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Rich and Poor Countries in Neoclassical Trade and Growth

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ABSTRACT

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A neoclassical growth model is used to provide an explanation for a "poverty trap," or "club convergence," in terms of specialization and international trade. The model has a large number of countries with access to identical constant-returns-to-scale technologies for producing and trading three goods using capital and labor. If initial factor endowments of these countries are sufficiently diverse, then initial equilibrium will not involve worldwide factor price equalization. Instead, there will be two cones of diversification, and countries within the lower of these cones will share identical factor prices and produce relatively labor-intensive goods, while countries in the upper cone will produce capital-intensive goods. If savings is determined only by wages, then it is quite possible, perhaps even likely, that there will be multiple steady states. Therefore over time, the poorer group of countries will converge to a low steady-state capital-labor ratio and hence remain poor, while the initially rich countries will converge to a high steady-state and remain rich. This occurs even though all countries share identical technological and behavioral parameters, and it is therefore an example of club convergence. The model is also suggestive of how patterns of growth may respond to changes in these parameters for particular countries, including an increase in the savings rate and the use of tariffs.

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I. Introduction

Why do some countries become rich and seem to stay that way, while others remain mired in poverty? The simple neoclassical growth model of Solow (1956) and Swan (1956) seems poorly suited to answering this question, since in the absence of some *deus ex machina* like exogenous technological progress, it seems to predict zero long-run per capita growth for all countries, as well as per capita incomes that differ in steady state only by amounts that can be explained by differences in saving. Unless the world is divided quite radically into some countries that save a lot and others that save very little, with few in between, the model seems unable to explain what some perceive as a growing polarization of the world economy into nations that are rich and nations that are poor.

In a recent paper, Oded Galor (1996) notes that a comparatively minor modification of the neoclassical growth model can change this conclusion. If all saving is done out of wages, as Galor motivates by considering a simple overlapping generations model, then with an

*I owe an obvious debt to Oded Galor, whose presentation of his results from Galor (1996) at a conference in Helsingor, Denmark, in August 1996 gave me the idea for this paper. I have also benefitted greatly from conversations on this topic with Susanto Basu, Andy Bernard, Ron Cronovich, Pat Deardorff, John Laitner, Bob Stern, and Jaume Ventura, and other participants in seminars at the University of Michigan, M.I.T., and the University of Nevada, Las Vegas.

appropriately shaped technology it is possible for the neoclassical model to generate multiple steady states. In that case, even if countries are all alike in their technologies and behavioral parameters, large enough differences in their initial conditions will divide them into separate groups, some of which will converge toward a lower steady state and others toward a higher. Galor calls this phenomenon "club convergence," and he notes a body of empirical evidence, also reviewed by Quah (1996), in its favor. There also exists a variety of other more elaborate theoretical growth models that can also yield club convergence, but a strong point of Galor's explanation is, with one exception, its simplicity.

The exception, I think, is the contortions that one must go through to get the technology of the simple model to yield the desired multiple steady states. This is a one-sector model, and it is simply too well behaved if the production function is, say, Cobb-Douglas. With a fixed portion of wages saved, the Solow model with Cobb-Douglas production yields a single steady state. Constant elasticity of substitution production functions are more promising, and indeed if the elasticity is sufficiently less than one, then the model does indeed yield three steady states, more or less as suggested by Galor. However, the lowest of these steady states is perhaps too low, since it has zero per capita income, and the middle steady state is of course unstable. In order to get two "clubs" that converge to positive but different steady states, one needs a rather special shape for the per capita savings function, and this in turn would require quite a special shape for the production function. Thus the Galor model shows that club convergence is possible, but it does not make it seem particularly likely.

Another feature of the Galor model, in common with a surprising amount of the literature on the growth convergence of countries and even some of the recent literature on endogenous trade and growth, is that it is a model of a closed economy, or at least it allows no explicit role for international trade.[1] Yet it turns out that by allowing for international trade in much the same way as in the early neoclassical trade and growth literature of Oniki and Uzawa (1965) and others, we can transform Galor's model into something that is not much more complex, but that easily yields his special shape for per capita savings. The trick is only to recognize the role of specialization in international trade. By including multiple goods (the model here will have three) in a Heckscher-Ohlin model of production and trade, the same heterogeneity in initial factor endowments that starts Galor's countries toward different steady states can also prevent world-wide factor price equalization. There emerge instead two separate cones of diversification, into which different countries are drawn by the growth process, and in which they then remain, due to the international factor price differences themselves.

That, then, is the message of this paper: that a model comprising three components -- simple neoclassical growth, savings primarily out of wages perhaps due to overlapping generations, and multi-good Heckscher-Ohlin trade -- provides a compact explanation of why countries that start out different may remain so. Interestingly, the model does not suggest that trade is necessarily a force for making countries more alike, but rather the opposite. Without trade, these countries seem more likely to converge, although not necessarily to a steady state one would regard as desirable. Furthermore, the model also has implications for how policy, including trade policy, may work to change a country's steady state, and even to permit it to escape the poverty trap that a low initial capital stock may otherwise imply.

[1]It is a one-sector model, and it could therefore describe a country that is completely specialized and that therefore exports its one good in exchange for all others.

I will begin in section II with a brief look at data on the world distribution of national per capita incomes and what these data suggest about poverty traps and club convergence. In section III, I will briefly recapitulate the Solow growth model and Galor's variant of it yielding multiple steady states. Then I will recall, in section IV, the extension of the Solow model to a two-sector trading economy, such as was the focus of the early neoclassical literature on trade and growth. In section V, this model will be modified to allow more than two goods and thus the possibility of multiple cones of diversification. Multiple steady states are then shown to arise naturally from Galor's saving assumption, requiring only that some production functions display inelastic (not necessarily constant) elasticities of substitution. With multiple steady states, otherwise identical countries can reach different outcomes depending only on their initial conditions. However the model also suggests interesting effects of having countries with different behavioral parameters. These comparative static and comparative steady state properties are explored in section V. Finally, I look at trade policy in section VI, and I conclude in section VII.

II. Poverty Traps and Club Convergence

It is hardly news that countries are very unequal in their per capita incomes. The distribution of that inequality across countries may be instructive, however. Chart 1 shows the distribution for 1990 and, since Chart 1 is dominated by China and India, Charts 2-4 show similar information for 1960, 1975, and 1990 but excluding these two countries. In all cases, the charts graph population opposite national per capita income expressed as percentiles of the highest per capita income, which is that of the United States in each year. For that purpose, countries have been grouped into intervals of two percent of U.S. real per capita income.[2] Thus in 1990 as shown in Chart 1, China and India (whose populations are noted as 1134 and 850 million respectively) had per capita incomes in the fourth 2-percentile -- that is, between six and eight percent of U.S. per capita income.[3] The United States alone occupied the highest 2-percentile in all of these graphs. With fifty intervals and over one hundred countries, there are of course multiple countries in many of them. For example, in 1990, the 40th 2-percentile (representing per capita incomes between 78% and 80% of U.S. per capita income and thus between $14,082 and $14,443) included both Japan and West Germany.

Chart 1 shows that the world's population may be easily divided into at least two groups of countries with low and high per capita incomes respectively, and that there is a range of incomes between the two groups that is only sparsely populated, if at all. This is seen more easily in Chart 4, where China and India are omitted so as to show the other countries more clearly and the countries with largest population are identified by name. Here the gap between developed and developing countries is quite evident, with no countries at all occupying the 28th through 31st 2-percentiles. Indeed, although you cannot tell this clearly from the Chart, only nine countries have per capita incomes between the 20th and the 34th 2-percentiles, and these nine countries have

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[2]Data are from the Penn World Tables, POP=population and RGDPCH=real GDP per capita in constant (1985) dollars. They cover, in addition to China and India, 123 countries in 1960, 132 countries in 1975, and 114 countries in 1990.

[3]The per capita income of the United States in 1990 was $18,054, while those of China and India were $1324=7.3% and $1264=7.0% respectively.

combined population of only 85 million, or only three percent of world population excluding China and India.[4]

It is of course possible for this sort of grouping to exist but to be temporary. Perhaps the two groups are moving together over time. Others have pursued more formal empirical tests of this possibility than I will here,[5] where I will be content with looking only at two more graphs of these distributions in the past. Chart 2 shows the distribution in 1960, where the most distinctive feature was that the developed countries were much further behind the United States than in 1990. One can still perceive a perceptible gap between the developed and developing worlds, although it is not as large or as clear as it became in 1990, and the developed countries were not as tightly packed.

By 1975, in Chart 3, the countries appeared altogether more spread out, although much of this impression is due to the progress made by Japan in transforming itself from developing to developed. Without Japan in Chart 3, the gap between rich and poor would be more clear. In any case, however, the three graphs together seem to support the impression that there is a polarization of national per capita incomes and that this polarization is not disappearing.

A possibility of what might be going on here is that the poor countries are mostly remaining poor, while the rich countries are growing increasing rich and leaving the poor behind. This explanation is implicit in the literature on endogenous growth, in which countries can grow indefinitely at different rates, so that the faster growing countries pull further and further ahead.

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[4]Or less than two percent if China and India are included. The nine countries are, in decreasing order of per capita income, Singapore, New Zealand, Spain, Israel, Ireland, Cyprus, Taiwan, Trinidad, and Portugal.

[5]See for example Sala-I-Martin (1996).

There now exists a plethora of theoretical models to provide this result, but the empirical evidence in its favor is weak. Charts 2-4 suggest this weakness, since if the rich countries were growing significantly faster than the poor countries, we should see the countries being drawn toward the two extreme ends of the distribution, and we do not.

Thus the data are at least mildly suggestive of the possibility that the countries of the world are neither converging to a single level of per capita income, nor diverging as they would if their growth rates differed permanently. Instead, there appears to be the presence of, and perhaps the converge toward, several different levels of per capita income -- exactly as in Galor's club convergence. Theoretical explanations of this phenomenon also are not particularly scarce. Azariadis and Drazen (1990) provided an explanation in terms of "threshold externalities" which lead to increasing returns to scale in human capital accumulation but only after a threshold level of human capital has been reached. Barro and Sala-I-Martin (1995) also get this result in a model with an average product of capital that alternately falls, then rises, then falls. These models are rather like Galor's, in that they depend on the particular functional form of some aspect of technology or behavior. By tinkering with that function, one can generate results of various sorts, including something rather like what has been observed. The advantage of the model here, however, is that the special shape needed for club converge arises more naturally from the economics of production, specialization, and trade in a Heckscher-Ohlin model.

These explanations for club convergence, including mine, also have in common the property that, if all countries were sufficiently similar in their initial conditions, then club convergence would not arise. For example, if all countries could somehow start above the threshold in the Azariadis and Drazen (1990) model, then all could enjoy the high steady state.

