Micro-churning with Smooth Macro Growth: Two Examples

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Macro-economic models of economies in the growth process are most often highly aggregated. There is no doubt that many variations at the detailed micro-economic level can yield the same overall macro levels of growth, perhaps remaining fairly constant at high levels for years if not decades. However, the smooth aggregate levels may disguise rather interesting churning activity at the micro level, with compositional changes that are not accidental and may, indeed, help to maintain high overall levels of growth. Here I wish mainly to consider two examples of this phenomenon, one focused on international trade and the other on technology.[1]

1. International Trade and Churning at the Micro-Level

By definition a country that engages in international trade forsakes the kind of balanced growth associated with autarky, with local production responding to local demand. However, in simple text-book models of international trade that limit production and consumption to two commodities, it is possible to consider a balanced expansion in the composition of a country's production levels, with aggregate growth rates matched by those in each sector. What is missing in this account is the potential of international trade to allow (or force) a country to produce only a narrow range of products for the world market while consuming a wide variety of commodities, some

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[1] John Pitchford invited me to Canberra to give a summer course in 1967, and on this occasion we had many talks about topics of mutual interest, including international trade and the role of technology.

requiring higher capital/labor ratios than found in home production, and others that would utilize more labor-intensive techniques than endowment ratios available at home. Furthermore, economic growth usually entails rising levels of *per-capita* income, often accompanied by net investment (either from local savings or from foreign sources), and perhaps by improvements in technology. Here I concentrate on the former possibility, *viz*. that an open economy with endowments of two factors, labor and capital, succeeds over time in accumulating capital while keeping population relatively in check. Leaving aside changes in the terms of trade stemming from alterations in production or demand in world markets, consider the sectoral changes at the micro level that might accompany overall growth at a fairly constant level.

Trade theorists often use the *Hicksian composite unit-value isoquant* diagram to describe this setting. Figure 1 illustrates how growth in a country's overall capital/labor ratio can severely alter the composition of its production for world markets. Explicitly shown are unit-value isoquants for four different world-traded commodities. The *convex hull* of this set, the locus ABCDEF (extended at each end) consists of sections of individual unit-value isoquants, *e.g*. BC or DE, as well as linear segments involving production of two commodities, *e.g*. AB or CD. The nickname often used to describe this locus is "the best way of earning a buck in world markets". Four alternative rays from the origin are drawn, with each ray illustrating a particular overall capital/labor ratio available in this economy. For example, at the low ratio illustrated by ray *a*, this country's production patterns consists of fairly equal shares of commodities 1 and 2. Consider a smooth growth of the capital/labor endowment ratio from ray 0*a* to ray 0*b*. At first growth of output in sector 2 is associated with a release of factors from the first sector with no change in the intensities used in each. That is, the increase in the capital/labor endowment ratio is totally absorbed by the change in the composition of outputs, with commodity 2 increasing and commodity 1 falling. At point E the first sector has completely shut down. As capital accumulation continues until point D (along ray *0b*) is reached, the economy is completely specialized in producing the second commodity and its rate of growth matches that of the economy as an aggregate. (I am ignoring the existence of non-traded commodities). Growth in the second sector is positive all the way from ray *0a* to ray *0b*, although in the initial phase the growth rate in the second sector is higher than in the DE stretch because it is not only absorbing all the new capital supplied but, as well, taking resources of both capital and labor away from the first sector. As further accumulation proceeds from ray *0b* to *0c*, output in the second sector goes into decline while the third sector witnesses rates of growth much larger than that of the economy's national income. Finally, from ray *0c* to *0d*, the third commodity experiences initially more rapid rates of growth than it registers in the BC range in which it is the only commodity produced, and then suffers declines until, along ray *0d*, it produces about the same fraction of the national income as it did earlier along ray *0c*.

