Capabilities, Wealth and the Export-Mix

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ABSTRACT

This paper re-explores the relation between a country's level of wealth and the mix of products it exports. It shows how a country's capabilities i.e., its productivity and quality levels in each good, simultaneously determines both the mix of goods it produces and exports, and its level of gdp per capita. In our multi-product general equilibrium setting, the relation between a country's quality level in an industry and its level of capability and wealth (gdp per capita) is non-monotonic. It is this non-monotonicity that generates a relation between capabilities, wealth and the product mix. We show that directly the presence of this non-monotonicity in the empirical data. We examine per capita gdp growth and changes in the product mix by country over a 25-year period. For the poorest third of countries, changes in the product mix substantially over-predict per capita gdp growth.

Preliminary and incomplete.

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1 Introduction

What is the relationship between a country's mix of exports, and the country's wealth? Or, if we consider some particular product, what determines the set of countries for which it is a relatively important export?[1] Questions of this kind have attracted ongoing attention in the literature from Michaely (1984), to Lall, Weiss, and Zhang (2006), and Hausmann, Hwang, and Rodrik (2007). (See also Chenery (1960) and Leamer (1984) on ladders of development more generally.) These authors proceed by examining the *average* gdp per cap of (major) exporters of each good. The point of departure of the present paper lies in the observation that the range of countries producing any specific good, in terms of countries' gdp per capita, is usually very wide. This has been documented by Schott (2004, 2008) and Khandelwal (forthcoming). This can be seen as reflecting two contributory effects. The first is 'aggregation': i.e. it merely reflects an overly broad definition of a 'good' or an 'industry'. The second is that different producers across this range differ in 'quality'. We argue that the latter contribution is substantial and possibly dominant– and so we set out to examine how this range of producers emerges endogenously within a 'Quality Competition' model. Such models form the basis of the recent literature on Quality and Trade, which emphasizes the role of productivity and quality (in whatever basket of goods the country produces) as the driver of cross-country differences in gdp per capita. One aim of the present paper is to show how a country's capabilities i.e., its productivity and quality levels in each good, simultaneously determines both the mix of goods it produces and exports, and its level of gdp per capita.[2] [3]

In the recent literature on 'Quality and Trade', it is widely assumed that higher quality is monotonically related to (positively correlated with) higher markups and higher market shares. This is indeed a prediction of partial equilibrium models in which producers with

[1]This is a bad sentence because as phrased it is too broad. It encompasses most of what trade economists think about wherease we are focussed on the trade patterns *and wealth* nexus.

[2]Productivity and Quality are used throughout this paper in the broad sense of 'cost shifter' and 'demand shifter', respectively. Thus quality includes all influences on consumers' willingness to pay: technical features, design, brand image, customer service etc.

[3]There is huge literature on trade and quality, parts of which are particularly relevant here. Feenstra (1984), Schott (2004), Hummels and Klenow (2005), Hallak (2006), Verhoogen (2008), Hallak and Schott (2008), Kugler and Verhoogen (2008) and Khandelwal (forthcoming) have made important contributions to the measure of international differences in quality. These authors as well as Hummels and Skiba (2004), Schott (2008), Baldwin and Harrigan (2009), Choi, Hummels, and Xiang (2009) and Johnson (2009) examine the relationship between trade flows and quality. Verhoogen (2008) explores the relationship between quality, trade and inequality. (See also Goldberg and Pavcnik (2007).) Amiti and Khandelwal (2009) explore the impact of trade restrictions on quality upgrading.

different quality levels face a common wage level in their single domestic market. We show, however, that in a multi-product General Equilibrium trade setting, this is no longer true. If we consider a range of exporters, ranked in increasing order of gdp per capita, then countries at the top of the range offer the highest qualities, but they also have the highest wage rates, deriving from the demand for their domestic labour from firms operating in other, more 'sophisticated' industries. Their higher quality is accompanied, therefore, by a higher marginal cost. A country at the top end of the range faces opportunity costs in terms of the use of domestic labour in the production of higher-ranking goods: a country can be 'too rich' i.e. have too high wages, to warrant its participation in a market. By the same token, a country can, as it moves upwards in terms of the quality levels it can achieve across all markets, find its quality and markup rising in a given market, but its market share declining, as more of its firms and workers migrate to other, more sophisticated industries. The Apple company could doubtless make colour TVs of outstanding quality and command high markups; but its efforts yield a greater return in more sophisticated products. What emerges from this is that the relation between quality and market share in a general equilibrium trade setting is non-monotonic; the form of the relation will depend on standard Ricardian comparative advantage considerations. This non-monotonic relation is what drives the appearance of a range of countries, ranked by gdp per capita, that produce each good at equilibrium.

Once we have established this range, and have identified it with quality differences, we note that a country can become rich in two ways: either by improving its quality and/or productivity in its existing goods, or by moving to more sophisticated goods. The above-cited authors have emphasized the 'changing mix' contribution. We show in what follows that improvements in the product mix systematically under-predict rises in gdp per cap, for low-income countries over the past 25 years. We interpret this as showing that these countries typically enter new markets at the 'low quality' end of the range. (We acknowledge that, in some cases, this can be interpreted as moving into a relatively undemanding sub-market within the larger market.)

The driving assumption of the present model is that, if we rank products in order of the capabilities their production requires, then the number of countries capable of producing a product to a given relative quality level falls as we move up to higher ranked products. This notion of 'scarce capabilities' (Sutton, 2001)[4] is motivated by a central idea in the modern 'market structure' literature: if firms must incur fixed and sunk outlays to develop their

[4] right cite?

capabilities, then the number of firms that find it profitable to develop these capabilities will be limited: the greater the elasticity of response of quality (or productivity) to R&D or other fixed outlays, the greater the degree to which firms 'escalate' their R&D spending in competing with rivals, and the fewer the number of producers surviving in the market (Sutton, 1991, 2007). Thus even if all firms in all countries were symmetric, some capabilities will remain scarce and valuable. In a world with inherited historical asymmetries, where firms in one country face different costs of building capabilities, then these effects may be accentuated. In this paper, we simply take as a given that some capabilities are relatively scarce; for a general equilibrium analysis of the mechanism of entry and R&D competition, leading to this. See Sutton (2007).

Once this notion of relatively scarce capabilities is admitted, then it follows that a relationship will exist between a country's product mix and its level of gdp per capita. Relationships of this kind have been studied in the literature by a series of authors over the past twenty years.

The literature has focussed on the export mix, largely for reasons of availability of consistent data. While authors' methods differ in some respects, as explained later, all begin by asking: how rich, on average, are the countries that produce this product? This leads to a score for each product in terms of 'producer-wealth'. Then, each country's product mix is examined, and an index is computed as a weighted average of the 'producer-wealth' scores for each of the products it exports. This index constitutes an 'implied gdp per capita' for the country, that may be compared with its actual gdp per capita. Our point of departure lies in examining such scatters of 'implied' versus 'actual' gdp per capita, which we refer to as 'product-mix diagrams'.

Figure 5 below shows a product-mix diagram, based on Hausmann, Hwang, and Rodrik (2007); the details of its contruction are set out in section 5. The horizontal axis shows a country's actual gdp per capita in U.S. dollars, and the vertical axis shows the implied gdp per capita. Two features of this scatter are striking:

1. The relation is very 'flat' relative to the 45° line.

2. The relationship is quite diffuse. The Philippines has a slightly higher implied gdp per capita than Austria, but Austria's actual gdp per capita is over 30 times higher.

Our starting point lies in explaining these two features of the data.

2 Theory I: A Baseline Model

The Setting

There are K countries. Countries differ in their types, indexed by $k = 1, 2, 3, \ldots, T$, where T is the total number of country types. The number of countries of type k is denoted N_k. Hence, $\sum_{k=1}^{k=T} N_k = K$. There are G goods (markets), indexed by $g = 1, 2, 3, \ldots$, etc. The index g is also used to refer to the associated industry, i.e. the set of firms, in various countries, that produce good g. We will use the terms 'product' and 'good' interchangeably.

Consumer Choice

Each country has a population of the same size, in which each of **N** identical individuals has the same Cobb-Douglas utility function defined over G goods, indexed by g, and labour:

$$U = \prod_g (u_g x_g)^{\delta_g} - \frac{1}{2} l^2 \tag{1}$$

where $\sum_g \delta_g = 1$, l denotes hours of labour supplied, and u_g and x_g denote the quality and quantity of good g consumed. It follows from the form of the utility function that each consumer spends fraction δ_g of income on good g. We assume that all profits accrue to a separate group of individuals, who also have a utility function of the form (1) but with l constrained to zero. From this it follows that we can treat all firms in the global market for g as facing a unit-elastic market demand schedule, i.e., the total global expenditure on good g is a constant, which we denote as S_g, independently of equilibrium prices. We note that the S_g are proportional to the δ_g. We will assume throughout that all the δ_g, and so all the S_g, are equal, and so drop the product suffix, writing total expenditure on each good as S.

Equilibrium in the Product Market(s)

We characterize product market competition using the standard 'Cournot model with quality' introduced in Sutton (1991).[5] In this model, firms are characterized by a level of

[5] Melitz and Ottaviano (2008) use partial equilibrium with declining markups as a firm moves down its demand schedule, but we use a model involving variable markups in a general equilibrium setting; it turns out that the drivers of the equilibrium pattern of markups is more complex than a partial equilibrium analysis would suggest.

capability, consisting of a quality level and a productivity parameter denoting the number of worker hours per unit of output produced,[6] together with a ('local') wage rate specific to the country in which the firm is located. At equilibrium, some sub-set of firms are active in the production of good. For each active firm, indexed by i, its output level is related to its productivity c_i, its quality u_i, and its (local) wage rate w_i. Solving for a Nash equilibrium in quantities (Sutton, 1998, Appendix 15), we obtain the firm's equilibrium price,

$$p_i = \frac{\sum_j (w_j c_j / u_j)}{N_g - 1} u_i \tag{2}$$

and its output level,

$$x_i = S \frac{N_g - 1}{u_i \sum_j \frac{w_j c_j}{u_j}} \left\{ 1 - (N_g - 1) \frac{w_i c_i / u_i}{\sum_j \frac{w_j c_j}{u_j}} \right\} \tag{3}$$

where N_g denotes the total number of firms that are active in the global market for good g, S is total expenditure on good g and the sum $\sum_j$ is taken over all active firms. The condition for firm i to be active, i.e., have strictly positive output at equilibrium, is that

$$\frac{c_i w_i}{u_i} < \frac{1}{N_g - 1} \sum_j \frac{c_j w_j}{u_j} = \frac{N_g}{N_g - 1} (\overline{\frac{c_j w_j}{u_j}}) \tag{4}$$

where $(\overline{\frac{c_j w_j}{u_j}})$ denotes the mean capability of all active producers. Note that the r.h.s. of equation (2) depends on u_i and c_i only through the ratio u_i/c_i, which we refer to as the 'capability' of firm i. It follows that all relationships between capabilities and wages developed below will depend only on firms' or countries' relative qualities and productivities in

[6]Thus all costs are labour costs, and fixed costs are sunk, and so do not enter the present (short run) analysis. Materials cost, though of crucial importance in general, are here ignored in order to keep the analysis as clear as possible. This issue is examined in depth in Sutton (2007). The key point is this: in the absence of material cost, low-wage countries can become viable in world markets even at low quality once their wage costs are sufficiently low: only the ration wc/u matter to viability, and shortcomings in u can be offset by a low value of w. But once material inputs as well as labour are required, a fall in w can only reduce unit costs to the world-market value of the material input. This places a floor on price, and so establishes a corresponding minimum quality level, independent of local wages, that is required for viability. Deficiencies in productivity can always be compensated for by low wages, but deficiencies in quality cannot. This is an important reason for emphasizing the role of quality in our present discussion.

the production of each good, and not on their absolute levels. We will refer to $w_i c_i / u_i$ as firm i's 'effective cost level'.

In the special case where all the firms producing good g have the same effective cost level, the output equation (3) takes the form

$$x_i = S \frac{N_g - 1}{N_g^2} \frac{1}{w_i c_i} \tag{3'}$$

Finally, combining (2) and (3) we have the expression for the sales revenue of firm i,

$$R_i \equiv p_i x_i = \{1 - (N_g - 1)\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}}\} \cdot S \tag{5}$$

We now state four properties of the output and revenue functions that follow from inspection of (3) and (5); see the technical appendix for proofs.

1. $\dfrac{\partial x_i}{\partial w_i} < 0$ everywhere.

2. $\dfrac{\partial x_i}{\partial u_i} > 0$ on the domain where $\dfrac{w_i c_i}{u_i} < \dfrac{1}{N_g - 1} \sum_{i \neq j} \dfrac{w_j c_j}{u_j}$, i.e. where i's effective cost level is above the average (or common) value of its rivals'.

3. A rise in u_i and w_i that leaves u_i / w_i unchanged implies a fall in x_i.

4. R_i depends on u_i and w_i only through the ratio u_i / w_i; and it is strictly increasing in u_i / w_i everywhere.

Cross-Country Production Patterns: A 'Baseline' Case

The set of countries active in the production of each good g at equilibrium depends on the value of the quality and productivity parameters and on equilibrium wage rates. Recall that there are K countries, divided into 'types' comprising identical countries, with N_k countries of type k, so that $\sum_{k=1}^{k=T} N_k = K$.

We divide the G goods into T equal-sized 'product groups', where m denotes the number of goods in each group, so $G = mT$. It will be convenient to begin with a 'baseline' case in which each country-type is associated at equilibrium with the production of exactly one 'product group'. In this special case, all producers of any good will have the same quality

Table 1: Notation

Notation	
T	Number of country types (=number of product types).
k	Index of country types, $k = 1, 2, \ldots, T$.
N_k	Number of countries of type k.
$K = \sum_{k=1}^{T} N_k$	Total number of countries.
m	Number of products (industries) in each 'product (industry) group'.
$G = mT$	Total number of products (industries).

Table 2: Production Patterns

Country Type	Number of Countries	Product Group	Number of Products
$k = 1$	N_1	$k = 1$	m
$k = 2$	N_2	$k = 2$	m
...	...	...	...
$k = T$	N_T	$k = T$	m
	Total $\sum_{k=1}^{T} N_k = K$		Total $G = mT$

and productivity levels (for all goods), and so the same equilibrium wage level, and the same output level of each good. It follows that in this special case we may use the country index k to label, also, the set of goods produced at equilibrium by country k, which we denote as G_k, i.e., a good is produced by countries of type k iff $g \in G_k$ (tables 1 and 2). This 'baseline' case corresponds to a simple Ricardian model of a standard kind, in which each industry is characterized by the basic Cournot model.

We assume there is (at most) one firm capable of producing any particular good, in each country, so that if a good is produced (only) by countries of type k, then the number of active producers of that good is N_k. We further assume that $N_k \geq 2$ for all k, so that there are at least two producers of every good.[7]

We assume that countries in group k can produce all goods in product groups 1 to k at 'standard' levels of productivity c and quality u; but not goods $k + 1$ and upward; the interpretation, as noted above, is that goods of a higher index require capabilities that are 'scarcer'. We will, in what follows, place restrictions on the number of countries of type k, and

[7] If $N_k = 1$, the equilibrium (monopoly) price is undefined (i.e. goes to infinity).

so on the number of countries capable of producing goods in product group k. Specifically, we assume that $N_k \geq N_{k+1} + 3$ for all k. It is shown below that this restriction is sufficient to ensure that goods in group k are produced, at equilibrium, only by countries of type k; and that all producer countries of goods in this product group are of type k.

Labour Market Equilibrium in a Country of Type k

The set of goods G_k produced by the firms in country k comprise the m goods in product group k, all of whose producers face the same country-specific wage rate, which we denote w_k, and have the same level of output, (for each of the m products in product group k). We denote the equilibrium level of output of each product g by the single firm in each producing country k as x_{gk}. It follows from equation (2)

$$x_{gk} = \frac{N_g - 1}{N_g^2} \frac{S}{w_k c_k} \tag{3''}$$

so the total demand for labour in a country of type k is

$$L_k^D = \sum_{g \in G_k} c_k x_{gk} = \sum_{g \in G_k} \frac{N_g - 1}{N_g^2} \frac{S}{w_k} = m \frac{N_k - 1}{N_k^2} \frac{S}{w_k} \tag{6a}$$

where the sum over $g \in G_k$ comprises the m products in G_k, and where N_k denotes the (common) value of the number N_g of producers of any good $g \in G_k$, which in the present special case equals the number of countries of type k, or N_k.

We now turn to labour supply: it follows from the form of Equation (1) that each individual has a labour supply function that takes the form of a ray through the origin, viz.

$$l(w) = w \prod_g (\delta_g \frac{u_g}{p_g})^{\delta_g}$$

where w is the wage rate; denoting the wage rate in country k as w_k, total labour supply in country k equals

$$L_k^S = \mathbf{N} l(w_k) = \mathbf{N} w_k \prod_g (\delta_g \frac{u_g}{p_g})^{\delta_g} \tag{6b}$$

where $\mathbf{N}$ denotes country population, (which we have assumed to be equal for all countries), and where δ_g corresponds, as before, to the share of expenditure devoted to good g (which we have assumed to be equal for all goods).

Since we have solved in equation (3′′) for product market equilibrium, we may characterize general equilibrium by equating the supply and demand for labor within each country (type).

Labour market equilibrium requires, given the form of the labour supply function (6b), that for any two country types k and k',

$$L_k^S : L_{k'}^S = w_k : w_{k'} = L_k^D : L_{k'}^D$$

whence from (6a) and (6b) we have[8]

$$w_k^2 : w_{k'}^2 = \frac{N_k - 1}{N_k^2} : \frac{N_{k'} - 1}{N_{k'}^2}$$

$$\text{or} \qquad \frac{w_k}{w_{k'}} = \sqrt{\frac{N_k - 1}{N_{k'} - 1}} \cdot \frac{N_{k'}}{N_k}$$

This equation serves to define the chain of wage ratios between country type 1 and country type k.

