countries will in general export to different sets of countries. Therefore, we need to be careful both in computing and interpreting aggregated sectoral prices.

3 Export Cutoffs and Prices Around the World

Building on the model in Section 2, the objective of this section is to: (1) to estimate cutoffs ($\frac{z_{xicd}}{z_{Hic}}$) for a wide range of countries and destination markets using world sector level data on participation in bilateral trade and relative prices; (2) study whether prices across destinations for a given exporter, across source countries for a given importer, and across countries within sectors respond to variation in these estimated cutoffs as in the model.

3.1 Estimation Procedure

Helpman, Melitz, and Rubinstein (2007) outline a method that exploits variation in the set of bilateral trading partners to estimate a latent variable that can be used to predict export productivity cutoffs. The key insight in this approach is that the productivity cutoff $\frac{z_{xicd}}{z_{Hic}}$ is a monotone function of the ratio of the profits of the most productive firm relative to the fixed costs of exporting. To see this, we follow Helpman et al. and define this ratio as:

$$\alpha_{icd} = \frac{\frac{1}{\theta_i}\left(\frac{\theta}{\theta-1}\frac{w_c}{Z_c z_{Hic}}\tau_{icd}\right)^{1-\theta_i} P_{di}^{\theta_i-1}E_{di}}{\frac{w_c}{Z_c}f_{xicd}} \tag{20}$$

Combined with the fact that the same ratio of profits to fixed costs for the marginal exporter equals 1, it is straightforward to show that:

$$\frac{z_{xicd}}{z_{Hic}} = \alpha_{icd}^{1/(1-\theta_i)}. \tag{21}$$

This implies that the formulas for relative export prices across markets can be rewritten in terms of α_{icd}. This is unhelpful to the extent that we do not observe α_{icd} directly. However, we do observe whether two countries engage in bilateral trade. Specifically, two countries trade with one another if and only if $\alpha_{icd} > 1$. Then, define a new indicator variable that takes on a value of one when we observe exports from c to d:

$$T_{icd} = \mathbf{1}(\alpha_{icd} > 1) = \mathbf{1}(log(\alpha_{icd}) > 0) \tag{22}$$

Then taking logs of both sides of the expression for α_{icd} yields:

$$\begin{aligned}\log(\alpha_{icd}) = \log\left(\frac{1}{\theta_i}\right) + (1-\theta_i)\log\left(\frac{\theta_i}{\theta_i-1}\right) - \theta_i\log\left(\frac{w_c}{Z_c}\right) - (1-\theta_i)\log(z_{Hic}) \\ + (1-\theta_i)\log\left((\tau_{icd}\right) + \log\left(P_{di}^{\theta-1}E_{di}\right) - \log(f_{xicd}).\end{aligned} \tag{23}$$

Then parameterize the bilateral variable and fixed costs such that:

$$(\theta_i - 1)\log(\tau_{icd}) = \gamma D_{icd} + u_{icd} \tag{24}$$

$$\log(f_{xicd}) = \phi_{ic} + \xi_{id} + \kappa_i \vartheta_{cd} + \epsilon_{icd}, \tag{25}$$

where D_{icd} and ϑ_{cd} are multidimensional, possibly overlapping sets of observable proxies for bilateral fixed and variable trade costs (e.g., distance, common language, etc.), u_{cd} reflects random unobserved variation in variable trade costs, ϵ_{icd} reflects random unobserved variation in fixed trade costs, and ϕ_{ic}, ξ_{id} are exporter and importer fixed effects. Note that we place no restrictions on the correlation of u_{icd} and ϵ_{icd}. Then, subbing this parameterization back into the expression for $\log(\alpha_{icd})$ we arrive at a reduced form:

$$\log(\alpha_{icd}) = \beta_0 + \beta_{ic} + \beta_{id} - \gamma_i D_{cd} - \kappa_i \vartheta_{cd} - \eta_{icd}, \tag{26}$$

with $\eta_{icd} = u_{icd} + \epsilon_{icd}$. Then substituting into a new indicator variable that takes on a value of one when we observe exports from c to d:

$$\begin{aligned} T_{icd} &= \mathbf{1}(log(\alpha_{icd}) > 0) \\ &= \mathbf{1}(\eta_{icd} < \beta_0 + \beta_{ic} + \beta_{id} - \gamma_i D_{cd} - \kappa_i \gamma_{cd}). \end{aligned} \tag{27}$$

Further, we know that:

$$\mathbf{E}[T_{icd}] = \mathbf{Pr}\{T_{icd} = 1\} = \mathbf{Pr}\{\eta_{icd} < \beta_0 + \beta_{ic} + \beta_{id} - \gamma_i D_{cd} - \kappa_i \gamma_{cd}\} \tag{28}$$

Making an assumption regarding the distribution of the error then allows us to estimate the (normalized) coefficients.[20] For example, assuming that the underlying errors u_{icd} and ϵ_{icd}

[20]Though I proceed by assuming normally distributed errors, one could easily substitute other standard distributions (with the leading alternative obviously being the logistic distribution).

are distributed normally with mean zero, then η_{icd} is distributed $N(0, \sigma_\eta^2)$ with $\sigma_\eta^2 = \sigma_u^2 + \sigma_\epsilon^2$. Then we can write:

$$\mathbf{Pr}\{T_{icd} = 1\} = \mathbf{\Phi}(\beta_0^* + \beta_{ic}^* + \beta_{id}^* - \gamma_i^* D_{cd} - \kappa_i^* \gamma_{cd}) \equiv \rho_{icd}, \tag{29}$$

where x^* indicates that that x has been divided by $\sigma_u^2 + \sigma_\epsilon^2$ so that η_{icd}^* has unit variance. Then we can estimate the set of normalized coefficients and predict $\hat{\rho}_{icd}$. Inverting the distribution then yields $\hat{\alpha}_{icd} = \exp\{\sigma_\eta \mathbf{\Phi}^{-1}(\hat{\rho}_{cd})\}$. Obviously, we do not know σ_η so we cannot estimate the level of the productivity cutoff directly. Furthermore, to translate these cutoff levels into absolute price differences, we also need estimates of θ_i and k_i. Even without these additional parameters, however, we are able to make meaningful statements about the model by characterizing the correlation between relative export productivity cutoffs and export prices across countries and markets.

To perform this analysis, we focus on the object $\hat{\alpha}_{icd}^* = \exp\{\mathbf{\Phi}^{-1}(\hat{\rho}_{cd})\}$ that we obtain by fitting a Probit as discussed above within each sector. For ease of interpretation, we then assign a value for θ_i and transform this object to generate a "normalized productivity cutoff" defined as: $\widetilde{\frac{z_{xicd}}{z_{Hic}}} = (\hat{\alpha}_{icd}^*)^{1/(1-\theta_i)}$. We can think of the resulting estimates as "normalized" in the sense that it sets $\sigma_\eta = 1$ and $\theta_i = 6$ across all sectors. While this approach is somewhat ad hoc, we stress that the sign of the correlation between prices and the "normalized productivity cutoffs" is invariant to both the normalization and the choice of θ. Moreover, because we assume θ_i and σ_η are constant across countries, we can also characterize the relative levels of the cutoffs across countries.[21]

[21]In future work, we could envision using Broda-Weinstein estimated elasticities to improve the accuracy of the levels and dispersion of estimated cutoffs across sectors.

3.2 Data and Implementation Details

We now turn to implementing this procedure in sector-level world trade data. The main body of data on world trade at the SITC 4-digit level of disaggregation has been compiled by Robert Feenstra and Robert Lipsey and is available from the NBER and the Center for International Data at UC Davis. Because data for the United States in the Feenstra-Lipsey data is less reliable and comprehensive than US-sourced data, I also use United States trade value and quantity data compiled Robert Feenstra, John Romalis, and Peter Schott.[22] Because US-sourced trade data is reported in different quantity units than the international trade data, we must be careful in how we combine the two sources of data. Since estimating the productivity cutoffs requires information on participation in bilateral trade only, we are able to merge US source data with the international data. In analyzing prices, we work with the US and rest-of-the-world trade data separately.[23] In addition to this data, we use data on proxies for bilateral trade costs as compiled by Helpman et al. (2007). These include measures of distance between capital cities and dummies for a common border, past colonial relationship, common legal origin, and common religion. The final estimation sample includes 118 countries (listed in Table 1) for which we have data on trade, prices, and trade costs.[24] In analyzing prices and cutoffs, we also employ data on real GDP per capita and population across countries from the Penn World Tables (Version 6.1).[25]

[22]The Feenstra-Lipsey data includes quantity information for the years 1984-2000. Data for the US is available for 1973-2001. Though the analysis below focuses on one year, future work will extend the analysis to additional time periods. We may also consider obtaining COMTRADE data available at the higher HS 6-digit level of disaggregation.

[23]Whereas quantities/prices are available for nearly all US trade, quantity data is somewhat patchier in the Feenstra-Lipsey data. Missing data appears to be due principally to quasi-random reporting gaps and does not follow obvious systematic patterns. Most countries have prices for upwards of 80-90% of exports. By construction, every country included in the estimation sample has observed prices for at least 60% of manufacturing exports (not including exports to the US).

[24]It should also be noted that the former communist countries in Central and Eastern Europe are under-represented in the sample because many of them fragment into sub-units in the sample and they are missing trade cost data.

[25]Data from the Penn World Tables is not available for a relatively small number of countries in the estimation sample.

Before moving on to results, we pause to discuss some additional details of the estimation procedure. We begin by aggregating trade flows for an arbitrary year (1996) at the SITC 3-Digit level of disaggregation for manufacturing trade (SITC Categories 511-899, exactly 150 sectors).[26] Even at this level of aggregation, most countries export in only a subset of possible sectors to a limited number of destination markets. For example, Figure 1 plots the number of countries that have zero aggregate exports by 3-digit sector. This number ranges mostly between 20-80 depending on the sector, and seems to decrease as we move up in the SITC nomenclature. Importantly, Figures 2 and 3 illustrate that the incidence of zeros seems to vary systematically with country characteristics (here proxied by exporter GDP per capita). Figure 2 plots the fraction of SITC 3-digit categories in which each country exports versus the exporter's GDP per capita. Figure 3 then plots the log of the mean number of destination markets per SITC 3-digit good versus exporter GDP per capita.[27] Clearly, not only do wealthier countries tend to export in a larger number of categories, but they also tend to export to a larger number of destinations within each category. These stylized patterns are important inputs to the estimation procedure.

