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. A theoretical model is presented which offers an interpretation of the two most salient features of the familiar plots of actual versus implied gdp/capita: flatness and diffuseness. The main focus of the paper is on dynamics: how do changes in product mix relate to changes in national wealth?

Preliminary and incomplete.
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1 Background

The relationship between a country's level of wealth and the mix of (manufactured) goods it produces and/or exports has been explored in the literature by several authors, including Lal ( ), XXX (YYY) and most recently Hausmann and Rodrik (2003).[1]

The idea motivating this literature is that products differ in respect of the degree of the level of (R&D or manufacturing) 'capability' needed for their production. To go from this idea to a relationship between a country's product mix and its level of gdp per capita, we need to assume that, in some sense, some 'capabilities' are relatively scarce, i.e., the number of countries enjoying a given degree of absolute or comparative advantage in their production is relatively small (Sutton (2001)).[2] There are various ways of formulating such an idea in a precise way. In the present paper, we appeal to the central idea in the 'market structure' literature: products differ both in the extent to which fixed and sunk costs (including both R&D expenditures and other such outlays[3]) are effective in raising the willingness to pay of all, or some given fraction of, buyers in the market. Insofar as the effectiveness of such expenditures is greater, so too is the degree to which firms will 'escalate' their spending, thus leading to an outcome in which the industry will contain fewer firms (or beome more 'concentrated'), both within countries and at a global level (Sutton (1991, 1998)).

Under these circumstances, countries whose firms enjoy these relatively scarce capabilities will have a comparative advantage in the production of the associated 'high end' goods.[4] The primary beneficiaries will be workers in the country's 'local' labor market: at equilibrium, the wage rate in this country will be relatively high, and so therefore will be the unit cost of production and equilibrium price of the goods produced. It is the absence of ('high quality' or 'high productivity') makers of these goods in other, 'low-wage', countries that allows these firms to dominate the market for the high-end good.[5]

The model developed below is a multi-product, multi-country Ricardian model. The key features of the model are

[1] See also Hausmann, Hwang, and Rodrik (2007).

[2] A firm's capability is reflected in its level of productivity and quality in the production of each good it produces, or can produce. It is helpful to think of a firm's short run profit flow as being determined solely by its cost schedule and its demand schedule, and of 'productivity' and 'quality' as a 'cost shifter' and a 'demand shifter' respectively (Sutton (2007)).

[3] These outlays also include non-financial 'opportunity costs' that can not usually be measured by outside analysts: for example, a maker of auto-components may take on a lots making contract with a leading auto maker in order to benefit from the learning effects that will enhance its capability in the longer run.

[4] The term 'sophisticated' is used by some authors.

[5] We do not consider in this paper the process by which some countries acquire(d) these capabilities, or with the origins of 'scarcity'. Here, we are concerned solely with analysing the consequences, rather than the causes of this.

(a) that competing firms' products can differ in quality and in productivity.[6]

(b) that the number of producers of 'high end' products is relatively small. Thus, the present model is not of the familiar 'competitive' or 'monopolistically competitive' kind, in which there are many sellers of each good; and it is fundamental to our analysis that this is so.

This, then, provides a setting in which we may ask: how should the relation between a country's production and/or export mix and its level of real wages, or gdp/capita, be characterized and interpreted? In what follows, we first remark on a number of different 'product mix' indexes that have been used in the literature, and on two striking features of the relationship that emerges. We then go on to present a theoretical model that allows an interpretation of these relationships. Our primary focus, however, is on dynamics. The aim of the paper is to explore how changes over time in a country's product mix are associated with changes in its level of gdp/capita. As a matter of theory, a country's wealth might advance either through improvements in the 'quality' or 'productivity' in the production of its existing mix of products, or through its shifting to a different mix of products. In general, we might anticipate that both these factors might be present, and so the question reduces to one of decomposing the components of growth into these two contribution factors.