Up to this point, we have *assumed* that country group k are the sole producers of product group k. We now note that the restriction on the N_k introduced above, viz, $N_k \geq N_{k+1} + 3$, ensures this is so. To do this, note that a necessary and sufficient condition for this is that firms in each country $k + i$ have wages $w_{k+i} > w_k$ sufficiently high to render them unviable in the production of good k. Using equation (2) this requires that

$$\frac{\overline{u}}{w_{k+i}} < \frac{N_k - 1}{N_k} \frac{\overline{u}}{w_k}$$

$$\text{or} \qquad \frac{w_{k+i}}{w_k} > \frac{N_k}{N_k - 1}$$

A sufficient condition for this is that, for all k,

$$\frac{w_{k+1}}{w_k} = \sqrt{\frac{N_{k+1} - 1}{N_k - 1}} \frac{N_k}{N_{k+1}} > \frac{N_k}{N_k - 1}$$

It is easy to verify that, given our assumption that $N_k \geq 2$ for all k, this inequality is satisfied if, as assumed above, $N_k \geq N_{k+1} + 3$ for all k.

The interpretation of this restriction on the N_ks, as noted in the Introduction, is that higher indexed products require relatively scarce capabilities; and that these higher indexed goods are ones in which the to investment in capability building are relatively high, thus

[8] JOHN: 1. Where the squares come from is not clear. 2. I hate the notation ':' and, since we barely use it anymore, let's get rid of it.

implying a high level of industry concentration at the global level.[9]

The Product Mix Diagram

We are now in a position to describe the analytical foundations of the product mix diagram plot described in Section 1 above. We begin by noting that, in the present 'baseline' case, in which there is a 1 : 1 mapping between country types and product groups, the product mix plot coincides with the 45° line. This follows from the fact that the horizontal axis shows a country's wage rate w_k and the vertical axis shows, for that country, the (weighted) mean income of the countries producing the products produced by this country, which here are simply the products in group k, all of whose producers have the same wage rate w_k. Here, the 'implied wage' coincides with the 'actual wage' (**??**).

We now ask, what would happen to this plot if industries were aggregated in a way that lumped low index industries and high index industries in the same composite (aggregate) industry? (as in the Glass industry example cited earlier). With this in mind, recall that we have m products (or industries) of each type k. We distinguish the first r of these products, labelled 1 to r, from the remaining products. We construct a 'data set' in which the *j-th* product of each product group is placed in a single newly defined industry, labelled industry j. In other words, industry j comprises both low end products (k close to 1) and high end products (k close to K). There are r such composite industries indexed by $j = 1, 2, \ldots, r$ (table 3).

Note that the mean wage rate of countries producing product group j is simply the global mean wage, which we denote as $\overline{w}$. Now we re-compute the product-basket index. Note that the weighted index of wage rates of each good in country k's basket now takes the form of a weighted average of the true wage rate (for goods $r + 1$ to m) and $\overline{w}$ (for goods 1 to r). The result is that as r increases the plot swivels from the 45° line towards the horizontal (and in the extreme case where $r = m$, all countries baskets score $\overline{w}$, and information on the product basket conveys no information about a country's type, or its wage rate.); see Figure 1. This provides an interpretation of the empirically observed 'flatness' property found in product-mix diagrams.

[9] We are here dealing with short run analysis, in the sense of the Industrial Organization Literature, in which all costs of developing capabilities are sunk costs that were incurred in the past. The scarcity of capabilities reflects the equilibrium outcome (from an earlier (unmodelled) stage of 'competing in capability building. The industries with few players are those for which a given proportionate increase in a firm's investment in capability building yields a relatively large return in terms of (global) market share (Sutton, 1991, 1998, 2007).

Table 3: Aggregate Data

	Product Group	Products
Low Capability	1	$1, 2, \ldots, j, \ldots, r+1, \ldots, m$
	2	$1, 2, \ldots, j, \ldots, r+1, \ldots, m$
	r	$1, 2, \ldots, j, \ldots, r+1, \ldots, m$
	r+1	$1, 2, \ldots, j, \ldots, r+1, \ldots, m$
High Capability	T	$1, 2, \ldots, j, \ldots, r+1, \ldots, m$

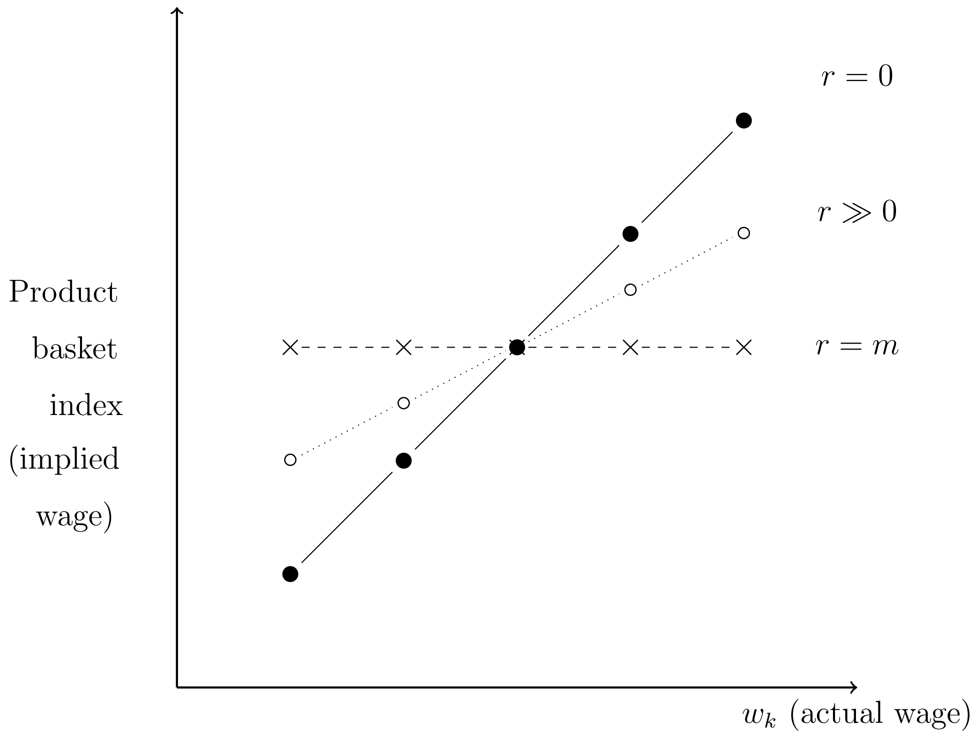
Notes: The jth product ($j = 1, 2, \ldots, T$) in each product group forms part of the newly formed industry j. Thus the first r products in each group are lumped together in the data. Industry j includes lower capability products ('bottles') as well as higher capability products ('plate glass').

In what follows, we will use as our point of departure the baseline case in which all industries are classified appropriately, and so the product mix diagram falls on the 45° line. Our focus will be on introducing quality differences across different firms (countries) operating in each industry. One outcome of introducing these quality differences will provide a (candidate) explanation for the second key feature of the product-mix diagram, viz, the dispersion observed in the scatter.

3 Theory II: Quality Differences

In this section, we relax the assumption characterizing the baseline model, that all producers in each industry have the same (productivity and) quality. The central aim is to characterize the band of countries, in terms of their real wage rate (gdp per capita) that will be active in a given industry at equilibrium. With this in mind, we examine a country initially producing good $k-1$, whose capability in the production of good k advances, in the sense that its quality, denoted v, rises from 0 to the standard quality u. As v rises, the country's mix of output will gradually shift from the production of goods of group $k-1$ to those of group k. This change will, in general, affect the equilibrium wage rate of all countries of adjacent types. The general solution in this setting is analytically intractable, and so we introduce a 'small' country approximation in order to permit a full solution. The idea is as follows: we begin from the basic model, but we now introduce a new, additional,

Figure 1: The Flatness Property



Notes: The product basket index, shown on the vertical axis, is the weighted mean income of countries producing the products that are produced by country k. The schedule $r = 0$ corresponds to the case in which all products are appropriately classified. The aggregation of products of distinct types leads to a flattening of the plot.

'small' country ('country $K + 1$'). This country's population n is very small compared to $\mathbf{N}$, the (common) population level of all other countries. Moreover, its capabilities are confined to only some fixed number r of the m products in each product group; we may think of these products, for example, as products 1 to r (see Table 2). The result will be that, holding r fixed and in the limit $m \to \infty$, this country's presence (or absence) from r of the m markets of type k will have a neglibible influence on the equilibrium wage of other (large) countries. Hence, we may investigate the fortunes of this 'small developing country' while treating the wage rates of all other ('large') countries as being (approximately) constant.[10]

With this in mind, we proceed as follows: We begin from a situation in which the new country has the standard level of productivity in all products, but has quality zero, except

[10]We maintain here, as elsewhere, the assumption that labour market faced by the firms operating in country k is competitive, i.e. the firm is a price taker in the labour market.

in the first r products in product groups 1 to $k-1$, where it has the standard quality u. The country's equilibrium wage falls monotonically as its population n rises.[11] We choose the small country's population n so that its equilibrium wage coincides with the equilibrium wage of type $k-1$ countries. At equilibrium, it will be active in, and only in, the first r products of group $k-1$.[12] Thus there are $N_{k-1}+1 = N'_{k-1}$ producers in this market.

We now examine the effect of allowing its quality in (the first r products) of group k, which we denote by v, to rise from zero to the standard quality level u of existing group k producers.

The rise in v has no effect on the new country's wage until v reaches the quality threshold at which the new country is viable in market k. This level of v is implicitly defined by the viability condition

$$\frac{v}{w} = \frac{N_k - 1}{N_k} \cdot \frac{1}{\overline{w}_k}$$

where w is the small country's initial wage rate (i.e. its wage rate when $v = 0$) and $\overline{w}_k$ is the wage rate of group k countries.

Once v advances beyond this threshold level, the new firm becomes active in both market $k-1$ and market k;[13] and thus continues to be the case up to a critical level of v at which it ceases to be active in market $k-1$. Its wage in this first phase can be deduced as follows: note that there are now $N_{k-1}+1$ producers in market k, all with quality u, where N_{k-1} producers have a local wage w_{k-1} and one has local wage w. There are $N_k + 1$ producers in market $k+1$, of which N_k has quality u and local wage w_k, and one with quality v and local wage w. The new country's output in each of the first r markets of type $k-1$ is therefore

$$x_{k-1} = \frac{1}{w} S(N_k + 1) \frac{w/u}{N_{k-1}\frac{w_{k-1}}{u} + \frac{w}{u}} \{1 - N_{k-1} \frac{w/u}{N_{k-1}\frac{w_{k-1}}{u} + \frac{w}{u}}\}$$

and its output in market k is

$$x_k = \frac{1}{w} S(N_k + 1) \frac{w/v}{N_k\frac{w_k}{u} + \frac{w}{v}} \{1 - N_k \frac{w/v}{N_k\frac{w_k}{u} + \frac{w}{v}}\}$$

[11] To see this, note that its demand for labour equals its firm's output of good m, which falls as its unit cost, w, rises.

[12] To ensure this, we assume that $N_{k-2} > (N_{k-1}+1) + 3 = N_{k-1} + 4$. In this section we assume $N_{k-1} > N_k + 4$ for all k.

[13] **JOHN**: The notation here is problematic. For all of the empirical section we will use k to denote countries and x_k will be the total exports of country k. Yet here x_k is going to mean product k. This gets especially bad in the empirical section when we refer back to figure 3 which has x_k on its axis.

These expressions define a pair of functions $x_{k-1}(w(v))$ and $x_k(w(v), v)$ respectively. We note that x_{k-1} and x_k are monotonically decreasing in w.

We now note that labour demand in the new country equals (recalling that the productivity parameters have been set to unity),

$$L^D = rx_{k-1}(w(v)) + rx_k(w(v), v)$$

while labour supply is

$$L^S = w\frac{1}{m}\mathbf{N}l(w) = w\frac{1}{m}\mathbf{N}\prod_g(\delta_g\frac{u_g}{p_g})^{\delta_g} = \lambda w$$

where λ is a constant, independent of v, by our small country assumption (i.e. $m \to \infty$).

We measure the wage of the new country relative to the equilibrium wage of group k countries. We have, on equating L^D to L^S,

$$\lambda w = x_{k-1}(w(v)) + x_k(w(v), v) \tag{7}$$

We begin by showing that, as v increases, w increases. To see this, differentiate (7) with respect to v to obtain

$$\lambda\frac{dw}{dv} = \frac{\partial x_{k-1}}{\partial w}\cdot\frac{dw}{dv} + \frac{\partial x_k}{\partial w}\cdot\frac{dw}{dv} + \frac{\partial x_k}{\partial v}$$

whence

$$\frac{dw}{dv}[\lambda - \underbrace{\frac{\partial x_{k-1}}{\partial w}}_{(-)} - \underbrace{\frac{\partial x_k}{\partial w}}_{(-)}] = \underbrace{\frac{\partial x_k}{\partial v}}_{(+)}$$

where the indicated signs on the derivatives follow from properties 1 and 2 above. It follows that dw/dv is positive.

We next show that as v, and hence $w(v)$ rises, the ratio $v/w(v)$ rises i.e. the proportionate rise in w is less than the proportionate rise in v. To show this, suppose the contrary viz. that w rises proportionally more than v. By property 3, this implies a fall in x_k. Referring to equation (7), the left hand expression in (7) is increasing with v, as we have shown, while the right hand expression is decreasing (recall that $x_{k-1}(w(v))$ decreases by property 1).

It follows that, as v increases, w rises, but by a smaller proportional amount, so v/w rises.

But by inspection of the revenue equation (5), the developing country's revenue in market k depends on v and $w(v)$ only through the ratio $v/w(v)$, and is strictly increasing in this ratio; whence its equilibrium sales revenue in market k increases with v.

This first phase ends when w rises to the critical value at which the new country is no longer viable in the production of goods of type $k-1$. This critical wage rate is defined implicitly by the condition

$$\frac{u}{w} = \frac{N_{k-1}}{N_{k-1}-1}\frac{u}{w_{k-1}}$$

As v increases further, the new country specializes in the production of good k. Now labour market equilibrium requires

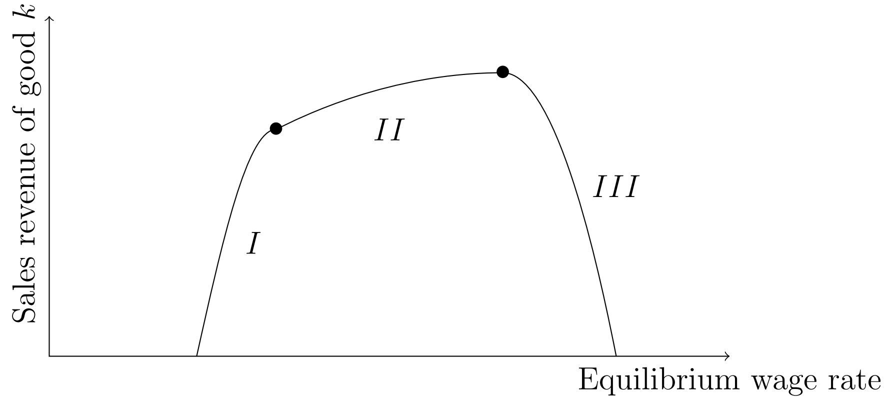
$$\lambda w = r x_k(w(v), v)$$

and w rises with v as v increases to u. It follows from property 1 and property 4 that its sales revenue in market $k-1$ declines.

We now extend the analysis, by allowing the new country to build capabilities in the next group of products, i.e., group $k+1$. Specifically, we now denote by v the new country's quality level in the first r products of group $k+1$, holding its quality in products of group k (and in all markets 1 to $k-1$) at the standard quality level u. Following the same argument as set out above, its wage rises with v and sales revenue in market k now declines to zero as it becomes a 'high quality' but 'high wage' producer relative to incumbent firms (Figures 2 and 3).[14] We can now re-consider the product mix diagram in the light of the addition of this new country. Consider the critical values of v at which the new country ceases to produce good $k = 1$. Its product basket will now coincide with that of type k countries, so that its product basket index, or implied wage, equals w_k, but its actual wage will lie strictly below w_k, and will advance to w_k only when v reaches the standard quality level u (figure 4.) This provides an explanation for the diffuseness feature of empirical product-mix diagrams: a horizontal movement across the diagram corresponds to an advance in quality (and/or productivity) in the country's existing basket of goods.