To explicitly estimate the productivity cutoffs, we run a Probit regression within each of the 150 3-Digit sectors, predict the probability of bilateral trade between each pair of countries ($\hat{\rho}_{icd}$), and use this to construct the normalized cutoff. As motivated by the theory, the Probit regression includes exporter and importer fixed effects, along with proxies for trade costs such as log distance and dummies for a common border, past colonial relationship, common legal origin, common religion, existence of a free trade agreement between the partners, common currency, and common language.[28] We then merge the predicted export

[26]Future work may present results at the 4-digit level of disaggregation and for non-manufacturing sectors. Main results are not sensitive to the level of aggregation.

[27]This mean is calculated over all goods, including categories in which the country does not export. We get a similar figure if we plot the mean number of destinations calculated over categories in which the country has positive exports.

[28]In general, predicted probabilities of trade are not very sensitive to exactly which trade cost proxies are included in the regression. Though we may increase the number of proxies in future work, results are likely to be unchanged.

thresholds with data on unit value export prices by exporter, destination market, and sector separately for the US and the rest of the world.[29] To make the analysis internally consistent, we drop observations for which the Probit predicts no trade (i.e., a cutoff productivity greater than the maximum in the sector).[30]

Turning to discuss results of this procedure, Table 2 includes select results from the first stage probit regression for eight representative sectors. We naturally omit from the table estimates for the 200+ coefficients on the exporter and importer fixed effects. Suffice it to say that the vast majority of these coefficients are significantly different from zero and that they account for significant portion of the variation in the data. The probability of trade between two countries is strongly and robustly decreasing in the distance between them. The probability of trade also tends to increase if the countries share a common border, colonial history, common language, common legal system, or free trade agreement. The effect of shared currency and/or religious composition has both significant positive and negative effects depending on the sector.

In addition to evaluating the plausibility of the estimated Probit coefficients, we might as well ask whether the resulting predicted cutoffs behave in sensible, theoretically consistent ways. In particular, the theory predicts foreign market size will be a crucial determinant of the cutoff for exporting to a given market. Is this true in the data? The answer is yes. Figures 4 and 5 plot the trade-share weighted average export threshold for the US against two proxies for foreign market size – log GDP per capita and log population of the destination market. As one might think, the threshold is decreasing in both the average income and the

[29]In some 3-Digit Sectors, trade is reported in multiple units across different partners. We calculate prices separately for each of these different units, and assign them the corresponding bilateral estimated productivity cutoff corresponding. Further, it should be noted that prices in the data are a mixture of CIF and FOB prices due to the way the data are compiled. Though this is issue is not of first order importance, we will attempt to adjust CIF prices to CIF prices by purging them of transport costs (estimated as a function of distance off of US bilateral trade) in future work.

[30]The first stage Probit predicts no trade in about a quarter of observed trading relationships. This is of course due to the fact that there is an unobserved error in the specification of fixed and variable trade costs. In practice, none of the results presented below are modified if we include observations for which trade is counterfactually predicted to be zero.

population of the foreign market. In addition, these unconditional correlations hold up if we control for determinants of trade costs.[31]

3.3 Export Prices and Thresholds for Exporting

We now proceed to document the “four stylized facts” identified in the introduction.

Fact 1: Rich countries export at higher average prices than poor countries.

Fact (1) is illustrated visually in Figure 6 which plots the log of the trade-share weighted average export price for each exporter against the log of the exporter's GDP per capita in four representative sectors.[32] Regression lines are inserted into the figure (as in all figures) when the slope is significantly different from zero at the 10% level or higher. In three of four sectors, export prices are clearly increasing in exporter GDP per capita. Not surpringly, this relationship holds outside these sectors as well. To illustrate this, I run a series of within-sector regressions of log average export price on log exporter GDP per capita. Further, because many sectors include only a small number of observations, I report results only for sectors that have a minimum number of observations, with thresholds set at 15, 35, and 55 observations. Table 1 contains summary statistics for the resulting collection of coefficients. In Panel 1, we see that the estimated coefficients are positive in 90+% of cases, and significantly positive in upwards of 70% of sectors. For comparision purposes, I show in the second panel that this result holds as well for US imports across sources within a given sector. These results are reminiscent of results in Schott (2004) and Hummels and Klenow (2005).

[31] To show this, I regress the average cutoff to each destination on log GDP per capita and log population along with the proxies for trade costs used previously. Details on request.

[32] It is important to note here, I change nomenclature when referring to a “sector.” Here a “sector” denotes a SITC 3-Digit good with homogeneous units. Thus, where trade at the 3-Digit is reported in multiple units, I break this 3-Digit category into multiple “sectors” with homogeneous units within each sector.

Fact 2: Rich countries export at lower average export thresholds than do poor countries.

We document this fact in a similar manner. Figure 7 plots the trade-share weighted average export cutoff for each exporter against the log of the exporter's GDP per capita in the same four sectors. In all four cases, export thresholds are negatively correlated with GDP per capita. Turning to US data, Figure 8 plots the weighted average of export cutoffs for exports in all sectors to the United States against the GDP per capita of the exporter. To account for the fact that countries do not export to the US in all sectors and that the within sector distribution may not have the same location across sectors, we calculate average export cutoffs by normalizing each country's within-sector cutoff against the weighted average cutoff in that sector. Specifically, defining $\bar{z}_{xc,us}$ to be the average cutoff for country c, we calculate:

$$\bar{z}_{xc,us} = \sum_{i \in I_{c,us}} w_{ic,us} \left(\frac{z_{xic,us}/z_{Hic}}{\bar{z}_{x,us}} \right),$$

where $\bar{z}_{x,us}$ is the trade-weighted average cutoff in the sector and $I_{c,us}$ is the set of sectors in which country c exports to the US. Thus, each country is implicitly compared only to other countries that export in the sectors in which it exports as well as only over the actual goods it exports.

In Figure 8, these average cutoffs are depicted along with a non-linear trend line generated via locally weighted polynomial regression (a.k.a. "lowess"). While the relationship seems to be non-linear, it is clearly downward sloping. Interestingly, one's visual first impression of the graph understates the strength of this correlation due to a small number of countries in the upper right quadrant. The identities of these countries – including Kuwait, Qatar, Iceland, Bahrain – are informative. They are all countries that could plausibly have quite high thresholds for serving the US market in manufacturing sectors due to geographic features or structural economic characteristics (e.g. oil-induced "Dutch disease" effects). To emphasize that this result is robust to disaggregating the data, Figure 9 plots this same relationship calculated separately for each SITC 1-Digit sector. The strong negative correlation is present in these more disaggregated sectors as well.

Just to pile on, we proceed to study within-sector regressions of log average export price on log exporter GDP per capita. In Table 1, the right portion of Panel 1 illustrates that the average sector-level export cutoff is negatively correlated (significantly so) in most sectors, and nearly all of sectors with more than 35 exporting countries in the sample. The same holds true for exporters to the US as demonstrated in the bottom panel.

If we put facts (1) and (2) together, it appears we are well on our way toward demonstrating that richer countries have both higher export prices and lower productivity cutoffs – exactly what the Melitz model predicts![33] Put differently, these facts suggest that Melitz-style endogenous non-tradability might be an important determinant of international prices. Digging deeper and proceeding to Facts (3) and (4), we realize that it is premature to jump to this conclusion. Specifically, if prices and cutoffs are causally linked to one another, then we should also observe that export prices and cutoffs are negatively correlated for a given exporter. Yet, generally speaking, this is untrue.

Fact 3: For a given exporter in a given sector, export prices across destinations are not decreasing in the export threshold. If anything, they are weakly increasing in the threshold.

Figure 10 illustrates the main result. In the figure, we plot export prices versus estimated export cutoffs by destination market for the UK and South Korea in SITC sector 781.[34] Two features stand out. First, the UK exports at uniformly higher prices (with a

[33] Obviously, the natural next figure to present would be one with log mean price by exporter versus the mean productivity cutoff. This figure is difficult to interpret, however, as average relative prices are determined by cutoffs, relative productivity-adjusted wages, and differences in the set of export destinations over which the average is taken.

[34] Note this should not be interpreted as comparing the UK versus Korean prices to markets that they both serve. Rather, they serve some markets in common and some independently. The figure plots both cases.

few exceptions) to all destinations than does Korea. Second, prices do not obviously covary with the estimated normalized export productivity cutoff.

Figures 11 and 12 reinforce and amplify these points in different ways. Figure 11 constructs similar plots for the UK versus other countries in the same sector to illustrate that this feature of the data is quite general. Note as well the fact that German and UK prices are relatively similar, in contrast with the UK versus the other lower income countries. Moreover, they seem to be both increasing, whereas China's prices are obviously decreasing. Moving to US data, Figure 12 constructs plots of US export prices versus predicted cutoffs within four representative sectors. These four sectors exhibit rather different behavior. In two sectors, there is no statistically significant relationship between normalized cutoffs and log export prices. The other two sectors display contrasting strong positive and weak negative correlations.

As before, these select results generalize to the sample as a whole. Table 2 contains summary statistics for within-exporter, within-sector regressions of log export price to a destination on the export productivity cutoff to that destination. The slight majority of coefficients are positive in both the US and non-US data, and there are many more significant positive coefficients than significant negative coefficients. Nonetheless, there are a substantial number of sectors in which the price is decreasing in the threshold.

This third stylized fact presents a serious problem for trying to interpret facts (1) and (2) in favor of productivity-based selection into exporting that is operative in the benchmark model. In fact, the within exporter correlation between export cutoffs and prices is *the key* prediction of the model that is properly identified. Thus, fact (3) is a serious blow to the standard theory. Fact (4) highlights another inconsistency between the simple model and the data.

Fact 4: Export prices to a common destination market are not strongly decreasing in the threshold at which exporters serve the market.

Table 3 again summarizes a sequence of results, this time for within-importer, within-sector regressions of the log export price of source countries on their export cutoffs. This provides evidence on the partial correlation implied by Equation (9). If productivity adjusted wages were equalized across countries,[35] the model implies that relative export prices to the same market should be strongly decreasing in the relative cutoffs, with high cutoff countries having low prices. Instead, for the broadest set of sectors, the results are quite mixed. For the US, positive and negative coefficients are split 50-50, with relatively few significantly different than zero in either direction. For the rest of the world, there are more negative than positive coefficients, but again most of these are insignificantly distinguishable from zero. As the restriction on the number of observations per importer and sector rises, the coefficients tend to become more negative but the sample size shrinks dramatically and the fraction of significant coefficients is stubbornly low.

Of course, these are only unconditional correlations. That is, they do not control for differences in productivity adjusted wages across countries. Thus, one might be tempted to argue that these weak results can be argued away by assuming that the productivity adjusted wage of a given source country is positively correlated with the productivity cutoff of that country. In simple terms, we can easily explain fact (4) if poor countries could have both high productivity adjusted wages and high thresholds for exporting. The problem is that the model seems to predict the exact opposite. Namely, if productivity differences (Z_c in the model) are a prime source of income differences across countries, then we would expect poor countries to have low productivity adjusted wages in equilibrium. Thus, this final fact presents a further internal consistency puzzle for the model.