The primary finding reported here relates to the very different experiences of low-income and middle-income countries in this respect, over the past quarter-century. What we find is that middle income countries have advanced primarily through a shift in their product mix; but low income countries have substantially 'advanced' their (apparent) product mix, but with very little effect on gdp/capita. We interpret this as follows: the low income group appear to have moved into more 'sophisticated' products, but have done so at low levels of quality, or productivity; whereas the middle-income countries have advanced towards being 'typical' producers of high-end products. If our present analysis is correct, it suggests that the focus of concern in industrial policies for low-income countries should lie in efforts to improve quality and productivity levels in these newly developed industries.

[6]We will use a framework in which the parameters representing quality and productivity enter symmetrically into firms' profit functions, so that the results permit either a 'quality' or 'productivity' interpretation. However, the main focus will be on quality differences, for two reasons. The first is that empirical evidence indicates a positive relationship across firms in respect of their market shares, and their relative prices, thus suggesting that the dominant differences are associated with 'demand shifters' ('quality') rather than 'cost shifters' (productivity). This is now a familiar point in the 'Quality and Trade' literature. The second reason is more fundamental: once we allow for the presence of some non-labour inputs to marginal cost, then if firms' sunk and fixed outlays in R&D are devoted to improving productivity ('process innovation'), the 'non-convergence property' that underpins our appeal to the idea that some industries are necessarily (highly) concentrated at the global level fails. Thus the motivation of the present model derives from the context of 'quality competition'.

2 Introduction

The literature to date has focussed on the export mix, rather than production mix,[7] and has used two competing measures of the product-mix. Each begins by asking: how rich, on average, are the countries that produce this product? This leads to an index of 'producer-wealth' for each product. Then, in a second step, each country's product mix is examined, and an index is computed as a weighted average of the 'producer-wealth' indexes for each of the products it exports is constructed. This index constitutes an 'implied gdp/capita' for the country, that may be compared with its actual gdp/capita. Our main focus of attention lies in examining scatters of 'implied' versus 'actual' gdp/capita, which we refer to as 'product-mix diagrams'.

The difference between authors lies in the weighting schemes they use. One approach weights products by asking, 'what fraction of total world exports in this product does the country account for, relative to its fraction of total world trade (in all products combined)?

The second, currently more popular, index asks, 'what fraction of this country's export basket does the product account for'?

[Dan: this needs re-wording, and we should include the definitions. Notation x_{gk}, g=product, k=country]

We argue below that both these indexes are informative, and that they should be seen as complementary, rather that competing. This point is best illustrated by noting a common objection to 'product-mix' studies: this objection notes that the U.S. still represents a large fraction of total world exports in the 'low-end' area of textiles and apparel. How, then, can we argue that the product-mix shifts upwards with national wealth? An examination of the two alternative indexes is revealing here: the first index illustrates the 'objection' just noted. The second index illustrates the fact that, notwithstanding the weight of the U.S. in global textiles and apparel exports, it remains the case that textiles and apparel nonetheless constitute a very small share of total export value for the U.S.. One of the themes developed in the next (Theory) section is that these two observations can both be true; the use of the two indices shows different aspects of the product-mix.

Figure 1 shows a product-mix diagram, using the latter form of index, based on Hausmann and Rodrik (2003). The horizontal axis shows a country's actual gdp per capita in U.S. dollars, and the vertical axis shows the implied gdp/capita. Two features of this scatter are striking:

(1) The relation is fairly 'flat' (a fitted regression line has a slope of 0.5 (check)).

(2) The relationship is quite diffuse. India and Portugal have the same level of implied

[7] One reason for this is data-availability. Since exporting a product requires that some minimal quality level be reached, and so excludes the lowest quality producers.

gdp/capita, but their actual gdp/capita differs by a factor of 4 (check!)

One focus in the next (Theory) section lies in explaining these two features of the data.

3 Model

There are K countries. Countries differ in their types, indexed by k. The number of countries of type k is denoted N_k. There are G goods (markets), indexed by $g = 1, 2, 3, \ldots$, etc. All products are sold in a single unified global market. There are no transport costs.