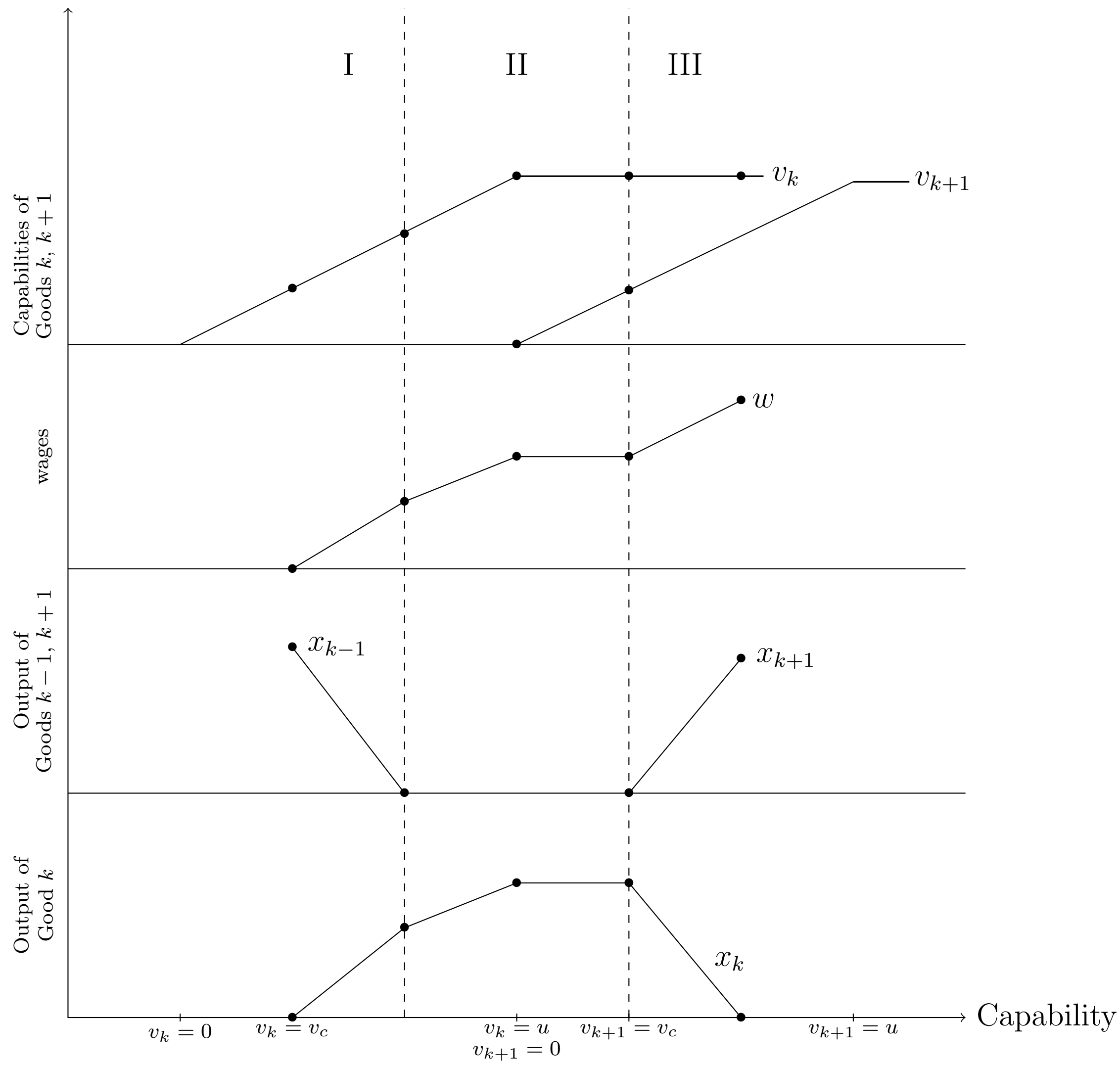
[14]The reader may see a similarity between these figures and the cone-of-diversification figures in Leamer (1984) and Schott (2003). However, empirically we will find no very little relationship between capabilities on the one hand and capital intensities/capital abundance on the other.

Figure 2: The 'Producer Band' for Product k



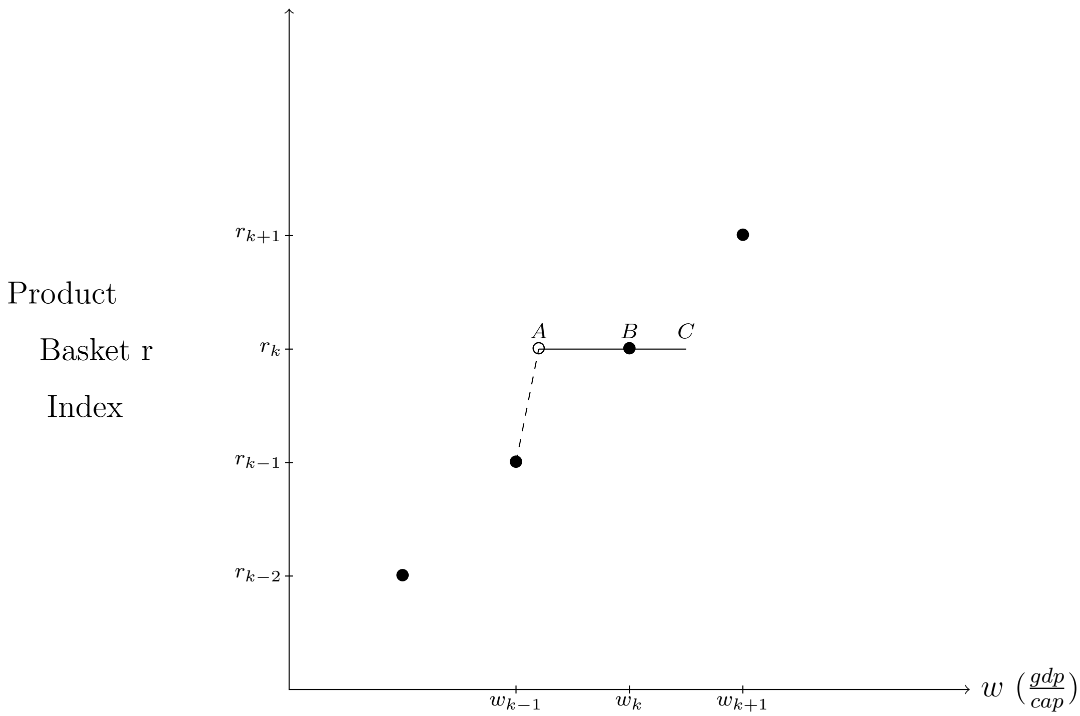
Notes: As the new country's quality v in market k rises, its output of good k rises (Phase I), and eventually it specializes in good k (Phase II). When v rises to the standard (maximal) quality u, its output peaks. As its capability in good $k+1$ rises, its wage rises further and its output of good k falls to zero (Phase III).

Figure 3: Advancing Capability



Notes: The 'capability axis' shows the new country's capability in good k advance from $v = 0$ to $v = u$, and then its capability in good $k+1$ from $v = 0$ to $v = u$. The critical value of v at which production becomes viable is labelled v_c.

Figure 4: The Diffuseness Property



Notes: The horizontal line labelled ABC shows the product-basket index of a country of type $k-1$ that produces goods of group k at quality level v. (Phase II of figure 3.) The hatched line corresponds to Phase I. Point A corresponds to the point at which production of good $k-1$ ceases. The case $v = u$ is shown as point B. The case $v > u$ is shown as point C.

3.1 An Implication for Current Measures of Quality

The most direct way of inferring quality is by observing its elements, as in Feenstra's (1984) work on autos where auto characteristics are observed. A related approach is to infer quality from the quality of inputs, as in Verhoogen's (2008) use of the share of non-production workers in total employment. In international trade, the most common method of inferring quality is to equate quality with unit import price indexes (import value divided by quantity) using U.S. HS10 import data. See Schott (2004) and Hallak (2006). **?** combine the two approaches (observable quality and prices methods (1) and (2) by examining the unit value import prices of purchased inputs.

A problem with equating price with quality is that a high price may reflect a high cost.[15] However, if market share is high when price is high then we can be more confident that the high price is due to quality. This insight is used in Hummels and Klenow (2005), Hallak and Schott (2008) and Khandelwal (forthcoming) to improve their estimates of quality. The former two papers take an index approach to this problem while the latter paper uses Berry's 1994 nested-logit approach.Khandelwal (forthcoming) develops this insight using a nested-logit approach while Hallak and Schott (2008) take an index-number approach. Both are extremely careful to connect the estimation to theory. [16]

Our work demonstrates that these insights about the use of market shares do not carry over into a multi-sector general equilibrium model. Central to our work is the fact that increasing quality in one sector draws resources out of other sectors. As country with high quality in product g gains capabilities in producing product $g+1$, the country will experience a fall in its good g market share. Thus, in both the cross-section and time series, we should expect to see at least some countries for which high quality is accompanied simultaneously by a high price and a low market share.

4 The Data

The raw trade are from the COMTRADE website. We use 1980 and 2005. It will be important for our work to find a balance between a long time series, a detailed commodity break-down, and high country coverage. We thus use the 4-digit SITC Revision 2 classification (henceforth SITC4), which allows us to go back to 1980 for a large number of countries. To verify that *all* of our 2005 results hold for more detailed commodity breakdowns we also use the 2005 COMTRADE data at the level of 6-digit HS 1996 revision (henceforth HS6)[17] and 2005 U.S. import data at the 10-digit HS level (henceforth HS10). We use all industries/products except for agriculture and food. This leaves us with 746 SITC4 industry

[15]Another problem is that a high price may reflect the popularity of a good — 'black is in' — rather than its quality. This is why all authors in the literature provide the caveat that they are defining quality as *anything* that shifts demand shift out.

[16]Very roughly, Khandelwal regresses market shares on U.S. import prices indexes and product-exporter fixed effects. The latter are the estimates of quality. Hallak and Schott careful derive a country-level price index from HS10-level U.S. import price indexes. They then regress net exports on their price index, cost-shifters and country fixed effects. The latter are the estimates of quality.

[17]If we use the 2002 revision we loose many countries because poorer countries have been slow to make the transition to this new revision.

codes.[18]

We delete countries with a population less than two million. Population data are taken from the United Nations website. We also delete countries that do not appear in both the 1980 and 2005 COMTRADE data. This eliminates countries whose territorial integrity changed substantially over time such as the USSR, Czechoslovakia, Yugoslavia, and their present-day replacements. An exception is Germany where we defined 1980 German exports as the sum of East and West German exports. We also delete Hong Kong. The only significant participant in international trade not in our data is Taiwan, for which we have no data in 1980.[19] We are left with 94 countries, which accounted for 90% of world exports in 1980 and 85% of world exports in 2005. Appendix table A.13 lists these countries.

Per capita GDP figures are taken from the United Nations website. We use figures at current prices using standard IMF exchange rates. We do not include a PPP adjustment since we are interested in nominal price competition in world product markets.

5 Empirical Regularities I: Average Exporter Wealth vs. Range of Exporter Wealth

[20]

The conventional way of representing the relation between a country's product mix and its gdp per capita is in terms of a 'product-mix' diagram which shows actual gdp per capita on the horizontal axis and the level of gdp per capita implied by its export basket on the vertical axis. This latter is constructed in two stages. First a product *score* is calculated based on the gdp per capita of countries that export the product. Then an *index* of implied gdp per capita is constructed for each country based on these scores. (Throughout, 'score' refers to products, 'index' to countries.)

Different authors have proposed different definitions of the product score and so of the implied gdp per capita index. All authors define the score as the weighted average of the gdp per capita of the exporting countries; however, authors differ in the choice of weights. In Michaely (1984) and Lall, Weiss, and Zhang (2006) the weights equal the exporters' shares of world exports. Hausmann, Hwang, and Rodrik (2007) use weights which depend on the

[18]Specifically, we omit 2-digit SITC codes 00 (food and live animals), 01 (meat and preparations), 02 (dairy products), 03 (fish and other fish preparations).

[19]We have verified that all of our 2005 SITC4 results are unchanged when Hong Kong and Taiwan are included.

[20]John: Shorten this title?

relative importance of the good in each country's export basket. In what follows we adopt the currently more widely used index of Hausmann, Hwang, and Rodrik. This has the virtue in our context of linking in a more direct way to the theory presented above. Specifically, let x_{gk} be country k's exports of good g, let $x_k \equiv \Sigma_g x_{gk}$ be country k's total exports so that x_{gk}/x_k is the share of good g in country k's export basket. Denote by y_k the gdp per capita of country k; we work throughout in terms of $\ln y_k$. The producer-wealth score of good g is defined as

$$C_g \equiv \frac{\Sigma_k \frac{x_{gk}}{x_k} \ln y_k}{\Sigma_k \frac{x_{gk}}{xk}} \tag{2}$$

where 'C' denotes capability.

We now use the producer-wealth scores to define the index of a country's implied gdp per capita. This is defined as

$$I_k \equiv \Sigma_g \frac{x_{gk}}{x_k} C_g. \tag{3}$$

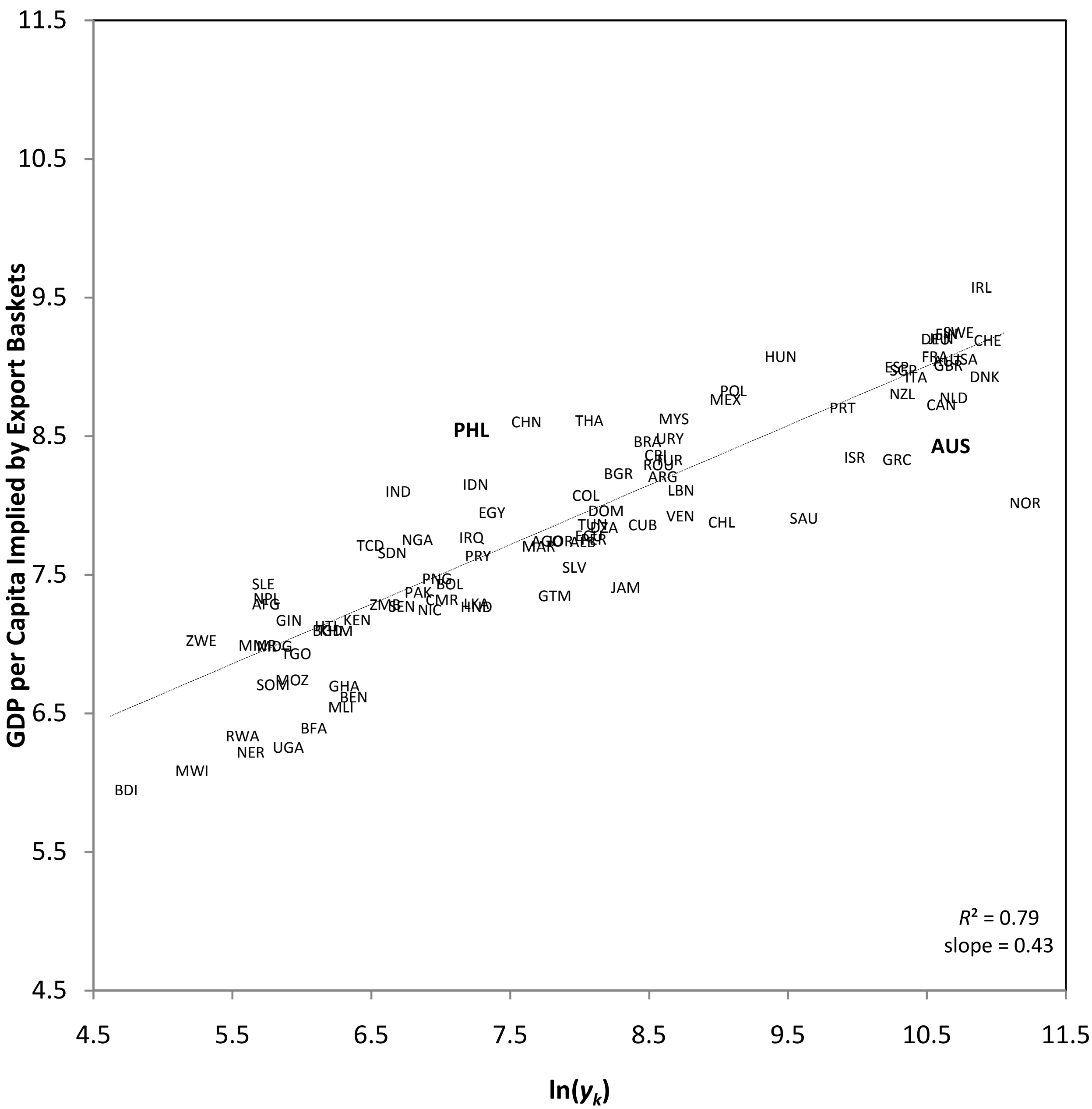
One can think of many alternative ways of imputing a country's index from its export basket and these are explored in on-line appendix figure B.14. However, all of these indexes yield the same key conclusions as I_k.

Figure 5 plots I_k against $\ln y_k$ for 2005. Each of the 94 points is a country. The figure shows the twin features of 'flatness' and 'diffuseness' noted in the Introduction. As we showed above, (a) if goods can be grouped into capability groups that are ranked by scarcity, (b) if countries are grouped into types of identical capabilities, and (c) if each country is fully specialized in a single product group, then the product-mix diagram would take the form of a 45° line. We also showed that if industries are classified in such a way as to incorporate or aggregate goods from different capability groups, then 'flatness' results. Consistent with this, the slope of the fitted line in figure 5 is only 0.43 i.e., the figure displays flatness. Finally we showed that 'diffuseness' would result if firms from different countries operating within each industry have different quality levels. This diffuseness is a major feature of figure 5: countries with very different gdp per capita have very similar predictions of gdp per capita e.g., the Philippines and Austria.

Flatness and diffuseness are invariable features of product-mix diagrams. As shown in on-line appendix B.14, they hold using (1) 2005 HS6 data, (2) 1980 SITC4 data, and (3) the Michaely world weights.[21] For examples, in cases (1)–(3), the slopes of the fitted lines are

[21] That is, the weights $x_{gk}/\sum_g x_{gk}$ in equation (2) are replaced by world weights $x_{gk}/\sum_k x_{gk}$. The Michaely index has a number of advantages in certain contexts. It is often observed that a large rich country may account for a large fraction of world trade in certain low-end products. In such cases, the Michaely approach assigns a large weight to rich countries when calculating product scores C_g. This is interesting

Figure 5: Product-Mix Diagram



Notes: This figure reports a product-mix diagram. The horizontal axis is log gdp per capita. The vertical axis is I_k of equation (3) i.e., log gdp per capita implied by a country's export basket. Data are for 2005 using the SITC4 classification.

0.44, 0.46, and 0.18, respectively.[22]

5.1 Quality and Ranges

[23]

Product-mix diagrams, whether based on the Michaely or Hausmann-Hwang-Rodrik index, rest on the idea of identifying with each industry some 'average' gdp per capita of exporting countries. Our key point of departure lies in focussing instead on the *range* of levels of gdp per capita of countries exporting the good. That is, for each product we identify the poorest and richest exporters of the product. Denote these by $y_{min,g}$ and $y_{max,g}$, respectively. To avoid 'noise' associated with small reported export figures, a problem to which trade data is notoriously prone, for each good we look only at the set of countries for whom the good is a 'significant' export, in the sense that the value of its exports in that good constitute at least 1% of the value of exports of the country's principal export good.[24] We will shortly show that the choice of cut-off makes no difference. To further avoid noise, We also require there to be at least three producers for whom the good is a significant export. Again, we will show below that this makes no difference to our results.

Ranges are displayed in figure 6. Each point is a unique SITC4 industry (g) and shows the range of wealth levels of producers who have significant exports of g. The horizontal and vertical axes show, respectively, the log gdp per capita of the poorest and richest significant producers. That is, each point displays $(\ln y_{min,g}, \ln y_{max,g})$. All the points lie above the 45° line because the richest significant producer must be richer than the poorest significant producer. For reference, along the axes we show the log gdp per capita of various countries

for some questions. However, in our theoretical setting, what matters is the impact of exporting on the derived demand for labour and so on the equilibrium wage rate. As such, the Hausmann–Hwang–Rodrik export-basket shares (which are typically large when employment shares are large) provide the appropriate weights for us.