Set together, these collected "stylized facts" are puzzling when examined through the lens of the simple model presented in Sections One and Two. For one, they suggest the model as written down in previous sections may be misspecified because within countries

[35] Chaney (2006) uses a model of this type in which productivity adjusted wages are equalized by trade in a homogeneous numeraire good.

prices do not strongly co-vary with predicted cutoffs. This forces us to think more carefully how exactly the model is estimating the productivity cutoff in the first place. We address this point below. Second, assuming the the cutoffs for exporting are appropriately estimated, the results seem to imply that the fact that low income countries have high cutoffs and the fact that they have low prices are not directly related as in the simple model. An important question then is whether these two facts are in fact related, and if so how? The following section argues that we can indeed modify the model to be broadly consistent with the four facts above. The resulting model is one in which both endogenous non-tradability and international prices depend on heterogeneous quality, and where the strong implications of the simple-Melitz model for international prices are inoperative.

[TO BE COMPLETED. MUCH MORE TO COME, INCLUDING MORE ANALYSIS, CHANGES THROUGH TIME, ADDITIONAL DETAILED RESULTS, AND ROBUSTNESS CHECKS.]

4 Extensions: Heterogenous Quality

Given the empirical results discussed above, we now move to modify the baseline model to allow for heterogeneous quality across countries and within sectors and illustrate how to reinterpret the empirical work above in light of these extensions. There are two dimensions on which we may consider introducing quality heterogeneity: (1) across countries within a sector; and (2) within sectors in a given source country. We begin by supposing that quality is heterogeneous across countries within a sector, but homogeneous within a sector for each country. In this case, cross-country quality differences provide a possible rationale for why productivity cutoffs are lower in high income, high quality countries on average than in low income, low quality countries even if fixed costs and/or market access do not vary across the countries. We then consider how the results are modified when quality is allowed to be heterogeneous within sectors as well as across countries. While the empirical case of interest is one in which product quality is increasing in the underlying productivity of the firm, we also discuss a more general specification of heterogeneous quality. In addition, we provide a simple model of quality choice at the firm level that delivers heterogeneous quality both within sectors and across countries. [**IN THIS DRAFT QUALITY DIFFERENCES ARE EXOGENOUS. FUTURE WORK WILL ALLOW FOR ENDOGENOUS QUALITY CHOICES.**]

4.1 Quality Differences Across Countries

Incorporating product quality differences in the model requires us to modify both preferences and the production technology. First, preferences over consumption in sector i are now given by: $\left(\int_{\omega}(\lambda_i(\omega)q_i(\omega))^{(\theta_i-1)/\theta_i}d\omega\right)^{\theta_i/(\theta_i-1)}$, where ω denotes a specific variety of the good. Further, we constrain $\lambda_i(\omega)$ such that $\lambda_i(\omega) = \lambda_{ic}$ for all varieties originating in country c so that λ_{ic} is a demand shifter common to all varieties produced by country c. We name this demand shifter product quality. Then, export demand for a firm in country c producing with productivity z and shipping to d is given by: $q_{xicd} = \lambda_{ic}^{\theta_i-1}(p_{xicd}(z)\tau_{icd})^{-\theta_i}P_{id}^{\theta-1}E_{id}$. Second, marginal costs of the firm are now assumed to depend on factor costs, productivity, and the quality of the good produced. We write these costs as: $\frac{w_c\lambda_{ic}^{\beta_i}}{Z_c z}$, where β_i governs the elasticity of costs with respect to quality. This specification maybe interpreted as saying that higher quality requires the firm to use more of the all factors of production in the same proportions. Thus, quality upgrading is assumed to be factor neutral.[36] Then, optimal pricing implies that prices are set at a markup over this marginal cost – $p_{xicd} = \frac{\theta_i}{\theta_i-1}\frac{w_c\lambda_{ic}^{\beta_i}}{Z_c z}$ – so higher quality goods have higher observed unit prices. Nonetheless, we assume that $\beta < 1$ so that

[36]One could also write down a technology in which quality upgrading is factor-biased. For example, upgrading quality may require hiring more human or physical capital. This then naturally induces relative factor price changes. We abstract from these complications in the main text.

quality adjusted prices are falling in quality.[37] Furthermore, for now, let us simply assume that countries are simply exogenously endowed with the ability to produce different quality goods.

With this setup, we can analyze the behavior of the productivity cutoff for exporting as in previous sections. Specifically, the marginal exporting firm is again the firm that earns zero profits from exporting:

$$\pi_{xicd}(z_{xicd}) = \frac{1}{\theta_i}\lambda_{ic}^{\theta_i-1}\left(\frac{p_{xicd}\tau_{icd}}{P_{id}}\right)^{1-\theta_i} E_{id} - \frac{w_c f_{xicd}}{Z_c} = 0. \tag{30}$$

Solving for the cutoff yields:

$$z_{xicd} = \frac{\theta_i}{\theta_i - 1}\lambda_{ic}^{\beta_i-1}\left[\theta_i\left(\frac{w_c}{Z_c}\right)^{\theta_i}\frac{f_{xicd}}{\tau_{icd}^{1-\theta_i}P_{id}^{\theta_i-1}E_{id}}\right]^{1/(\theta_i-1)}. \tag{31}$$

Thus, higher product quality entails a lower productivity cutoff for exporting, all else equal. This is intuitive since higher quality makes any given firm "more competitive" vis-a-vis rivals from other countries in a given foreign market and raises that firms market share and profits in that market. Thus, higher quality allows less productive firms to survive in that market. Consequently, if country c has higher product quality than an otherwise identical country c', the average unit value at which c sells in market d will exceed that at which c' sells in d for two reasons: (1) c's marginal cost of production (and hence prices) is higher; (2) c's productivity cutoff for exporting to country d is lower. Thus, product quality has both direct and indirect effects on relative prices. Put differently, endogenous non-tradability *amplifies* the effects of cross-country product quality differences on export prices when firms are selected into exporting on productivity alone.

Despite this complication, the estimation procedure outlined in Section 3.2 is un-

[37]Note that is is perfectly permissible to have $\beta_i = 0$. We can think of this case as capturing pure variation in preferences for goods from different countries, rather than variation in "quality" that influences both demand for output and the marginal cost of supply.

changed. We can see this by rewriting:

$$\alpha_{icd} = \frac{\lambda_{ic}^{\theta_i - 1}\left(\frac{\theta}{\theta-1}\frac{w_c \lambda_{ic}^{\beta_i}}{Z_c z_{Hic}}\tau_{icd}\right)^{1-\theta_i} P_{di}^{\theta_i - 1} E_{di}}{\frac{w_c}{Z_c} f_{xicd}}. \tag{32}$$

Then, since the ratio of profits to fixed costs for the marginal firm equals one and the marginal firm has the same product quality as the most productive firm, α_{icd} is still related to $\frac{z_{xicd}}{z_{Hic}}$ as in Equation (21). Further, because quality is country-specific, it is absorbed into the exporter fixed effect in the reduced form expression Equation (26). Though the estimation framework for $\frac{z_{xicd}}{z_{Hic}}$ is unchanged, we need to update our interpretation of average differences in the level of this cutoff across countries. We can now interpret the fact that poor countries export to fewer destinations within any given category as resulting from their low product quality relative to wealthier countries.

4.2 Quality Differences Across Countries and Within Sectors

The results above suggesting that export prices to different markets for a given exporter are essentially uncorrelated with the estimated productivity cutoff to that market suggest that we need to admit quality differences across firms within a given country and sector. Building on the previous section, we now allow quality now to have both a country specific and a firm specific component. To generate a flat profile for prices across destination markets, we choose the specific functional form: $\lambda_{ic}(z) = \lambda_{ic} z^{1/\beta_i}$. Thus, quality is increasing with productivity within a country-sector. With this functional form, we are able to rationalize both large differences in average cutoffs across different exporters as well as the invariance of prices for a given exporter across destinations. The productivity cutoff for exporting is only subtlety changed relative to the previous result with country specific quality only:

$$z_{xicd} = \left(\frac{\theta_i}{\theta_i - 1}\right)^{\beta_i} \lambda_{ic}^{\beta_i(\beta_i-1)} \left[\theta_i \left(\frac{w_c}{Z_c}\right)^{\theta_i} \frac{f_{xicd}}{\tau_{icd}^{1-\theta_i} P_{id}^{\theta_i-1} E_{id}}\right]^{\beta_i/(\theta_i-1)}. \tag{33}$$

Moreover, the procedure for estimating export cutoffs by exploiting selection into bilateral trading relationships is unchanged. It is straightforward to show that: $\frac{z_{xicd}}{z_{Hic}} = \alpha_{icd}^{\beta_i/(1-\theta)}$. So α_{icd} is still monotonically related to the relative productivity cutoff. In this variant of the model, then, firms all charge identical prices within a sector, but firms are still selected into exported based on productivity if productivity is measured using revenue-based methods as in previous literature. Here exporting is endogenous and consistent with robust cross-country facts (such as Figures Six and Seven), but it has no direct implications for international prices.