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

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

where $\sum_g \delta_g = 1$, and 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 as a Nash equilibrium in quantities (Cournot equilibrium).This is the standard 'Cournot model with quality' introduced in Sutton(1990).

Firms are characterized by a level of capability, consisting of a quality level and a productivity parameter denoting the number of worker hours per unit of output produced,[8]

[8]Thus all costs are labour costs, and fixed costs are sunk, and so do not enter the present (short run)

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 i. For each active firm, its output level is related to its productivity c_i, its quality u_i, and its (local) wage rate w_k. Solving for a Nash equilibrium in quantities (see Sutton (1998), Appendix 15), we obtain the firm's equilibrium price,

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

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 (3) 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 the production of each good, and not on their absolute levels. Finally, 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

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

analysis. Materials cost, though of crucial importance in general, are here ignored in order to keep the analysis as clear as possible

The Production Pattern of Goods across Countries[9]

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.

We divide the G goods into K equal-sized 'product groups', where m denotes the number of goods in each group. We will focus, to begin with, on the special 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 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 $g \in G_k$.

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.[10]

We assume that countries in group k can produced all goods in product groups 1 to k at 'standard' levels of productivity $\overline{c}$ and quality $\overline{u}$; 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 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. This restriction will have the effect of ensuring 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.

Labor 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 which face the same country-specific wage rate 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 by the single firm in each producing country as x_{gk}, where, using equation (3)

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

[9] Nomenclature: country types, product groups.

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

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

$$L_k^D = \sum_{g \in G_k} c_k x_{gk} = \sum_{g \in G_k} \frac{N_g - 1}{N_g^2} \frac{S}{w_k} = m \frac{N_k - 1}{N_k^2} \frac{S}{w_k} \tag{5}$$

where N_k denotes the number of firms (and so countries) producing product group k, and 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 $g \in G_k$, i.e., the number of countries in group 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 take 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

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

where $\mathbf{N}$ denotes country population, (which we assumed above 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).

Having solved, above, for product market equilibrium, we may characterize general equilibrium by equating the supply and demand for labor within each country (type).

Labour market equilibrium implies that for any two country types k and k', that

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

whence from (5) and (6) we have

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

$$\text{or} \qquad \frac{w_k}{w_{k'}} = \sqrt{\frac{N_k - 1}{N_{k'} - 1}} \cdot \frac{N_{k'}}{N_k} \tag{7}$$

This equation serves to define the chain of wage ratios between country type 1 and country type k, which is our central focus of concern in what follows.

Up to this point, we have assumed that country group k are the sole producers of product group k. We now place restriction on the N_k that 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 (3) this requires that

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

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

It clearly suffices that this is satisfied for $i = 1$, viz.

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

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

The Product Index Plot

We are now in a position to describe the analytical foundations of the product index plot described in Section 1 above. We begin our description in this section by reference to the well-behaved case we have just explored, in which there is a $1:1$ mapping between country types and product groups. Here, the plot coincides with the 45° line, since 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' (Figure 1).

We now proceed to explore three modifications in the basic model, and we examine their separate effects on the product basket plot.

Exercise 1: We begin with the first salient feature of the product basket plot explored in Section 1, viz. the fact that the empirical plot is much flatter than the 45° line. We interpret this by reference to the familiar shortcomings in official product classification schemes, as noted earlier. Using the 'Glass' example cited above as motivation, we proceed as follows: let the m products in each product group be labelled 1 to m. We distinguish the first r of these products, labelled 1 to r, from the remaining products. We construct a 'dataset' in which the j-th product of each product group is placed in a single 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 $j = 1, 2, \ldots, r$.

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.