Matsuyama (1996) provided an original and innovative alternative to this property in a model where some countries must, of necessity, remain poor. In his model there is agglomeration of different activities in different parts of the world, and this in turn implies the existence of a "pecking order" among nations, some of whom will be rich but some of whom must remain poor.

III. Solow Growth a la Galor

The Solow growth model is familiar to most. Income, Y, is generated from the employment of labor L and capital K in a function F that is homogeneous of degree one:

$$Y = F(K,L) \tag{1}$$

In the usual one-sector model, F is a production function, although it could, and will below, represent a more general relationship between factors and income. For later use, Y should be measured in the same units as investment and therefore the capital stock.

The labor force is assumed to grow at a constant proportional rate, n, while the capital stock grows due to investment, which is in turn equal to saving, S:[6]

$$\dot{L} = nL \tag{2}$$

$$\dot{K} = S \tag{3}$$

Letting $k = K/L$ be the capital-labor ratio, its change over time, $\dot{k} = dk/dt$, is

$$\dot{k} = S/L - nk \tag{4}$$

[6]A constant rate of depreciation is also easily incorporated.

That is, change over time in the capital-labor ratio is critically dependent on the specification of per capita saving, *S/L*. In Solow's model, saving was taken to be a constant fraction, *s*, of total income, so that $S = sY = sF(K,L)$. The homogeneity of *F* can then be exploited to express per capita saving in terms of per capita income, $y = Y/L = F(K,L)/L = F(K/L,1) = f(k)$:

$$S/L \;=\; sf(k) \tag{5}$$

The dynamic behavior of the model is seen graphically, as in Figure 1, where the positive and negative terms in (4) are graphed separately. The first, per capita saving, is just the fraction *s* of the per capita production function, *f*(*k*), which is also shown. The second term in (4) is just a ray from the origin with slope *n*. The time derivative of the capital-labor ratio is then the vertical distance between these two curves. Under standard assumptions about production functions,[7] per capita saving in this formulation is above *nk* at low *k* and below it at high *k*, crossing *nk* only once. That intersection is the steady state capital-labor ratio, *k**, and the dynamics of the model cause *k* to converge to *k** over time, as shown by the arrows.

It is this behavior that has led interpreters to associate the Solow model with what has been called (conditional) convergence. That is, any two countries with the same technology, *f*, and identical savings and population growth parameters (hence "conditional") but different initial factor endowments will converge over time to the same capital-labor ratio, *k**, and therefore to the same level of per capita income. The strong result can be weakened, as noted by Solow himself, by permitting a technology for which output per unit of capital, *f*(*k*)/*k*, stays always

[7]These assumptions include the Inada (1963) conditions that $f'(0) = \infty$ and $f'(\infty) = 0$.

above a lower bound greater than *n*.[8] This raises the possibility of indefinite endogenous per capita growth that has been the focus of so much recent endogenous growth literature. But it does not help to explain a case that may be more relevant empirically: countries whose growth does level off, but at vastly different levels of per capita income.

Galor's (1996) suggested modification of the Solow model to allow for this possibility is very simple: assume that savings occurs only out of wages, not out of total income. He motivates this assumption by placing the Solow model in a two-period, overlapping generations context, with only the first generation working. In such a model, only the first generation can save, and its income is obtained solely from labor, so that savings is some fraction, s_w, of labor income. That fraction could in general depend on a variety of things, including the rate of return on capital, but for simplicity we can take it to be a constant.[9] Savings per capita is then that same fraction of labor income per capita, ie., the wage: $S/L = s_w w$.

Now the wage must rise with capital accumulation, but it need not do so smoothly. It may rise quickly to a high level for low values of *k* and then rise only slowly as *k* rises further, as it will, for example, with a CES production function with σ, the elasticity of substitution, greater than one. Alternatively, it may be a constant fraction of per capita income, replicating the savings function in Figure 1, as it will with a Cobb-Douglas production function. Or it may stay very low until some critical *k* is approached, then rise rapidly to level off much higher, as it will

[8]Thus violating the second Inada Condition.

[9]This would be the case, for example, if consumers in the two-period overlapping generations model had Cobb-Douglas preferences for first and second period consumption.

with a CES production function if σ is sufficiently less than one. This last possibility is shown in Figure 2.

As seen in Figure 2, savings out of wages can, in the case shown, lead to multiple steady states, k_1^*, k_2^*, and k_3^*. The middle steady state is unstable, and the economy approaches either k_1^* or k_3^* over time depending on whether initial *k* is below or above k_2^*. This is more or less the club-convergence phenomenon, but it takes an extreme form, since $k_1^* = 0$. That is, countries end up either rich or, in effect, dead.

To get multiple steady states that start above zero is quite possible in this simple model, but it requires that the wage, as a function of *k*, wiggle even more than the one shown in Figure 2. Perhaps such a function could be justified, although at this point Galor's model may begin to strain the bounds of plausibility.

In any case, the Galor model has another characteristic that seems manifestly inappropriate for addressing growth of different countries in the world economy. This is that these countries do not seem to trade. Each produces a single good that it uses for both consumption and investment, and it has no use for exports or imports. The model could be reinterpreted to correct this, having each country specialize in a single good, then exchange it at world prices for what it needs to consume and invest, but that degree of specialization may also strain credulity. In any case, I will look next at neoclassical growth in the context of a Heckscher-Ohlin trade model, where patterns of specialization and diversification will be endogenous.

IV. Neoclassical Trade and Growth

Among the many extensions of neoclassical growth theory that were attempted in the 1960s and early 1970s, extensions to incorporate neoclassical trade were among the most prominent. After Uzawa (1961, 1963) first built and solved a two-sector neoclassical growth model of a closed economy, Oniki and Uzawa (1965) took the natural next step of allowing two such countries to trade. In their model, one sector produced a consumption good and the other an investment good, and the structure of the model was an elegant hybrid of the Solow growth model and the 2x2x2 Heckscher-Ohlin trade model. It was somewhat cumbersome, however, and was not itself the basis for many extensions.

I will work here with an approach to this model developed in Deardorff (1974). There I showed that, taking prices of the two goods as given, the per capita income of a country can be easily constructed from the per-worker production functions of the two industries, each multiplied by its price. As shown in Figure 3 for two goods, labor-intensive X_1 and capital-intensive X_2, the per-worker production functions, f_1 and f_2, are first drawn as functions of their respective sectoral capital-labor ratios, k_1 and k_2. Per capita income of the country, y, as a function of the country's capital-labor ratio, k, is then the convex hull of f_1 and f_2. That is, a straight line tangent to both sectoral curves is drawn from A to B, and y is then given by the curve OABD. Per capita outputs of the two sectors are given by curves OAFG and OEBD, which include the diagonals of the trapezoid formed by AB and the perpendiculars from A and B to the horizontal axis.

Using Solow's (and Oniki and Uzawa's) proportional savings assumption, per capita saving, $S/L=sy$, is then simply a scaled down version of OABD, itself including a straight segment between the vertical lines under A and B. If prices remain fixed over time, then this per capita savings curve can be used along with the usual population growth ray, *nk*, to infer the dynamics of growth. In the case shown in Figure 3, the steady state at k^* has the country producing both goods, although if it had started its growth at a much lower capital-labor ratio, it would first have specialized in the more labor-intensive good, X_1. Under the assumption of Oniki and Uzawa that one of the goods is the investment good, the pattern of trade can also be inferred by comparing the per capita output of that good, given above, to the demand for the investment good given by *sy*. In the case shown, for example, if the investment good is the capital-intensive X_2, an initially poor country will first produce none of it and instead import all that it requires in exchange for the consumption good, then at some point in time begin to produce it, and eventually, in steady state, export it.

This construction can be used for a variety of purposes, including many of those commonly served in trade theory by the more familiar Lerner-Pearce diagram based on unit-value isoquants. However, it is obviously best suited for analysis of neoclassical growth, because of its similarity to Figure 1 used by Solow. For a small open two-sector economy that takes world prices as given, it gives a complete picture of the growth process so long as the exogenous world prices can also be taken as constant over time. The diagram can also provide part of the analysis of the growth of a closed two sector economy or of a two-country world, although it must be supplemented in those cases with some other analysis to determine equilibrium prices.[10]

With proportional saving, this two-sector, open-economy growth model evidently behaves very similarly to the one-sector closed-economy Solow growth model, and it has the

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[10]Much of this was done in Deardorff (1971).

same implication of conditional convergence of the countries of a trading world. Indeed, one could have many countries all looking like Figure 3 and trading with the same world economy whose prices anchor the figure, and all would then converge eventually to the same k^* regardless of their initial conditions.[11]

Also like the Solow model, this model can be modified following Galor to generate a form of club convergence. I do not pursue that modification here, because I do not find the results as plausible as those of the next section, where I also allow for more goods and possible failure of factor-price equalization. But the interested reader may wish to investigate them.[12]

V. More Goods

Since the heyday of neoclassical growth theory, attention to the Heckscher-Ohlin model of international trade has extended beyond the two-good textbook version of the model to allow for more goods. At the same time, the role of factor price equalization (FPE) in Heckscher-Ohlin models has been clarified. We now know that if the factor endowments of all the countries in the

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[11]Of course the world market-clearing prices would be likely to change over time as the world factor endowments evolve, but at any point in time the picture would look enough like Figure 3 to generate convergence.

[12]With only wages saved, the two-good case of Figure 3 will generate club convergence somewhat like Figure 2, so long as the elasticity of substitution of the more capital intensive good is sufficiently small. In that case, and with, say, a Cobb-Douglas labor-intensive sector, per capita saving behaves as follows: It rises in proportion to national income to the left of E, is constant between E and F, then rises quickly to include almost all income to the right of F. For appropriate parameters s_w and n, there will be positive stable steady states to the left of F and also far to the right of F. In this scenario, the poor club does survive with positive income, and it may even produce both goods, while the rich club necessarily specializes completely in the capital intensive good. By making the labor-intensive good also substitution inelastic, another stable steady state at zero can also be obtained.

world are sufficiently similar, then it is possible for free and frictionless trade to lead to complete FPE, with all countries at least potentially producing all goods. But if factor endowments differ enough, then complete FPE will be impossible, and the world will sort itself into at least two groups of countries with different factor prices.[13] Exactly what this arrangement will be we do not know, but one such arrangement that can arise under particular circumstances has countries in just two groups, each group of countries producing a different group of goods. Such an equilibrium suggests itself for the problem here, where for a different reason we are also looking at groups of countries that may have different factor endowments. I will therefore extend the analysis of the previous section to a model of just three goods.