[22]The reader will have noticed that the theory uses wages whereas in the empirics we use gdp per capita. Here we have followed convention in measuring the product mix across the manufacturing sector while taking as our measure of equilibrium wages the level of gdp per capita. This introduces significant noise due to the relative importance of the non-manufacturing sector across different countries, this problem being most serious in the case of resource-rich economies. We have carried out our present analysis using manufacturing value-added per worker rather than gdp per capita, but these data are very noisy. None the less, our basic product-mix diagram still displays a clear positive correlation. It should be noted, moreover, that variability of the relative importance of manufacturing in the economy is an additional source of noise contributing to the diffuseness property.

[23]John, we really need terminology that is as cool as your 'windows'. At some point later you use 'wealth windows'. Something with quality and windows together would be perfect. We also discussed the use of 'ranges'.

[24]More formally, we use export data for a (g, k) pair when $x_{gk}/x_k \geq 0.01 \max_g x_{gk}/x_k$.

(Nepal, China, Poland and the United States).

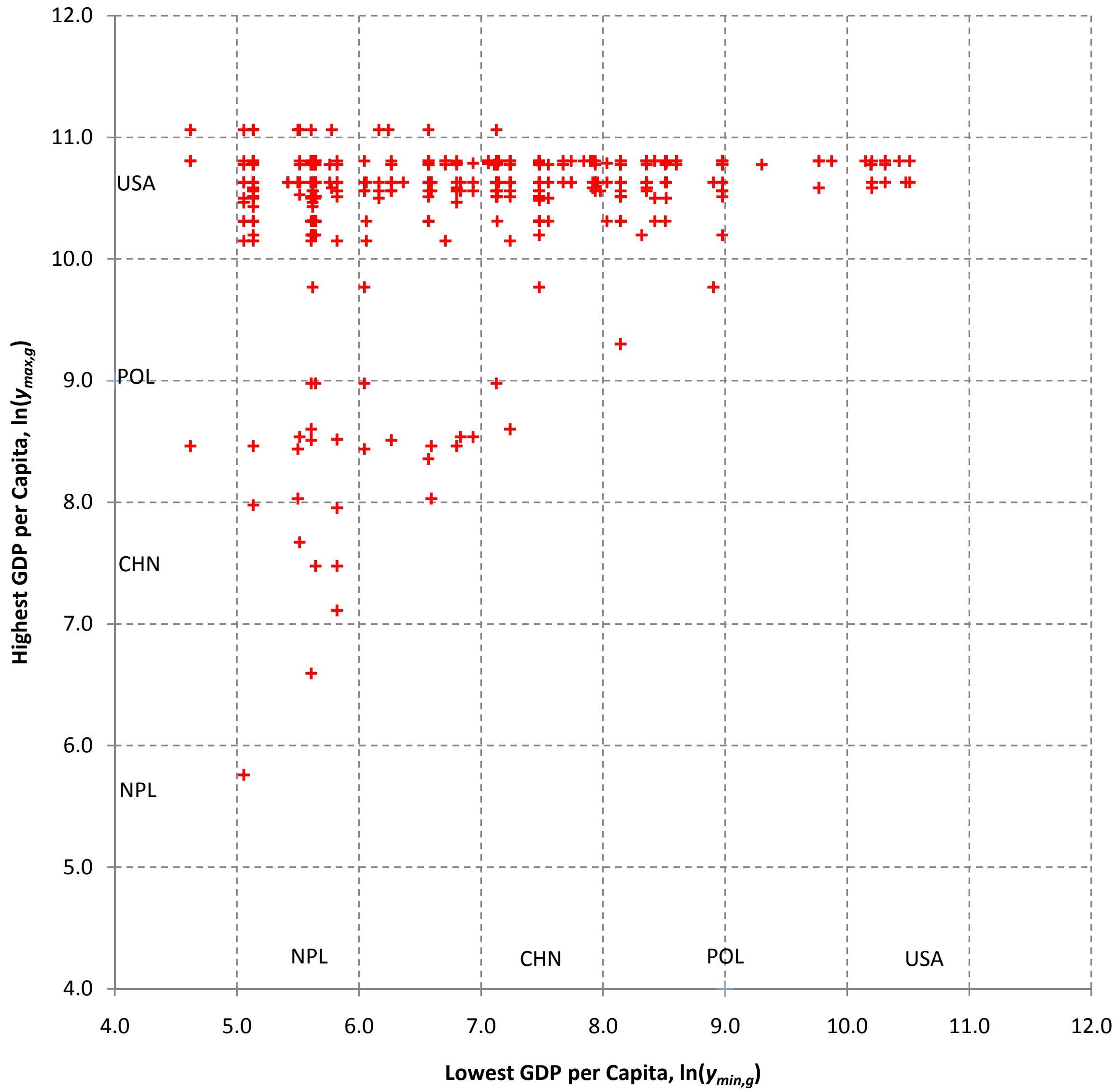
What is striking about figure 6 is the preponderance of points in the top left-hand corner, i.e. of industries for which the range is very wide. Goods of this kind are 'uninformative' in our present context, in the sense that knowing that this good (industry) is a significant contributor to a country's export basket tells us little about the country's income. Such 'uninformativeness' is the norm, rather than the exception.

There are two distinct groups of points that lie far from the top left hand corner in figure 6. These are 'informative' products. The first, lying in the bottom left, correspond to industries associated with low-income producers (the 'L-group'). The second, lying in the top right, are produced only by relatively high income countries (the 'H-group'). On our present interpretation, L-group goods are not produced by high income countries because these countries' wage costs are too high, whereas H-group goods are not produced by low-income countries because their capabilities (achievable quality levels) are too low.

A natural response to this interpretation is to suggest that by moving to a lower (i.e., finer) level of aggregation that we might obtain a narrowing of the ranges plotted in figure 7. This turns out not to be the case. We show in the top panel of figure 7 uses the HS10 classification (U.S. import data only). Once again, the pattern of ranges is similar.

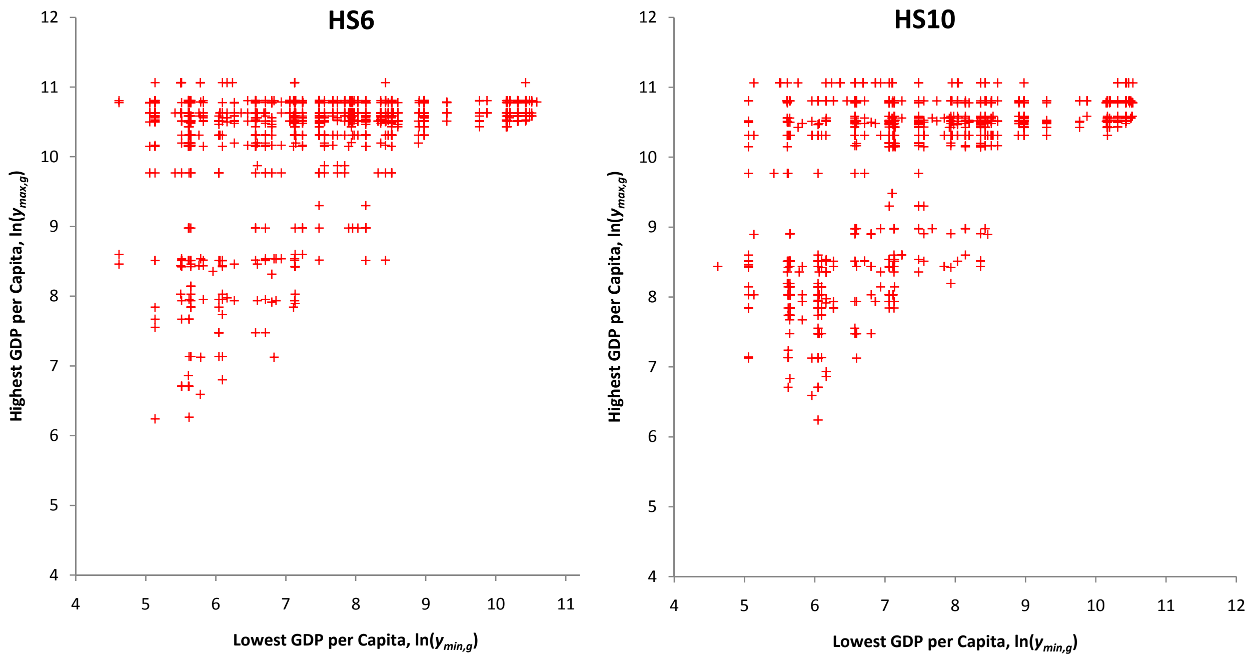
This may seem puzzling, since if the move to a finer level of aggregation involved the breaking up of technologically disparate sub-industries into individual industries, we might expect the range to narrow as we move to this new level of aggregation. An examination of the way in which industries are broken up in the HS6 and HS10 data throws light on why disaggregation beyond SITC4 does not alter the distribution of ranges. In some cases the SITC4 industry is as disaggregated as the HS6 and even the HS10 industries e.g., 'New tires for motor cars' is a single category in both SITC4 and HS6. In other cases, the disaggregation is based only on size or value, without any reference to capabilities e.g., 'New tires for motor cars' feeds into 7 HS10 codes which distinguish between fine differences in the diameter of the tire. In yet other cases, the SITC4 code is disaggregated only by introducing a capability-irrelevant 'parts of' HS6 or HS10 code. This is pervasive e.g., SITC4 7817 'Nuclear reactors.' In those cases where a technology based disaggregation of products is introduced it is often unclear whether this disaggregation conveys any information about differences in required capabilities: for example, SITC4 7252 'Machinery for making paper pulp, paper, paperboard; Cutting machines' is disaggregated in HS10 into a number of industries, including 'Machines for making paper bags etc.' and 'Machines for making paper cartons etc.' Were an ideal disaggregation of industries to be constructed on the basis of the capabilities required, this

Figure 6: Product Ranges



Notes: Each point represents an SITC4 product. The horizontal axis is $\ln y_{min,g}$, the poorest country for which the product is a significant export. The vertical axis is $\ln y_{max,g}$, the richest country for which the product is a significant export. 'Significant' for country k means that $x_{gk}/x_k \geq 0.01 \max_g x_{gk}/x_k$. Only 547 of the 746 SITC4 products are plotted because ranges are only calculated for products with at least three producers for whom the product is significant.

Figure 7: Product Ranges: Insensitivity to Aggregation



Notes: Each panel in this figure is the same as figure 6. Figure 6 used the SITC4 classification and COMTRADE data. The left-hand panel of the current figure uses the HS6 classification and COMTRADE data. The right-hand panel uses the HS10 classification and U.S. import data.

would doubtless lead to some narrowing in the relevant ranges. However, the limitations of the published data are quite serious.[25]

Another response to the wide ranges in figures 6–7 is that the wide ranges depend critically on the definition of 'significant' producer of good g i.e., the requirement that the value of a country's exports of good g constitute at least 1% of the value of exports from the country's principal export good. On-line appendix C.1 shows that the distribution of ranges is not sensitive to the choice of cut-offs. It considers a lower cut-off (0.1%), a higher cut-off (10%), cut-offs based on the level of export sales (e.g., x_{gk} > \$ 1 million) and cut-offs based on mixtures of export levels and export percentages. It also consider all products with at least

[25]A word about commodities is in order. For what we are doing, the relevant market is never equatable with an item in a government commodity classification, be it SITC4, HS6 or HS10. Sometimes the relevant market is more detailed than HS10 (as in many electronic parts) and sometimes the relevant market is less detailed than SITC4 (as in many apparel products). This raises two points. First, more detail is sometimes obfuscating. Second, all of our conclusions must be thought of relative to a definition of the market that is determined by the commodity classification, not the actual product producers.

two (rather than three) products with significant exports. In every single case the pattern displayed in figures 6–7 is repeated.

Because China has received so much attention, it is worth noting that China plays only a modest role in figure 6. China is the poorest significant producer for those points that are vertically aligned at 7.5. If China were removed from the data, these points would shift rightward to the next poorest significant producer. China is the richest significant producer for those two points that are horizontally aligned at 7.5. Omitting China would move these two points down. In short, this picture is not dominated by China.[26]

5.2 Export-Implied GDP per Capita with Quality Ranges

The observation that the large majority of industries are uninformative, prompts an obvious question: In understanding cross-country differences in gdp per capita, is there some natural alternative to the conventional product-mix procedure based on the *average* income of significant exports, a procedure which looks instead at the *range* of wealth levels of significant exporters?

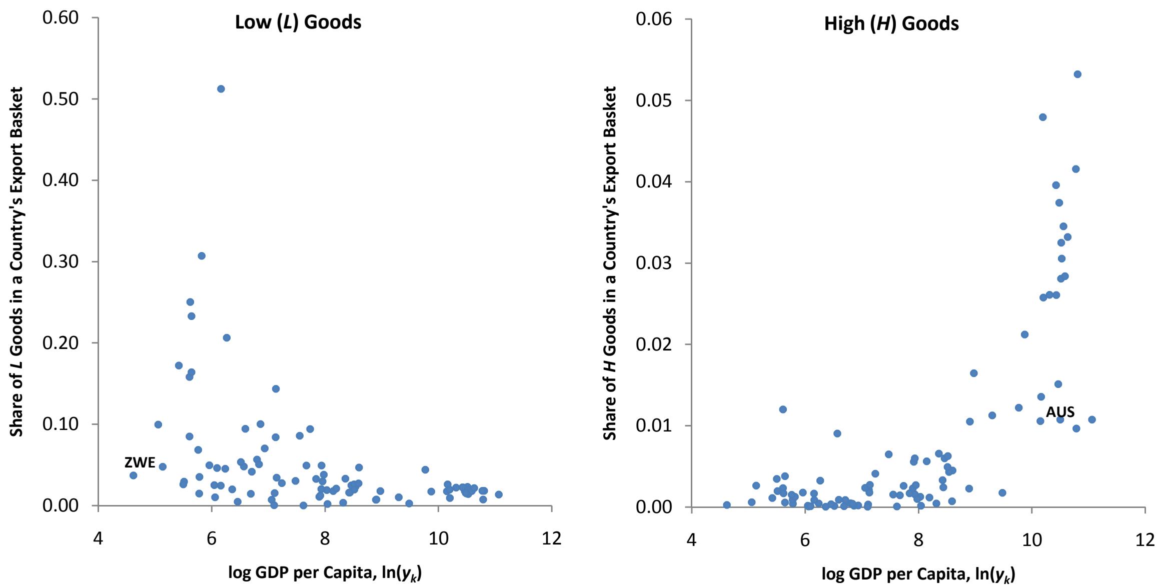
We might, for example, focus only on informative goods i.e., those to the top right and bottom left of figure 6. Define an H good as one for which the poorest significant producer has a log gdp per capita above 8.7 and an L good as one for which the richest significant producer has a log gdp per capita below 8.7. From figure 6, these are natural break points for identifying informative goods.[27] We show in figure 8 the relationship of a country's gdp per capita with (a) the share of H goods in its export basket (right-hand panel) and (b) the share of L goods in its export basket (left-hand panel).[28] We see a clear fall in the share of L goods and a rise in the share of H goods as wealth increases. But an important feature of figure 8 lies in the fact that the relation between the product-mix and wealth is not bi-directional: while significant exporters of H goods are necessarily rich, it is not the case that

[26] I am conflicted by this paragraph. People will ask about China. On the other hand, our answer is not what they will expect given Schott (2004), who emphasizes that China exports everything. While Schott's argument is a little over-stated (see Pham (2008)), it is still basically right. I am still unclear about why China is not more prevalent in figure 6. The reason I had expected dealt with our cut-off choice — China is so diversified in its exports that its 1% cut-off for good g translates into \$500 million in exports of good g. See on-line appendix section C.1, especially table B.4. Thus, China is removed from the calculation of most goods even though it exports a lot of most goods. However, even when I introduces a fix for this problem that keeps China in the calculations, China still rarely appears as the richest or poorest exporter. See on-line appendix section C.1 for details.

[27] On-line appendix figure B.19 shows that identical results are obtained using cut-offs of 8.0 and 9.7.

[28] Mathematically, define the sets of goods $L \equiv \{g : \ln y_{max,g} < 8.7\}$ and $H \equiv \{g : \ln y_{min,g} > 8.7\}$. The left-hand panel of figure 8 displays $\sum_{g \in L} x_{gk}/x_k$ The right-hand panel displays $\sum_{g \in H} x_{gk}/x_k$.

Figure 8: High (H) and Low (L) Goods: Shares in Export Baskets



Notes: Each point represents a country. (There are 94 points in *each* panel.) The horizontal axis is the country's log gdp per capita in 2005. The vertical axis is a country's exports of L goods (right-hand panel) or H goods (left-hand panel) as a share of the country's total exports. A good is an L good if $\ln y_{max,g} < 8.7$. A good is an H good if $\ln y_{min,g} > 8.7$.

rich countries are necessarily significant exporters of H goods. A very low contribution of H goods is consistent with a high level of gdp per capita. (See Austria in the right-hand panel). Similarly, while a high share of L goods necessarily implies that a country is poor, many poor countries have a very low share of L goods. (See Zimbabwe in the left-hand panel.)

We can restate this in a way that makes one the key point of our thesis crystal clear. *A poor country can advance out of L goods and still remain poor: this happens when the country enters as a low-quality producer into uninformative goods i.e., goods with wide quality ranges.* Since most goods are uninformative, we might expect this type of no-growth shift in product mix to be common. *By the same token, a country may move from being poor to being rich without changing its product mix: this happens when it improves the quality of the uninformative, wide-quality-range goods that it already exports.* We return to this point when we look at the dynamics of the product-mix diagram in section 7.