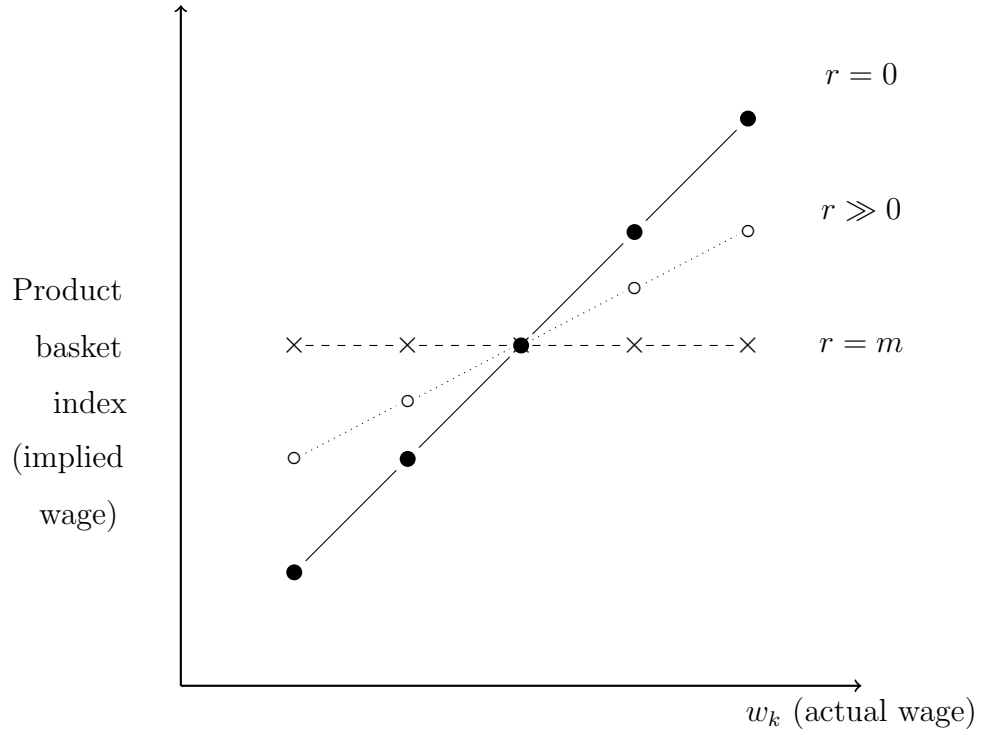

Figure 1: The effect of imperfect industry classification on the product basket plot. The aggregation of products of distinct types leads to a flattening of the plot

Exercise 2: We now return to the case where all products and industries are classified correctly, in order to set the scene for the next example, in which we explore the second salient feature of the product basket relationship, with this in mind, we examine what happens when one country of type $k-1$ advances its capability in the production of all goods in group k to fully match countries of type k, so that the number of countries of type $k-1$ falls from N_{k-1} to $N_{k-1}-1$ while the number of type k rises from N_k to N_k+1.

Here we have from the wage chain equation (7) that the three wage ratios $w_{k+1} : w_k$, $w_k : w_{k-1}$, and $w_{k-1} : w_{k-2}$ all change; but that other wage ratios are unaffected. In

particular $w_{k+1} : w_{k-2}$ remains unchanged. For example, the original ratio

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

now becomes

$$(\frac{w_k}{w_{k-1}})' = \frac{N_{k-1} - 1}{N_k}\sqrt{\frac{N_k}{N_{k-1} - 2}}$$

The resulting change in the plot is shown in Figure 2; it involves a flattening on the lower segment from $k-2$ to $k-1$, and a steepening of the upper segment from $k-1$ to k.

