DON'T OVERDO PPP ADJUSTMENT OF REAL OUTPUT

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Abstract

Conventional PPP-adjusted real output measures, invaluable for making international comparisons of living standards, may greatly exaggerate the productive capacity of poor countries. The equilibrium prices of an hypothetical world of full economic integration provide an instructive basis for evaluating the potential share of different countries in world output.

DON'T OVERDO PPP ADJUSTMENT OF REAL OUTPUT

1. Introduction

The increased availability of purchasing-power adjusted output data has resulted in an explosion of applications. The usual adjustments involve replacing actual goods prices by standard prices which are output-weighted averages of national prices. The adjusted figures for per capita output or consumption are a big improvement when it comes to comparing living standards. Furthermore, alternative approaches yield similar results in practice. But it is less clear that the usual PPP-adjusted figures are as appropriate for answering questions about the relative size, aggregate productivity and productive capacity of different economies.

If existing barriers to international price equalization were removed, both production patterns and relative prices would alter. Valuing actual and potential output (or factors of production) at these notional equilibrium prices can produce quite different figures for relative economic size. In particular, the relative size of poor countries may well be much smaller than that implied by conventional PPP-adjustment, and may even be close to what is shown by the unadjusted GNP figures.

One of the big messages of the PPP-adjusted data is an apparent shrinkage of the gap between rich and poor countries. For example, without PPP-adjustment, per capita output in Portugal is 104 times that in its former colony Mozambique, but using PPP-adjusted figures the multiple falls to 14. Likewise, arbitrarily selecting other ex-colonial pairings, per capita output gap between the UK and Bangladesh shrinks from a multiple of 83 to a multiple of 13; that between France and Côte d'Ivoire shrinks from 130 to 27; that between the Netherlands and Indonesia from 25 to 5.

Another consequence of this shrinkage is a re-ranking of countries by total economic size, as has recently been highlighted by the International Monetary Fund's *World Economic Outlook* and in many recent issues of *The Economist.* This applies especially to the populous countries of Asia. At PPPs, China's total GNP is larger than that of Japan - making it the second largest economy in the world on this reckoning, whereas at market exchange rates it slips to seventh place just ahead of Canada. At PPPs, India's GNP matches that of France

instead of being smaller than Australia's as it is if the comparison is made at market exchange rates.

Especially when expressed in terms of total economic size and re-ranking, the PPP figures suggest a much smaller degree of world economic dominance of the industrial, or advanced, countries. If recent growth rate differentials are maintained, the leading world economies will be passed out before long, and the economic centre of gravity will decisively move southward and eastward. By about 2007, according to IMF (1997) forecasts based on PPPs, total real output of China will surpass that of both the EU and the USA by about 2007.

Table 1: *Shrinkage Factors: Selected Country Pairs*

		Ratio of per capita GNPs		Shrinkage factor
		at market prices	at PPPs	
Portugal	Mozambique	104	14	7.4
United Kingdom	Bangladesh	83	13	6.4
Netherlands	Indonesia	130	27	4.8
France	Côte d'Ivoire	25	5	5.0
Slovenia	Mauritius	2.2	0.5	4.4
Mali	Uganda	1.3	0.4	3.2
Switzerland	Kuwait	2	1	2.0

The shrinkage factor (or what is sometimes called the ratio of national price levels) is typically larger the wider the initial output gap. Figure 1 shows the shrinkage factor relative to the US for each of 114 countries.[1] An upward-sloping trend (long known as the Samuelson-Balassa relationship) is evident: using the World Bank's definitions, for low-income countries the mean shrinkage factor is about 4.1, for lower (upper) middle-income countries it is about 2.6 (1.9); for high-income countries it just under 1.1 (Table 2)

[1]These are based on the World Bank Atlas approach which smooths the nominal figures over a three years average. Note that 38 of the 114 of the PPP-adjustments shown in Figure 1 are fitted values from a regression relationship, estimated from the ICP data on the remaining 76 countries, where the PPP adjustment is a function of secondary school enrolment and of the "Atlas-based" smoothed but unadjusted per capita GDP (cf. Ahmad, 1992).

Table 2: *Shrinkage Factor by Range of Income*

Country income group	GNP per capita (nominal $, mean)	Shrinkage Factor Relative to US* (unweighted mean)
Low-income	430	4.1
Lower-middle-income	1670	2.6
Upper-middle-income	4260	1.9
High-income	24930	1.1

*Ratio of PPP-adjusted to unadjusted per capita GNP, index US=100.

The statistical regularity underlying these large differences is clear: poor countries produce relatively more of goods that have a relatively low valuation at home. Two alternative theories explain why this should be so. The approach of Harrod (1933), Balassa (1964), and Samuelson (1964, 1974) is to suppose that countries have different production functions, with poor countries being less productive for both traded and non-traded goods, but with the productivity gap wider for non-traded goods. While trade will tend to bring the prices of the former to equality internationally, that is not true for non-traded goods, which will tend to have lower prices in the country where productivity is lower. The alternative approach of Kravis and Lipsey (1983) and Bhagwati (1984) envisages a common production function, but factor immobility implying that goods intensive in the plentiful factor will have a lower relative price.[2]

But shrinkage factors can vary considerably, even between countries at similar levels of income. The ratio of Slovenia's per capita output to that of Mauritius shrinks from 2.2 to 0.5; the Mali/Uganda ratio shrinks from 1.3 to 0.4; and the two-to-one advantage apparently held by Switzerland over Kuwait shrinks to nothing after the PPP adjustment.

[2]Both of these models assume common tastes: differential tastes would tend to run in the opposite direction, local preferences driving up the prices of specific non-traded goods. See also Asea and Mendoza (1994), Rogoff (1996).

The issue at hand is often phrased in terms of exchange rates. Market exchange rates, it is said, fail to recognize the true purchasing power of local currencies. So far as it goes, this proposition is fair enough, but it can mislead to the extent that it points in the direction of monetary or speculative factors as explaining the need for purchasing-power adjustments. Even in a world of permanently fixed gold parities purchasing power adjustments would be required whenever relative prices differ from country to country.