6 Empirical Regularities II: The Wealth Window

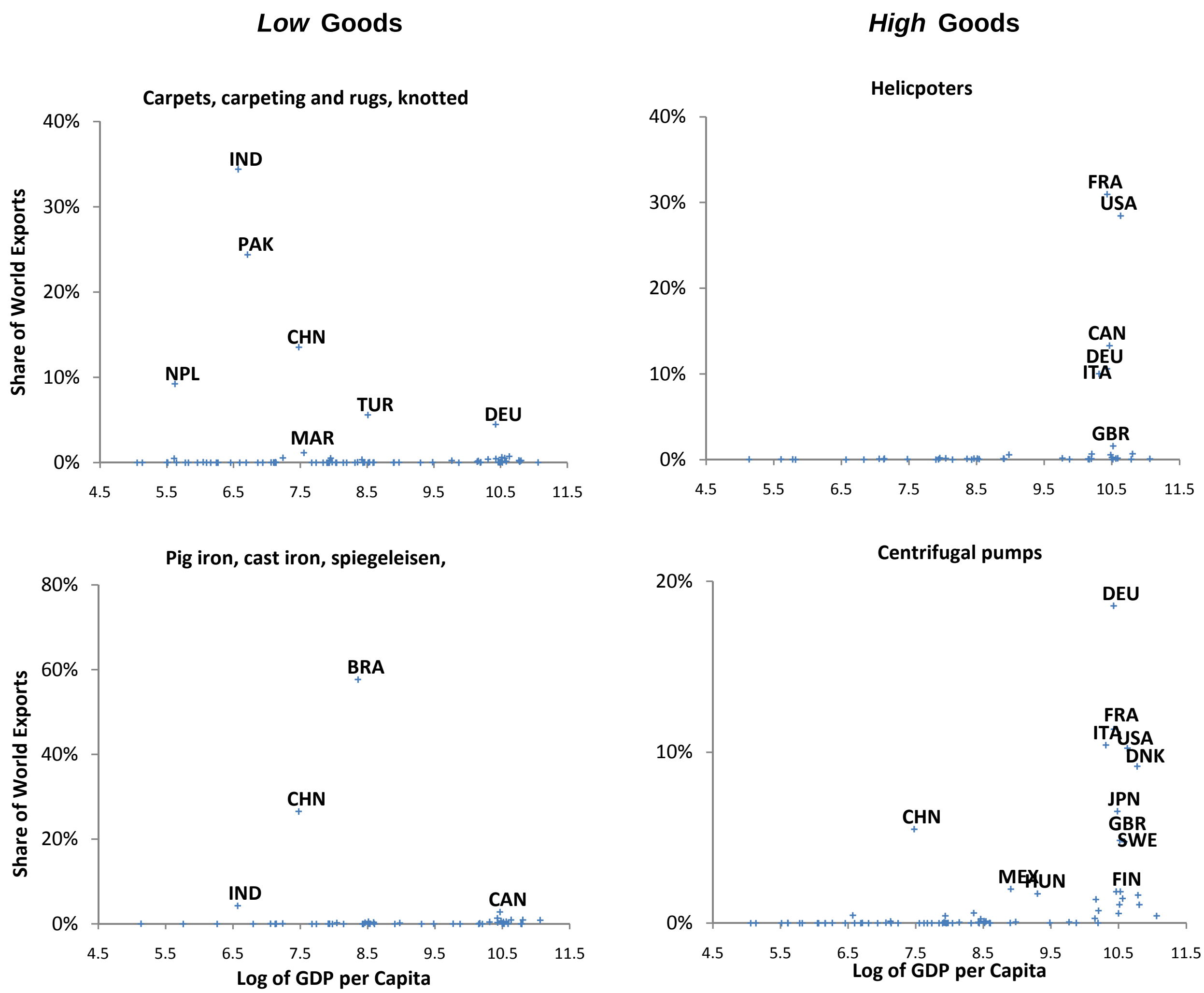
We noted in the theory section that, within a single country where all firms face the same wage, there is a 'capability window' in terms of quality and productivity in which a firm must lie in order to be viable; i.e. firms can be ranked in terms of u/c and there is a minimum value of capability u/c, i.e. a maximum level of effective cost c/u beyond which the firm will not be active in equilibrium. When we move to a multi-country setting where different firms face different wage rates, it is the effective cost level wc/u that determines viability. As we move up the spectrum of capability, u rises (and/or c falls) but w rises too. The result is an inverted U-shape relation between a country's wealth and its effective cost level wc/u, and so its equilibrium output, sales revenue, and global market share in a given industry. See the bottom panel of figure 3. It is this inverted-U relationship that determines the wealth range of products explored in the preceding section. In what follows, we examine this relationship directly.

In choosing informative goods, we avoid the 'wide range' (uninformative) industries; our focus is on the Low and High groups, respectively. Specifically, we use a subset of the industries to capture a 'Low' group where both end points of the inverted U will be interior to the empirical range of wealth levels; and a 'High' group to capture a set where the lower end (but not the upper end) of the inverted U is interior. In terms of figure 3, the Low and High groups are represented by goods k and $k+1$, respectively.[29] More formally, the Low group consists of goods g satisfying $\ln y_{min,g} > 5.25$ and $\ln y_{max,g} < 9.25$. The High group consists of goods satisfying $\ln y_{min,g} > 8.25$. These cut-offs are chosen because they capture natural break points in figure 6. Note from the figure that they are disjoint sets. We show in on-line appendix C.3 that the choice of cut-offs makes no difference to our conclusions.

Figure 9 provides some preliminary evidence supporting the theory. Each of the four plots deals with a single SITC4 good in 2005. A point on a plot is a country. The horizontal axis is the country's gdp per capita. The vertical axis is the country's share of world exports of the good i.e., $x_{gk}/\sum_k x_{gk}$ where g is the good and k indexes countries. Carpets and Pig iron are two Low goods. One can see that market shares are low for the poorest and richest countries, and highest for middle-income countries. This is the inverted-U shape predicted by the theory for good x_k in figure 3. Helicopters and Centrifugal pumps are two High goods. For Centrifugal pumps, market shares are small for middle-income countries and large for

[29] There is a third type of good which corresponds to good $k-1$ in figure 3. However, there are too few informative goods in this region to examine it empirically.

Figure 9: Market Shares for Four Typical Informative Goods



Notes: Each of the four plots deals with a single SITC4 good in 2005. A point on a plot is a country. The horizontal axis is the country's gdp per capita. The vertical axis is the country's share of world exports of the good i.e., $x_{gk}/\sum_k x_{gk}$ where g is the good and k indexes countries. The SITC4 codes for the four goods are, clockwise from the top left, 6592, 7921, 7133 and 6712. Carpets and Pig iron are Low goods while Helicopters and Centrifugal pumps are High goods .

rich countries, just as one would expect from good x_{k-1} in figure 3.[30] For Helicopters, only the very richest countries export the good. This is such a high-capability good that just five rich countries account for 93% of world exports.[31]

In order to generalize figure 9 to many products, we would like to place the world market shares for all Low goods on a single scatter. Likewise for High goods. However, one can immediately see the problem from figure 9: the vertical scale varies dramatically by product. In addition, the central tendency of the distribution of gdp per capita varies across goods e.g., it is 6.5 for Carpets and 8.5 for Pig iron.

We thus turn to normalizations. Consider country k's share of world exports of good g. We normalize the income level of k by reference to the income levels $y_{min,g}$ and $y_{max,g}$ of the poorest and richest significant exporters, respectively, of g; we represent the position of log gdp per capita $\ln y_k$ within this range as $(\ln y_k - y_{min,g})/(y_{max,g} - y_{min,g})$. We also need to adopt some normalization for the level of exports. This will be affected, as the theory indicates, not only by the effective cost wc/u, on which we want to focus, but also by (i) the country's size, as indexed by r_k in the theory, and (ii) the size of the global market for this industry's products, indexed by S_g (or equivalently δ_g) in the theory. We need to normalize the value of country k's exports of good g, denoted x_{gk}, to control for the influence of r_k and S_g. With this in mind, we divide x_{gk} by global exports of good g, denoted $x_g \equiv \Sigma_k x_{gk}$ (to control for S_g) and then divide this by $x_g \equiv \Sigma_g(x_{gk}/x_g)/N_k$ to control for r_k (where N_k is the number of goods exported by country k i.e., the number of goods goods for which $x_{gk} > 0$). Summarizing, we plot

$$\frac{\ln y_k - \ln y_{\min,g}}{\ln y_{\max,g} - \ln y_{\min,g}} \tag{4}$$

against

$$\frac{\frac{x_{gk}}{x_g}}{\Sigma_g \frac{x_{gk}}{x_g}/N_k} \tag{5}$$

where the numerator is country k's share of world exports of g and the denominator is country k's average share of world exports.[32]

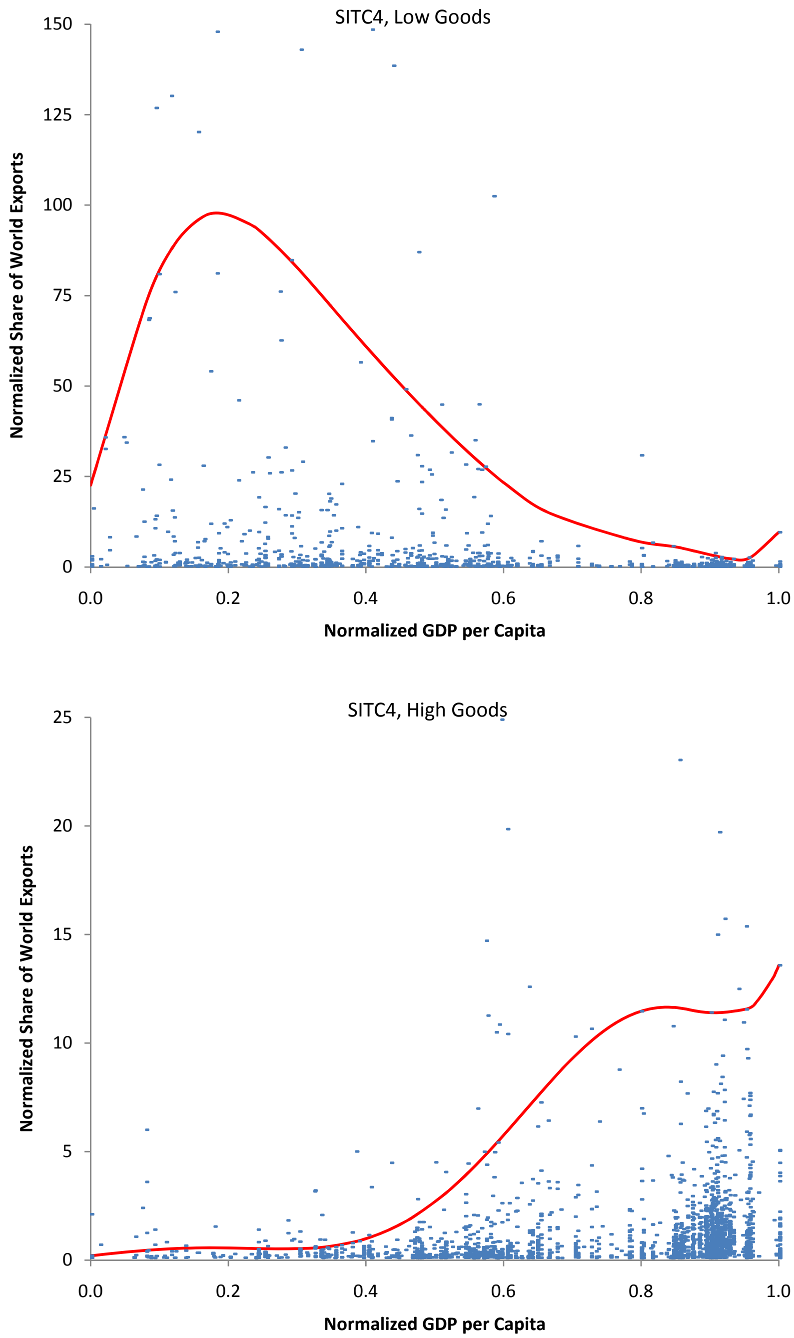
---

[30]Note that even though $y_{min,g}$ is above the gdp per capita for China, China still has a non-negligible world market share. This is because China is such a large exporter that it can have a large market share in good g without good g being a significant export.

[31]The helicopters graph displays the huge problems with the raw data. The many observations along the horizontal axis are countries that export tiny 'amounts' of helicopters, as low as $9 worth!

[32]We have experimented extensively with alternative norms for r_k i.e., alternative denominators. Specifically, for country k we have used the median value of $\{x_{gk}/x_g\}_g \equiv (x_{1k}/x_1, \ldots, x_{gk}/x_g, \ldots, x_{Gk}/x_G)$. We have also used various percentiles of $\{x_{gk}/x_g\}_g$, including the 75th, 90th, 99th and 100th (max) percentiles. The normalizations do not affect the shape of the curves in figure 10.

Figure 10: Normalized Market Shares



Notes: This figure displays plots normalized market shares against normalized log gdp per capita. The top panel is for Low goods, the bottom panel for High goods. Each point is a product-country pair (g, k). The vertical axis tracks country k's share of world exports of g: x_{gk}/x_g where $x_g \equiv \sum_k x_{gk}$. This market share is normalized by dividing by its average value for country k. See equation (5). The horizontal axis tracks the log gdp per capita of the exporter k, $\ln y_k$. It is normalized according to equation (4) in order to create a central tendency that is common across goods. The solid line is the result of a quantile regression for the 0.99 quantile. See appendix section B.3 for details.

The result is shown in the form of a pair of scatter diagrams in figure 10. In interpreting these scatters, we appeal to the idea used in the theory section, that a small country operating in industries of capability group k will not in general be active in all products/industries in that group. Rather it will spread its limited labour force over some subset of these products/industries. Hence in interpreting these scatters, our focus of interest lies not on the mean, but on the upper bound of the scatter. In other words, we aim to check whether the highest scores occur in the middle, rather than at the end points of the range.[33] With this in mind, we fit a quantile regression (the 99th quantile) to the data in each panel; the results are shown in the figure.[34] It seems that the inverted U-shape is interior to the range in the top panel of figure 10 and that it extends beyond the top of the range in the bottom panel. This is exactly as predicted.

Figure 11 repeats figure 10 using HS6 COMTRADE data (left-hand panels) and HS10 U.S. imports data (right-hand panels). Low goods are on the top panels, high goods on the bottom panels. As is apparent, the figures are similar despite the very different levels of aggregation.[35]

7 Empirical Regularities III: Dynamics

The preceding investigations of the range of exporter wealth associated with each industry raise certain questions as to what we can infer from observations of a country's product mix. The basic point is that advances in wealth are in general associated *both* with changes in the product mix and with the (traditionally emphasized) advance of productivity and quality[36] within a given set of industries. Now one point already noted is that we cannot fully separate these two contributions by reference to available data across the general run of industries; we acknowledge that some movements, especially in the wide range or 'uninformative' industries may involve *either* a quality (or productivity) improvement, or a shift from one set of products to another (more demanding) set of products within the industry.

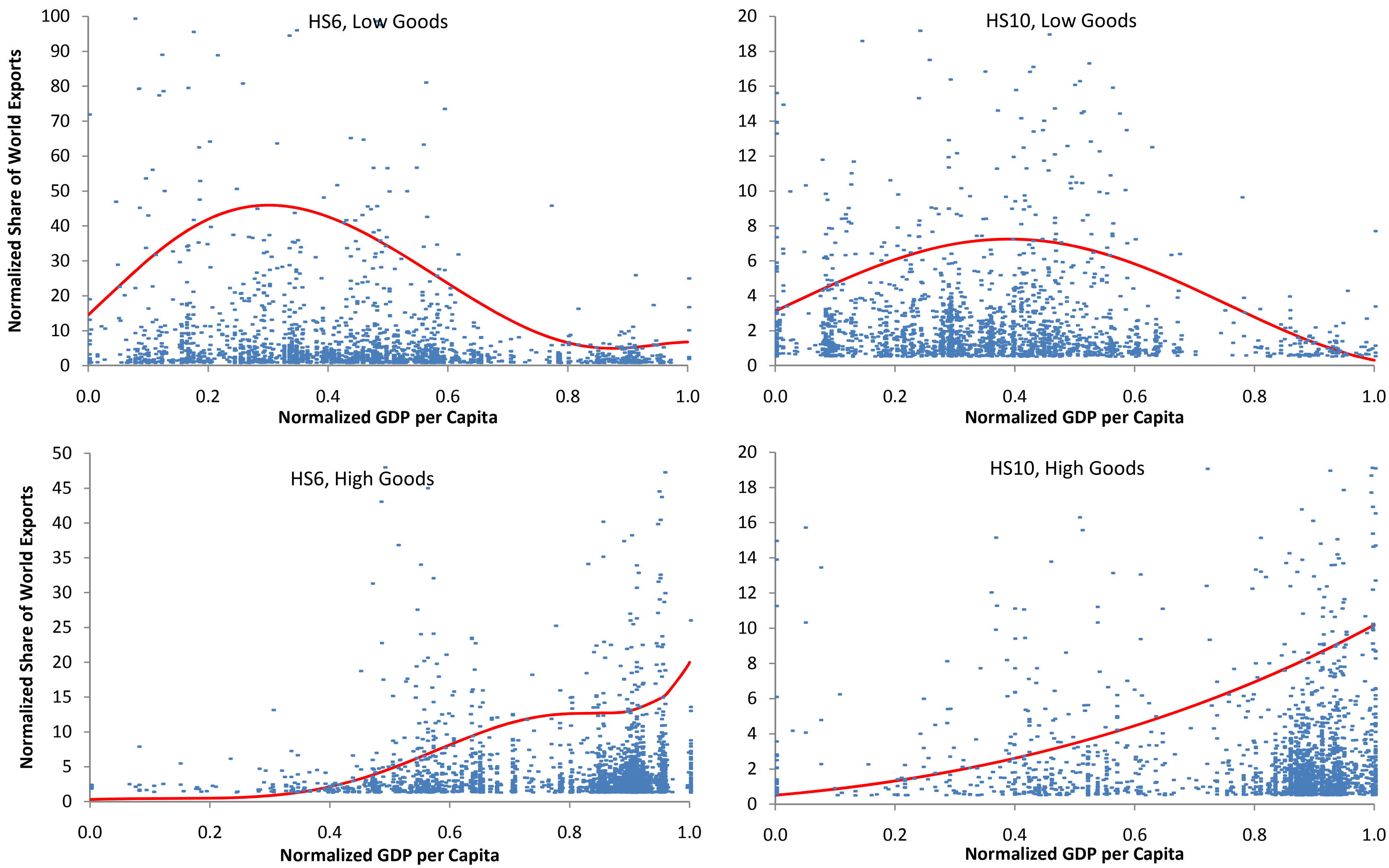
[33] Or, in the case of the top panel of figure 10, in the middle or at the right hand end of the range.