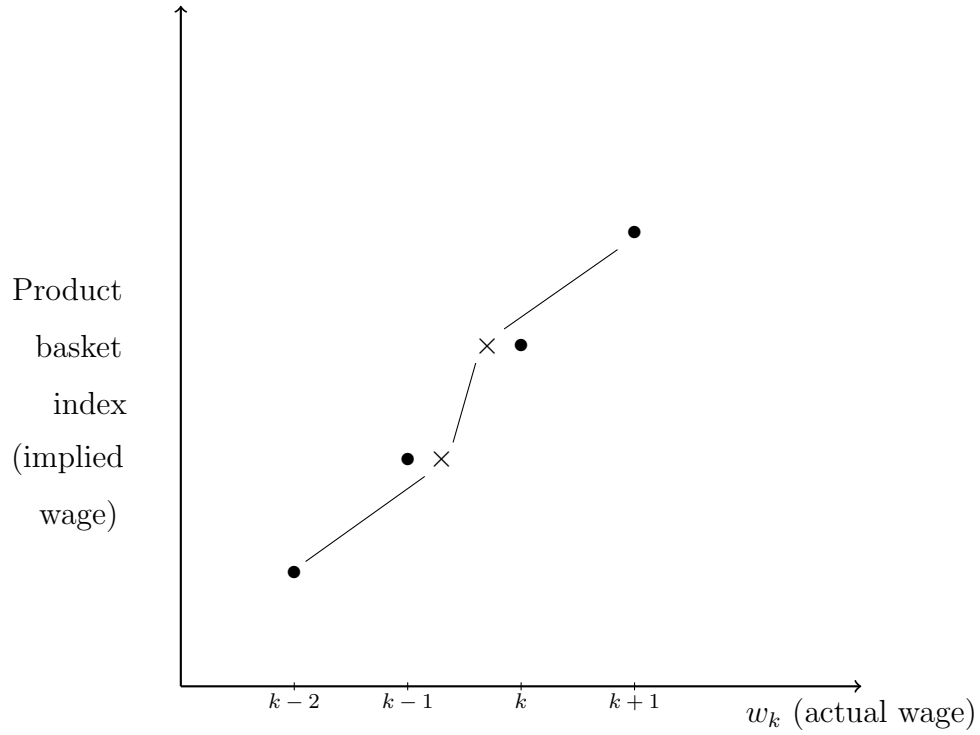

Figure 2: The effect of an upward movement of one country from type k to type $k+1$ on the product basket plot. The new actual wage and implied wage of countries in groups k and $k+1$ are shown both prior to this advance (black dots) and following this advance (crosses).

Note that when N_{k-1} and N_k are large, the resulting change is small.

Finally, notice that if we rebase the index, following the promotion of one country, by recomputing the 'score' for each product, then the 'rebased' plot again becomes the 45° line.

Exercise 3: Low (or High) Quality Entrants

We have so far considered a single country of type $k-1$ raising its capability in the production of all m products in group k to the average or standard level (u, c) associated with countries of type k. In this section, we consider the more general case, in which this single country of type $k-1$ raises its capability in the production of all m goods in group k, but not to the same level as existing producer countries of type k. We focus attention on the regime in which this single country no longer produces goods of group $k-1$ at equilibrium. (we examine the conditions that ensure this later). To simplify notation we let the level of productivity (measured by the unit cost parameter c above) be the same for all N_k+1 countries that now produce goods in group k. The quality of previous active type k countries in the production of products in group k is denoted u and the quality of the single country producer, newly promoted from type $k-1$, is denoted v. Our focus of interest is in looking at how the wage rate of this latter country, denoted w_v, compares with the wage rate w_u of the pre-existing producer countries of type k.

With this in mind, we first note that, since this new producer is active only in the m market of type k, we have from (3) above that

$$x_u w_u = SN_k \frac{\frac{w_u}{u}}{N_k \frac{w_u}{u} + \frac{w_v}{v}} \{1 - N_k \frac{\frac{w_u}{u}}{N_k \frac{w_u}{u} + \frac{w_v}{v}}\} \tag{8a}$$

$$x_v w_v = SN_k \frac{\frac{w_v}{v}}{N_k \frac{w_u}{u} + \frac{w_v}{v}} \{1 - N_k \frac{\frac{w_v}{v}}{N_k \frac{w_u}{u} + \frac{w_v}{v}}\} \tag{8b}$$