Suppose, then, that goods X_1, X_2, and X_3 have different capital intensities, and that world prices happen to be such that complete FPE is not possible. Trade theorists are familiar with this situation, which is usually depicted with the Lerner-Pearce diagram and unit-value isoquants that imply two cones of diversification, one for producing goods X_1 and X_2, the other for producing X_2 and X_3.[14] In the per capita income diagram used here and applied to this case, the convex hull of the three per worker production functions includes two straight line segments that correspond to these diversification cones. Figure 4 shows this hull and the two diversification cones, one between A and B, and another between C and D. I have omitted the portions of the per worker production functions that are not part of the hull to reduce clutter, but the reader can imagine what they must look like. The production function for the most labor-intensive good, X_1, simply continues the smooth curve begun by OA. That for good X_2 is a curve from O to B (starting

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[13]See Deardorff (1994b).

[14]See Deardorff (1979).

flatter than OA), includes the short curved segment BC, and then continues in another smooth curve to the right of C and below the hull. That for X_3 is a still flatter smooth curve from O to D and then follows the hull along DE.

This three good model would again behave very like the Solow one-sector model if savings were proportional to income. The per capita savings curve would be just a scaled down version of the per capita income curve, and the straight segments of it would have no substantive implications, except for their underlying message about how patterns of production and trade would vary during the course of growth.

But with Galor's assumption that savings comes only out of wages, this shape has startling implications. Throughout each straight segment of the per capita income hull, factor prices are constant due to FPE, and in particular, the wage is constant at the level given by the vertical intercept of the (extended) straight segment.[15] And where the per capita income curve is not straight, following one of the per worker production functions, the wage rises with k at a rate that depends essentially on the elasticity of substitution of that particular production function. Thus a curve representing the wage for all levels of k is like the one shown: rising from O to F, flat from F to G, rising from G to H, flat again at a higher level from H to I, and finally rising thereafter.

This unusual shape for w is also, under Galor's assumption, the shape of the per capita savings curve, since that is the same curve scaled down by the fraction s_w. Rather than draw yet another curve in Figure 4, I assume implausibly that s_w is unity (or alternatively that the entire

[15]This is a standard feature of two-factor production functions written in intensive form. Per worker output is $y = f(k)$, the rental price of capital is $r = f'(k)$, and the wage is $w = f(k) - rk$, which is the vertical intercept of the tangent to the curve $f(k)$.

vertical dimension of the figure has been scaled by s_w), and I therefore treat the wage curve itself as the per capita savings curve. Inserting a population growth ray, *nk*, it is then not hard to get two stable steady states, both in cones of diversification.[16][17] These are shown as k_1^* and k_3^*, and there is also an unstable steady state at k_2^*. Thus it is not only easy to get multiple steady states – and thus club convergence – once one allows for multi-good, Heckscher-Ohlin trade; the model even seems to suggest them as likely.

This is a bit of an overstatement, however, for I have implicitly made several assumptions that contribute to this result in drawing Figure 4. First, I have drawn the wage curve as quite steep between points G and H. This will only be the case if the elasticity of substitution in good X_2 is sufficiently less than one. In contrast, a Cobb-Douglas function would have had the wage just proportional to per capita output, and the resulting wage curve would cross rays from the origin only from above, preventing the unstable crossing at k_2^*. But with inelastic substitution in this good of intermediate factor intensity, the wage curve can cross rays from below as shown. Indeed, if good X_2 were Leontief, points B and C would coincide and GH would be vertical.

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[16]As long as the segment GH is steep enough to cut rays from the origin from below, as shown and as discussed further below, then there will exist values of *n* such that there are multiple steady states. However these will not necessarily occur in cones of diversification. The latter property is easy to get by drawing the production functions appropriately, as shown, but it is also easy to draw the functions so that a steady state in one cone can only be accompanied by other steady states outside of either cone. Of course, the per capita income curve on which this is all based depends not only on the sectoral production functions, but also on world prices, and these will have adjusted so that all goods are produced somewhere and world markets clear. To me that suggests that configurations such as Figure 4, with both steady states in cones of diversification, are more likely than configurations in which one steady state involves specialization. However, "likely" here has no rigorous meaning. In any case, the behavior of the model is pretty much the same in either case.

[17]If production functions have low elasticity of substitution, then the wage will rise rapidly to the right of point I, and additional steady states will exist with complete specialization.

I have also implicitly selected prices of the goods that yield the desired picture. However, that is not as arbitrary as it might seem. World prices must be such as to give equilibrium in all goods markets. If initial factor endowments are sufficiently different across countries to prevent FPE, then prices must adjust so that all goods are produced somewhere. This does not necessarily assure that countries diversify, but obtaining positive production of all goods is surely easiest if prices adjust so that both diversification cones include at least some countries.

I am treating the figure and the prices that underlie it as though they were fixed over time, but obviously they will not be fixed as long as a nontrivial portion of the world economy is still adjusting toward steady state. Nonetheless, it seems likely that at each point of time along the way, the picture will look something like figure 4, with countries below some dividing-line capital-labor ratio (here k_2^*) converging on a low k and countries above it converging on a high k. Ultimately, what will matter will be the prices that prevail when all countries have reached steady state. Since the countries are not being drawn closer together along the way, it will not be surprising if they remain too far apart for FPE in the steady state, and then steady state prices that permit all goods to be produced could easily give rise to the picture in Figure 4.

Let me summarize what this model, together with Heckscher-Ohlin trade theory, says. Suppose that countries have identical technologies and identical behavioral parameters (n and s_w), but different initial factor endowments. If those differences are not too large, then world equilibrium will entail FPE and we will be in something like the situation of section III, with only a single cone of diversification and a single flat in the wage curve. Convergence of all factor endowments to a single steady state is not assured, for multiple steady states can arise here just as in Galor's one sector model. But they do not appear particularly likely. However, if countries begin with endowments too diverse to permit FPE, then market clearing prices will necessarily imply multiple cones of diversification and a wage curve the wiggles as in Figure 4. As long as the good of intermediate factor intensity that is produced between these two cones is of sufficiently low elasticity of substitution, the wiggles *will* (not just "can") be big enough to yield multiple steady states. Thus the initial differences in factor endowments may remain over time, and the world will evolve toward a permanent situation in which countries remain divided into two groups, one rich and one poor.

VI. Comparative Statics and Comparative Steady States

Suppose now that we start in such a world steady state, with a large number of countries that are technologically and behaviorally identical but which, because of history and the dynamics described above, have sorted themselves into two such groups. What will happen to one such country if its behavior changes? The solid lines in Figure 5 reproduce the per capita savings and population growth curves from Figure 4. If we are in a world steady state, some countries are at k_1^* and others are at k_3^*. What happens if a poor country, starting at k_1^*, increases the fraction of its wages that it saves, from s_w to s_w'? A small increase will move its steady state only slightly to the right, and it will get a small increase in its per capita income over time, just as in the Solow model. But a larger increase in s_w, like the one shown, will shift the savings curve enough to eliminate the lower steady state. The capital-labor ratio of the country will therefore begin to rise over time, eventually approaching, if s_w remains elevated, a steady state even higher than k_3^*. Thus a comparatively small change in behavior can lead to a large change in the country's situation. Poor countries need not be condemned to poverty, it seems, and the cure for poverty here is the usual one: an increase in savings. But the increase has to be large enough to eliminate the poor steady state entirely, not just move away from it.

What's more, the increase in saving does not even have to be permanent. If the country saves at the rate s_w' and then returns to its old ways saving s_w, growth will continue to k_3*. The unstable steady state, k_2*, acts as a threshold that the poor country merely needs to get past in order to continue growing like a rich country.

All this assumes that a single, negligibly small poor country attempts to increase savings. What would happen if the entire group of poor countries were to try to do this? Part of the answer is that prices would then have to change, and the use of the diagram would be considerably more complicated. Results will depend in part on which good is the investment good, since it must serve as the numeraire for comparison with the ray *nk*. But a likely answer is not hard to find in the case where the investment good is an import of the poor countries. As the poor countries all increase their saving out of wages, they will all begin to grow, and as they do, their output of the most labor-intensive good will fall. To maintain equilibrium in good markets, the price of that good will have to rise relative to the others. As it does, the first curved segment of the per capita income curve in Figure 4 will also shift up, while the straight portion from A to B will become flatter. This raises the wage and shifts the per capita saving curve up even further in the relevant range for the poor countries. Figure 6 shows just the second part of this process, the increase in the price of good X_1. The total effect is then a combination of Figures 5 and 6. Clearly, and to me surprisingly, a smaller increase in savings by poor countries seems to be needed for them to escape poverty together than would be needed for them to do it individually!

What can be said about the savings rate can equally be said, in reverse, about the population growth rate, *n*. By lowering its population growth rate below that of the world, a single negligibly small country can also grow in per capita terms, and if the reduction is large enough, it may be able to eliminate the lower poor steady state entirely.

Analogous results can also be formulated for individual and groups of rich countries, who by saving less, or reproducing faster, may destroy the rich steady state that has sustained them.[18]

VII. Trade and Trade Policy

The multiple equilibria that may result when world prices reflect the absence of FPE may suggest that it is somehow free trade that enhances the possibility of a poverty trap. After all, in a closed economy the equilibrium prices would have to permit the production of all goods, and while the analysis of the one-sector closed economy above indicates that multiple steady states can arise even there, without multiple cones of diversification this seems distinctly less likely. It is therefore time to ask whether trade intervention may have a greater potential to improve the lot of a poor country in this model than we are accustomed to in more standard static models of international trade.[19]

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[18]One needs to be careful about increases in population growth rates, however, since a country that raises its population growth above that of the world will not be able to remain negligibly small, and there will have to be effects on prices. Growth in a neoclassical world with differences in population growth rates is explored in Deardorff (1994a), where it is noted that with international investment as well as trade, a country with a population growth rate lower than the world's can achieve endogenous sustained per capita growth at a rate that depends on its savings, much as in endogenous growth models, even without any form of increasing returns to scale or improvement in technology.

[19]It is already known that a tariff can have different effects in a static model with multiple cones of diversification than in the traditional Heckscher-Ohlin model. Davis (1996) has

To consider trade policy, we must first be careful about how price changes are introduced into this model. The critical consideration is that the per capita savings curve must be measured in the same units as capital, since savings is to provide the amount of new capital needed to sustain steady-state growth along the ray *nk*. Thus we must identify which of our three goods (or possibly a combination of them) is used for investment, and then hold the price of that good constant. Since there is no natural assumption to make regarding the factor intensity of the investment good, this means that we must consider three possible cases any time a change in prices occurs.[20]

In addition, there are two types of country to consider, rich and poor, as well as more than one possible pattern of trade between them. Allowing for all of these possibilities would be tedious, and I will therefore focus attention only on trade restrictions levied by a poor country, leaving the case of rich-country protection to be considered by the reader.