Obviously, this is but a special case. To think about how the estimated export cutoff and prices are related more generally, let us consider the general case where product quality is not necessarily directly tied to productivity as above. We start by characterizing the ratio of profits from exporting to fixed costs for a firm that produces variety ω as:

$$\alpha_{icd}(\omega) = \frac{\frac{1}{\theta_i}\lambda_{ic}(\omega)^{\theta_i-1}\left(\frac{\theta}{\theta-1}\frac{w_c\lambda_{ic}(\omega)^{\beta_i}}{Z_c z(\omega)}\tau_{icd}\right)^{1-\theta_i} P_{di}^{\theta_i-1}E_{di}}{\frac{w_c}{Z_c}f_{xicd}}. \tag{34}$$

Then, let us define a "competitiveness index" for the firm as: $k_{ic}(\omega) \equiv \lambda_{ic}(\omega)^{1-\beta_i} z(\omega)$. The "competitiveness index" then a one dimensional variable that characterizes the underlying heterogeneity in the model.[38] Moreover, note that the ratio of profits to fixed costs is increasing in this index. Thus, firms select into exporting based on this index. Then, as

[38]Hallak and Sivadasan (2006) also point out that the Melitz model with heterogeneous quality is isomorphic to a model in which firms are heterogeneous along one dimension only as in the main text.

above, it is straightforward to show that:

$$\frac{k_{xicd}}{k_{Hic}} = (\alpha_{icd})^{1/(1-\theta_i)}. \tag{35}$$

In words, the ratio of the cutoff "competitiveness" level for exporting is a monotone function of α_{icd}, the ratio of export profits to fixed costs of exporting for the most "competitive firm." Thus, α_{icd} *is still an estimate of the threshold for selection into exporting.* Moreover, with this specification it will also be true that revenue based TFP accounting methods will show that exporters are "more productive" than non-exporters. However, the strong link between the level of the cutoff and relative export prices across destinations is broken.[39] In fact, the model does not make predictions regarding the correlation between export prices and the productivity cutoff. To see this, note that the price for firm ω is:

$$p_{ic}(\omega) = \frac{\theta_i}{\theta_i - 1}\frac{w_c\lambda_{ic}(\omega)^{\beta_i}}{Z_c z(\omega)} = \frac{\theta_i}{\theta_i - 1}\frac{w_c\lambda_{ic}(\omega)}{Z_c k(\omega)}, \tag{36}$$

where $k(\omega)$ is the "competitiveness index." Then, for two different firms lying just at the productivity cutoffs for exporting to markets d and d', their relative price is given by $\frac{\lambda_{xicd}k_{xicd'}}{\lambda_{xicd'}k_{xicd}}$. So, now we cannot make a definitive prediction about the relative export price across markets without knowing something about the relative λ cutoffs across the markets. We can make predictions only when λ is monotone in productivity. In the special example above, this restriction holds. Moreover, it also holds if quality is constant across all firms as in the previous section. More generally, anything goes.

[TO BE COMPLETED]

[39]Moreover, the model's prediction that non-traded goods have higher prices than traded goods is also invalidated.

5 Conclusion

[TO BE COMPLETED]

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Table 1
List of Countries Included in Estimation Sample

AFGHANISTAN	GUATEMALA	PARAGUAY
ALBANIA	GUINEA-BISSAU	PERU
ARGENTINA	GUYANA	PHILIPPINES
AUSTRALIA	HAITI	POLAND
AUSTRIA	HONDURAS	PORTUGAL
BAHAMAS	HONG KONG	QATAR
BAHRAIN	HUNGARY	REUNION
BANGLADESH	ICELAND	ROMANIA
BARBADOS	INDIA	RUSSIA
BELGIUM-LUX.	INDONESIA	RWANDA
BELIZE	IRAN	SAUDI ARABIA
BENIN	IRELAND	SENEGAL
BERMUDA	ITALY	SINGAPORE
BRAZIL	JAMAICA	SOMALIA
BULGARIA	JAPAN	SOUTH KOREA
BURKINA FASO	JORDAN	SPAIN
CAMBODIA	KENYA	SRI LANKA
CAMEROON	KIRIBATI	ST KITTS AND NEVIS
CANADA	KUWAIT	SUDAN
CHAD	MADAGASCAR	SURINAM
CHILE	MALAWI	SWEDEN
CHINA	MALAYSIA	SWITZERLAND
COLOMBIA	MALTA	SYRIA
COSTA RICA	MAURITANIA	TAIWAN
CYPRUS	MAURITIUS	TANZANIA
DENMARK	MEXICO	THAILAND
DOMINICAN REPUBLIC	MONGOLIA	TOGO
ECUADOR	MOROCCO	TRINIDAD-TOBAGO
EGYPT	MOZAMBIQUE	TUNISIA
EL SALVADOR	NEPAL	TURKEY
EQ. GUINEA	NETHERLANDS	UGANDA
ETHIOPIA	NEW CALEDONIA	UNITED ARAB EMIRATES
FIJI	NEW ZEALAND	UNITED KINGDOM
FINLAND	NICARAGUA	URUGUAY
FRANCE	NIGERIA	USA
GABON	NORWAY	VENEZUELA
GERMANY	P.DEM.REP. LAOS	VIETNAM
GHANA	PAKISTAN	ZAMBIA
GREECE	PANAMA	ZIMBABWE
GREENLAND		

Table 2
Representative First Stage Probit Regression Results

	SITC 522 Coef./se	SITC 541 Coef./se	SITC 673 Coef./se	SITC 681 Coef./se	SITC 728 Coef./se	SITC 741 Coef./se	SITC 847 Coef./se	SITC 895 Coef./se
log distance	-.893***	-.766***	-1.025***	-.870***	-.869***	-.862***	-.867***	-.922***
	(.046)	(.041)	(.051)	(.073)	(.049)	(.049)	(.054)	(.058)
common border	.675***	-.009	.411**	.207	.277	.010	.413**	.419**
	(.170)	(.161)	(.181)	(.273)	(.172)	(.171)	(.194)	(.200)
colonial	-.069	.590***	.398**	.548*	1.277***	.997***	.288	1.066***
	(.173)	(.186)	(.181)	(.289)	(.190)	(.186)	(.179)	(.191)
legal system	.112*	.398***	.274***	.196	.205***	.247***	.299***	.297***
	(.067)	(.061)	(.070)	(.125)	(.069)	(.067)	(.081)	(.086)
religion	.297**	.297**	-.085	.015	.146	.292**	-.203	-.503***
	(.131)	(.122)	(.153)	(.310)	(.142)	(.136)	(.180)	(.183)
fta	.178	-.035	.416**	.813***	.086	.622**	.073	.225
	(.197)	(.207)	(.204)	(.216)	(.243)	(.250)	(.187)	(.224)
cu	-1.293*	.448	1.431***	1.160	.892*	.813	1.884***	2.545***
	(.686)	(.547)	(.538)	(.982)	(.525)	(.681)	(.685)	(.754)
language	.371***	.366***	.386***	.182	.219**	.305***	.462***	.328***
	(.092)	(.079)	(.099)	(.167)	(.091)	(.088)	(.110)	(.112)
Pseudo R^2	.612	.652	.620	.667	.700	.670	.681	.699
Obs.	8513	9945	7296	4764	10092	9280	9288	7458

Notes: Exporter and Importer fixed effects included in all regressions. Standard Errors in Parentheses. * p<.10, ** p<.05, *** p<.01

Table 1
Cross-Exporter, Within-Sector Regression Results

Panel 1: Exports to All Destinations Within Sector

	Log Price on Log Y/L			Norm. Cut on Log Y/L		
	(1)	(2)	(3)	(4)	(5)	(6)
positive	91%	96%	96%	15%	2%	0%
positive & significant	68%	79%	74%	4%	0%	0%
negative	9%	4%	4%	85%	98%	100%
negative & significant	0%	1%	0%	66%	94%	100%
min obs. per sector	15	35	55	15	35	55
No. of sectors	219	126	23	219	126	23

Panel 2: US Imports By Sector from All Sources

	Log Price on Log Y/L			Norm. Cut on Log Y/L		
	(1)	(2)	(3)	(4)	(5)	(6)
positive	80%	87%	83%	1%	0%	0%
positive & significant	45%	59%	67%	0%	0%	0%
negative	20%	13%	17%	99%	100%	100%
negative & significant	5%	3%	11%	83%	96%	100%
min obs. per sector	15	35	55	15	35	55
No. of sectors	212	76	18	212	76	18

Notes: "Log Price" and "Norm. Cut" are trade-share weighted country averages within each sector. Positive/Negative entries indicate the % of positive/negative point estimates. Positive/Negative entries indicate the % of positive/negative point estimates for which we can reject $H_0 : \beta = 0$ against a one-sided alternative at the 10% level or better. "min obs. per sector" indicates the minimum number or observations necessary for the sector to be included.

Table 2
Within-Exporter, Within-Sector Regression Results

Dependent Variable=Log Export Price
Independent Variable=Norm. Estimated Export Cutoff

	US Exports			ROW Exports		
	(1)	(2)	(3)	(4)	(5)	(6)
positive	60%	64%	64%	56%	57%	57%
positive & significant	30%	33%	34%	22%	26%	27%
negative	40%	36%	36%	44%	43%	43%
negative & significant	13%	12%	11%	15%	16%	18%
min. obs per sector	15	35	55	15	35	55
No. of Exp.-Sector pairs	255	215	160	2682	925	300

Notes: "Log Price" and "Norm. Cut" are trade-share weighted country averages within each sector. Positive/Negative entries indicate the % of positive/negative point estimates. Positive/Negative entries indicate the % of positive/negative point estimates for which we can reject $H_0 : \beta = 0$ against a one-sided alternative at the 10% level or better. "min obs. per sector" indicates the minimum number or observations necessary for the sector to be included.

Table 3
Within-Importer, Within-Sector Regression Results

Dependent Variable=Log Export Price
Independent Variable=Norm. Estimated Cutoff of Exporting Country

	US Imports			ROW Imports		
	(1)	(2)	(3)	(4)	(5)	(6)
positive	50%	45%	39%	44%	23%	25%
positive & significant	16%	16%	22%	12%	6%	0%
negative	50%	55%	61%	57%	77%	75%
negative & significant	17%	24%	39%	18%	42%	25%
min. obs per sector	15	35	55	15	35	55
No. of Imp.-Sector pairs	212	76	18	3084	148	4

Notes: Positive/Negative entries indicate the % of positive/negative point estimates. Positive/Negative entries indicate the % of positive/negative point estimates for which we can reject $H_0 : \beta = 0$ against a one-sided alternative at the 10% level or better. "min obs. per sector" indicates the minimum number or observations necessary for the sector to be included.