We introduce the symbol ρ, $0 \leq \rho \leq 1$, to denote the ratio

$$\frac{N_k \frac{w_u}{u}}{N_k \frac{w_u}{u} + \frac{w_v}{v}}$$

whence the above equations reduce to

$$x_u w_u = S\rho(1-\rho) \tag{9a}$$

$$x_v w_v = SN_k(1-\rho)[1 - N_k(1-\rho)] \tag{9b}$$

Since it follows from the properties of the labour supply function that $w_u : w_v = x_u : x_v$ we have, on dividing $(9b)$ by $(9a)$ that

$$\frac{w_v^2}{w_u^2} = \frac{N[1 - N(1-\rho)]}{\rho} \tag{10}$$

We note form the definition of ρ that it follows that

$$\frac{\rho}{1-\rho} = N \frac{w_u}{w_v} \frac{v}{u} \text{ whence } \frac{w_v}{w_u} = N \frac{v}{u} \frac{1-\rho}{\rho} \tag{11}$$

Using (11) to substitute for w_v/w_u in (10) and re-arranging we obtain

$$N(1-\rho)^2(\frac{v}{u})^2 = \rho[1-N(1-\rho)] \tag{12}$$

We denote the squared ratio of the qualities $(v/u)^2$ as θ, where $\theta = 1$ corresponds to the case of entry by an equally capable new producer country, as analysed in the preceding section. The solution to equation (12) is illustrated in Figure 3, (top panel), where the falling and rising schedules represent the left hand and right hand expressions respectively.

Equation (12) defines the equilibrium value of ρ, as a function of the relative quality of v and u, measured by $\theta \equiv (v/u)^2$. This equilibrium value of ρ serves to define the key outcome of interest, being the ratio of the relative wage ratio w_v/w_u to the quality ratio v/u, since from the definition of ρ it follows immediately that

$$\frac{w_v/w_u}{v/u} = N_k(\frac{1}{\rho}-1) \tag{13}$$

Denoting this ratio as $\omega(\rho(\theta))$, we may use (13) to illustrate the solution to equation (12) in terms of $\omega(\rho(\theta))$ in the bottom panel of Figure 3.