[34] See appendix B.3 for further details. In order to prevent the figure from being unduly pushed towards the horizontal axis, two observations with large normalized market shares have been suppressed from the display (though not from the quantile estimation).

[35] Since there can be over 30,000 observations (country-product pairs) per panel, for purposes of display only the 2,000 observations with the largest normalized market shares are displayed. This accounts for the narrow 'white' band close to the horizontal axis. In addition, an average of 11 observations per panel are not displayed because their large normalized market shares tend to compress the figures.

[36] Usually labelled as 'Total Factor Productivity'; for the problems associated with this concept, see for example, Foster, Haltiwanger, and Syverson (2008).

Figure 11: Normalized Market Shares: HS6 and HS10



Notes: This figure is identical to figure 10 except that the left-hand pair of panels use HS6 COMTRADE data and the right-hand pair of panels use HS10 U.S. import data. The top panels are for Low goods, the bottom panels for High goods.

With that caveat in mind, we return to the conventional product mix diagram of Figure 5, and we now examine how countries have moved on this diagram over the 25 year period 1980 to 2005. Since average global income has risen substantially over the period, leading to a rightward shift in the cloud of points, we measure 2005 gdp per capita as ...[37]. The resulting scatter is shown in the 'Arrow diagram' of figure 12.

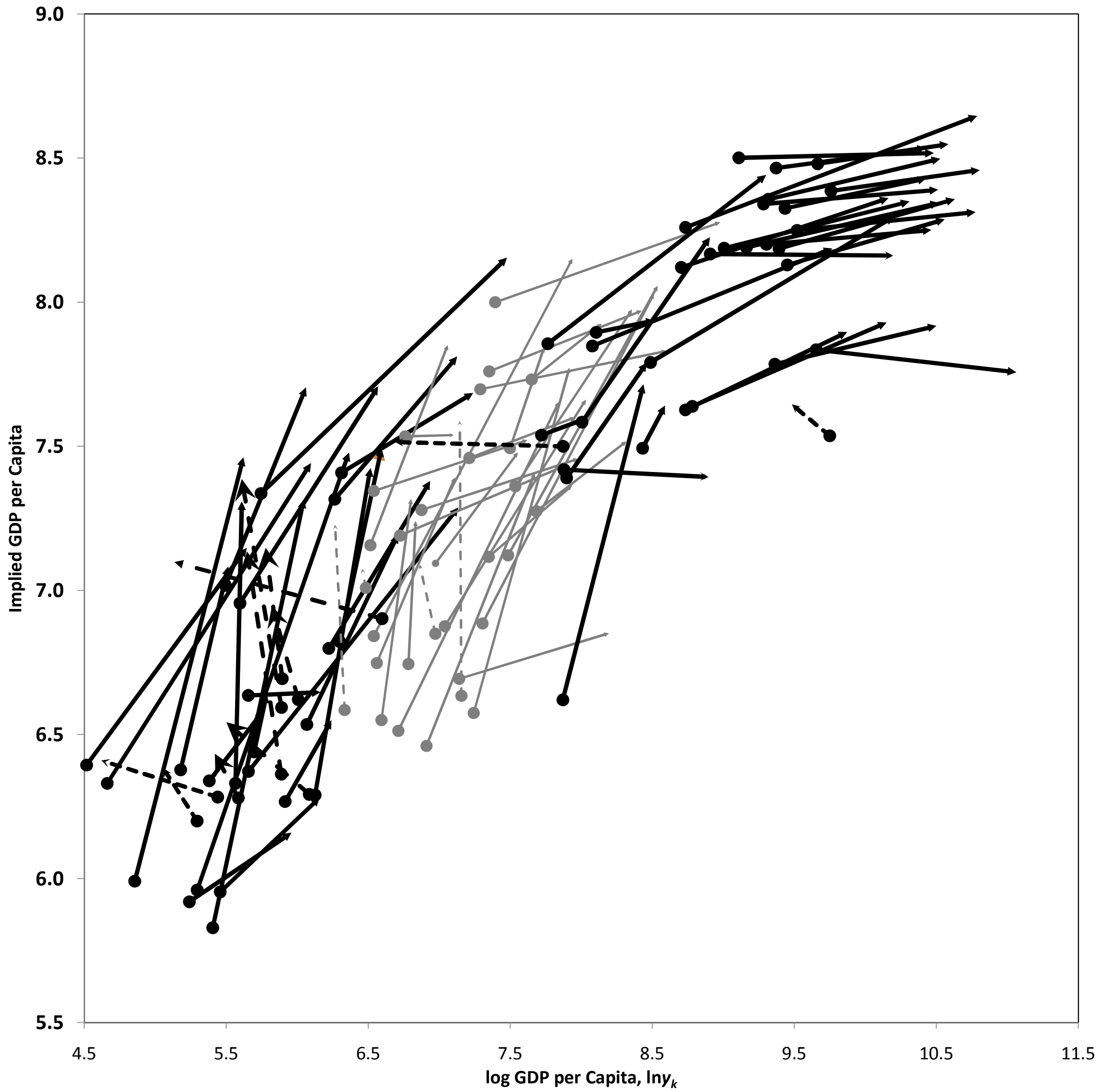
A solid line links the 1980 position to the 2005 position for those countries whose normalized gdp per capita rose over the period; the hatched lines correspond to the (few) cases where it fell, i.e. the right-hand end point of a hatched line is the 1980 position.

The striking feature of this figure is best seen by splitting countries into three equal sized groups (low, middle and high-income countries). It is clear a priori that for high income countries, an initial concentration on high end products may limit the extent to which the product mix, and so the implied gdp per capita, can rise further; so here the arrows are relatively flat. The point of interest relates to the difference in experience between the low income and middle income groups. The mid-income countries advanced 'through the cloud', moving up on average so as to become 'typical' or average' producers within the new industries they entered, whether in terms of product quality or in terms of the products they offer within their industries. In contrast to this, the low income countries exhibit a very steep slope, which indicates that they typically moved into the bottom end or 'wider range' industries, (which can be interpreted either as becoming low quality producer, or as producing low end products within these industries). This difference in average slope between the low- and mid-income groups can be confirmed by means of a nonparametric regression of the slopes against initial gdp per capita. See appendix figure B.21. We can interpret this in a purely arithmetic sense as follows: if a low -wage country that hitherto produced L goods enters new markets where it produces goods for which the producer range is very wide, so that the product score is close to world average income, the country's implied income rises. In economic terms, we interpret this by saying that the developing country enters at the 'low-quality' end of the range, and so achieves only a small benefit to actual gdp per capita.

While it would be dangerous to draw strong inferences here, this does emphasize the basic point that advances in gdp per capita involve both changes in product mix and improvements in quality and productivity; and the trajectory followed by this group of countries suggests that the key challenges to development may be more on the traditional emphasis

[37]explain normalization; what base did we use – I think 1980. If so, refer reader to an appendix picture of SITC4 1980 windows and perhaps discuss some issues about sample selection.

Figure 12: Arrows Diagram



Notes: The arrows in this diagram link the point corresponding to actual and implied gdp per capita in 1980 to the corresponding point in 2005. To facilitate the discussion of differences between low, middle and high initial income countries, the weight of the arrows has been lightened for the one-third of countries in the middle of the distribution of 1980 gdp per capita. Countries whose gdp per capita fell over the period are indicated by hatched arrows.

on improving quality and productivity within existing activities.

8 Related Literature

8.1 International Trade Literature

There are a number of models of international trade that could have been used to deliver our results e.g., Eaton and Kortum (2002), Bernard, Eaton, Jensen, and Kortum (2003) and Melitz (2003). Why have we not used these? Recall what the core of our model is. First, capabilities are scarce so that poor countries do not produce high-k goods. Second, wages adjust to changes in capabilities so that rich countries are priced out of low-k goods. One could obtain such results in these other models, but it would be cumbersome. Specifically:

1. Our core assumption is about scarcity of capabilities: high-k producers are scarce and they are to be found in rich countries. In these other papers, scarcity is described by the distribution of productivities ($G(a)$ in Melitz, 2003; the Type II extreme value distribution in Eaton and Kortum, 2002 and Bernard, Eaton, Jensen, and Kortum, 2003). To use these other models one would have to provide a detailed specification of how these distributions vary across countries and industries. This can be done, but it would require so much asymmetry that the elegance of the models would be lost. Restated, these other models are designed to handle within-industry heterogeneity and are less concerned with standard between-industry comparative advantage. In contrast, we have made the extreme assumption that there is at most one firm per country and focussed instead on the cross-country, cross-industry distribution of capabilities that are central to our Ricardian logic.

2. In these other models wage adjustment plays a role in determining entry thresholds. Beyond this, there is little discussion of wages e.g., of why some countries are rich and others poor. In our model, wage adjustment also determines thresholds, but in a more structured and asymmetric way. As wages rise in response to rising capabilities, firms in low-k industries become inactive and firms in high-k industries become active. Thus, in our model the labour supply and demand equations become the central equations of the model.

In short, we have chosen the simplest model possible that focuses on (1) Ricardian asymmetries in the distribution of capabilities and (2) the role of wages as an adjustment mechanism in a multi-industry world populated with rich and poor countries.

8.2 Long-Term Growth Literature

The driving assumptions on this paper are that (a) some capabilities are relatively scarce, and (b) the relatively scarce capabilities are distributed asymmetrically across countries. (We have chosen to take (a) and (b) as given, and explore their consequences.) It might seem natural to endogenize the entry process, and so derive (a) and (b) from more primitive assumptions. We have chosen not to do this for the following reasons. Endogenizing (a) is straightforward, and has been done elsewhere (Sutton, 1991, 1998, 2007). To model (b), however, requires that some assumption be made regarding asymmetries between countries. This could be done by assuming that the (unobservable) relationship between the fixed and sunk costs of product development, and product quality, differ across countries; but to do this would simply beg the question, why? This leads, then, into the broad economic history of industrial development, and so to the issues that lie far beyond our present scope; no single way of modelling the origin of these cross-country differences could hope to command general acceptance. And so we have chosen to present the theory in its simplest form, staying close to the empirical observables, by taking (a) and (b) as our primitives.

9 Conclusions

The aim of this paper has been to explore the way in which advances in wealth are associated both with changes in the product mix and with changes in quality and productivity within a given set of industries. The central point relates to the fact that the range wealth levels of significant exporters of most goods, defined at the conventional 6-digit level, is very wide, and that moving to more disaggregated data does not, in the case of most industries change or improve this. At a theoretical level, one reason for the wide range lies in aggregation of disparate sub-industries; another lies in the fact that within any industry, there will, in a general equilibrium multi country setting, be a viable range of producer wealth levels.

The central property of this producer-wealth range is that, in a multi market general equilibrium setting, the relation between quality and price on the one hand, and output, sales revenue and global market share on the other, is non-monotonic. There is at equilibrium a range of producer capabilities (and so wealth) levels that are viable in a given industry. As capability rises, the country moves into the production of higher ranked goods, and its equilibrium wage (or gdp per capita) rises. But this means that its output, sales revenue and global market share exhibits an inverted-U relationship with capability, and so with gdp per capita. As capability rises, market share rises, and wages rise also. As the country advances into the production of higher ranked products, the rise in wage causes its effective cost level to rise, and its global market share in this industry to fall. It is this inverted U relation that is the basis of the selection effect that links a country's wealth to its product-mix.

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A Technical Appendix

We begin by stating the solution in the form

$$p_i = \frac{1}{N_g - 1}[\sum_j \frac{w_j c_j}{u_j}] \cdot u_i \qquad (A1)$$

$$x_i = \frac{N_g - 1}{u_i \sum_j \frac{w_j c_j}{u_j}} \{1 - (N_g - 1)\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}}\} S \qquad (A2)$$

$$R_i \equiv p_i x_i = \{1 - (N_g - 1)\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}}\} S \qquad (A3)$$

It is also convenient to re-write the output equation in two other forms, viz.

$$u_i x_i = \frac{N_g - 1}{\sum_j \frac{w_j c_j}{u_j}} \{1 - (N_g - 1)\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}}\} S \qquad (A2a)$$

$$\begin{aligned} w_i c_i x_i &= (N_g - 1)\frac{w_i c_i / u_i}{\sum_j \frac{w_j c_j}{u_j}} \{1 - (N_g - 1)\frac{w_i c_i / u_i}{\sum_j \frac{w_j c_j}{u_j}}\} S \\ &= z(1 - z) \cdot S \quad \text{where} \quad z = (N_g - 1)\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}} \qquad (A2b) \end{aligned}$$

We now state the following properties of the output and revenue functions:

Property 1. $\frac{\partial x_i}{\partial w_i} < 0$ *everywhere.*

Proof: Using (2a), note that $\sum_j \frac{w_j c_j}{u_j}$ is increasing in w_i, and $\frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}}$ is increasing in w_i, whence the r.h.s. expression rises.

Property 2. $\frac{\partial x_i}{\partial u_i} > 0$ *on the domain* $\frac{1}{2} < z = \frac{w_i c_i / u_i}{\sum \frac{w_j c_j}{u_j}} \leq 1$.

Proof: Using equation (2b), note that z is decreasing in u_i, and the function $z(1 - z)$ increases on $0 \leq z < \frac{1}{2}$ and decreases on $\frac{1}{2} < z \leq 1$.
The domain restriction on z can be interpreted as follows: $z = 1$ corresponds to the case where the effective cost level $w_i c_i / u_i$ reaches the level where i's output falls to zero. The

domain restriction $z > \frac{1}{2}$, in explicit form, states that $\frac{w_i c_i}{u_i} > \frac{1}{2} \sum \frac{w_j c_j}{u_j}$, which implies that $\frac{w_i c_i}{u_i} > \frac{N_g - 1}{2N_g - 3} \cdot (\overline{\frac{wc}{u}})$ where $(\overline{\frac{wc}{u}})$ is the mean of rivals' effective cost levels, viz. $(N_g - 1)(\overline{\frac{wc}{u}}) \equiv \sum_{j \neq i} \frac{w_j c_j}{u_j}$. Since $N_g \geq 2$, it follows that this domain restriction is satisfied up to the point at which $\frac{w_i c_i}{u_i}$ coincides with the (average, or common) level of rivals' effective cost levels.

Property 3. *A rise in u_i and in w_i, leaving u_i/w_i constant, implies a fall in x_i.*

Proof: From (2a), note the r.h.s. depends on u_i and w_i only via the ratio u_i/w_i, whence $u_i x_i$ remains constant, and so x_i falls.

Corrolary 1. *If w_i rises by a greater proportion than u_i, then x_i falls. (This follows on decomposing the rise in w_i into two parts, one proportional to the rise in u_i, and a residual positive increase; and applying property 1).*

Property 4. *R_i depends on u_i and w_i only through the ratio u_i/w_i; and $\frac{\partial R_i}{\partial (u_i/w_i)} > 0$ everywhere.*

Proof: This follows from inspection of the revenue function (3), on noting that z is decreasing in u_i/w_i.

B Appendix

B.1 To Do for Final paper

1. Use exclude dairy from HS.

2. Include Hong Kong and Taiwan. Taiwan is not included because it's not in year 1980 sitc2. Hong Kong is not included because the population data didn't include HKG. However, Pen World Table does have HKG population, so we could include HKG in our data. HKG appears both in 1980 and 2005 comtrade.

3. Get standard errors for quantile regressions.

B.2 Data Appendix

COMTRADE reports each bilateral transaction twice, once by the importer and once by the exporter. We always use the importer's data as this is known to be more reliable for most countries.

When omitting agriculture and food from the HS classification we omit agriculture (HS2 codes 01 – live animals; 02 – meat; 03 – fish). When omitting agriculture and food from the SITC classification we omit SITC 00-03 which is 00 – food and live animals chiefly for food; 01 – meat; 02 – Dairy products; 03 – fish.

B.3 Quantile Regressions

Explain quantile regressions. We use the SAS QUANTREG procedure with an 8th order polynomial.

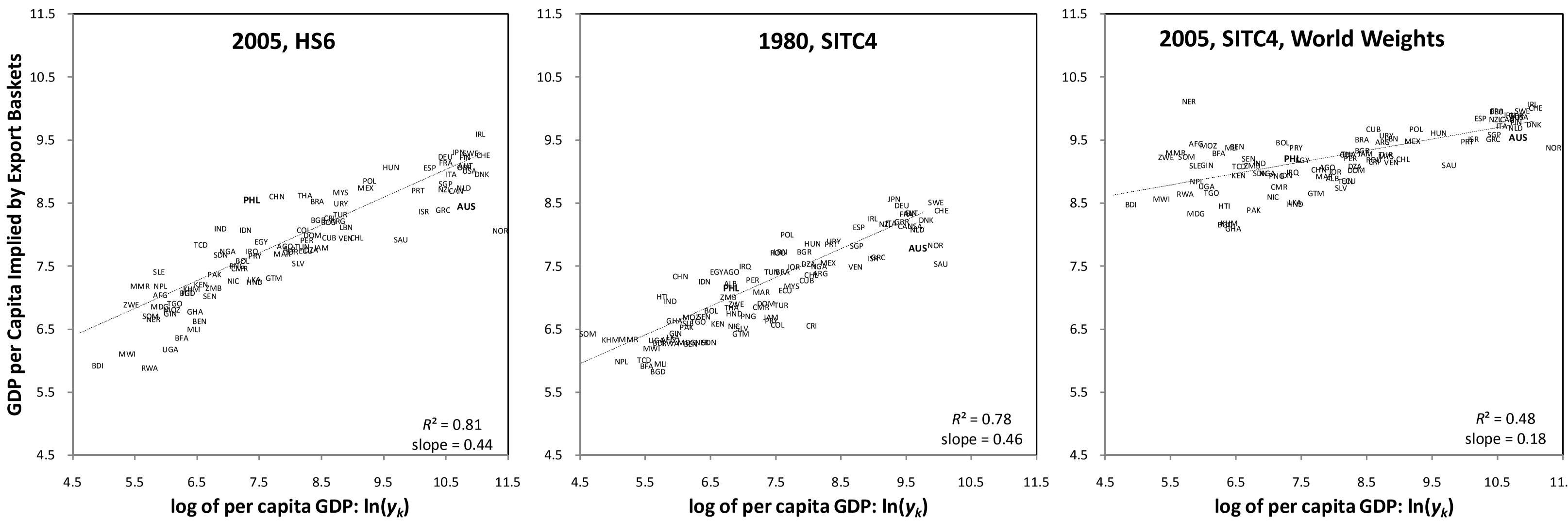
In figure 10, the vertical axis is truncated above. In the top panel, New Zealand exports of raw sheep wool (SITC4 code 2682)is truncated. In the bottom panel, Senegal exports of groundnut oils (SITC4 code 4234) and Ghana exports of Raw roasted cocoa beans (SITC4 code 0721) are truncated.