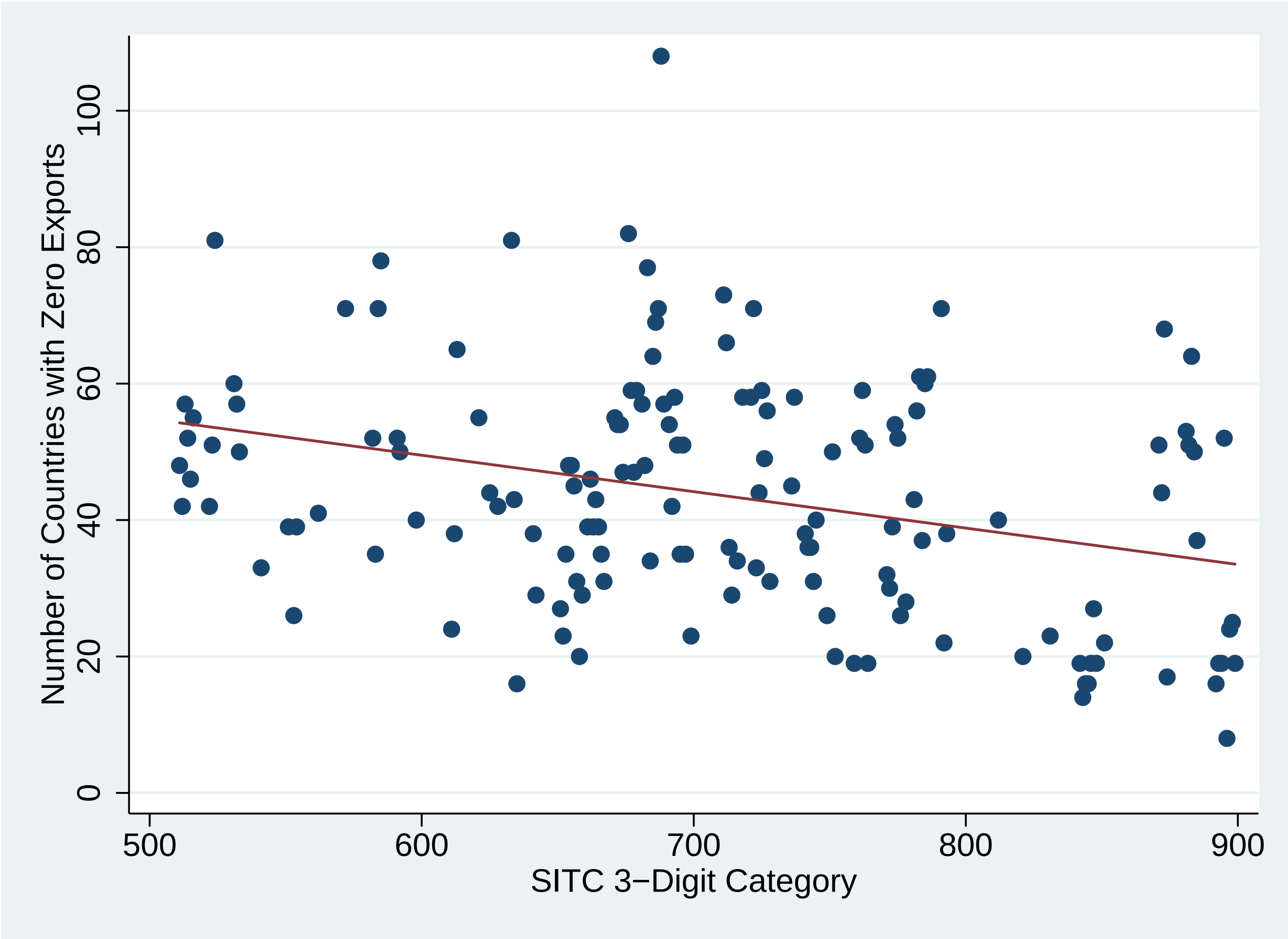

Figure 1: Fraction of Countries with Zero Exports by SITC 3-Digit Manufacturing Sector

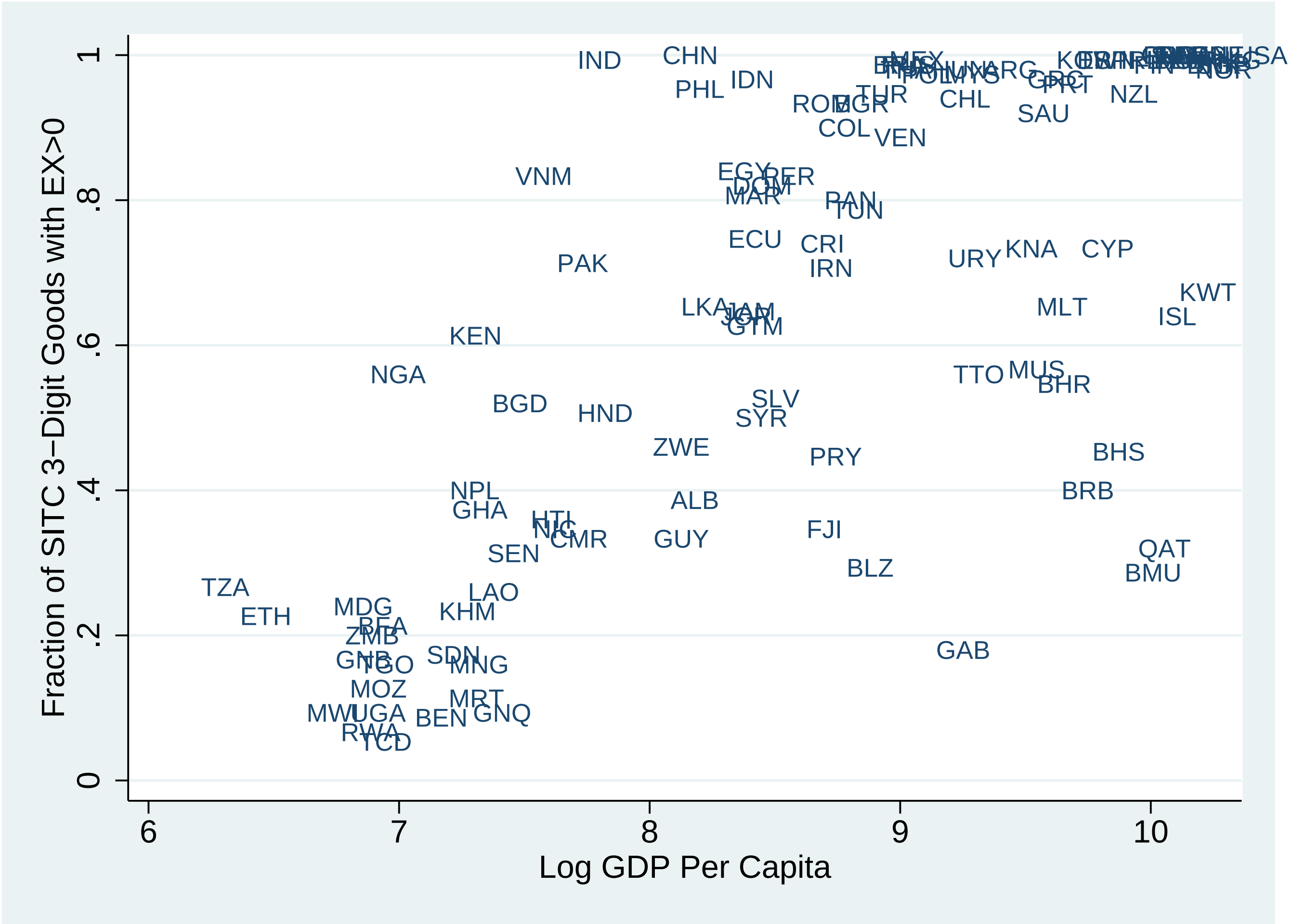

Figure 2: Fraction of SITC 3-Digit Manufacturing Sectors with Positive Exports vs. Log Real GDP Per Capita of Source Country

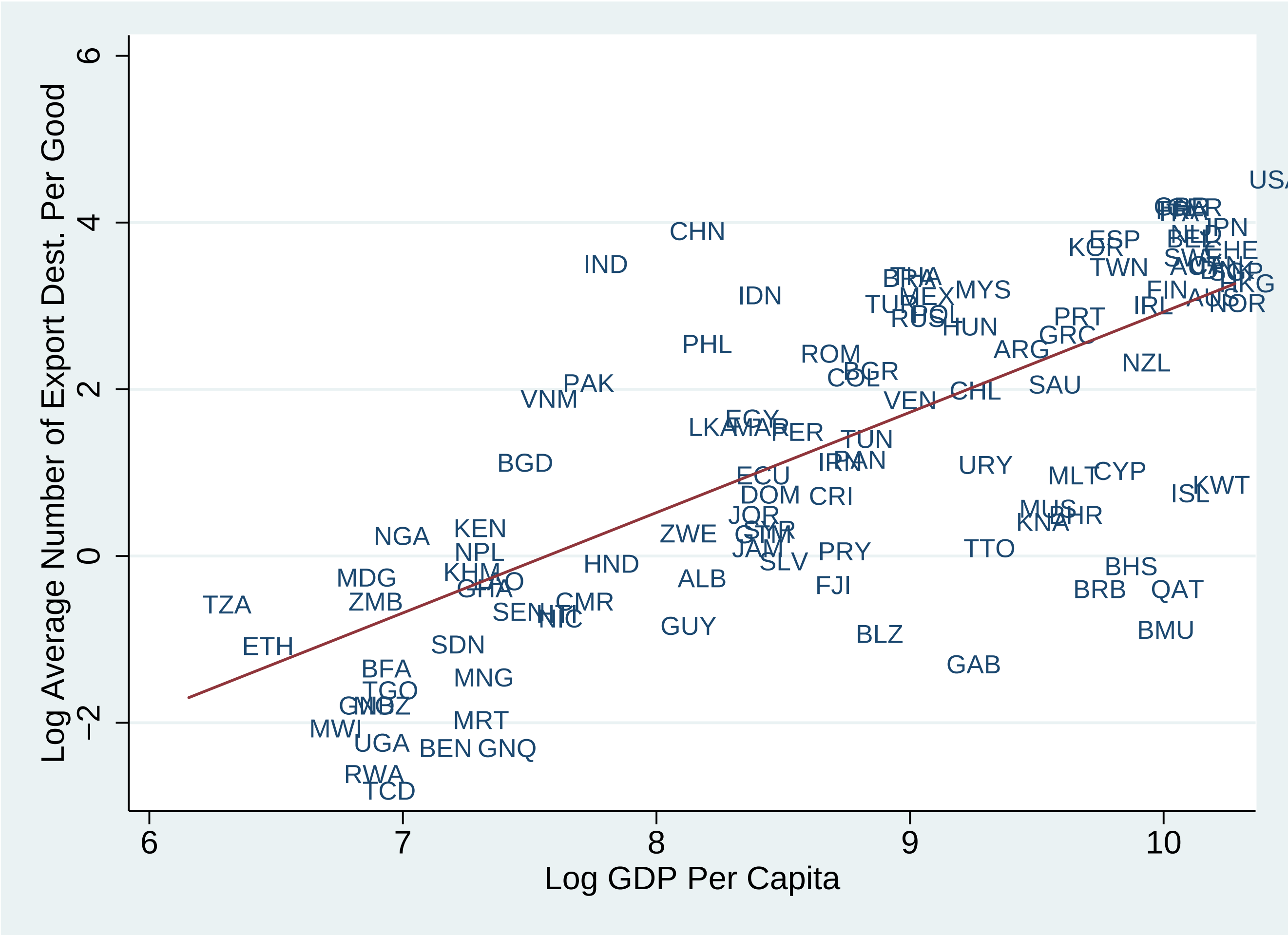

Figure 3: Unweighted Average Number of Export Destinations Per SITC 3-Digit Manufacturing Sector vs. Log Real GDP Per Capita of Source Country