Suppose then that the world starts in a free-trade steady state with large numbers of technologically and behaviorally identical countries having sorted themselves into rich and poor groups as discussed above, due to having started with different initial factor endowments.[21] Only

examined the effects of protection and trade liberalization in a static model identical to the one considered here.

[20]Uzawa (1961, 1963) found that if the investment good were capital intensive, this could introduce various kinds of instability, either in the disequilibrium dynamics of price adjustment at a point in time, or in the steady states over time. That has led some to prefer the opposite factor intensity assumption, for reasons analogous to the Samuelson's (1948) Correspondence Principle. However it is precisely such instabilities that may cause multiple equilibria such as we study here, and I therefore would not rule them out.

[21]There is no reason why one could not also examine a country that is different from the others in technology or behavioral parameters, but this would add still more to the cases to consider.

the poor countries can produce the most labor-intensive good, X_1, and they must therefore export it. At the same time, the rich countries must produce and export X_3. But either group of countries could export X_2 to the other, depending on the sizes of the groups and their steady-state factor endowments. Thus the poor countries may be importers of only X_3, or they may import both X_2 and X_3. Again, for the sake of brevity, I will consider only the first of these cases.

That is, our chosen poor country, an importer of X_3, now levies a tariff on those imports, raising the country's domestic price of X_3 above the world price (which I hold constant, due to the presence of many other countries, both rich and poor, who continue to trade freely). If good X_3 is not the investment good (whose price in the domestic economy we must hold fixed as numeraire), then the curve $p_3 f_3$ that underlies *y* would shift upward due to the tariff, raising *y* and rotating it counterclockwise to the right of C in Figure 4. If instead, good X_3 *is* the investment good, then the rise in its price above the world price would appear as a *downward* shift of both $p_1 f_1$ and $p_2 f_2$ and thus of the *y* curve in Figure 4 from O to D. These two possibilities, both for a small tariff, are shown in panels (a) and (b) of Figure 7.

In both cases, I have kept savings constant, as a fraction of the wage, implicitly assuming that tariff revenue is not saved.[22] In the case that X_3 is the investment good, panel (a), the proportional downward shift of both $p_1 f_1$ and $p_2 f_2$ causes the wage in the lower diversification cone to fall. There is also a larger change in the wage in the upper cone, due to the fact that the tangency at C moves down and to the left, and the vertical intercept of the tangent itself (not shown) falls substantially. This does not matter for the poor country, however, since its

[22]If tariff revenue is saved, then this slightly improves the chance that the tariff may be beneficial. But as usual in second best analysis, any less distorting tax could provide revenues to be saved and yield a superior outcome.

endowment ratio is in the lower cone. What does matter is that the wage in the lower cone falls (by the percent of the tariff), and because this reduces saving the country's steady state capital-labor ratio is reduced. Thus when X_3 is the investment good, the tariff levied by the poor country just increases its poverty in steady state. This is not surprising, since X_3 is also the import good, and what the tariff is doing is making investment more expensive.

If X_3 is *not* the investment good, the outcome is only slightly better, as shown in panel (b) of Figure 7. Now the tariff does shift a portion of the per capita income curve upward, to the right of C, also moving the tangency at C slightly to the left. However, the vertical intercept of that tangency falls, and therefore the wage is reduced in the upper cone of diversification. This does not matter for the poor country, however, since it is not there. Instead, in this case the wage in the lower cone is left unchanged by the tariff, and there is no effect on the poor country's steady state. The tariff here has not hurt growth, but it has not helped either.[23] Thus in neither case does a small tariff -- one that leaves the poor country still not producing good X_3 -- help it to escape the impoverished steady state.

But what if the tariff were raised still higher, to the point that production of good X_3 were to become viable? This would draw factors out of good X_2, until either X_2 would be imported or a tariff would be placed on imports of it as well. Assume the latter, so that we examine broad protection that moves the country all the way to autarky.

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[23]Of course static welfare, if we were to look at it, would still be reduced by the tariff due to the usual inefficiency that it causes in choices between X_3 and other goods. This is a good example of Mazumdar's (1996) point that trade liberalization, even though it may increase static welfare by reducing inefficiency, will increase growth only if it lowers the price of the investment good, contrary to the claim of Baldwin (1992).

If X_3 is the investment good, then this means that the downward shifts in Figure 7a cease to be equiproportional when production of all three goods becomes possible. Instead in Figure 8a, to keep production of X_2 viable, a tariff will be placed on imports of it as well, and the per worker value of production functions for X_1 and X_2 (not shown) will both shift down, maintaining a common tangency, A′′D′′, with $p_3 f_3$. The latter is shown as the thin solid curve in Figure 8a. The result is seen to be an even greater reduction in the wage. This lowers saving even more and causes the country to move to a still poorer steady state.

If X_3 is not the investment good, then the continuation of the story begun in Figure 7b depends, but only slightly, on which of X_1 or X_2 is the investment good. If X_2 is the investment good, then $p_2 f_2$ stays fixed, the thin solid curve in Figure 8b. The further rise in tariff on X_3 again requires a tariff also on X_2, which now shows up as a downward shift in $p_1 f_1$ (not shown). In effect, once there is a common tangent to all three curves, A′′D′′, it rolls around the $p_2 f_2$ curve until autarky is reached. Again, the wage in units of the investment good falls, lowering saving and leading to an even poorer steady state.

Finally, if X_1 is the investment good, then the thin solid curve $p_1 f_1$ in Figure 8c remains fixed, while the growing tariff on X_3 together with a smaller tariff on X_2 cause $p_2 f_2$ and $p_3 f_3$ (not shown) to shift up, rolling the common tangent to all three curves, A′′ D′′, around $p_1 f_1$ to autarky. Yet again, the result is a fall in the wage and therefore in savings, reducing the steady state.

Therefore, while the exact picture does depend on the identity of the investment good, the conclusion is robust that a move to autarky by a poor country leads it to an even more impoverished steady state than was attainable with free trade.[24] Therefore it is not international trade that should be faulted for the sad steady state that such a country finds itself in with free trade. The solution to such poverty will not be found in withdrawal from the world market, but rather in finding some way to increase savings as discussed in the previous section.

VIII. Conclusion

The world of this paper is not a happy one, for it condemns whole populations to permanent poverty, not because they behave any differently from more fortunate folk, but only because of their place in history. If that is the case in the real world as well, then it is very important to find out why, and what can be done to change it. I find it rather surprising that the Heckscher-Ohlin model of international trade, which I tend to think of as quite well-behaved, can yield this result in one of its more plausible equilibria.

[24]One must be careful, however, in drawing conclusions about welfare across steady states, since to get from one steady state to another one traverses a non-steady-state growth path where welfare can be quite different. See Deardorff (1973).

References

Azariadis, Costas and Allan Drazen 1990 "Threshold Externalities in Economic Development," *Quarterly Journal of Economics* 105, pp. 501-526.

Baldwin, Richard E. 1992 "Measurable Dynamic Gains from Trade," *Journal of Political Economy* 100, pp. 162-174.

Barro, Robert and Xavier Sala-I-Martin 1995 *Economic Growth*, New York: McGraw Hill.

Davis, Donald R. 1996 "Trade Liberalization and Income Distribution," in process, Harvard (June).

Deardorff, Alan V. 1971 *Growth and Trade in a Two-Sector World*, Ph.D. Thesis, Cornell University, (June).

Deardorff, Alan V. 1973 "The Gains from Trade In and Out of Steady-State Growth," *Oxford Economic Papers*, 25 (July), 173-91.

Deardorff, Alan V. 1974 "A Geometry of Growth and Trade," *Canadian Journal of Economics* 7, (May), pp. 295-306.

Deardorff, Alan V. 1979 "Weak Links in the Chain of Comparative Advantage," *Journal of International Economics* 9, (May), pp. 197-209.

Deardorff, Alan V. 1994a "Growth and International Investment with Diverging Populations," *Oxford Economic Papers* 46, (July), pp. 477-491.

Deardorff, Alan V. 1994b "The Possibility of Factor Price Equalization, Revisited," *Journal of International Economics* 36, pp. 167-175.

Galor, Oded 1996 "Convergence? Inferences from Theoretical Models," *Economic Journal* 106, (July), pp. 1056-1069.

Inada, Ken-ichi 1963 "On a Two-Sector Model of Economic Growth: Comments and a Generalization," *Review of Economic Studies* 30, (June), pp. 119-127.

Matsuyama, Kiminori 1996 "Why Are There Rich and Poor Countries?: Symmetry-Breaking in the World Economy," NBER Working Paper No. 5697, August.

Mazumdar, Joy 1994 "Do Static Gains from Trade Lead to Medium-Run Growth?" *Journal of Political Economy* 104, December, pp. 1328-1337.

Oniki, H. and H. Uzawa 1965 "Patterns of Trade and Investment in a Dynamic Model of International Trade," *Review of Economic Studies* 32, (January), pp. 15-38.

Quah, Danny T. 1996 "Twin Peaks: Growth and Convergence in Models of Distribution Dynamics," *Economic Journal* 106, (July), pp. 1045-1055.

Sala-I-Martin, Xavier 1996 "The Classical Approach to Convergence Analysis," *Economic Journal* 106, (July), pp. 1019-1036.

Samuelson, Paul A. 1948 *Foundations of Economic Analysis*, Cambridge: Harvard University Press.

Solow, Robert 1956 "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70, pp. 65-94.

Swan, T. W. 1956 "Economic Growth and Capital Accumulation," *Economic Record* 32, pp. 334-361.

Uzawa, H. 1961 "On a Two-Sector Model of Economic Growth," *Review of Economic Studies* 29, pp. 117-124.

Uzawa, H. 1963 "On a Two-Sector Model of Economic Growth: II," *Review of Economic Studies* 30, pp. 105-118.