But are the poor countries really as productive as the PPP adjustments seem to imply? One factor that may cloud the issue is that the usual PPP adjustments are based on valuing national output at standard price vectors that are essentially value-weighted averages of national price levels. Such a procedure can be justified when the questions of interest relate to welfare. But it is not at all obvious that the same standard price vectors are the most relevant for answering questions about productivity and productive capacity. For example, consider the world price vector that would emerge if the barriers that cause international price differences were removed. We argue that, if one were to evaluate national outputs at that price vector, one would probably obtain sharply different results, with lower shrinkage factors.

Section 2 provides a brief review of the standard price approach to international comparisons, and suggests how an application of the logic of the economic index can help in selecting a "world equilibrium" standard price vector differing from the usual weighted averages. Section 3 presents a simple model of productivity differences. It points out how GDP comparisons at factor prices and market exchange rates may in the limit be standard price comparisons - implying no shrinkage at all. The model is used to compute several alternative "world equilibrium" standard price vectors appropriate to comparisons of productive capacity and shows how heavily dependent the shrinkage factors can be on the choice of standard price vector. Section 4 assesses how realistic the model is, by reference to recent empirical work on international productivity differences. Section 5 contains concluding remarks.

2. Standard Price Indexes

The index number problem

International comparisons of output call for the use of index number theory to deal with the fact that relative prices and the composition of output differ from country to country.[3] There are several established ways of using price and output data for constructing international comparisons of aggregate GDP, but we will focus here on the approach which allows us to make our main points in the simplest possible way, namely, the use of a set or vector of standard international prices to value the product groups. This approach also happens to be the most widely used in practice.[4]

But what standard price vector should be used, and how much does it matter? The case where equivalence refers to *per capita* utility has been extensively discussed and neither the conclusions of that discussion nor customary practice are here being questioned. But we do question whether the same standard price vector is the most appropriate for judging the relative size, aggregate productivity and productive capacity of different economies.

Hill (1997) lists eight different formulas that have been proposed in the literature for generating the standard price vector. Each of these formulas is based on some kind of averaging of the price vectors prevailing in the different countries. They differ as to

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[3]The typical PPP adjustments begin with the collection of prices in the different countries for precisely specified final products, representative of product groups into which expenditure on GNP is subdivided. There is a lively debate on alternatives, especially for the purpose of sectoral productivity comparisons. Thus, in their study of manufacturing productivity, Van Ark and Pilat (1993) employ unit values instead of the specification pricing technique of the ICP. Another point of disagreement is whether productivity and productive capacity are best measured by reference to gross output or net output (net of depreciation) (Hulten, 1992). Van Ark and Pilat (1993) favour net output, a decision which, along with the use of unit values, is criticized by Jorgenson (1993). Bernard and Jones (1997) make sectoral productivity comparisons using the usual standard-price PPP adjustment.

[4]Though there are other methods in use for adjusting GNP ratios: Diewert (1990) and Hill (1997) provide lucid surveys. In terms of Hill's taxonomy the standard price methods to which we chiefly refer here are his "average price symmetric star" methods. The most prominent competitor to these in practice are the "mean asymmetric star" methods, involving an averaging over the different ratios produced by each pair of national prices; of these the so-called EKS method is most widely used.

functional form of the averaging and as to the use of output weights in the averaging. Loosely speaking, the closer the standard price vector is to rich country prices the larger the shrinkage factor (a consequence of the well-known Gerschenkron effect). Thus the weights used in the averaging can matter in a systematic way.

Geary-Khamis prices

The most widely used procedure for choosing standard prices was introduced by Geary (1958) and elaborated by Khamis (1972).[5] The Geary-Khamis procedure generates currency conversion factors (PPPs) as well as a standard set of international prices (one of Hill's eight). These satisfy two criteria. First, the international price for each good is a weighted average of national prices (converted at the PPPs), with the weights corresponding to output shares. Second, the value of GDP for each country computed at national prices and converted at the PPPs equals the value of GDP computed at international prices.

Because of the dependence on output shares, a small poor country contributes little to the formation of the Geary-Khamis prices; this tends to yield a relatively high shrinkage factor for small poor countries, as a result of the Gerschenkron effect. Does the dependence of shrinkage on size reflect an underlying reality, or is it an arbitrary artefact of the averaging procedure? Concerns of this type have kept alive the long-running debate over alternative averaging procedures, including the use of price averages which are not weighted by volumes. The choice between such alternatives has generally been couched in terms of an axiomatic approach to index numbers in which aggregation and symmetry criteria are to the fore. There has been a tension in this literature between the search for "representativeness" and the need to avoid undue influence of "tiny countries". Can economic equilibrium concepts provide some additional guidance in helping to match the choice of standard price vector more closely with the economic issues being addressed?

Economic indexes

As an alternative to applying the standard prices to *actual* quantities, the so-called economic

[5]Including use in the Penn World Tables from the International Comparison Project (ICP) (Summers and Heston, 1988, 1991)

indexes use *imputed* quantities purporting to represent the quantities that take account of the demand or supply response that would be entailed by a change from actual prices to the standard price vector. In order to calculate economic indexes, however, there is the major drawback that, in addition to actual price and quantity information, it is in general necessary to have some estimate of the demand or supply elasticities in order to take account of the responses. In other words one needs to have some estimate of the parameters of utility or production functions in the different countries. Nevertheless, the economic index approach in an instructive one. Furthermore, even if the parameters of the utility or production functions are not fully known, some usable results can be obtained for economic indexes.[6]

World equilibrium prices

A line of thinking analogous to that which leads to the economic index suggests an alternative approach to choosing standard prices that relates more closely to the economic issues being addressed. Thus, instead of simply employing one of the available averages of actual prices as a standard price vector, one could in principle compute the price vector that would prevail in the equilibrium of some hypothetical economic configuration.

Specifically, in order to get a standard price set that is informative in the context of measuring underlying or potential productivity, imagine a world economy endowed with existing resources, but in which all barriers to trade had been removed, and in which a single price prevailed for each good. This hypothetical "world equilibrium" price vector would be an interesting one to use as a standard price for the international comparisons. Alternatively, we could imagine a world in which factors were free to migrate. This too would produce an equilibrium goods-price vector which can in principle be used as a standard price.