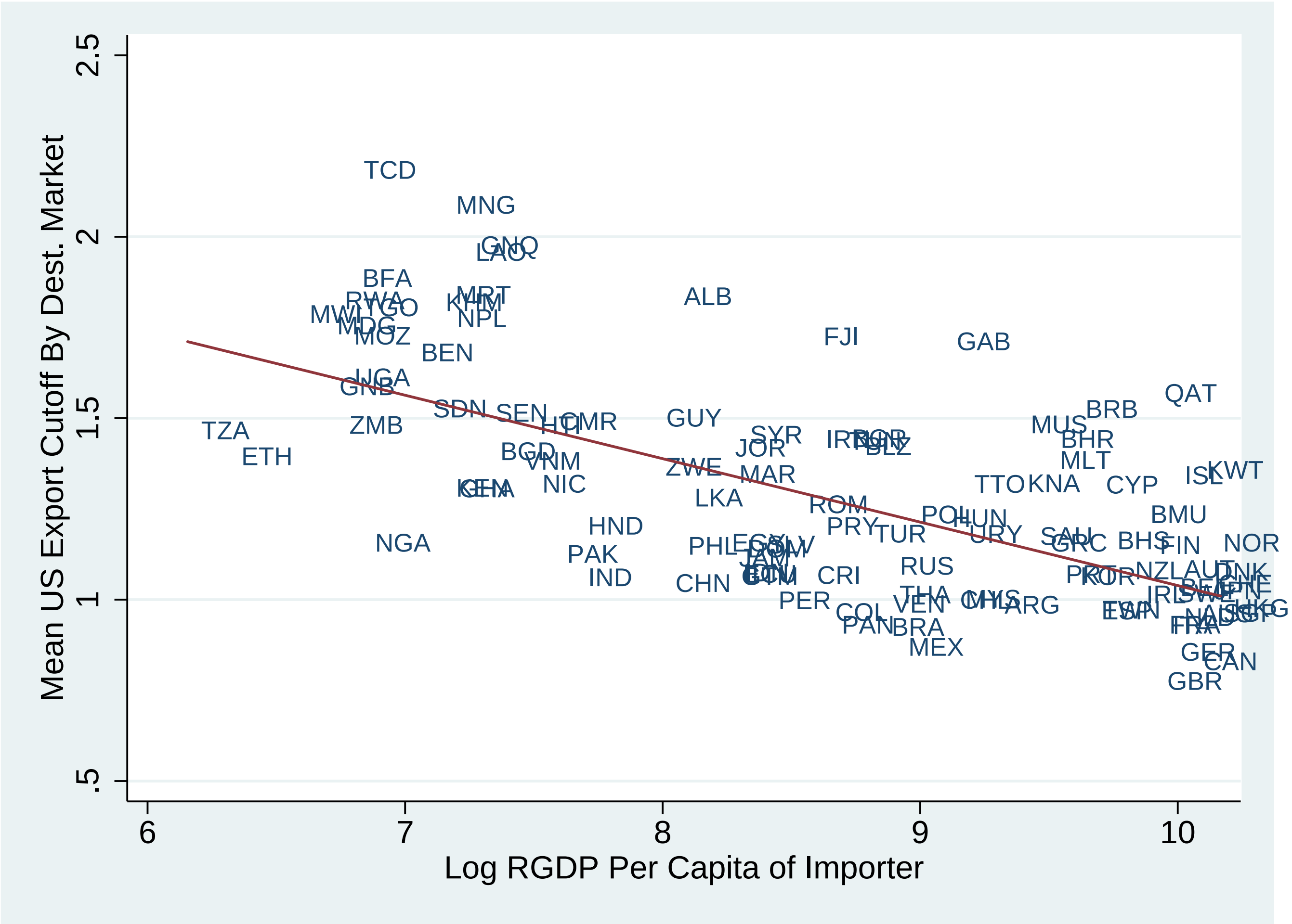

Figure 4: Weighted Average US Export Cutoff By Destination Market vs. Log RGDP Per Capita of Destination Market

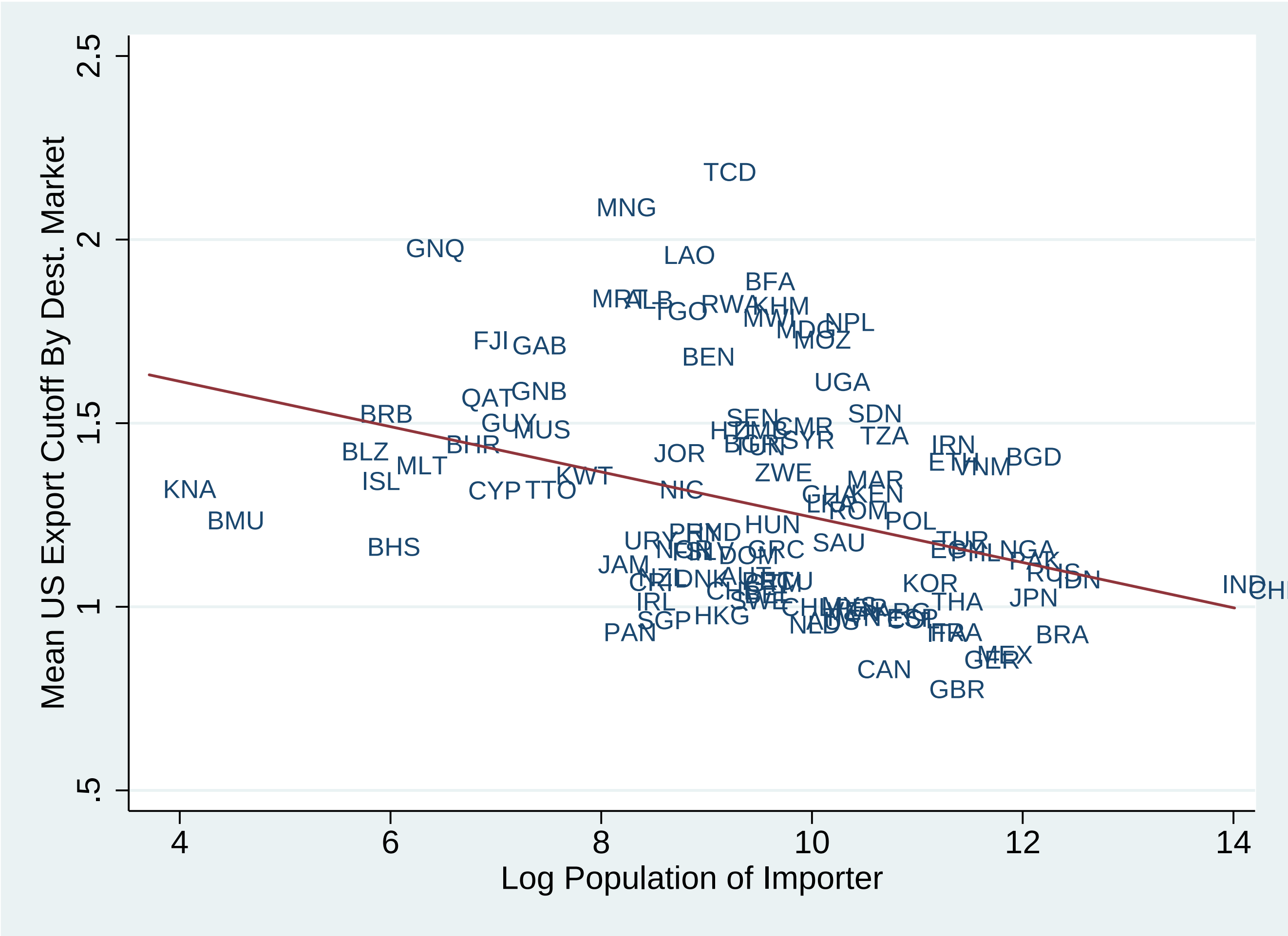

Figure 5: Weighted Average US Export Cutoff By Destination Market vs. Log Population of Destination Market

Figure 6: Weighted Average Export Price in SITC 3-Digit Sector vs. GDP Per Capita of Exporter

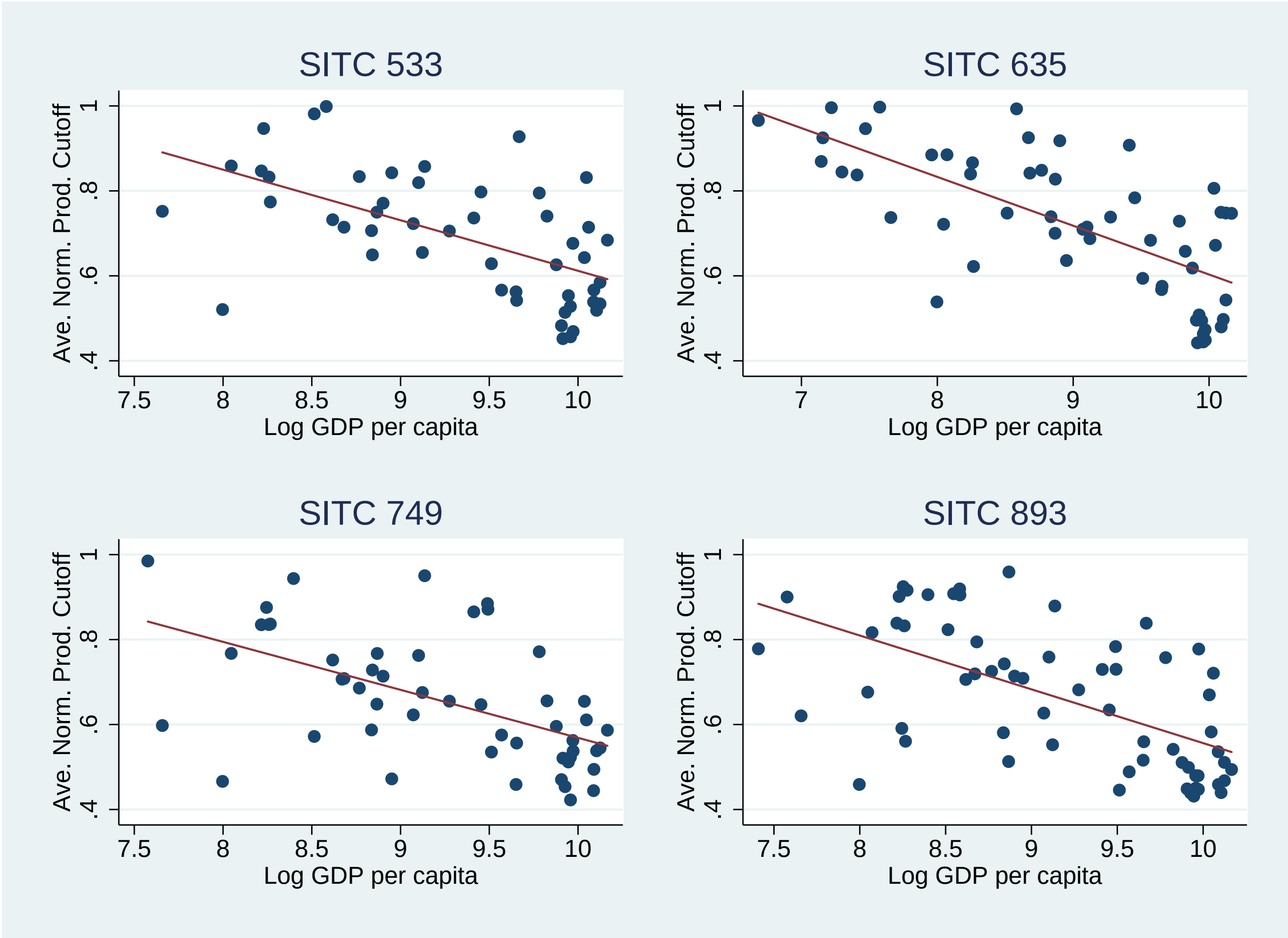

Figure 7: Weighted Average Normalized Export Productivity Cutoff in SITC 3-Digit Sector vs. GDP Per Capita of Exporter