Figure A.13: List of Countries

Code	Country	GDP per Capita (2005, $US)	Code	Country	GDP per Capita (2005, $US)
BDI	Burundi	101	ALB	Albania	2,691
MWI	Malawi	157	COL	Colombia	2,739
ZWE	Zimbabwe	170	ECU	Ecuador	2,794
RWA	Rwanda	226	THA	Thailand	2,797
NER	Niger	245	TUN	Tunisia	2,846
MMR	Myanmar	248	PER	Peru	2,911
SLE	Sierra Leone	273	DOM	Dominican Rep.	3,073
AFG	Afghanistan	273	DZA	Algeria	3,115
NPL	Nepal	276	BGR	Bulgaria	3,441
SOM	Somalia	283	JAM	Jamaica	3,622
MDG	Madagascar	283	CUB	Cuba	4,093
UGA	Uganda	317	BRA	Brazil	4,260
MOZ	Mozambique	323	ROU	Romania	4,557
GIN	Guinea	325	CRI	Costa Rica	4,616
TGO	Togo	337	ARG	Argentina	4,728
BFA	Burkina Faso	387	TUR	Turkey	4,969
BGD	Bangladesh	422	URY	Uruguay	4,996
HTI	Haiti	429	MYS	Malaysia	5,098
KHM	Cambodia	444	VEN	Venezuela	5,374
MLI	Mali	473	LBN	Lebanon	5,436
GHA	Ghana	475	CHL	Chile	7,297
BEN	Benin	513	MEX	Mexico	7,365
KEN	Kenya	526	POL	Poland	7,923
TCD	Chad	580	HUN	Hungary	10,942
ZMB	Zambia	637	SAU	Saudi Arabia	13,119
SDN	Sudan	675	PRT	Portugal	17,457
IND	India	713	ISR	Israel	19,389
SEN	Senegal	730	GRC	Greece	25,562
NGA	Nigeria	803	ESP	Spain	25,947
PAK	Pakistan	820	NZL	New Zealand	26,789
NIC	Nicaragua	899	SGP	Singapore	26,968
PNG	Papua New Guine	928	ITA	Italy	30,053
CMR	Cameroon	955	DEU	Germany	33,718
BOL	Bolivia	1,028	FRA	France	33,862
PHL	Philippines	1,163	CAN	Canada	35,071
IRQ	Iraq	1,213	JPN	Japan	35,646
HND	Honduras	1,225	AUS	Australia	36,321
IDN	Indonesia	1,244	AUT	Austria	36,760
LKA	Sri Lanka	1,253	GBR	United Kingdom	36,954
PRY	Papua New Guin.	1,266	FIN	Finland	37,307
EGY	Egypt	1,392	NLD	Netherlands	38,512
CHN	China	1,766	SWE	Sweden	39,539
MAR	Morocco	1,906	USA	USA	41,348
AGO	Angola	2,039	DNK	Denmark	47,839
GTM	Guatemala	2,147	IRL	Ireland	48,373
JOR	Jordan	2,293	CHE	Switzerland	49,282
SLV	El Salvador	2,545	NOR	Norway	63,704

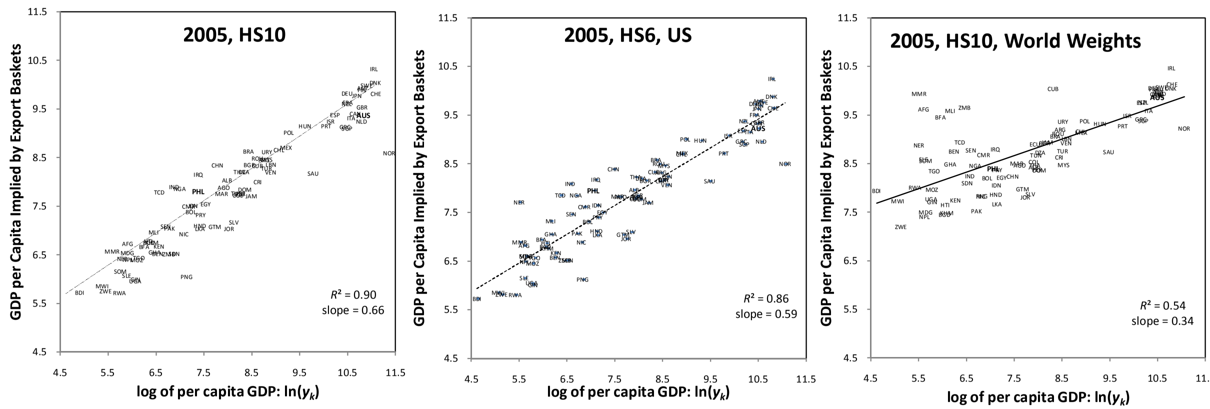
C On-Line Appendix

Figure B.14: Product-Mix Diagrams: Sensitivity



Notes: This figure display product-mix diagrams i.e., each plots gdp per capita on the horizontal axis against gdp per capita implied by a country's export basket on the vertical axis. See equations (2)-(3). The left-hand panel uses HS6 data for 2005. The middle panel uses SITC4 data for 1980. The right-hand panel uses SITC4 data for 2005, but constructs predicted gdp per capita using world weights as in Michaely (1984). That is, the weights $x_{gk}/\sum_g x_{gk}$ in equation (2) are replaced by world weights $x_{gk}/\sum_k x_{gk}$. See section 5 for details.

Figure B.15: Product-Mix Diagrams: Sensitivity to US HS10 Data



Notes: This figure displays the product-mix diagrams using HS10 U.S. import data for 2005. The left-hand and middle panels use equation (2) weights while the right-hand panel uses world weights as in Michaely (1984). That is, the weights $x_{gk}/\sum_g x_{gk}$ in equation (2) are replaced by world weights $x_{gk}/\sum_k x_{gk}$. See section 5 for details. The middle panel is constructed in exactly the same way as the left-hand panel except that the data are first aggregated to the HS6 level. *This shows that the good fit at the HS10 level is because we using U.S. data and not because we are using 10-digit data.*

C.1 Windows: Sensitivity

There are several choices made in constructing the windows. First, we required there to be at least three producers for whom the product was significant. Figure B.16 shows that the results are almost identical when we only require that there be at least 2 producers.

Second, when defining the windows we only looked at country-product pairs for which the product accounted for a significant share of the country's exports. As in the main text, let x_{gk}/x_k be the share of country k's exports accounted for by product g. Let $x_{max,k}/x_k \equiv \max_g x_{gk}/x_k$ be the share for the largest product. We considered country-product pairs with $x_{gk}/x_k \geq \alpha x_{max,k}/x_k$ where $\alpha = 0.01$. In figure B.17 we choose $\alpha = 0.001$ in the bottom panel and $\alpha = 0.10$ in the top panel. As is apparent, the results do not change. This reflects a tradeoff between wider windows and more products. With the lower α windows are necessarily wider because there are now more producers of g included in the analysis. On the other hand, there are now more products because there are more products with at least three producers for whom the product is significant. Apparently, these additional products mainly are largely at the top of the figure and so are uninformative. Thus, we are widening existing ranges and adding uninformative products. With the higher α, the windows become narrower, but we there are many fewer products for which there are at least three producers for which the product is significant.

An alternative to choosing the cut-offs based on $x_{gk}/x_k \geq \alpha x_{max,k}/x_k$ is to use an absolute cut-off e.g., $x_{gk} > \alpha$ where, fore example, $\alpha =$ \$1,000,000. This will not work. For small values of α the ranges are always so large that not a single product is informative. On the on the other hand, for α large, small countries are essentially eliminated from the analysis. One might then want to consider a cut-off that mixes the absolute cut-off with the one used in the paper. Consider table B.4. For each country, it shows the implied absolute value of exports needed to pass the threshold $x_{gk}/x_k \geq 0.01 x_{max,k}/x_k$. It shows how the threshold is smaller for smaller, poorer countries that export less. However, there are two anomalies, China and several oil exporters such as Iraq.

To deal with these we could impose a cut-off that is the less restrictive of $x_{gk}/x_k \geq 0.01 x_{max,k}/x_k$ or $x_{gk} > \alpha$. Figure B.18 shows this. One can see that it makes no difference to our conclusions. The reason is not hard to see. The lower threshold makes the ranges larger for existing products and the new products introduced (i.e., ones that now have at least three producers) are almost all uninformative. Thus, nothing is gained.

Table B.4: Windows: Cut-offs in Dollars

Country	log of GDP per Capita	Export Threshold	Country	log of GDP per Capita	Export Threshold
SOM	5.6	$91,787	MMR	5.5	$16,210,715
AFG	5.6	$185,457	PRT	9.8	$16,337,100
RWA	5.4	$455,000	ROU	8.4	$19,013,515
BDI	4.6	$909,053	EGY	7.2	$19,294,679
ALB	7.9	$983,481	PER	8.0	$23,093,117
MDG	5.6	$987,697	POL	9.0	$24,182,764
NPL	5.6	$1,010,569	TUR	8.5	$27,076,347
TGO	5.8	$1,281,693	CRI	8.4	$30,745,778
LBN	8.6	$1,300,654	TCD	6.4	$32,866,771
SLE	5.6	$1,353,763	COL	7.9	$39,191,028
URY	8.5	$1,486,522	ARG	8.5	$44,786,870
NER	5.5	$1,611,540	SWE	10.6	$54,343,473
HTI	6.1	$1,634,652	DNK	10.8	$54,565,596
BEN	6.2	$1,793,887	SDN	6.5	$55,872,203
UGA	5.8	$1,954,706	ECU	7.9	$59,452,607
BFA	6.0	$2,294,106	HUN	9.3	$67,216,661
NIC	6.8	$2,411,011	ITA	10.3	$81,217,148
ZWE	5.1	$2,564,666	THA	7.9	$83,410,127
JOR	7.7	$2,749,504	IDN	7.1	$84,429,959
SEN	6.6	$2,938,374	ESP	10.2	$86,971,779
LKA	7.1	$3,145,579	BRA	8.4	$87,350,856
KHM	6.1	$3,729,159	CHL	8.9	$94,486,859
MWI	5.1	$3,973,561	FIN	10.5	$101,092,753
KEN	6.3	$4,250,348	CHE	10.8	$107,481,753
SLV	7.8	$4,295,625	ISR	9.9	$112,332,844
PAK	6.7	$4,341,558	IND	6.6	$122,632,209
DOM	8.0	$4,357,565	AUS	10.5	$145,127,740
MLI	6.2	$4,471,047	PHL	7.1	$152,644,266
CUB	8.3	$4,648,008	FRA	10.4	$159,061,521
PRY	7.1	$5,389,065	MYS	8.5	$191,791,041
GTM	7.7	$6,567,015	GBR	10.5	$214,956,879
BGR	8.1	$7,227,169	IRL	10.8	$230,333,055
HND	7.1	$7,366,361	NLD	10.6	$233,466,859
GIN	5.8	$7,803,830	USA	10.6	$236,804,497
NZL	10.2	$8,115,637	AGO	7.6	$257,154,694
ZMB	6.5	$8,154,019	SGP	10.2	$264,824,184
MAR	7.6	$8,527,255	MEX	8.9	$279,967,326
TUN	8.0	$8,689,875	VEN	8.6	$309,567,427
GRC	10.1	$8,870,669	CAN	10.5	$328,268,552
PNG	6.8	$8,935,557	DZA	8.0	$335,096,866
BOL	6.9	$9,942,916	JPN	10.5	$354,351,944
GHA	6.2	$10,236,297	DEU	10.4	$388,623,800
MOZ	5.8	$13,722,254	NGA	6.7	$409,102,327
JAM	8.2	$14,372,427	NOR	11.1	$495,407,821
BGD	6.0	$14,973,958	CHN	7.5	$505,115,970
CMR	6.9	$15,900,890	SAU	9.5	$1,202,699,579
AUT	10.5	$16,115,844	IRQ	7.1	$17,413,209,928

Notes: This table translates the country-specific cut-off $x_{gk}/x_k > 0.01 \max_g x_{gk}/x_k$ into the a dollar figure. Since this criterion is equivalent to $x_{gk} > 0.01 \max_g x_{gk}$. Let G_k be the set of goods satisfying this criterion for country k. Let g' be the industry in G_k with the smallest value of exports ($x_{g'k}$). The table reports $x_{g',k}$.

Figure B.16: Windows: Sensitivity to Number of Producers

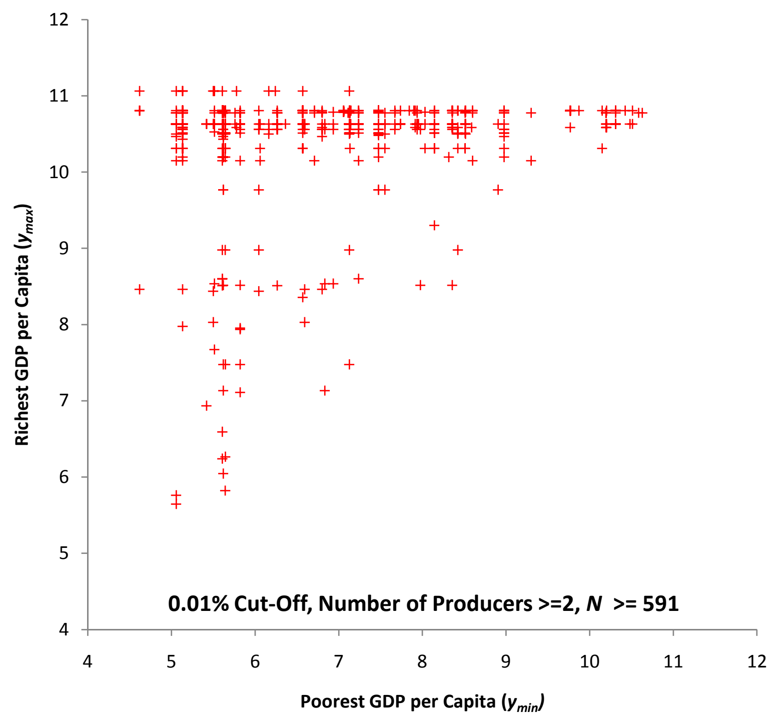
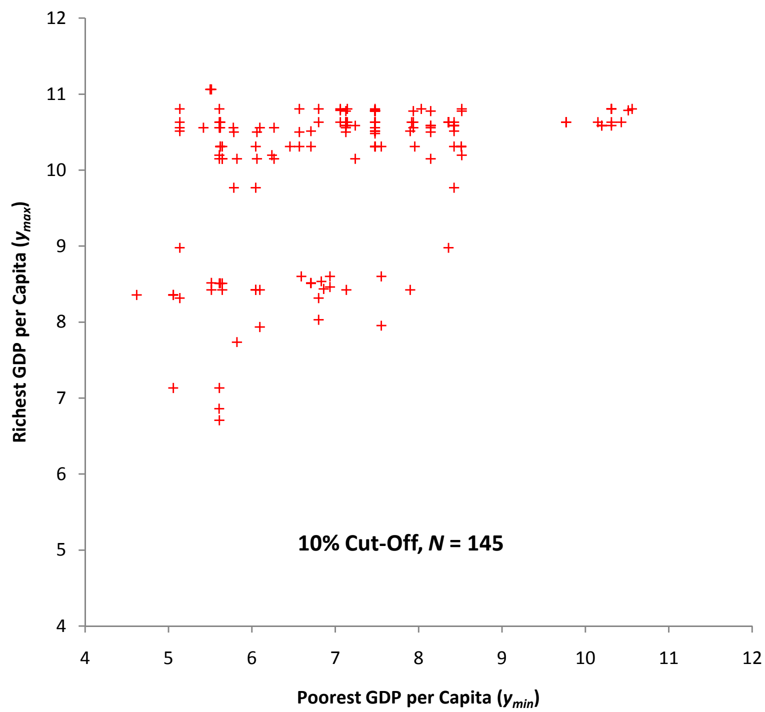