Since barriers to goods or factor movements are thought to be at the root of international prices differences, and as these barriers are gradually being eroded, use of one or other of

[6]For example, Dowrick and Quiggin (1997), show that quite a narrow range (about +/- 15 per cent) bounds the value of a true cost-of-living index based on arbitrary homothetic preferences. For productivity comparisons (though not in a standard-price context) Caves et al. (1982) show that, if the production function is translog, under mild restrictions, the ratio of (Malmquist) indices can be calculated from price and output data alone.

these "world equilibrium" price vectors could throw new light on the comparative potential productivity of different economies.

Of course, it is easier to specify such equilibrium price vectors in theory than in practice, but that need not preclude all consideration of the likely consequences of such calculations. If it could be argued that moving from the usual approach to a world equilibrium price vector made but little difference, that itself would be an important source of comfort.[7] But the remainder of this paper offers reasons why the effect might be very large indeed, specifically because the world equilibrium might be much closer to poor country prices than to rich country prices.

Standard factor prices

It is equally possible to approach the question of international comparisons on the basis of GNP computed at standard factor prices. But a standard factor price approach for making international productivity comparisons quickly encounters severe practical problems. For one thing, the specification of the factors of production is considerably more difficult in practice than the specification of goods needed for the expenditure comparison. While there are problems in achieving quality equivalence in goods prices, they are more severe for factor prices. Comparing skill levels of labour inputs, for example, is notoriously difficult, and even the best attempts to do this by using information such as number of years' schooling are inevitably very imperfect (Barro and Lee, 1993). This may not matter so much if "years of schooling" is being used as an explanatory variable in a growth regression (e.g., among many others, Mankiw, Romer and Weil, 1992); it matters more when it is being used to compare skill-corrected wage rates across countries. Any measure of capital stocks raises well-known and difficult questions; adding the dimension of international comparison only adds to a severe problem. As a result, there is probably much less agreement on the degree to which relative factor prices differ across countries than there is for the relative prices of different

[7]For example, it turns out that, in a model without production, and for a class of homothetic utility functions, the market-clearing prices that would result from equal distribution of world welfare are generated by the Geary procedure (Neary, 1996).

types of output.[8] While this increases the uncertainty of any conclusions, it also points to the possibility that qualitatively different conclusions may be forthcoming from the factor-based approach.

[8]If the hourly wage of the average textile factory operative in Germany is a hundred times that of the average textile factory operative in Bangladesh, are we comparing like with like?

3. Alternative standard price comparisons for measuring productive potential

Equilibrium in a simple model of international productivity differences and non-traded goods
We consider a simple model of traded and non-traded goods production designed to capture in a simple way the Balassa-Samuelson idea that high productivity is harder to achieve on average in the production of non-traded goods, while retaining some of the flavour of the Kravis-Lipsey-Bhagwati approach. Thus, suppose that there are just two goods: a traded good is produced with capital and skilled labour, and a non-traded good with capital and unskilled labour. Secondly, let us suppose that labour in country i is endowed with a skill level λ_i which thus enters as a multiplicative factor in the production of the traded good, but does not contribute to production of the non-traded good.

$$y_{iT}=f(K_{iT}, \lambda_i L_{iT})$$
$$y_{iN}=g(K_{iN}, L_{iN})$$

Finally let capital be internationally and intersectorally mobile, let both of the production functions be constant returns to scale and well-behaved, and take the price of traded goods to be unity everywhere.

These are conditions under which the so-called non-substitution theorem applies: in other words knowledge of the international rental rate of return on capital (together with the production technology) is enough to determine wages and outputs. Except to the extent that it affects the international rental rate on capital, domestic demand has no influence on the equilibrium relative price of non-traded goods or on the wage rate. The logic of this familiar argument[9] is as follows: international mobility of capital implies that the world rental of capital determines the ratio of capital to labour efficiency units used in the traded goods sector; this in turn determines the wage rate of labour efficiency units. Using the traded good as numeraire, the relative price of non-traded goods and the capital-to-labour ratio in the non-traded goods sector are both determined by the conditions that the marginal products of labour and capital equate the wage and rental rates already determined in the traded goods sector.

[9]This all assumes that the country is producing traded goods as well as non-traded. For a recent textbook treatment, see Obstfeld and Rogoff (1996).

Consider first the situation where labour is internationally immobile. In terms of labour efficiency units the wage is the same in all countries; thus the ratio of wage rates per worker is proportionate to the ratio of efficiencies. In other words the wage rate for labour of skill level $\lambda=1$ is common internationally. The wage rate *per person* is higher in richer (high-efficiency) economies, as it is effectively determined by labour's opportunity cost in the traded-goods sector; as a result, the price of the non-traded good will also be higher in rich countries - though increasing less than in proportion to wages.

So we have some of the high-skilled labour in the rich countries producing the non-traded good even though this does not actually use their skills. It would be cheaper to replace these high-skill workers in the non-traded good production with low-skilled labour, but this is not possible because of labour immobility and the fact that this good is non-traded.

In this model, the ratio between *per capita* labour income in two countries *A* (think of America) and *B* (think of Bangladesh), measured in terms of the traded good, is proportional to the ratio of skill levels λ_A/λ_B. But it is important to recognize that in real terms the difference is smaller because of the relatively high price of the non-traded good in *A* (Figure 2). As to the question of relative productive capacity or potential productivity in the two countries, at one level (and ignoring capital[10] for a moment), the true productivity ratio of labour is λ_A/λ_B, and should not be subject to any shrinkage.

Note that, considering skill-adjusted wages and the return on capital, factor-price equalization prevails, at least when measured in terms of the traded good as numeraire. It is instructive to realize that this implies that a GNP comparison based on market exchange rates is in this case a standard (factor) price index. Of course it represents only one of many possible standard price indexes, but the fact remains that if factor price equalization prevails, the unadjusted GNP ratios are valid, and no shrinkage factor need arise.

[10]As for capital, we have made no statement about its ownership. In theory workers could have an equal share of ownership in the world capital stock. In practice history will likely dictate that capital ownership is lower in poor countries, thus reinforcing the point being made here.

So much for the base case; now consider what might happen in the model of the previous section if some of the barriers to economic integration were removed whether through factor mobility or technological change. The resulting redistribution of labour resources, or unification of the market for non-traded goods, will result in a new set of market-clearing prices and production patterns. Thus the choice of standard price vector can be used as a forward-looking tool to consider future potential, and not only a static picture.