Chart 1:
1990 Population Distribution of Per Capita National Income

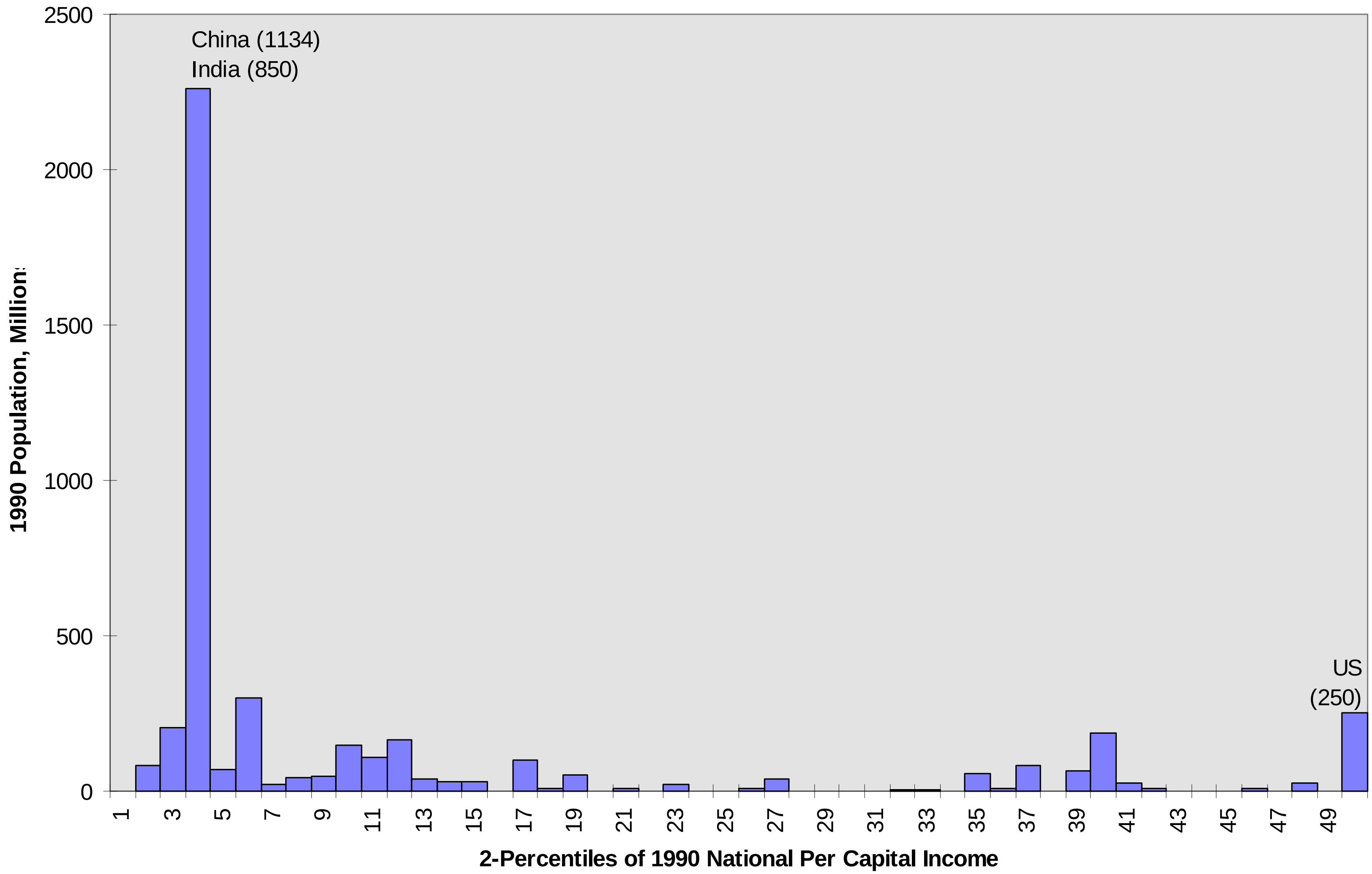


Chart 2:
1960 Population Distribution of Per Capita National Income
Excluding China and India

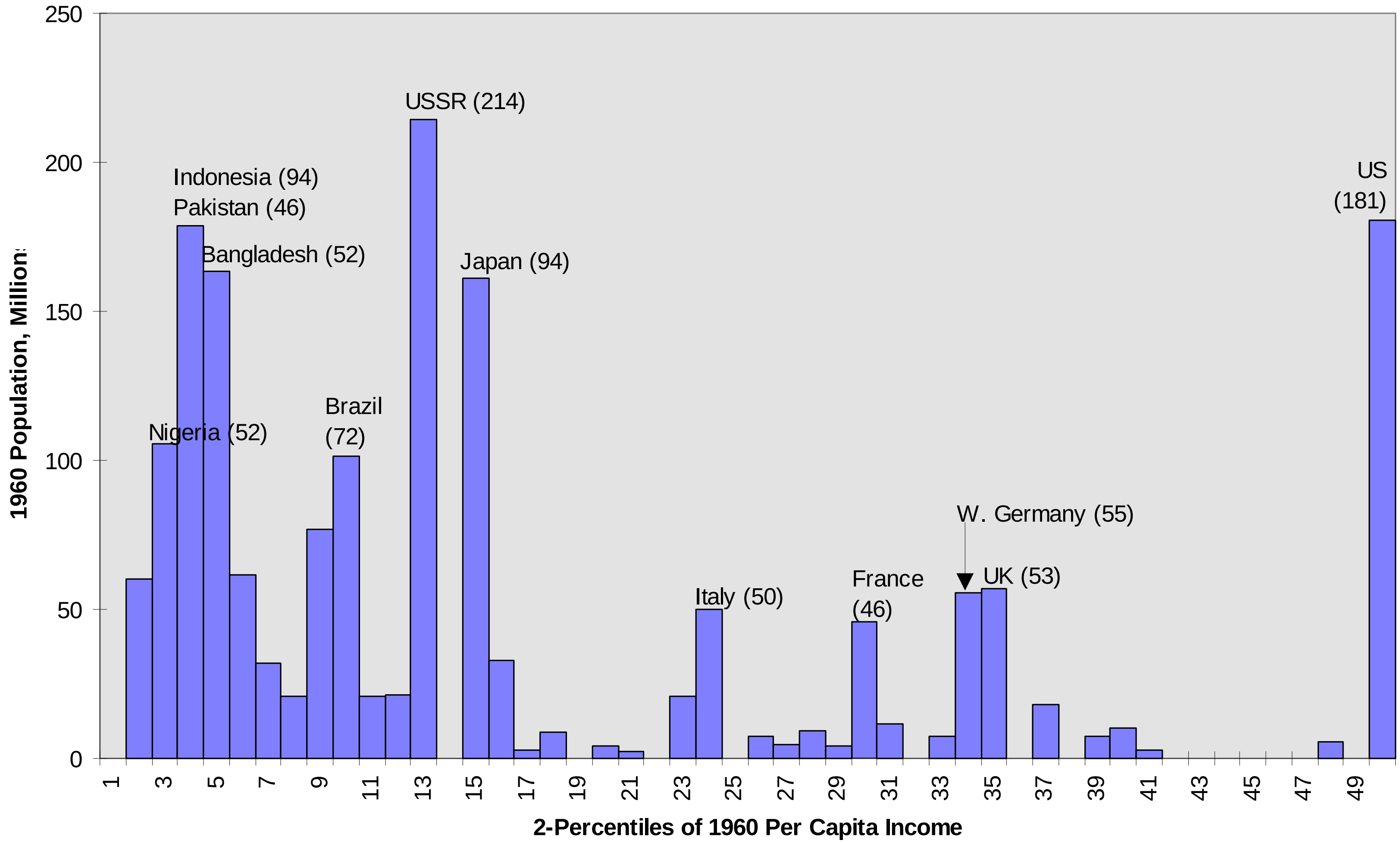


Chart 3:
1975 Population Distribution of Per Capita National Income
Excluding China and India