The growth pattern in this simple setting in which capital and labor are the only two factor inputs must be such that if only one commodity is produced its growth rate matches that of the aggregate, but if more than one commodity is produced (and more than two is not required, unless commercial policies or transport costs provide an umbrella of protection), it must be the case that the overall growth rate is flanked by higher rates for an expanding sector and *negative* rates of growth for the other participant sector.[2] Note how this churning activity as a consequence of the country being engaged in international trade would not be found in a closed economy, in which growth of incomes would spill over to encourage growth in all sectors, perhaps not at the same rate.[3] With a growing country embedded in a world trading community, capital accumulation could lead to steady overall rates of growth, but churning activity at the micro level is a natural consequence of the country losing its comparative advantage in some sectors while gaining it in others. The successful growth experience of the Asian tigers in the past few decades illustrates (*e.g*. in Taiwan) how one-time leading sectors such as labor-intensive footwear or umbrellas shrink in the face of competition from other countries (*e.g*. China) as new industries (such as electronics and computer-related products) loom larger in national output. The point is not that such churning activity among sectors of production is possible, instead it is a natural consequence of countries being actively engaged in world trade. The composition of production with trade is no longer tied to the fairly stable composition of national demands.

2. Followers Leapfrogging Leaders

Turning, now, to technology, consider the situation in a particular industry within a country. Typically there will be leading firms and following firms, and suppose the leaders have established their position by having been in the industry for a longer period of time and thus having proceeded further along a learning curve. There is a particular class of technology currently relevant to producers in the industry, and I label this the θ-

[2] This is an expression of the Rybczynski effect (1955) for the growth of capital with a stable labor force at given commodity prices (along a flat in Figure 1).

[3] There may also be relative price changes that occur with growth of capital as well as the possibility of inferior goods in consumption.

technology.[4] However, this industry is only one of many, and in each efforts are being expended in research and development with new ideas emerging. Some of these ideas have spill-over value to other industries because advances in technology need not be limited in their relevance to the industry or firms in which they are developed. I am assuming that in the particular industry in which leading and follower firms are found many of these ideas from the rest of the economy have little relevance, but there may be some externalities that are of value. In particular, I consider an alternative class of technologies, the β-technology, that initially has no advantage over the currently used θ-technology, but if adopted in place of the θ-technology would, with sufficient learning, prove to be superior in a future period. As a consequence both firms might switch to the β-technology, or both firms might conclude that the costs are too high and stay with the θ-technology, or one firm might switch and not the other. It is this latter possibility that is of interest, especially as an asymmetry in firm choice can often lead to the follower overtaking the other firm and emerging as the industry leader, even when both firms do not suffer any myopia that prevents them from seeing the future outcome of their choices.

Figure 2 illustrates the possibilities in a two-period setting. Let the vertical axis measure the productivities of the two alternative technologies in period 1, while the horizontal axis represents the values of the β and θ-technologies in the second (and final) period. The figures of interest all lie below the constructed 45^0 ray, reflecting the power of the learning curve – productivities in general in period 2 are higher than in the first period. I choose an asterisk, (*), to distinguish the follower firm from the initially leading firm, so that with the current θ-technology the leader's θ dominates that of the

[4] This account, and Figure 2, rely heavily on Michihiro Ohyama and Ronald W. Jones (1995).

follower's θ^* for both periods. That is, the leader would maintain that position throughout with this technology. A pair of downward-sloping straight lines through the θ and θ^* points has been drawn. These lines allow the vertical intercepts, V_θ and V_θ^*, to denote the present discounted values of the two θ-productivities since the slope of the lines depict the discount factors, δ and δ^*, here taken to be the same for the two countries. For example, $V_\theta = \theta_1 + \delta\theta_2$.

The points representing the β-technology for the two countries could in principle be anywhere in the diagram. To illustrate the possibility of asymmetry in firm selection, they have been selected such that (i) both β_1 and β_1^* are inferior even to the follower's net productivity in the current period, θ_1^*; (ii) in the next period both β_2 and β_2^* exceed what the net productivity of the leader would be in that period if it had stayed with the θ-technology; (iii) the *undiscounted* sum of the β-technologies over both periods would exceed the undiscounted sum of the θ-technology over the two periods for the leader; (iv) Finally, I assume that the leader not only has superior knowledge of the θ-technology, but also would have an *absolute advantage* over the follower in the new β-technology in both periods. Thus the β points lie above a negatively-sloped 45^o line through the leader's θ point and β lies northeast of β^*.