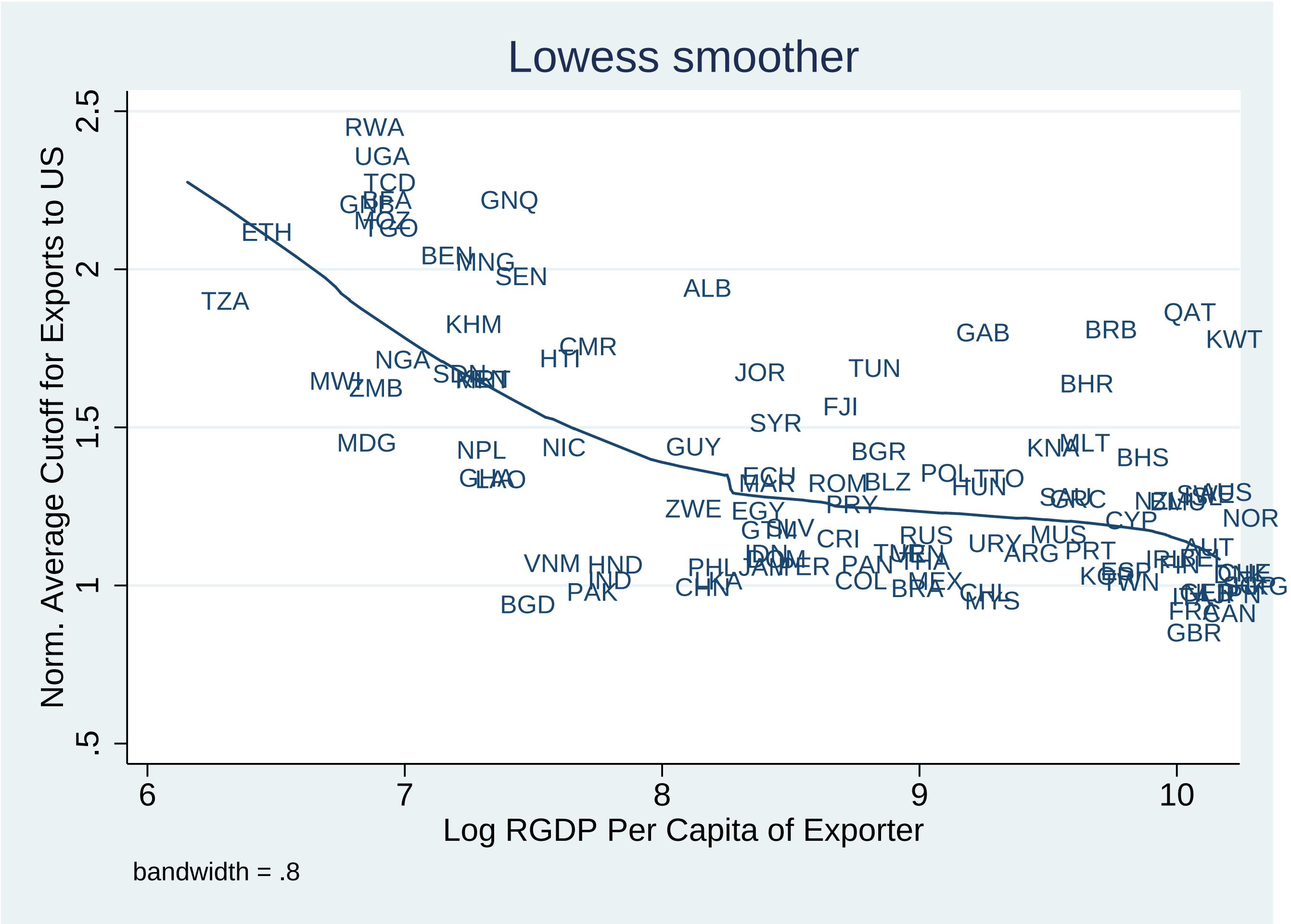

Figure 8: Weighted Average Export Cutoff to US vs. Log RGDP Per Capita of Export Market

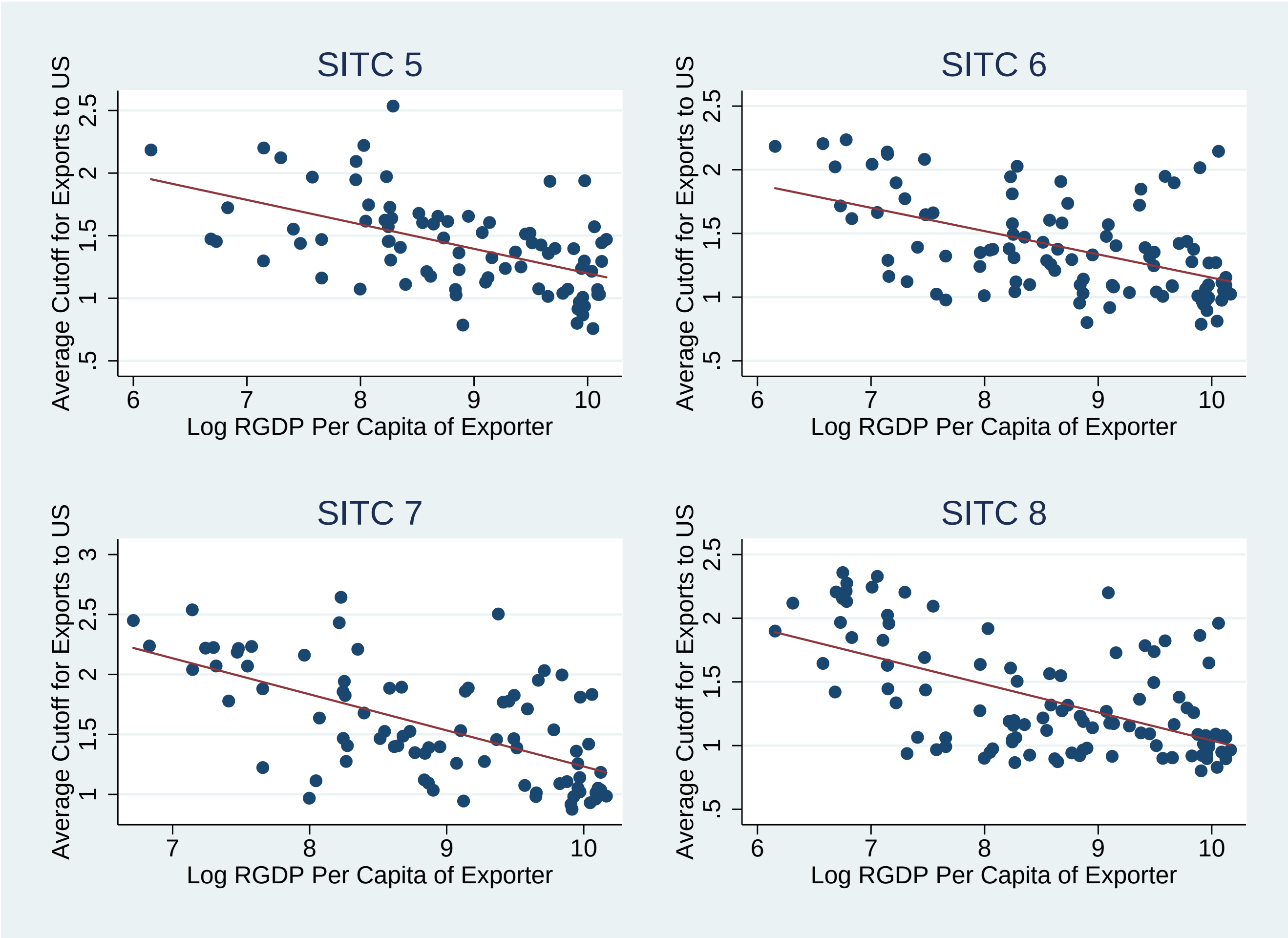

Figure 9: Weighted Average Export Cutoff to US by SITC 1-Digit Sector vs. Log RGDP Per Capita of Export Market