Standard prices based on adjustment of production following unification of goods markets
Unification of the world market for what are at present non-traded goods would result in a relevant, albeit somewhat extreme candidate as a standard price vector. After all, removal of tariff and administrative barriers and continual technological changes in information and communications technologies will render tradable an increasing range of goods and services which are at present non-tradable.

The consequences of making all goods tradable in our simple model are dramatic. The relative price of the two goods becomes common worldwide reflecting the law of one price. Because of its lower skill requirements, production of the formerly non-traded good shifts to the poorer countries, while the richer countries specialize in the skill-based traded good. Specifically there is a particular value λ^* of the skill parameter which divides the countries. Those with a higher skill level produce only the skill-based traded good, while those with a lower skill level produce only the formerly non-traded good.

It is easy to show that the *per person* wage rate in the high-skill countries remains proportionate to the skill parameter, as it was in the base case of non-tradability. But, because of the specialization, factor price equalization does not apply as between the high skill and low skill countries. In the latter, because the skills are not being used, the *per person* wage rate is fixed at the rate applying in the borderline country with skill level λ^*.

If the rental rate on capital is the same as in the base case, then we can plot the *per person* real wage in this unified goods market case as in Figure 2. For low skill levels this is constant, but above λ^* it increases in proportion to the skill parameter λ. The effect of unifying goods markets is thus to compress international real wage differentials for low skill

levels, while expanding them for high skill levels. The real wage ratio between a high skill country and any country that is not too far below the borderline skill level will be higher at these price levels than in the base case.

If few countries have skill levels far below the borderline skill level, then comparisons based on this hypothetical world equilibrium price set will tend to imply less shrinkage than conventional comparisons based on the usual price averages. In practice, the distribution of skills or productivity is, on most measures, positively skewed. This creates a presumption that there will be fewer countries with a skill level far below the borderline value than there are countries far above it.

Of course, the identity of the borderline country, and thus the equilibrium prices in an unified market, depends on demand patterns. The prices of the formerly non-traded good will be lower than before in rich countries: how far will this induce increased demand in rich countries? At one extreme we could imagine that the formerly non-traded good was an inferior good and with little elasticity of substitution. This would result in low demand and a low equilibrium price. On the other hand, if the formerly non-traded good was a luxury good and with high substitutability between the two goods, the world demand for the formerly non-traded good would be strong, requiring the output of many countries, and thus resulting in a high equilibrium price in the unified market.

Calibrated simulations

These two cases are illustrated in Figures 3 and 4 which show the results of simulations carried out on a simple implementation of this model with Cobb-Douglas production technology. We modelled 50 countries and assigned values of the skill parameter to each in such a way as to result in a distribution of skills corresponding to the actual world distribution of countries by average per capita GNP.[11] The market-clearing relative price in each country, the Geary-Khamis standard price and the world skill-adjusted wage rate are first calculated before unification of the goods market. The world market price, and the *per person* wage rate

[11]The flat segments in the plots correspond to the average levels of productivity of India and China, which are assigned to a sufficient number of hypothetical countries in the simulation to match India and China's relative size in the actual world population.

in the borderline country are then calculated on the assumption of goods market unification. The resulting shrinkage factors are plotted against the skill level in panel *a*; and the Lorenz curves of actual *per capita* GNP calculated on the basis first of the Geary-Khamis prices and then of the world equilibrium prices are plotted in panel *b*.

Figure 3 is based on the assumption of zero price and income elasticity of demand for the non-traded good: each person consumes the same quantity of that good; this yields a low world equilibrium price, low shrinkage factors at that price and a more unequal distribution of *per capita* GNP. Figure 4 is based on each country acting as if they all had identical Cobb-Douglas utility functions (constant value share) giving much higher price and income elasticity of demand for the non-traded good and a much higher world equilibrium price. Even with Cobb-Douglas demand the world equilibrium standard prices yield lower shrinkage factors than the Geary-Khamis prices and a more unequal distribution of *per capita* GNP.[12]

The full "economic index" corresponding to each of these cases was also calculated (i.e. using the imputed production quantities as well as the imputed world equilibrium prices). If plotted on figures 3 and 4, the economic index is in each case quite close to the plot shown for actual quantities evaluated at world equilibrium prices.

The simulations reveal the very substantial effect in this model of moving to world equilibrium prices for standard price indexes of income. Indeed, the assumptions underlying Figure 3 would imply that comparing GNP at market exchange rates could make for better international comparisons than the Geary-Khamis prices. Our approach can thus be interpreted as one way of giving precise substance to concerns (mentioned above) that Geary-Khamis prices are unrepresentative of poor countries.

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[12]The essential parameters for the simulations shown are as follows: both production functions have a capital share parameter of 0.4; the required minimum consumption of good *n* in the zero demand elasticity case is just within the production capacity of the poorest country and the Cobb-Douglas case is calibrated to delivers the same share of good *n* consumption for the richest country as in the zero demand elasticity case.

Standard prices based on modelling equilibrium with labour mobility

As a further example, we assume once again the low-skill good is non-traded, but ask what happens if labour is fully mobile, and redistributes itself efficiently across countries. Both goods are produced in all countries. Once again the lower-skill workers end-up producing the low-skill good. The same borderline value of λ^* divides those who are employed in the traded goods sector from the others, and the world equilibrium price is as in the unified goods market case.

A two country illustration

If the world is divided into two countries, the unified market case is simple and dramatic. There as essentially just two possibilities to be distinguished: either the poor country produces all of the world's supply of the formerly non-traded good (and also some of the other good); or it becomes totally specialized in the formerly non-trade good, with some still produced in the rich country. In other words either the rich, or the poor country becomes the borderline country with skill level λ^*. The world relative price of the formerly non-traded good is higher in the latter sub-case than in the former. The poor country workers benefit more in the latter sub-case, the rich country workers more in the former.

Sub-case I: Poor country produces total world output of non-traded good.

If there are enough workers in the poor country they will produce the entire world production of the formerly non-traded good, as the rich country workers will be exploiting their higher skill level by producing the other good. As a result, the price of non-traded goods in the rich country falls, and the workers there gain an increase in real wages.

Sub-case II: Poor country totally specialized in formerly non-traded good.