These restrictions cause the β and β^* points to lie in the triangular area, CDE, in Figure 2. Now consider the shaded region, in which the present discounted value of the follower's β^* point exceeds that for the original θ-technology, given by V_θ^*, but the present discounted value of the leader's β point falls short of that of its original θ-technology. As a consequence, the follower firm switches from the θ to the β

technology, which proves to be less productive in the current period, but makes up for this in the future with greater productivity. By contrast, the leader finds that the new β-technology is an inferior choice for it, and so stays with the θ-technology. As a consequence, in period 2 the net productivity of the original follower, β_2*, exceeds that of the leader, θ_2. The original follower becomes the leader.

This process of overtaking or leapfrogging is an example of the principle of *comparative advantage*. What is the cost of switching to the new technology for the follower? The current loss in productivity would be (θ_1*- β_1*), while the future gain would be (β_2*- θ_2*), so that the relative cost of switching would be their ratio, (θ_1*-β_1*)/(β_2*-θ_2*). This is lower than the comparable relative cost of switching for the current leader, (θ_1-β_1)/(β_2- θ_2). That is, the current follower has a comparative advantage in the new β-technology relative to the current leader. And this is the case despite the assumption that the original leader has an absolute advantage in the new β-technology. It is just that its absolute advantage is not as great as it is in the current θ-technology. Having "learned-by-doing" in one technology, and thus becoming a leader in it, paves the way for having a comparative *dis*advantage in the new technology.[5]

3. Concluding Remarks

These are but two examples in which the possibility exists of seemingly smooth growth from period to period at the same aggregate growth rate, but where at the micro-level there is systematic churning activity. In the first of these international trade rids the

[5] In Ohyama and Jones (1995) a case is considered in which each firm can devote only a *fraction* of its resources to using (and learning) the new technology. It is shown that if each firm does this, the original follower will devote a larger fraction of its resource base to the new technology.

economy of the necessity of producing all of the variety of commodities it wishes to consume, and as a consequence allows a great degree of concentration of resources to the traded goods sectors that utilize productive factors in the same proportions as found in local supplies. As the stock of capital per capita increases with growth, the composition of the output bundle in the traded sector systematically changes, with the country gaining a comparative advantage in new, more capital-intensive sectors than previously produced at the same time as losing its comparative advantage in more labor-intensive commodities. Thus at the disaggregated level not only are all sectors not growing at the same rate, some sectors are actually in decline. In the second example the doctrine of comparative advantage again comes into play, but this time of relevance to the composition of firms within a productive sector. If asymmetries in productive capabilities are rooted in large part in being at different points along a learning curve, and if in other sectors of the economy new technologies are being developed that may have some applicability to the sector under consideration, would some of these new technologies ever be adopted by one firm and not another? Yes, and it is the originally leading firm, the one that has mastered better the current technology, that tends precisely for that very reason to have a comparative *dis*advantage in the new technology. Being relatively good at one task tends to make the other firm relatively good at a new way of doing things. Thus the process of leapfrogging or overtaking of the leader by the current follower is a natural phenomenon, not necessarily tied to any myopia on the part of the firm being overtaken.

Many years ago Paul Samuelson, in his presidential address to the International Economic Association (1969), recalled his earlier years as a member of the Society of

Fellows at Harvard. In particular, he related being asked by the mathematician, Stanislaw Ulam, to name a proposition in the social sciences that was true but not trivial. According to Samuelson, it was only somewhat later that he thought of a good answer – the doctrine of comparative advantage. In this note I have tried to suggest a pair of instances in which this doctrine also suggests that at the micro-economic level it is natural to expect that activities or firms that are favored in one period of time may lose out in future years as a country grows or as new technologies become available.