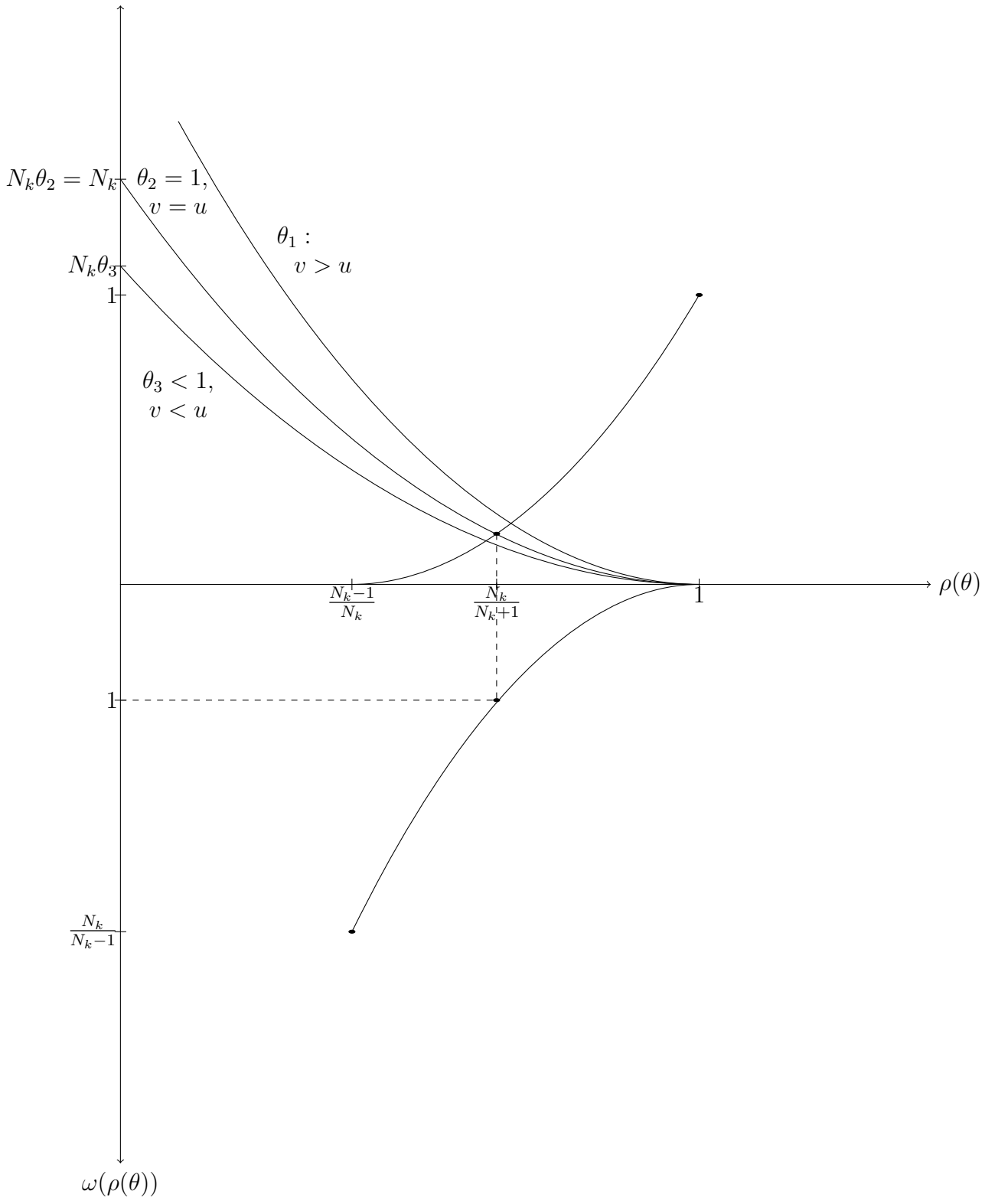

Figure 3: The solution for $\omega = \frac{w_v/w_u}{u/v}$ as a function of the quality ratio parameter $\theta = (v/u)^2$. The falling schedule in the upper panel is indexed by the quality ratio parameter. As v rises relative to u, θ rises, and the equilibrium value of ρ rises, whence, as shown in the lower panel, the 'relative wage to relative quality' index $\omega = (w_v/w_u)/(v/u)$ falls. When v rises to equal to u, then ω equals 1, reflecting the fact that $w_v = w_u$

Note that when $\frac{w_v}{v}$ rises to the point where $\rho \to \frac{N_k - 1}{N_k}$, the new producer country becomes non-viable in market for goods of group k. As we approach this limit, w_v will fall to a critical level at which this country will (also) produce goods of group $k-1$; here, we focus on the regime where this is not the case). Note next that when $v = u$, $\rho = \frac{N_k}{N_k+1}$ and $\omega = 1$; this is the symmetric case considered earlier. Finally, as $v \gg u$, we reach the stage where the high quality offered by the new producer country is so high that the sales of the pre-existing producers fall to zero; again, as this limit is approached, we will reach a point where w_u is so low that these countries begin to produce products in group $k-1$; again, we focus on the regime where this is not the case. Within this regime, then, what happens is: as v rises (or falls) above (or below) u, the wage ratio w_v/w_u rises (or falls), partially offsetting the rise (or fall) in v/u.