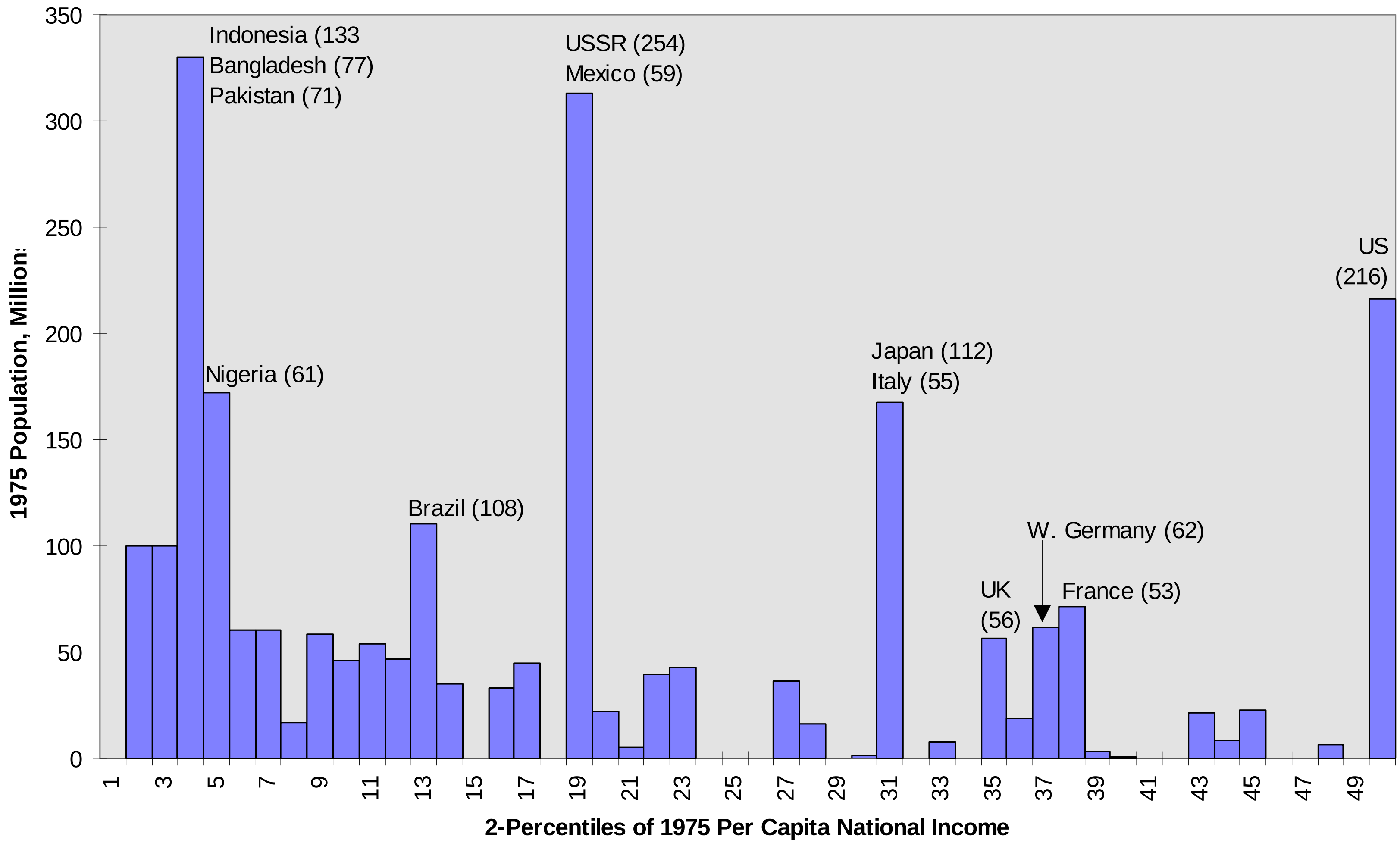
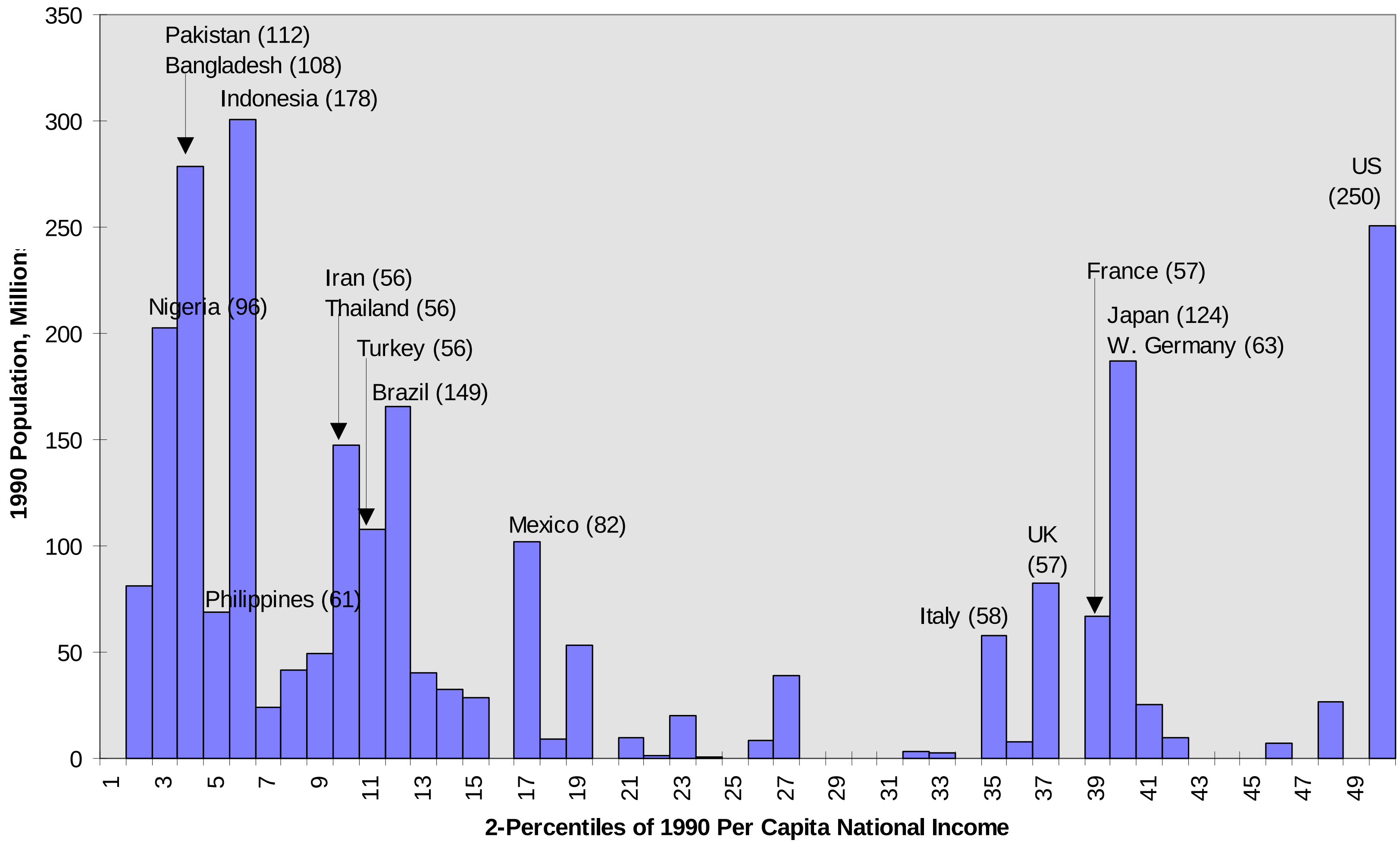


Chart 4:
1990 Population Distribution of Per Capita National Income
Excluding China and India