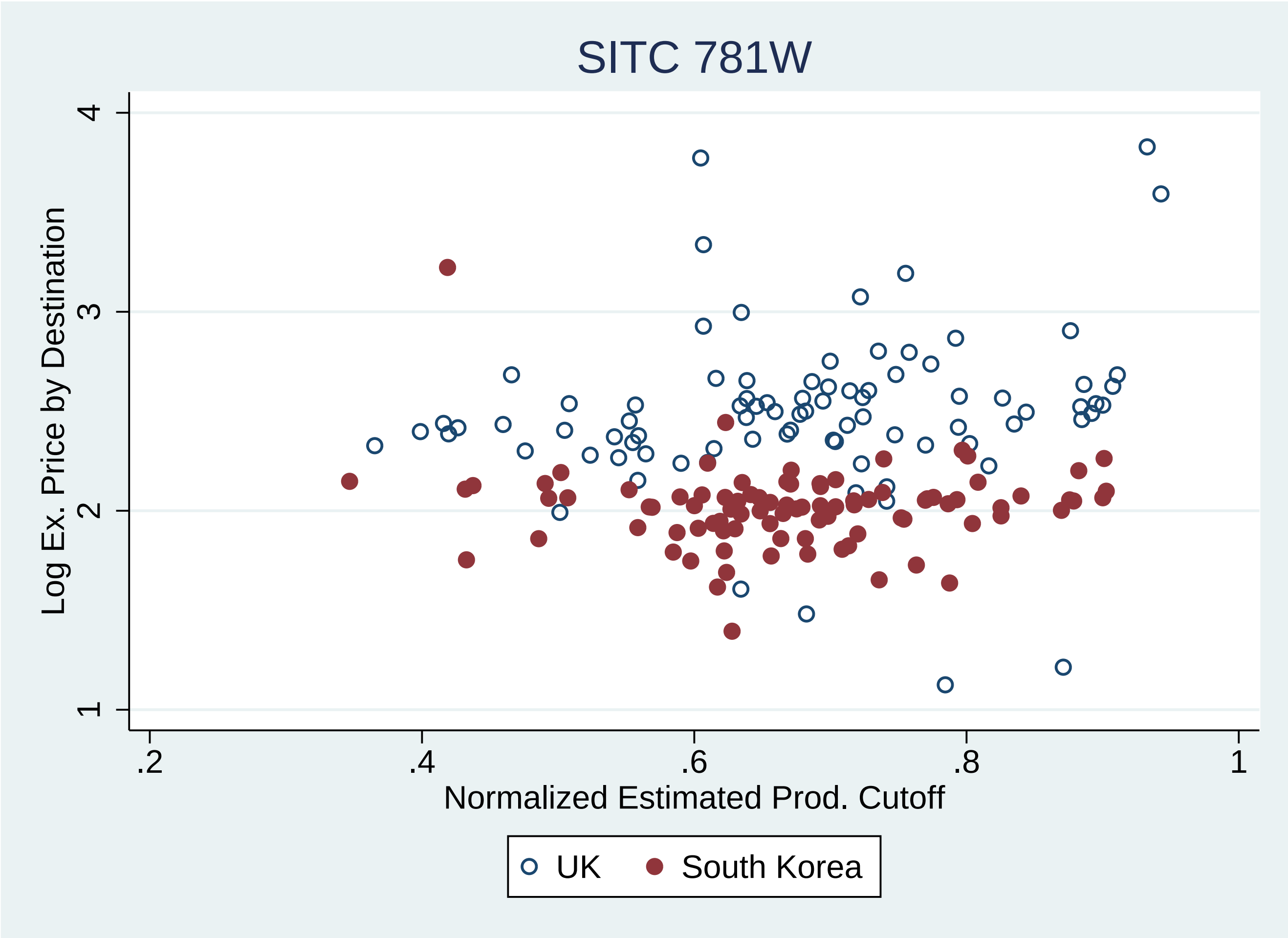

Figure 10: Bilateral Export Prices vs. Normalized Export Productivity Cutoffs for South Korea and UK in SITC Sector 781

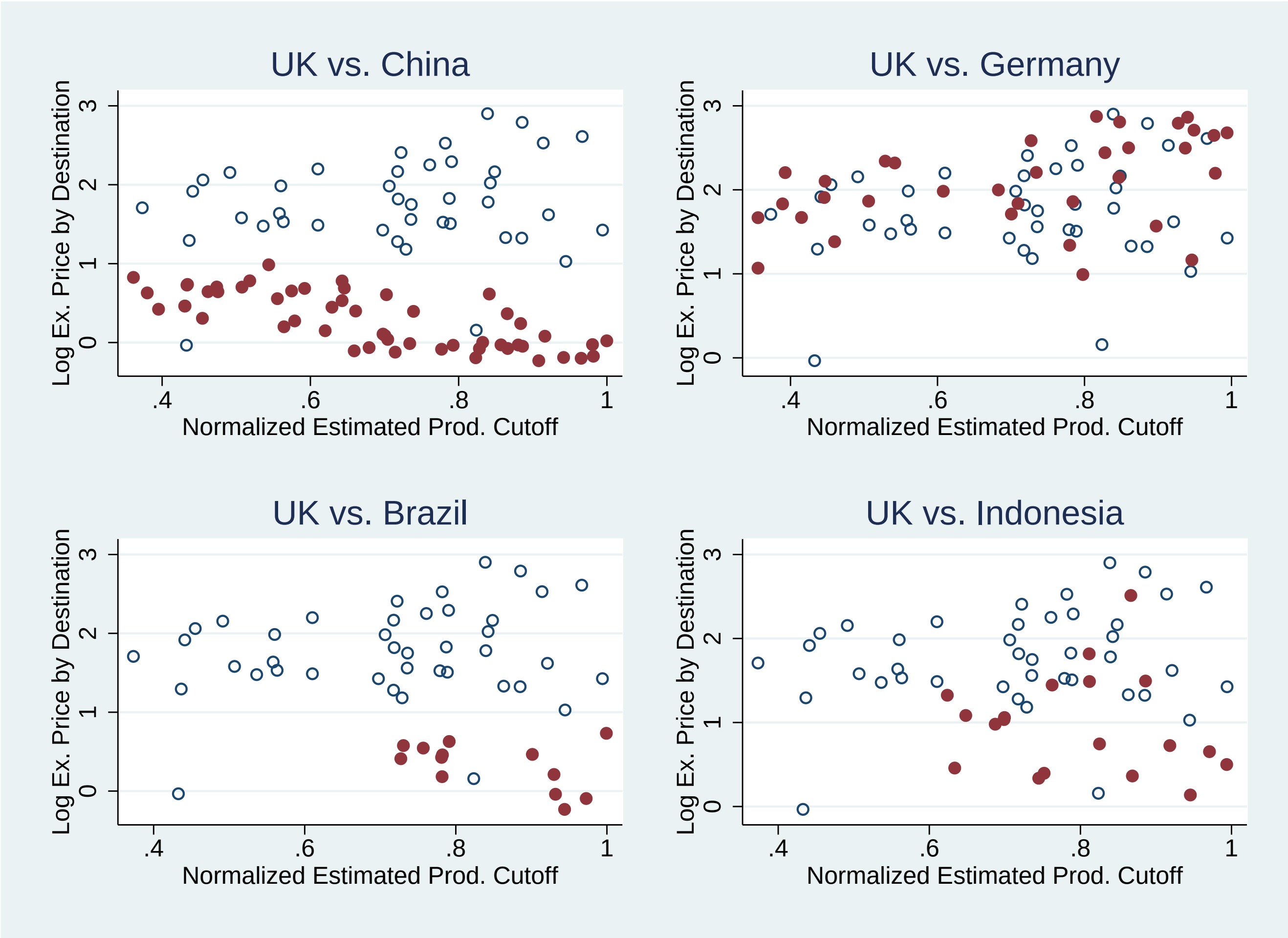

Figure 11: Bilateral Export Prices vs. Normalized Export Productivity Cutoffs for Various Countries vs. the UK in SITC Sector 781

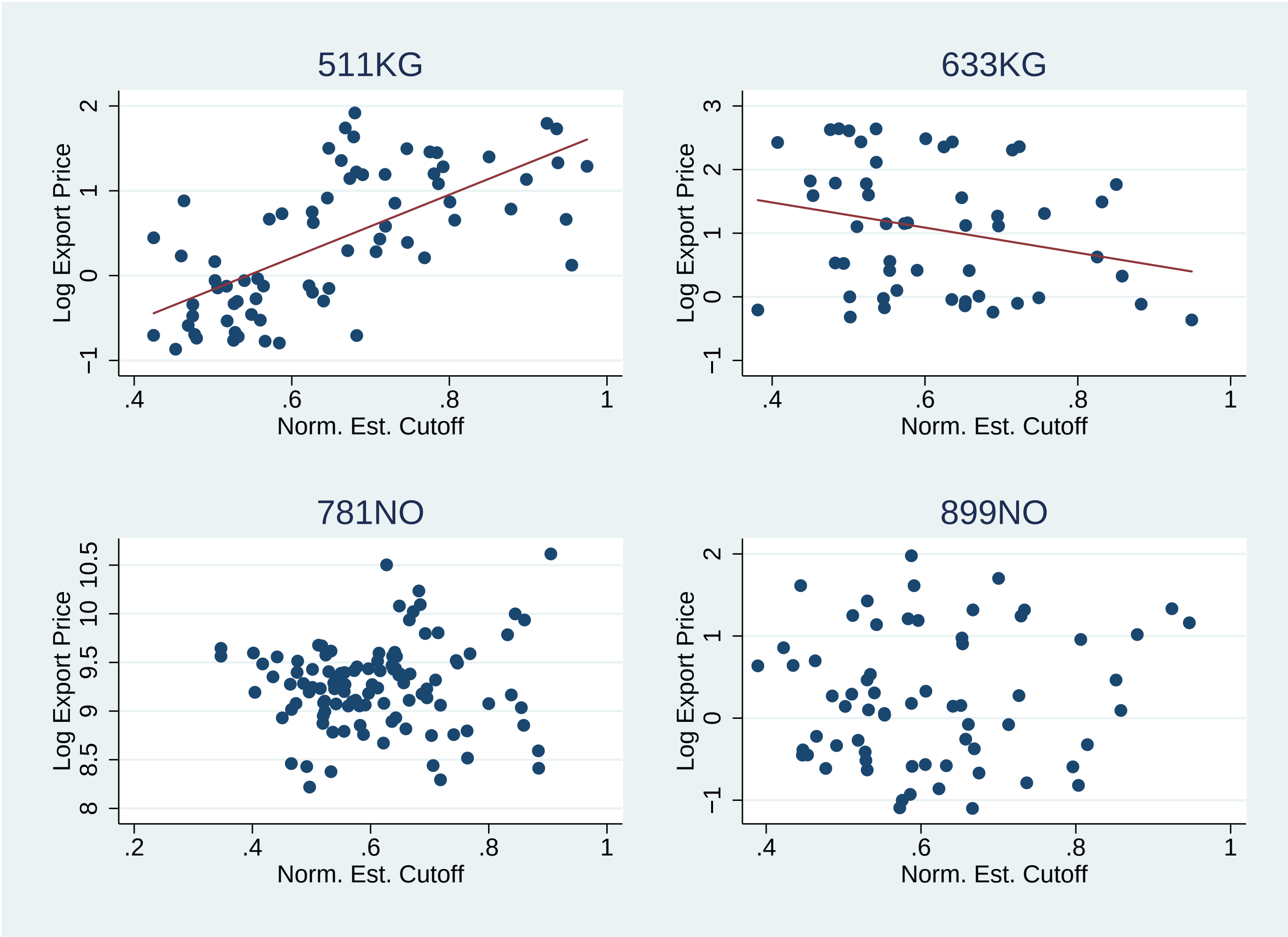

Figure 12: Bilateral Export Prices vs. Normalized Export Productivity Cutoffs for the US by Sector