Here, because the rich country is still producing the non-traded good, the wage of the low-skilled workers jumps, as their output of the formerly non-traded good is competing directly with that of high-wage workers in the rich country, and they suffer no disadvantage on account of lower skill. Their real wage will not increase by as much, as the price of the formerly non-traded good will jump to rich country levels. There will also be secondary effects, such as an increase in the capital-labour ratio in the poor country.

Valuing the actual (base-case) output of the two countries at these two standard price vectors gives quite different shrinkage values. Sub-case I, with the low price of the formerly non-

traded good, yields the lower shrinkage factor and it can be shown that (always assuming no change in the rental rate of capital) this shrinkage factor also has to be lower - perhaps much lower - than that given by the Geary-Khamis prices.

A two-country application of the labour-mobility-with-non-traded-goods case gives us prices corresponding to Sub-case II (as the non-traded good will continue to be produced in both countries).

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Discussion of this model has highlighted four reasons why conventional shrinkage factors may exaggerate the relative productivity of poor countries. First, factor prices, measured relative to traded goods, may be equal even if goods prices are not: if so, GDP comparisons at market exchange rates using these world factor prices are valid standard price comparisons. Second, skill differentials that manifest themselves only in the production of some goods may be concealed by PPP-adjusted comparisons. Third, the world equilibrium relative prices that would prevail if goods or factor markets were unified might well be closer to those now prevailing in poor countries; if so, such a unification would result in wider gaps between per capita GNP than is indicated by conventional PPP adjustments.

4. Discussion: Modelling Productivity Differences

It is not necessary to accept the model of the previous section in this extreme form (notably its implication of factor-price equalization) to draw these qualitative conclusions. Nevertheless, the relevance of the analysis does depend on whether the simple production structure proposed does at least partially reflect real-world features of productivity differences between rich and poor countries. Our modelling can be seen as part way between the Harrod-Balassa-Samuelson approach and that of Kravis-Lipsey-Bhagwati. Thus, while (in line with the former) the production functions are the same across the world and there is labour immobility between countries, our model essentially does contain features of the latter approach in that labour in different countries have different efficiencies. In our model, the productivity differences between rich and poor arise primarily in the traded good sector.

International productivity differences by sector

An alternative dividing line of relevance in this context is that between services and other sectors. Detailed comparisons of manufacturing productivity covering both rich and poor countries (Maddison and van Ark, 1989, Pilat and Rao, 1996) reveal that there are very substantial productivity differences between manufacturing in rich and poor countries.[13] This is true not only for labour productivity, but for total factor productivity, taking into account the amount of capital employed also.[14] Data for mining, agriculture and services are not so readily available for a wide range of rich and poor countries. However, though there are evident international productivity differences in sub-sectors here too, there appears to be little reason to dispute the proposition that, as Bhagwati (1984) put it so long ago, it is services that are relatively cheap in developing countries, and by extension that productivity in services is not so different as between rich and poor countries.

Of course there are service sectors for which rapid technological progress and high skill requirements are the norm. And international trade in services is growing rapidly. But so

[13]Indeed, they show that the shrinkage factor implied by the sectoral PPP for manufacturing is comparatively small. Convergence among industrial countries in sectoral productivity in manufacturing is documented by Dollar and Wolff (1988), cf. OECD (1996).

[14]For reflections on the problems raised in trying to distinguish between capital accumulation and productivity growth see Rodrik (1997) and Young (1995).

far traded services represent a fairly small proportion of total trade. Furthermore traded services likely include most of the service subsectors in which productivity differences are large. Thus a presumption of lower average productivity differences in services can be mapped to a presumption of lower productivity differences in non-traded goods in a two-good model.

Why are international productivity differences in services relatively low?

Our modelling is consistent with the idea that service sector productivity is (on average) relatively high in poor countries because the potential for productivity in services is anyway limited, not because (as Yotopoulos, 1995, has suggested) the service sector has somehow transcended the factors that inhibit poor countries from reaching rich country productivity in manufacturing.

These factors are increasingly being sought under the heading of political, historical and geographical infrastructures (cf. for example, Easterly and Levine, 1996, Hall and Jones, 1997a and b, Landes, 1990). It is hard to imagine why the service sector would not be faced with the same social infrastructure. If so, then the fact that productivity differences are less in the service sector suggests not that the developing countries have somehow climbed higher on the productivity ladder in services but (in line with our model) that, in aggregate, the ladder is not as steep in services.[15]

Do marginal labour productivities differ?

Our model attaches the international productivity differences to one factor, labour, though similar results would be obtained provided at least part of the productivity differences are of the labour-augmenting type. That this is a reasonable assumption is supported by, for example, the work of Hall and Jones, already mentioned above, which does indicate that both the accumulation of capital and the productivity of factors of production in place are influenced by the social infrastructure factors. Analysis of the wage experience of immigrants

[15]Nevertheless, it may be necessary to take account of the consideration that some of the social infrastructure advantages of the host country may be inherited by the migrant.

to the United States (e.g. Borjas, 1987) can also throw light on this question, though it is necessary to take account of the fact that immigrants may not be a representative sample of the source country labour force, and that their labour market experience after reaching the host country will be influenced by transitional adjustment factors as well as by post-migration human capital accumulation by them.

5. Conclusion

Although PPP adjustments provide a major improvement over the use of unadjusted data in comparing living standards across countries, they can present an overly rosy picture if interpreted as indicative of relative productivity. Not only will catch-up rates be slower for PPP-adjusted than for unadjusted per capita output, but future developments in migration and technology may reveal that the handicaps suffered by poor countries are deep-seated and perhaps better reflected in present productivity differentials in traded-good production than in their apparently better performance on average in service sector productivity.

We have presented one static model which supports this line of reasoning, highlighting the productivity differences between traded and non-traded goods. Although it is a two good model, it provides insights into equilibrium price and output behaviour which can be applied to a multi-good world.

Analysis of the model illustrates the sense in which the aggregate productive potential of poor countries may not be much understated by direct comparison of per capita GDP at factor prices. Although the purchasing power of their wages is currently higher than implied by market exchange rates, this advantage would likely be eroded by reductions in the barriers to trade or migration, thereby revealing the underlying gaps in productivity.

Key to this line of reasoning is that the price of non-traded goods and of labour of different skills may be highly sensitive to structural change. A calculation of production potential that neglects this sensitivity misses much of the story.