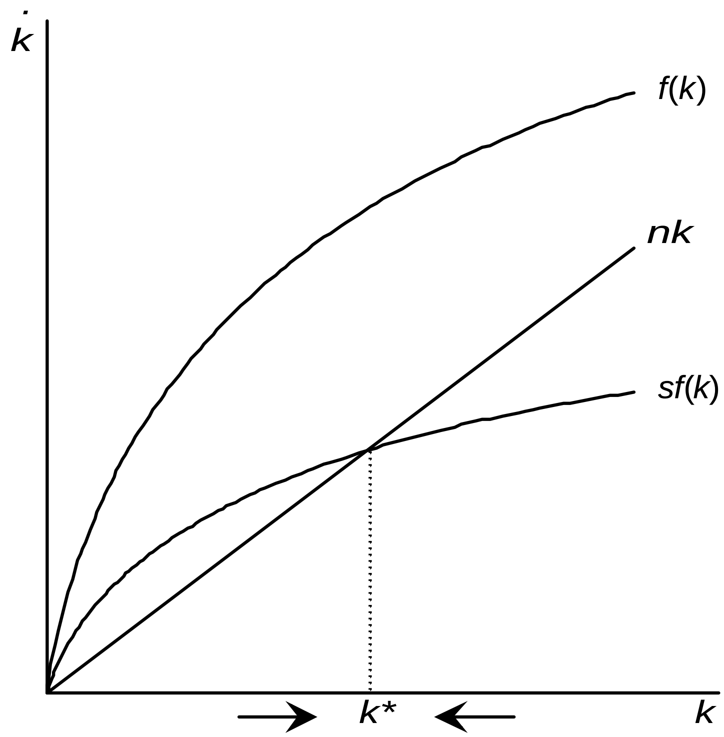


Figure 1

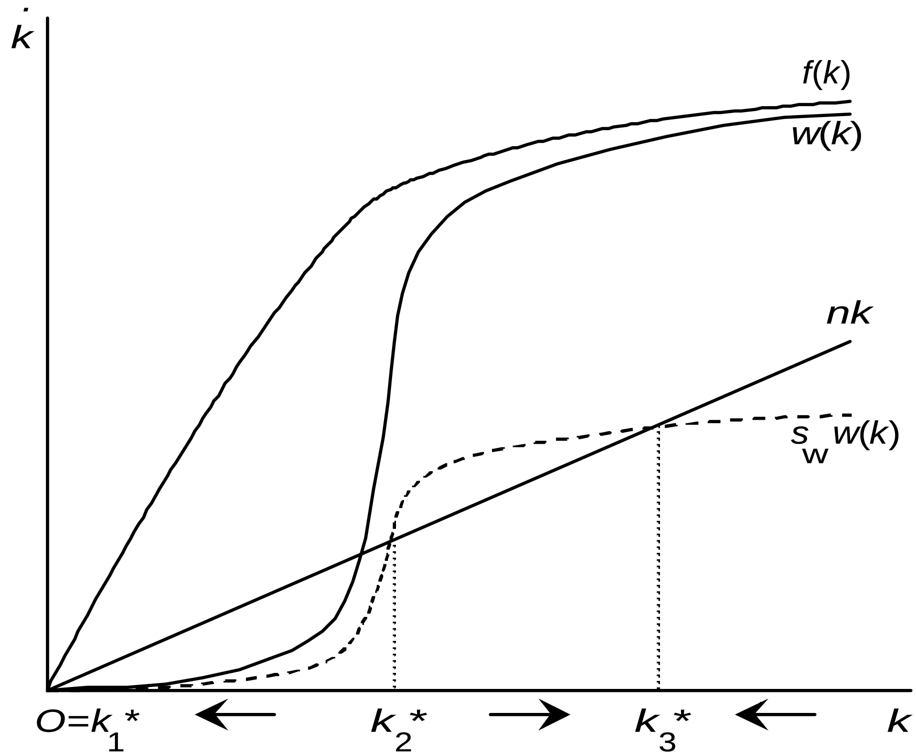


Figure 2

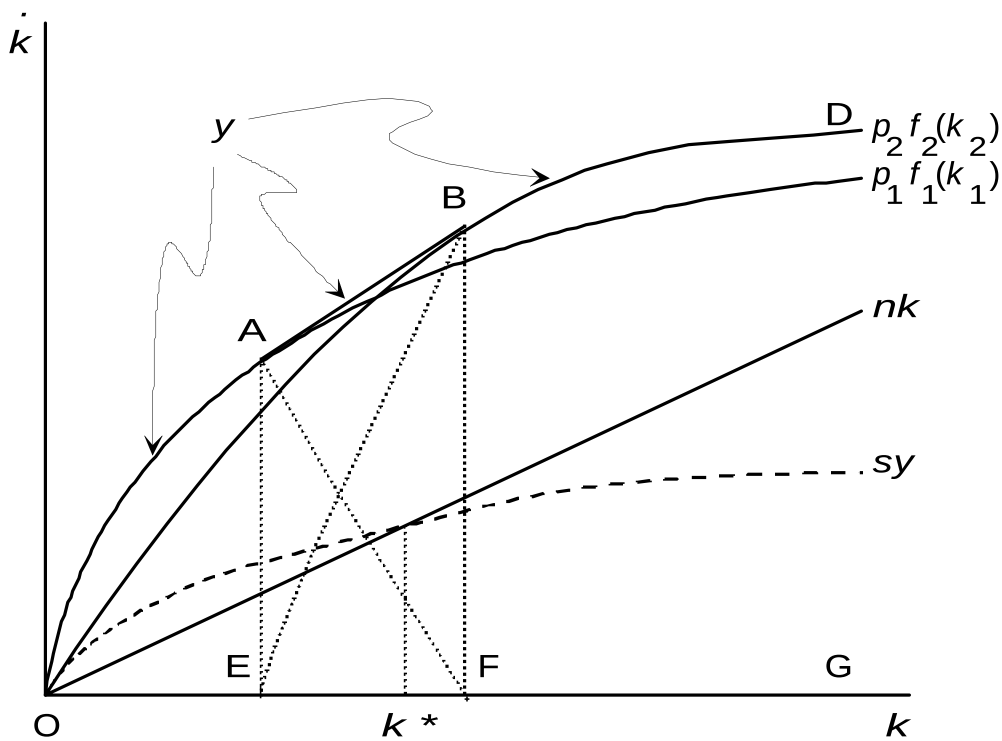


Figure 3

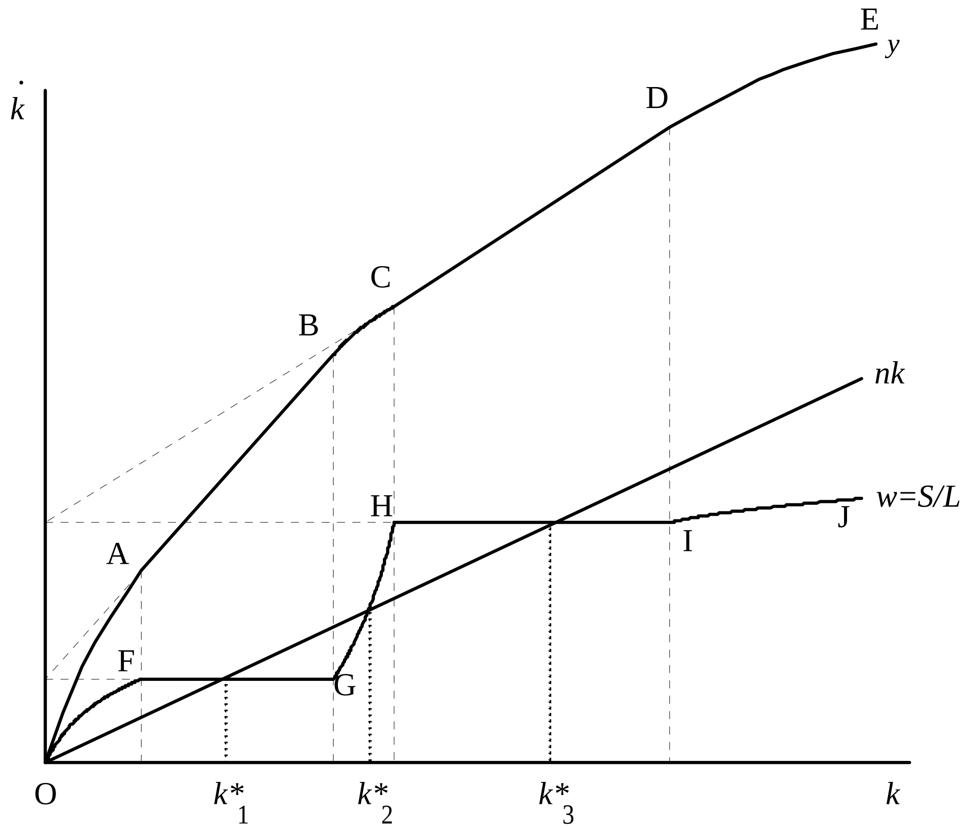


Figure 4

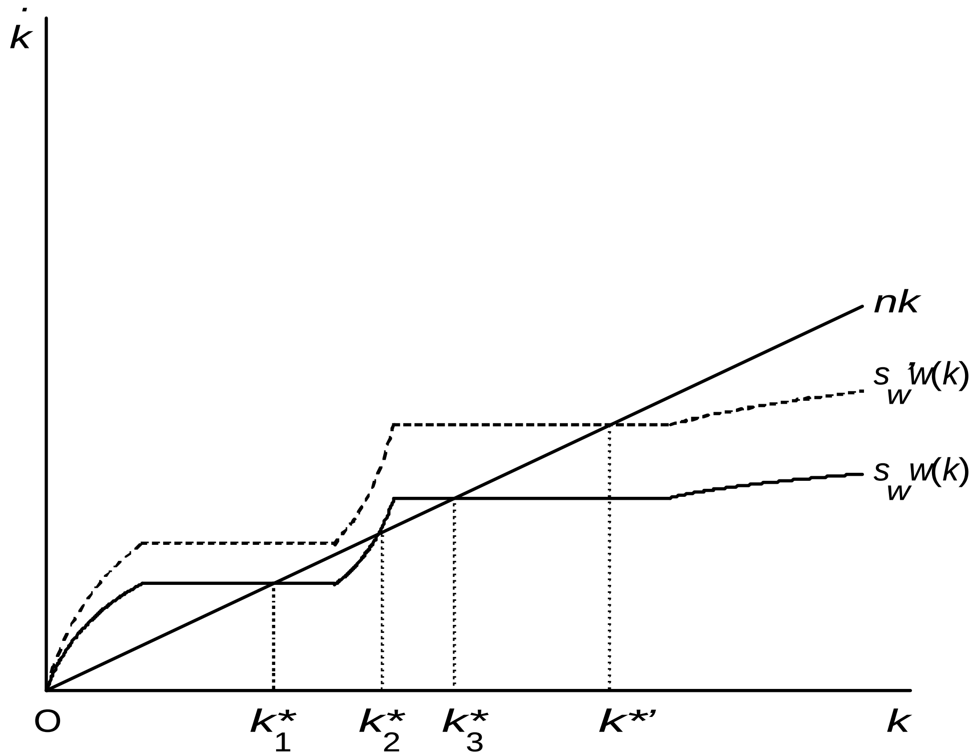


Figure 5

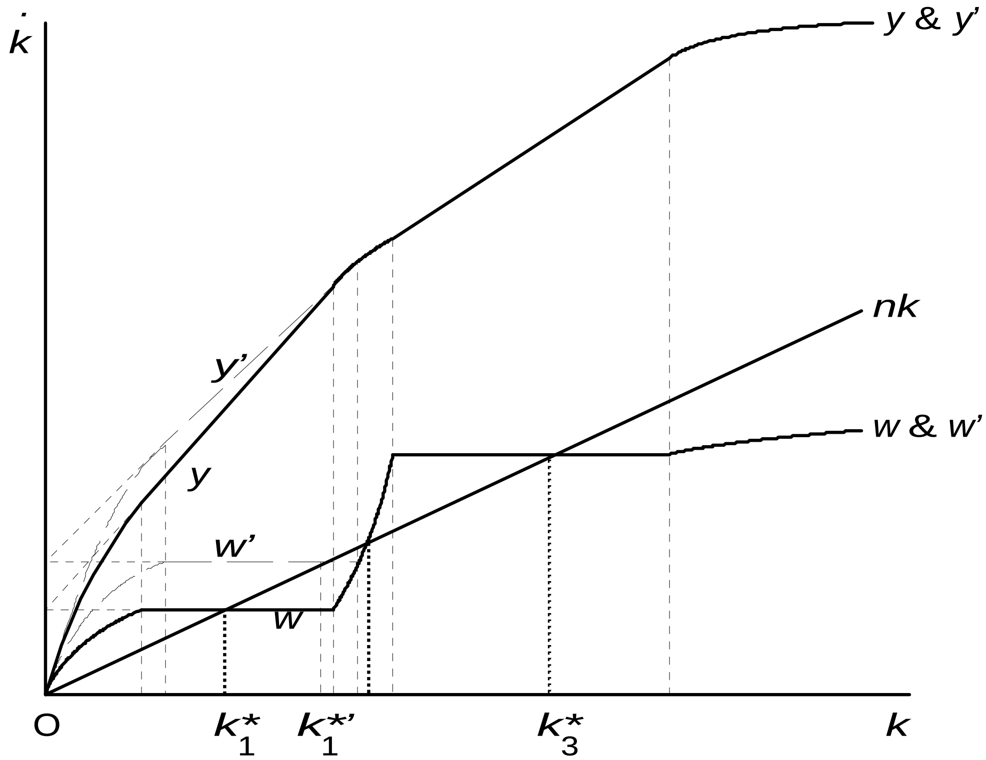
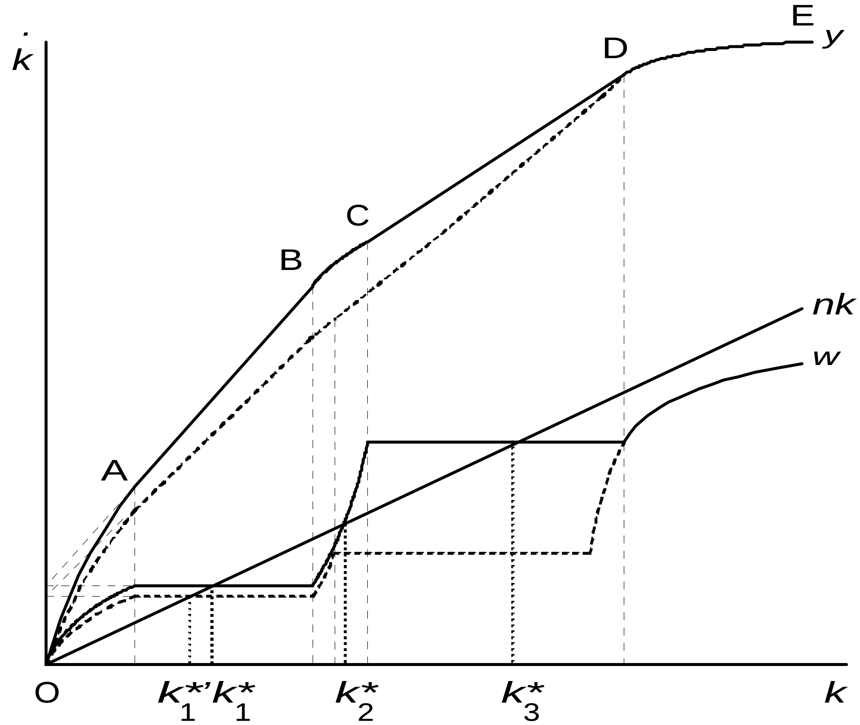