We illustrate the implications for the product basket plot in Figure 4. As v/u rises (through this regime), r remains constant as w_v rises. The key point of interest lies in the lower limit of this regime, i.e., the point where v is high enough to ensure that $r = w_k$, that the country produces only products in group r. We may calculate this as follows: the wage w_v must rise to the point where the single country newly active in the production of goods in group k can no longer be viable in the production of goods in group $k-1$. Given that, at this critical point, there are now only $N_{k-1} - 1$ producers active in the production of goods in group $(k-1)$. The threshold level of the effective cost index $\frac{w_v}{u}$ is given by

$$\frac{w_v}{u} = \frac{N_{k-1} - 1}{N_{k-1} - 2} \frac{w_{k-1}}{u}$$

Since all these firms produce products of group $k-1$ at the same quality level u; and so the wage ratio at the critical point is

$$\frac{w_v}{w_{k-1}} = \frac{N_{k-1} - 1}{N_{k-1} - 2}$$

which, for large N_k, is arbitrarily close to 1. Hence the wage ratio at which r_v attains the value r_k corresponds to a wage ratio which exceeds that of w_{k-1} by an amount that can be arbitrarily small. This is illustrated in Figure 4.

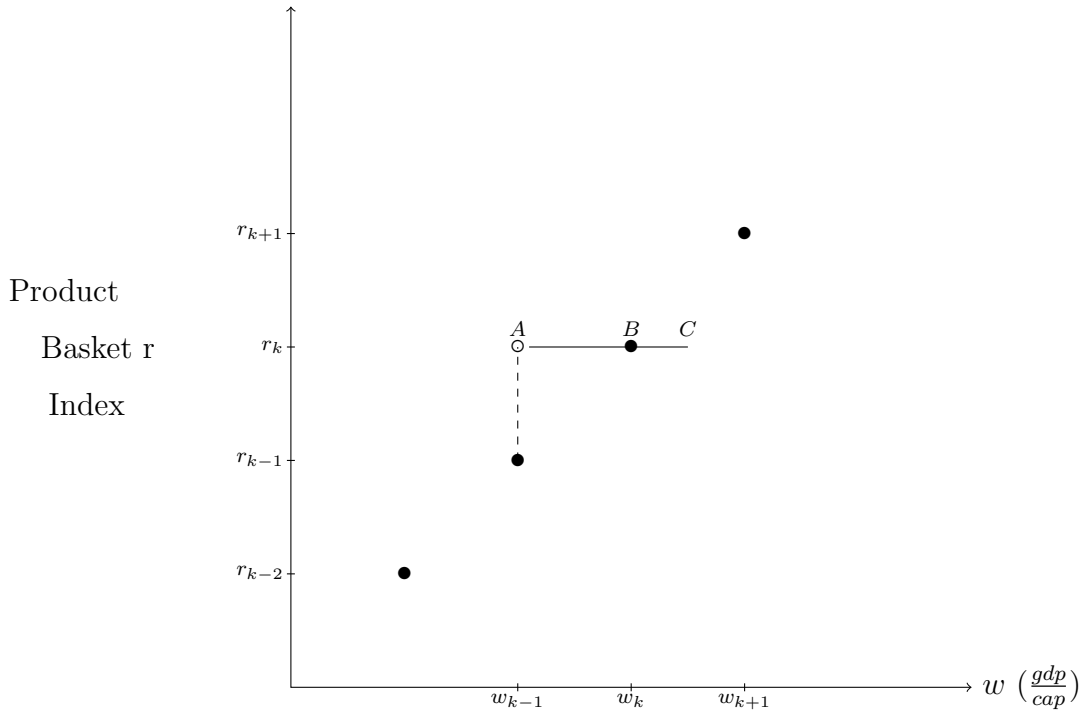

Figure 4: The Product Basket Index of a country of type $k-1$ that produces goods of group k at quality level v. The case $N_{k-1} \gg N_k$ is illustrated; here, r jumps to r_k when $w_v \simeq w_{k-1}$. This is shown at point A in the figure. The case $v = u$ is shown as point B. The case $v > u$ is shown as point C.

The figure also serves to illustrate the 'thickness' property of the product basket plot noted in Section 1 above: according as countries producing a given basket do so at higher or lower qualities than average, their (r, w) combinations spread our in the manner of points (A, B, C) in the figure, leading to a thick scatter diagram of the form shown in Section 1.

The relation illustrated in Figure 4 will be central to our discussion of the dynamics of the (r, w) plot in the next (empirical) section.

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