Figure B.17: Windows: Sensitivity to Cut-offs



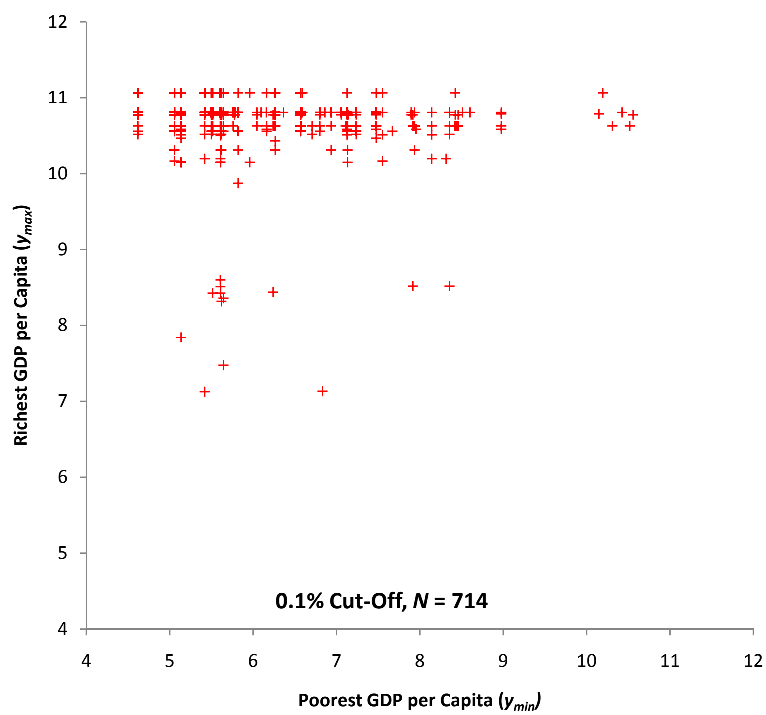
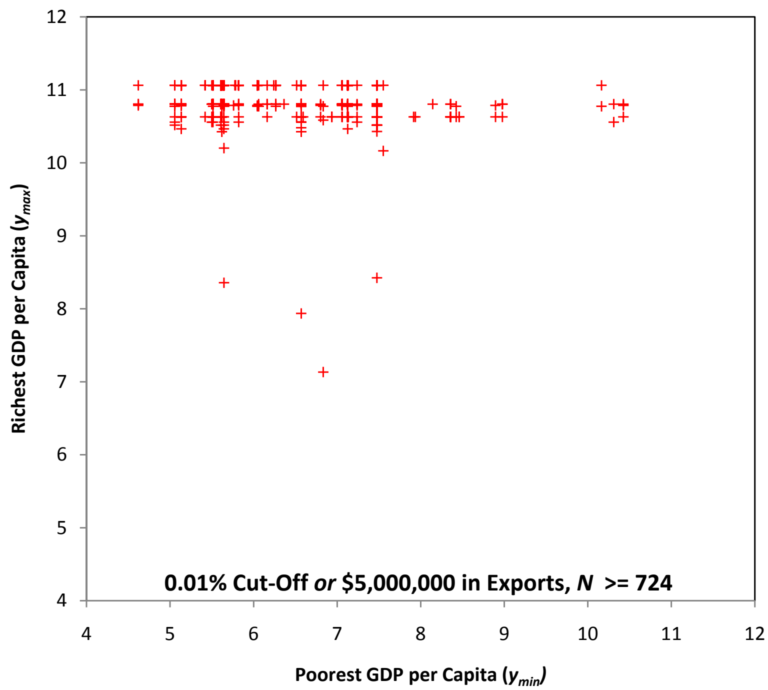
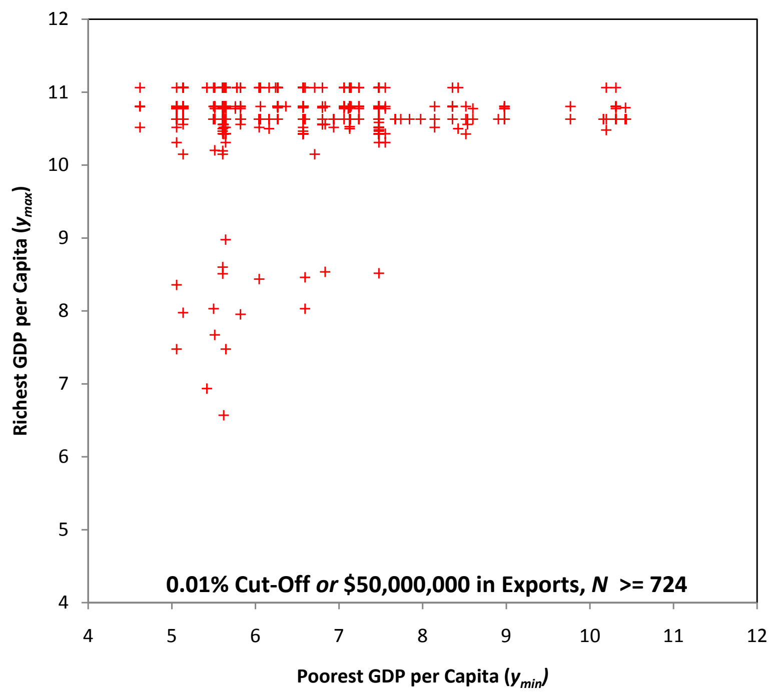


Figure B.18: Windows: Sensitivity to Absolute Thresholds

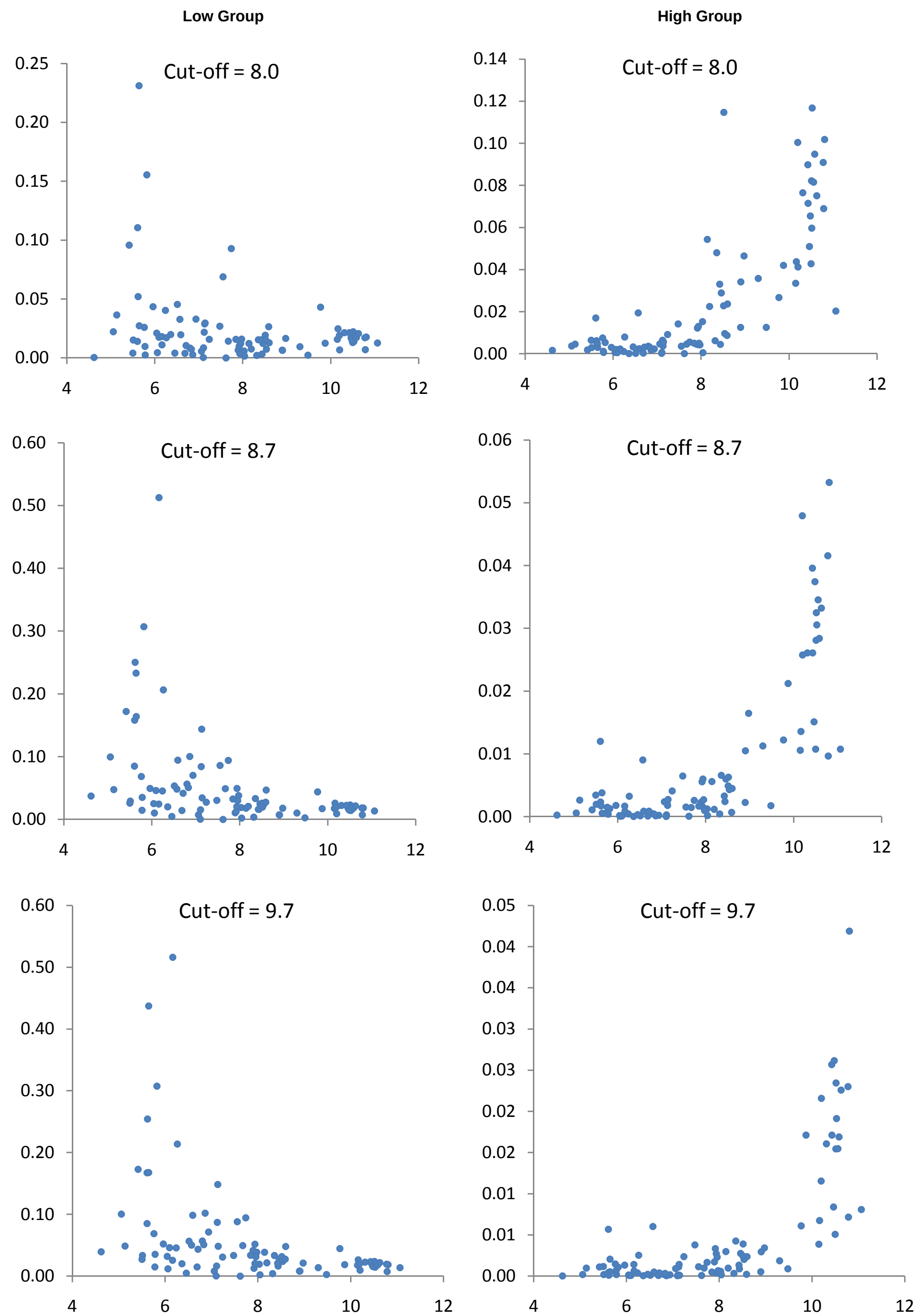




C.2 High and Low Goods — Sensitivity

Table B.19 shows that the figure 8 is not sensitive to the choice of cut-off.

Figure B.19: High and Low Goods: Share in Country Baskets — Sensitivity to Cut-Offs



Notes: Each pair of panels in this figure is identical in structure to the pair of panels in figure 8. Indeed, the middle pair of panels here just repates those in figure 8. Each point in a panel represents a country. The vertical axis is the country's gdp per capita in 2005. The horizontal axis is the share of the country's exports that are accounted for by L goods (right-hand panel) and H goods (left-hand panel). An L good is one for which the richest significant producer has a gdp per capita below the indicated cut-off. An H good is one for which the poorest significant producer has a gdp per capita above the indicated cut-off.

C.3 Market Share Diagrams — Sensitivity

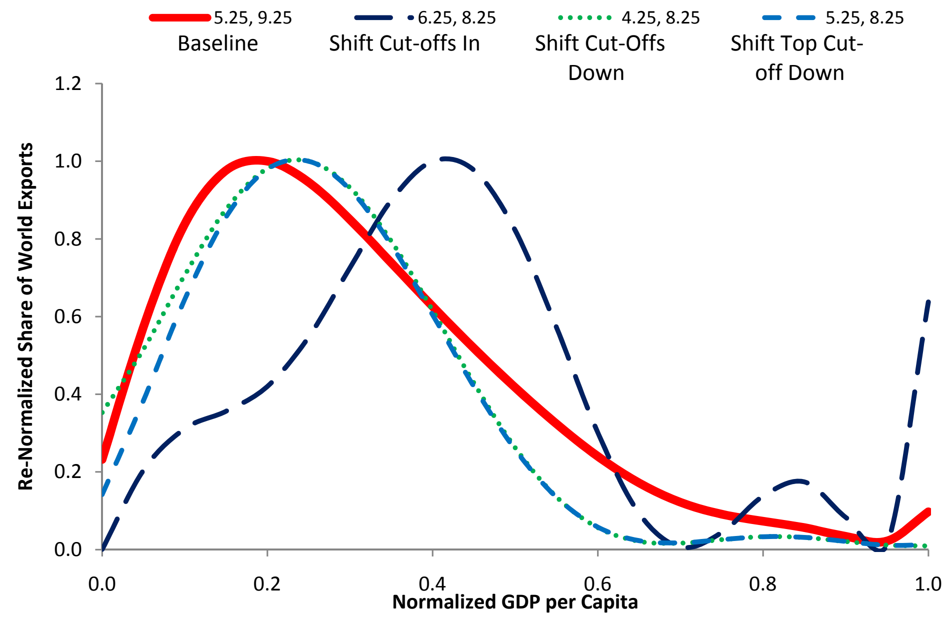
The market share figures 10 and 11 are drawn for specific definitions of Low goods and High goods. Recall that a good g is a Low goods if $\ln y_{min,g} > 5.25$ and $\ln y_{max,g} < 9.25$. The good is a High good if $\ln y_{min,g} > 8.25$. These cut-offs are chosen because they capture natural break points in figure 6. Note from that figure that Low and High goods form disjoint sets. In this section we examine the sensitivity or results to these cut-offs. See figure B.20. We confine attention to SITC4 goods. However, all our conclusions hold for HS6 and HS10 data.

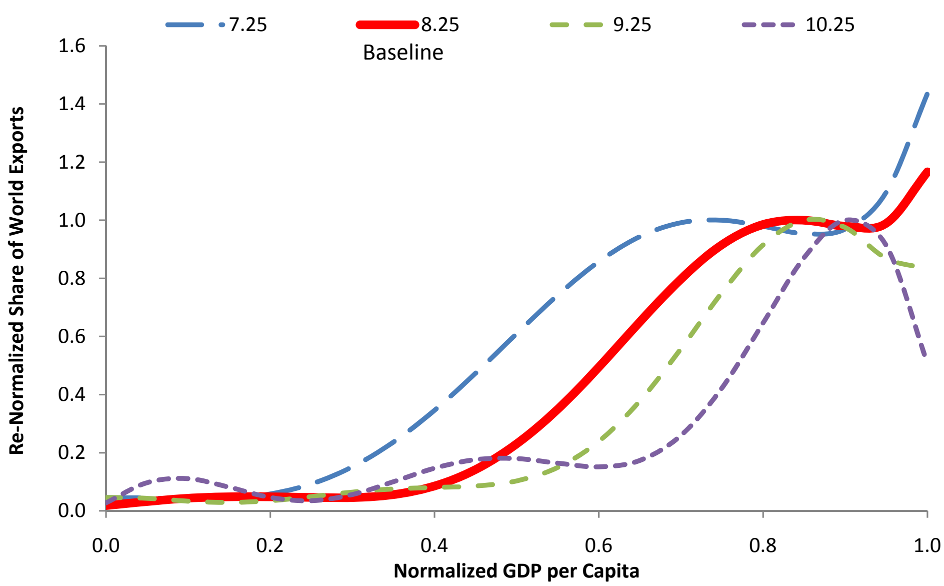
The bottom panel deals with High goods. We define these as goods satisfying $\ln y_{min,g} > \alpha$ for some α. The panel plots the quantile regressions for four cases, $\alpha = 7.25, 8.25, 9.25, 10.25$. As we vary the set of goods, we loose the normalization underlying the original figure 10. We therefore re-normalize so that the turning point of each of the four series occurs at a vertical height of unity. Consider the points to the left of the turning points. As expected, as α increases, the curves shift rightward. To the left of the turning point the curves shift down as α increases. The reason for this is simple: as α increases, there are fewer and fewer industries (observations). As a result, the quantile regression gives more weight to the Norwegian observations. These are ones with a normalized GDP per Capita of 1.0 and with very small market shares. Thus, as Norway receives more weight, the quantile regression tends to bend downwards.

The top panel deals with Low goods. We define these as goods satisfying $\ln y_{min,g} > \underline{\alpha}$ and $\ln y_{max,g} < \overline{\alpha}$. In our baseline specification — the thick (red) line in the top panel of figure B.20 — $\underline{\alpha} = 5.25$ and $\overline{\alpha} = 9.25$. If we center the cut-offs by shifting them inwards ($\underline{\alpha} = 6.25$ and $\overline{\alpha} = 8.25$), the quantile regression also ends up being more centered. If we shift both cut-offs downward ($\underline{\alpha} = 4.25$ and $\overline{\alpha} = 8.25$) or shift just the top cut-off downward ($\underline{\alpha} = 5.25$ and $\overline{\alpha} = 8.25$), almost nothing changes. This means that it is the movement in $\underline{\alpha}$ from 5.25 to 6.25 that affects the centering of the quantile regression.

Figure B.20 makes it clear that the Low goods quantile regression has inverted-U shape regardless of the choice of cut-offs. Further, the High goods quantile regression is either rising throughout or has the top of its inverted-U very close to the farthest right of the figure. This is true unless the cut-off α is allowed to drop very low (7.5, which is China's level of gdp per capita). Thus, the two panels in figure B.20 are exactly as predicted by theory.

Figure B.20: Sensitivity of Normalized Market Share Figures to the Choice of Cut-Off

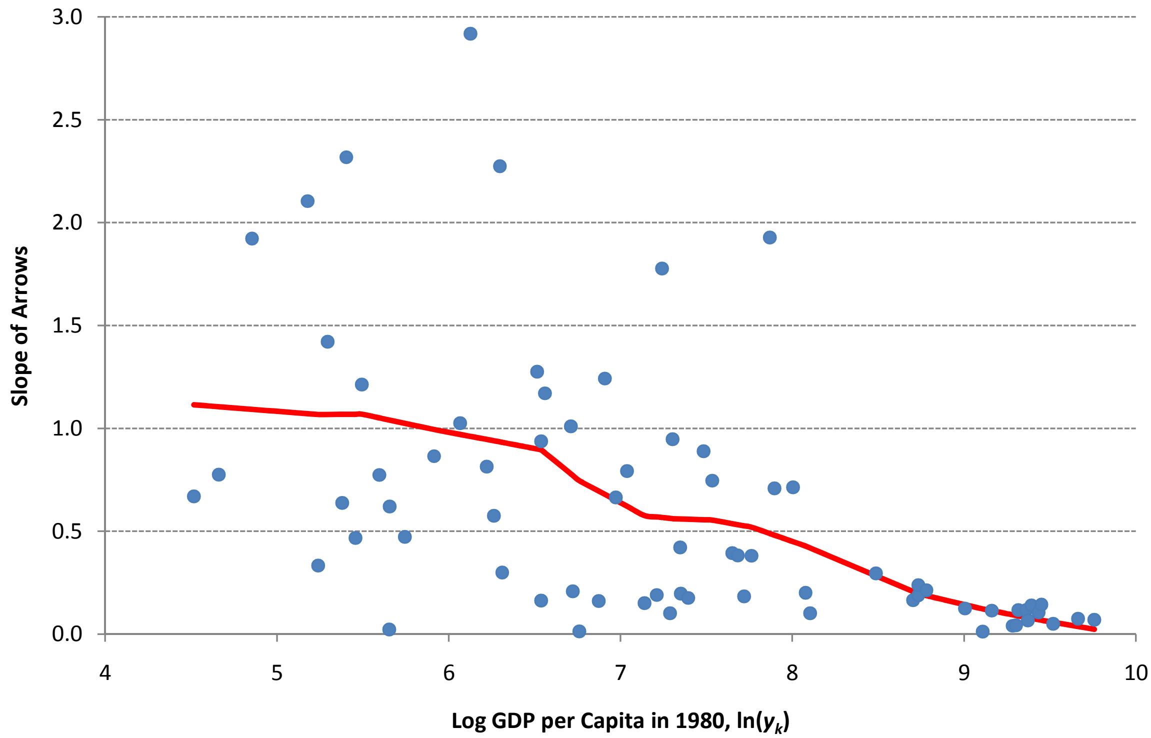




Notes: ??

C.4 Arrow Diagrams Slopes

Figure B.21: Mean Arrow Slopes by 1980 GDP per Capita



Notes: Each point in the diagram represents a country. The horizontal axis is initial (1980) log GDP per capita. The vertical axis is the change in implied gdp per capita divided by the change in actual gdp per capita (1980–2005). That is, the vertical axis is the slope of the arrows in figure 12. Countries with annual average log growth of less than .01 are omitted because, as can be seen from figure 12, their arrow slopes are huge (in absolute value).