Figure 6

a) X_3 is the investment good



b) X_3 is not the investment good

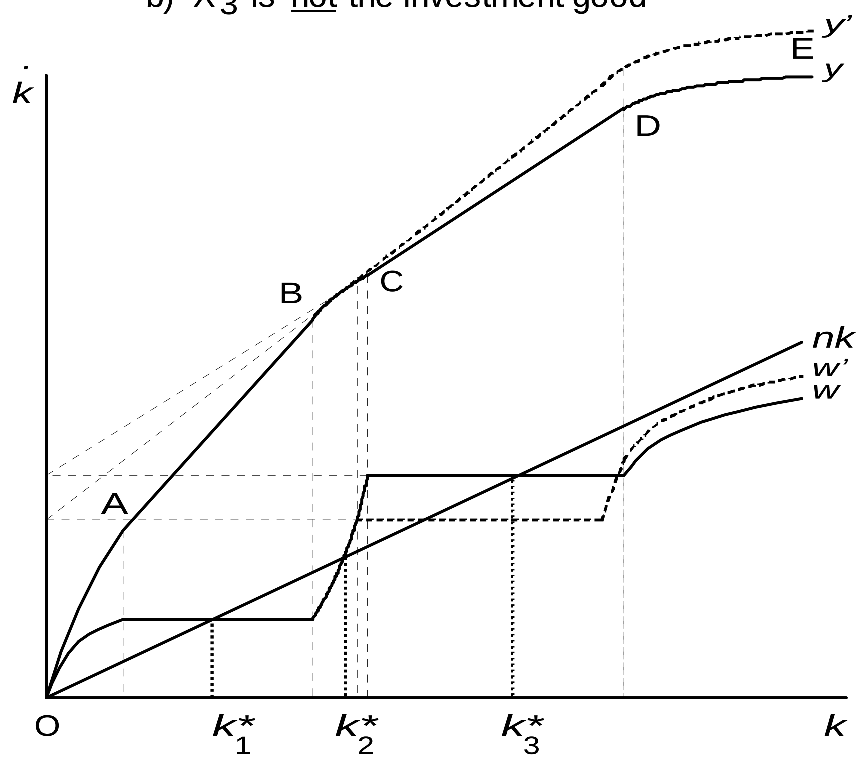


Figure 7

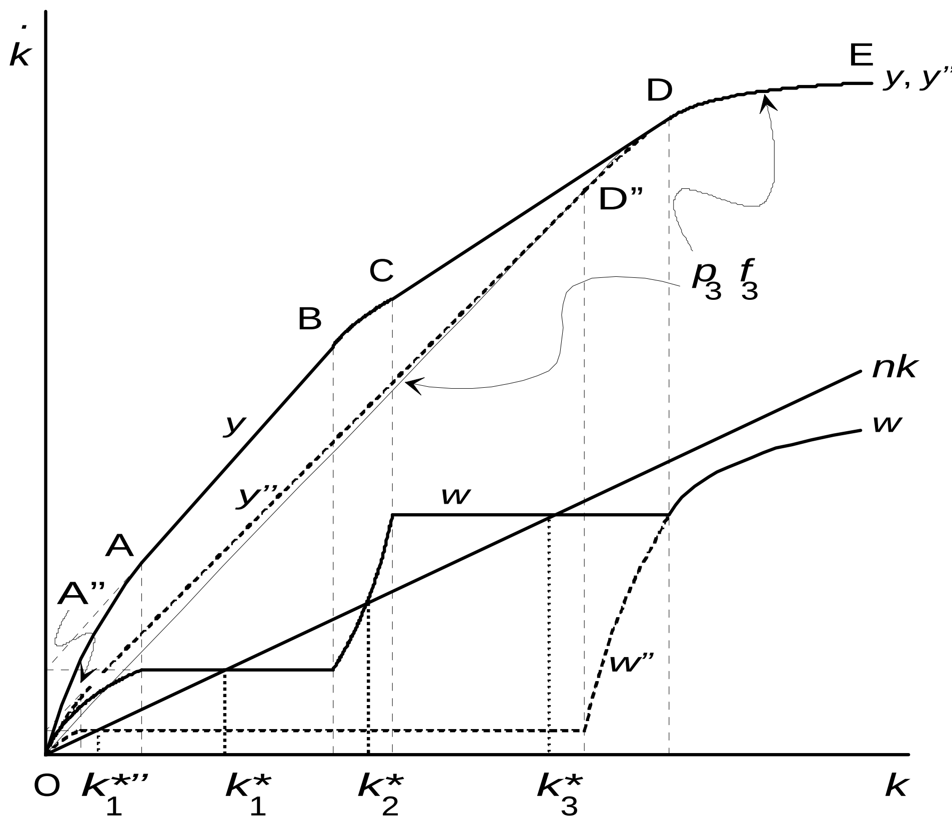


Figure 8a: X_3 is the investment good

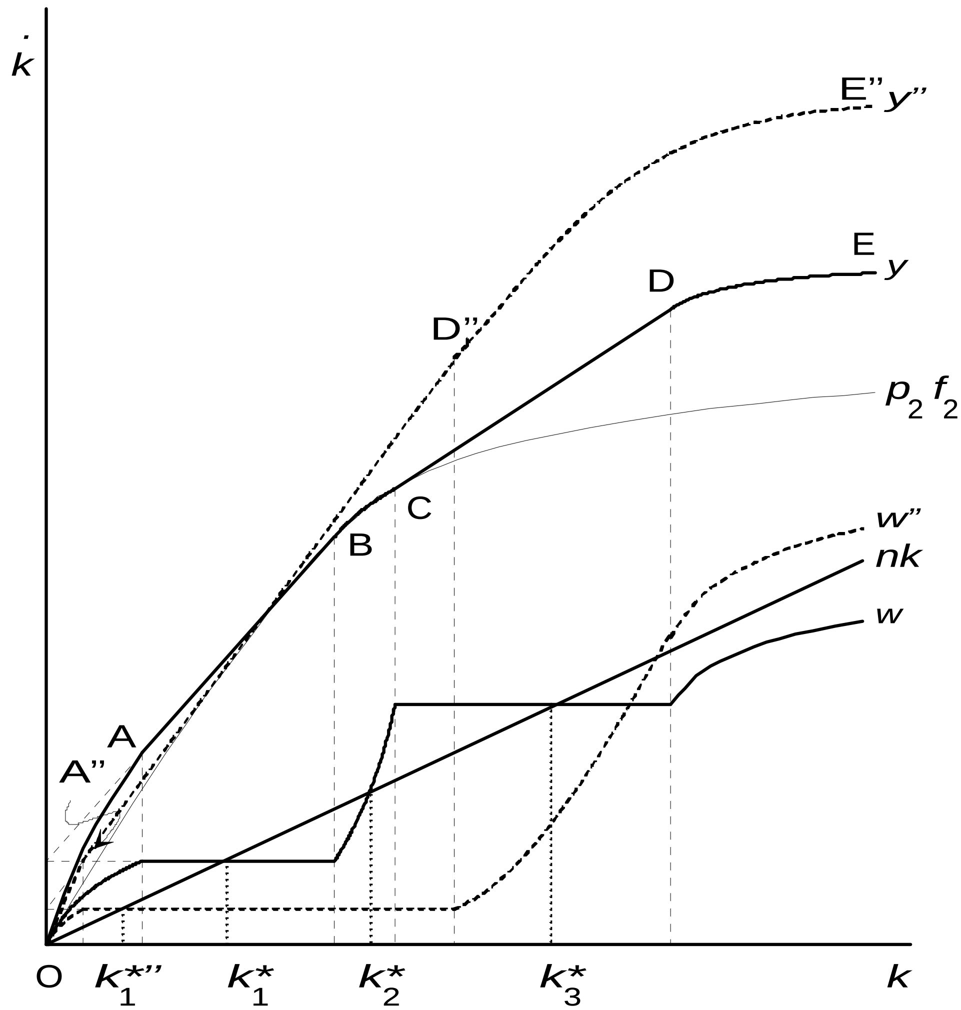


Figure 8b: X_2 is the investment good

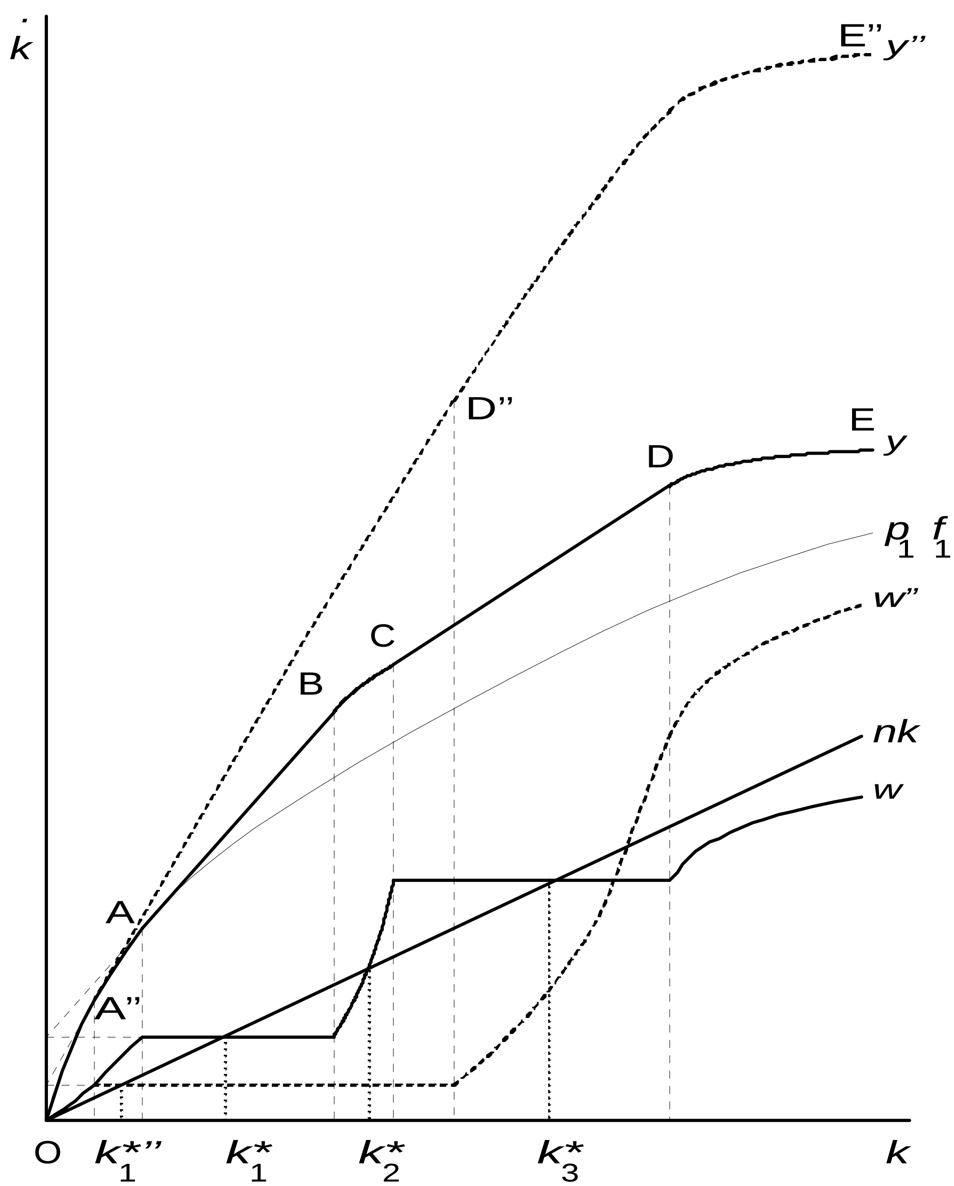


Figure 8c: X_1 is the investment good