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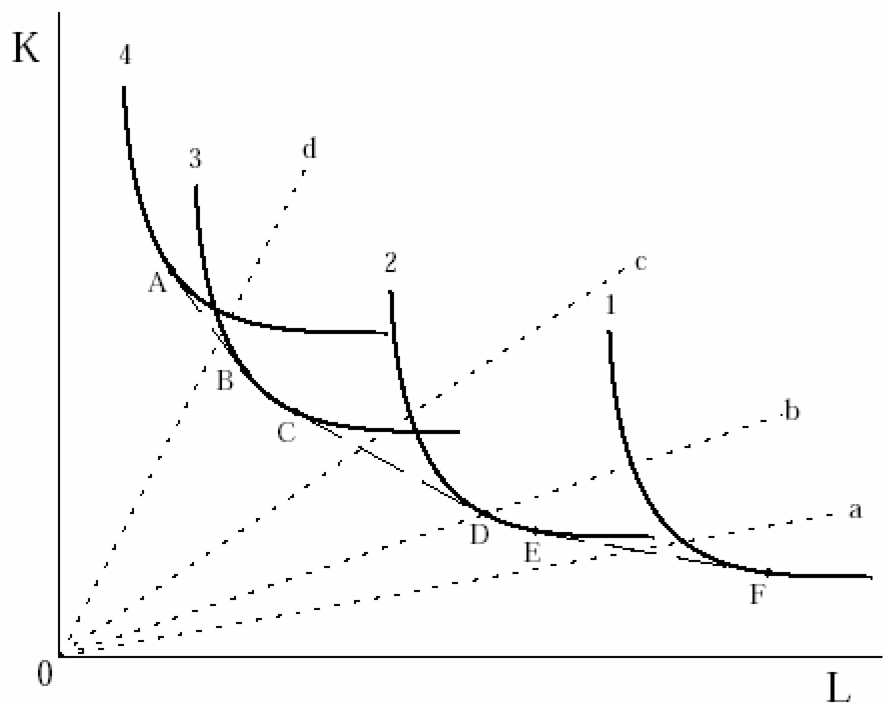

Figure 1. The Hicksian Composite Unit-Value Isoquant

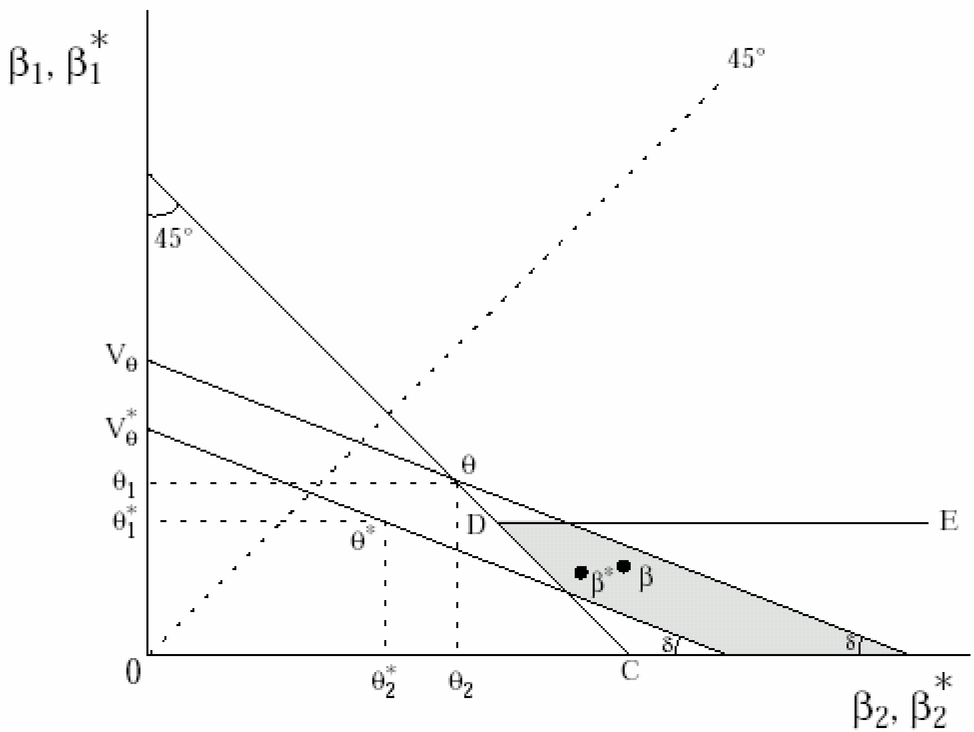

Figure 2. Leapfrogging Possibilities