The model does not represent a worst case: the situation could be even less advantageous to developing countries that are unable to overcome the factors that at present hold them back. Indeed, to the extent that information and communications technologies increase not only the tradability of services but also the potential productivity in their production, the underlying skills and infrastructure deficiencies of the poorer countries could manifest themselves in a widening of real income differentials, as this hitherto protected segment a growing share of GDP becomes subject to competition from low-cost imports.

The issues raised are conceptual ones, but will also benefit from further attention being given to international empirical comparisons of productivity and factor quality at the sectoral level.

Finally, a word about measurement in the Transition economies. Protection through policy-created barriers masked the productivity gaps of transition economies for decades. The expenditure-based PPP adjustments concealed the potential for collapse which resulted when competition from higher productivity countries was allowed to enter. Clearly, the output collapse in these countries had other causes also, but some past developments and future prospects can best be interpreted in terms of production and employment readjustment the need for which was better signalled by the use of market-clearing prices than by a relatively arbitrary averaging of home and foreign prices as in bilateral PPP adjustments.

Figure 1: *Shrinkage factors*

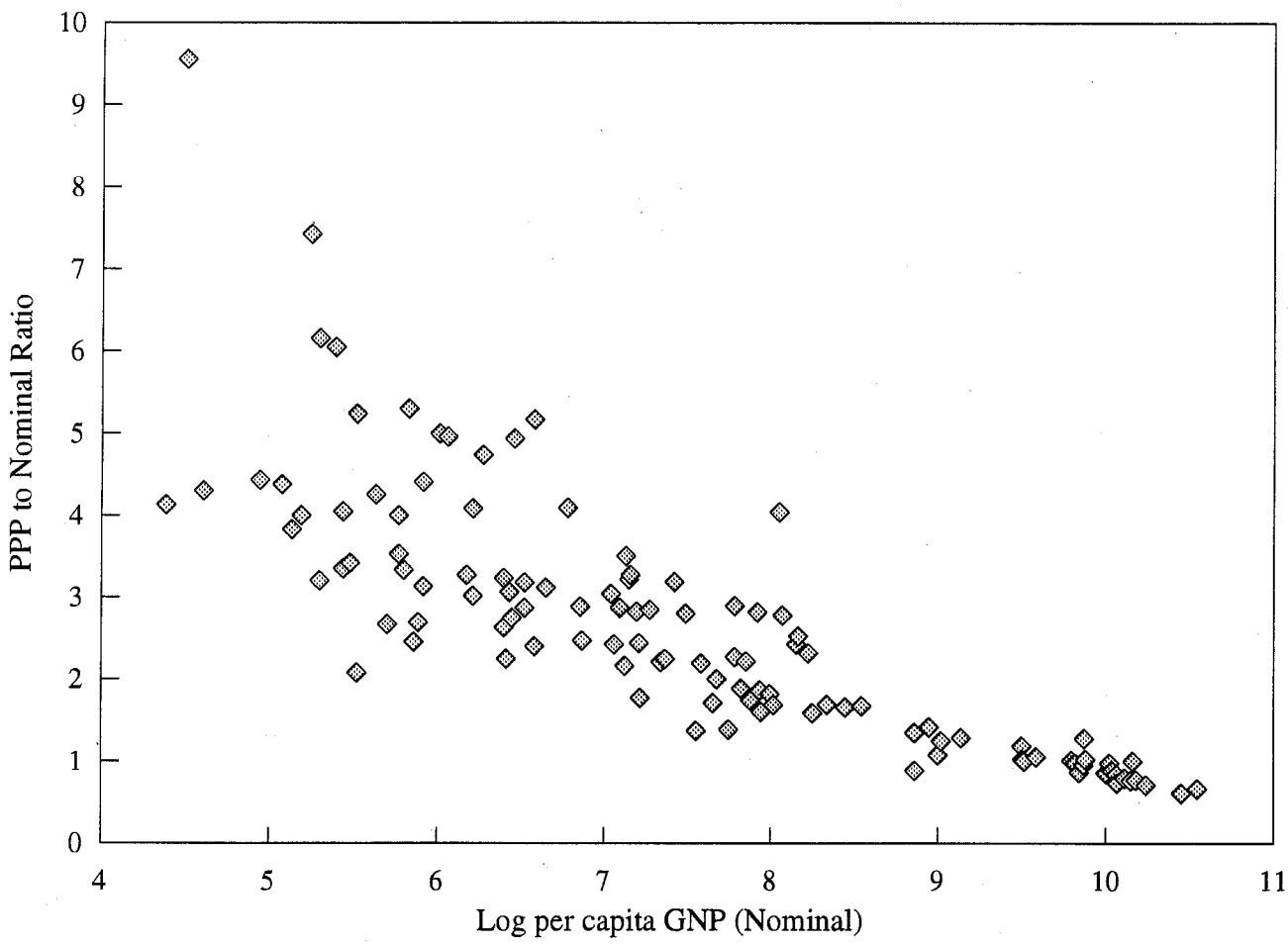


Figure 2: *Real wage at different productivities*

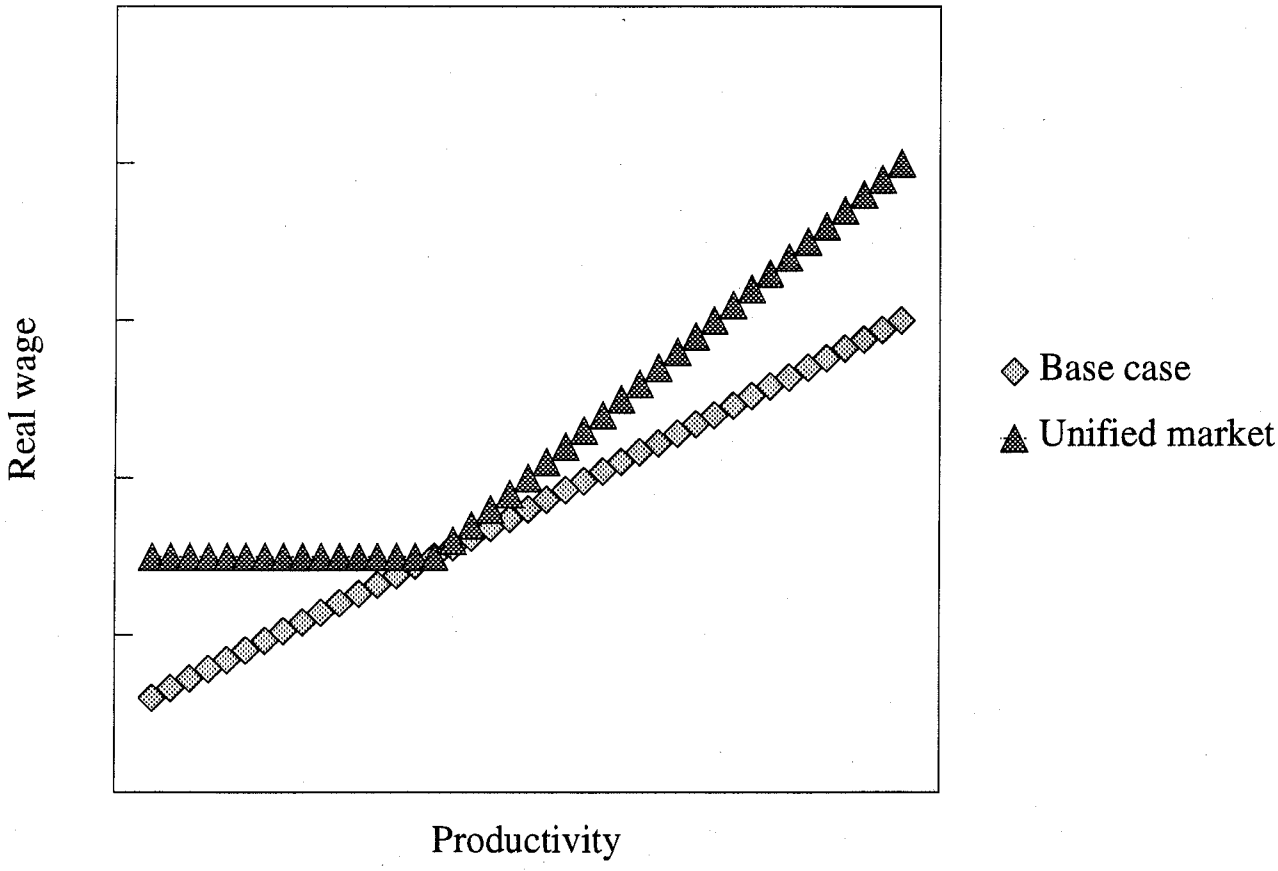


Figure 3: *Shrinkage Factors and Lorenz Curves at Different Standard Prices*

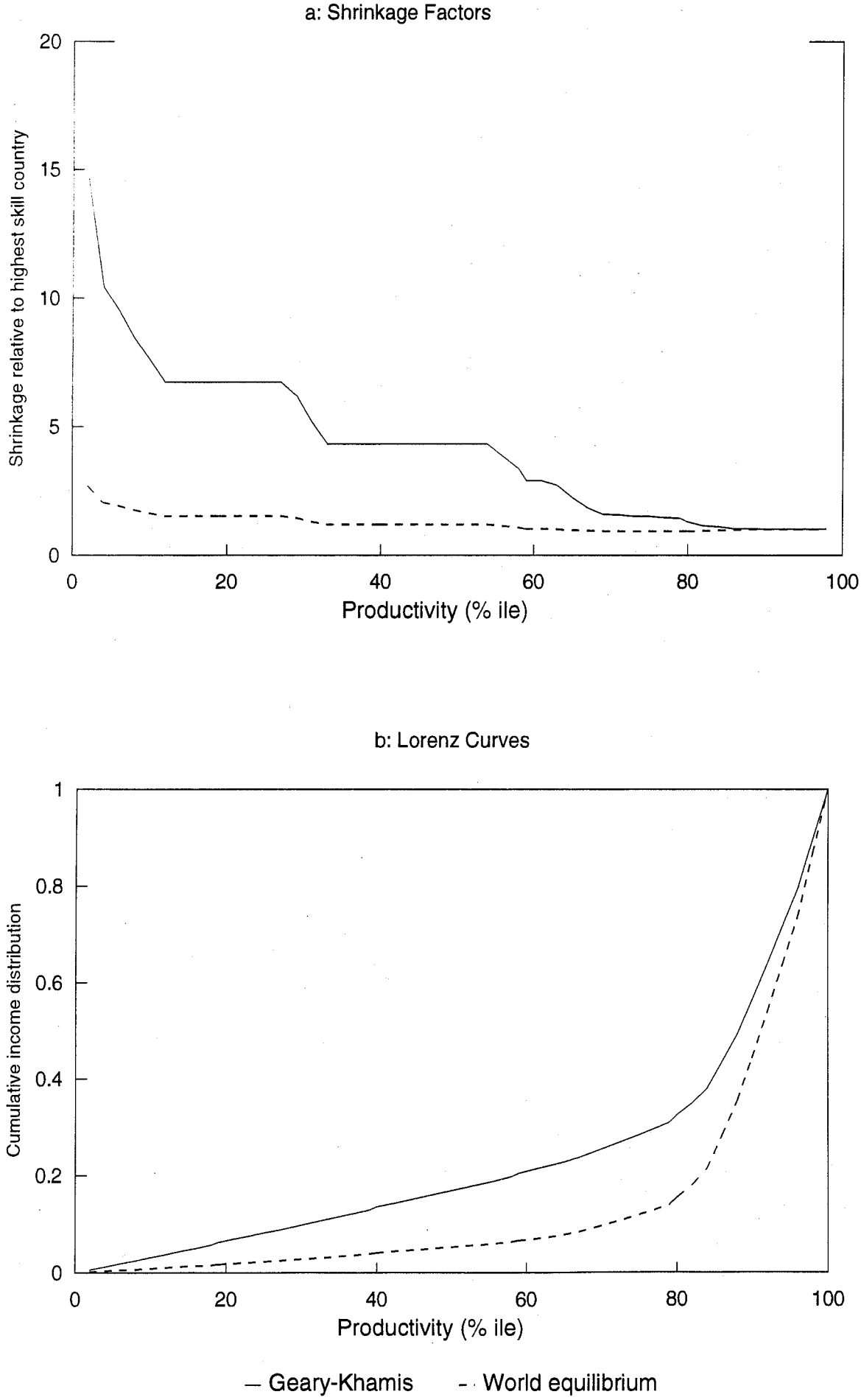
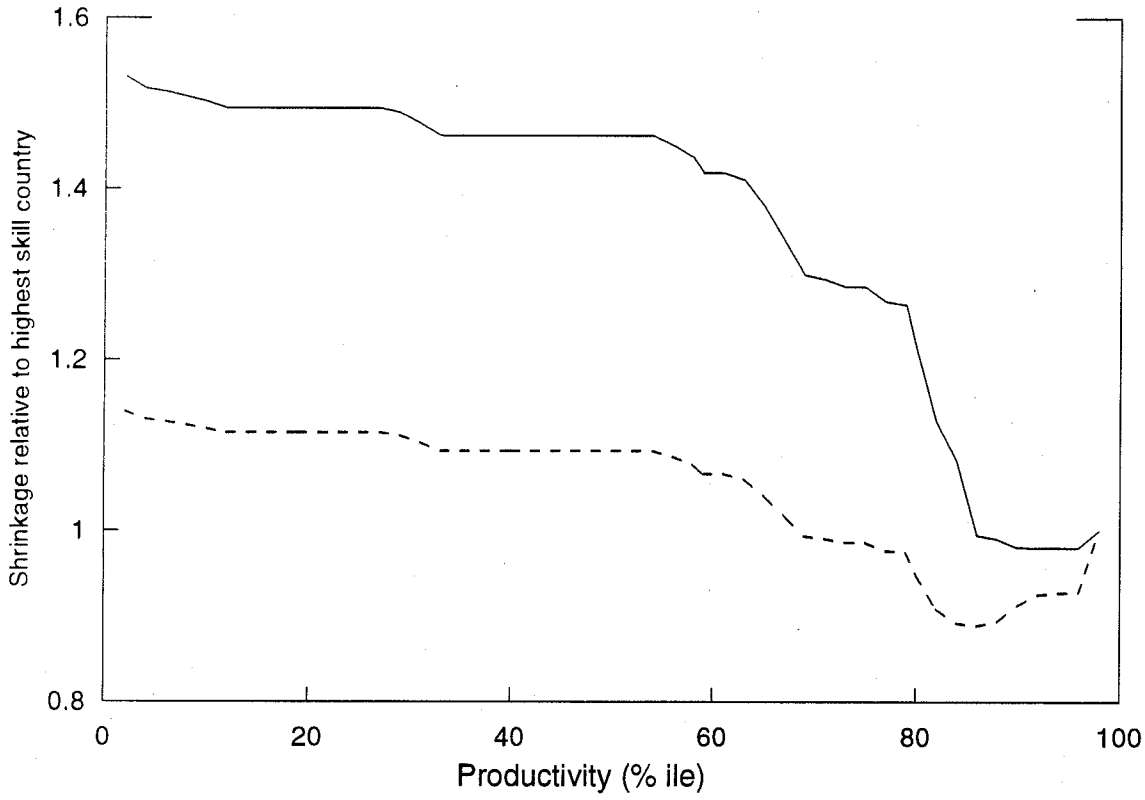
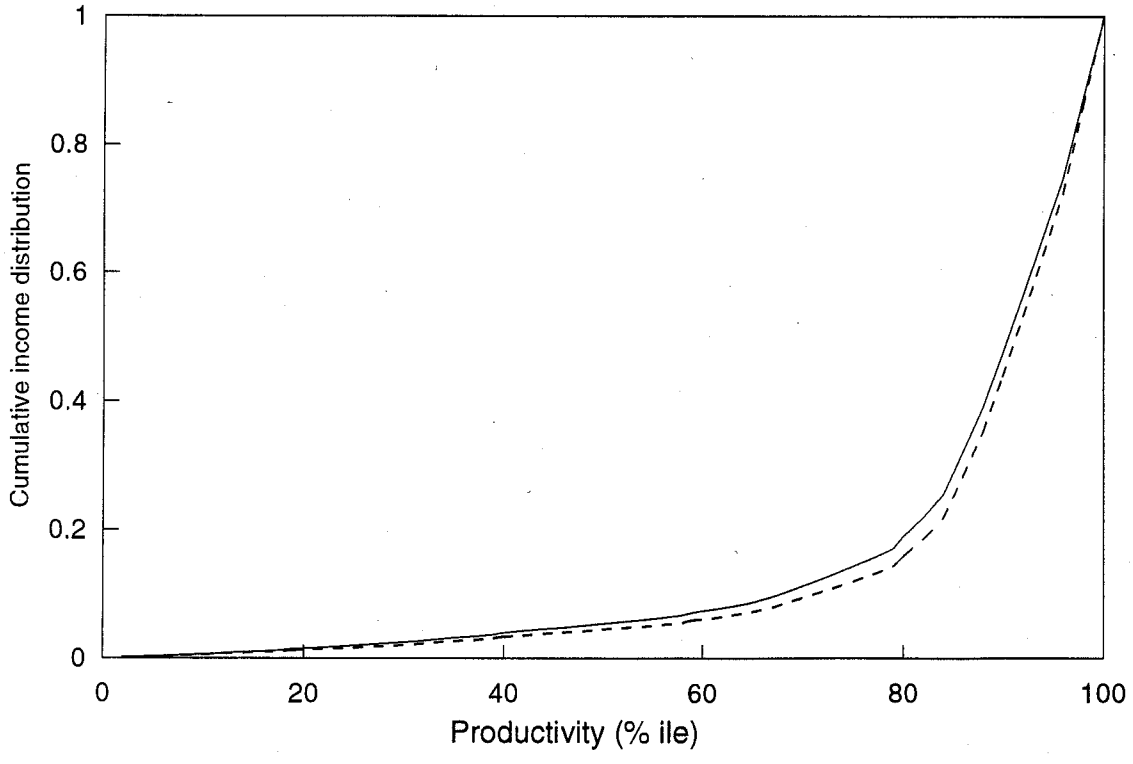


Figure 4: *Shrinkage Factors and Lorenz Curves at Different Standard Prices*

a: Shrinkage Factors



b: Lorenz Curves



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