A MODEL OF REGIONAL GROWTH-RATE DIFFERENCES ON KALDORIAN LINES[1]

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PROFESSOR Kaldor has been a long standing critic of the application of neo-classical modes of thought to the analysis of economic growth and development. In recent years, in particular, he has followed the line of Myrdal [1] in attacking the predictions of neo-classical theory that regional (national) growth-rate differences will tend to narrow with trade and the free mobility of the factors of production. The essence of the argument is that once a region gains a growth advantage it will tend to sustain that advantage through the process of increasing returns that growth itself induces—the so-called Verdoorn effect [2]. The fullest statement of Kaldor's views at the regional level is contained in a lecture to the Scottish Economic Society published in 1970 [3]. Unfortunately, the model he presents is purely verbal and lacks the rigour and precision that one normally associates with Kaldor. The purpose here is to attempt to formalize the model in order to clarify its structure,[2] and to consider such questions as: the role of the Verdoorn effect in contributing to regional growth-rate differences; whether regional growth-rate differences will tend to narrow or diverge through time; and how policies of regional 'devaluation' can raise a region's growth rate.[3]

[1] We are grateful to Professor Kaldor, Professor G. Rosenbluth, Professor C. Kennedy, Mr. I. Gordon, and Mr. J. Craven for critical comments and suggestions for improvement on an early draft of the paper.

[2] This would seem to be worth while especially in view of the confusion that already seems to have arisen. For example, one author (Richardson [4], pp. 30–4) represents Kaldor by specifying productivity growth as increasing at an increasing rate with respect to the growth rate, and the efficiency wage decreasing at an increasing rate with respect to the growth rate. This leads to the odd result that a region with a steeper productivity-growth relation will end up with a lower equilibrium growth rate! Furthermore, Richardson's representation of Kaldor's model lacks an explicit export demand function which is the heart of Kaldor's model. The price and income elasticities of demand for a region's exports turn out to be important determinants of its equilibrium growth rate (see later).

[3] Kaldor, it will be remembered, has been credited with the invention of the Regional Employment Premium which since 1967 has given a flat-rate subsidy per unit of labour employed to employers in manufacturing industry in Development Areas. It should be stressed, however, that local 'devaluation' can only raise permanently a region's *growth rate* if the export demand function is additive rather than multiplicative; that is, if the demand function is such that the rate of growth of exports is based on absolute price differences between domestic suppliers and competitors as opposed to the difference in the rate of growth of prices between domestic and competitive suppliers. If the rate of growth of exports is the dependent variable, a multiplicative export demand function is much easier to handle, but, as we shall see, if it is employed, a flat-rate subsidy to labour combined with 'mark up' pricing, cannot raise the equilibrium growth rate permanently. The same is true of the effect of currency devaluation at the national level. For a fuller discussion, see later.

The model is difficult to formulate the way Kaldor describes it but we can capture its essence relatively easily and bring out its important features. Kaldor sets up the problem by assuming two regions, initially isolated from one another, each with an agricultural area and an industrial and market centre. Trade is then opened up between the two regions, and Kaldor suggests that the region with the more developed industry will be able to supply the needs of the agricultural area of the other region on more favourable terms with the result that the industrial centre of the second region will lose its market and will tend to be run down without any compensating advantage in the form of increased agricultural output. The way that we can capture the spirit of this idea is to model an individual region's growth rate and then to consider the sources of interregional differences—stable or divergent—in terms of the parameters of the model. For example, in the two-region case a necessary condition for the persistence of stable regional growth rate differences is that the steady-state equilibrium growth rates of the two regions differ. For the growth rates of two regions to diverge a necessary condition is that the growth rate of one of the regions diverges from its own equilibrium rate. It is also a sufficient condition if the growth rate of the other region is stable or diverges from equilibrium in the opposite direction. If Kaldor's arguments are first used to examine equilibrium growth in one region, therefore, the assumptions implicit in the hypothesis that regional *per capita* incomes and/or growth rates may diverge can then be readily seen. This is the approach adopted here in an attempt to formalize the model without violating its spirit. His more complex verbal argument is easily accommodated within the framework outlined. The approach is essentially partial equilibrium in the sense that each region is considered in isolation from all others, and interregional relationships are not considered explicitly. Interregional relationships are considered implicitly, however, since we argue that it is the Verdoorn effect which can sustain high growth in one region once it obtains an initial growth advantage, which then makes it difficult for other regions to compete on equal terms.

In setting up the model we have five specific purposes in mind: First, to make clear the role of the Verdoorn relationship as it affects regional growth-rate differences; secondly, to suggest that while the model in theory can generate divergent or convergent regional growth paths, in practice, given reasonable parameter values for the model, regional growth divergence is not likely, as is sometimes implied by use of such phrases as 'circular cumulative expansion and contraction' and 'vicious spirals',[1] and that the model is best interpreted as predicting constant persistent regional growth-

[1] Beckerman [5], in a model of export-led growth which bears many similarities to Kaldor's, and predates it, seems to be suggesting a divergent process at the national level.

rate differences sustained by the Verdoorn effect;[1] thirdly, to bring out the importance of regional structure in determining the equilibrium growth rate, a feature of regional growth which Kaldor does not stress; fourthly, to evaluate wage subsidies as a policy device for reducing persistent regional growth-rate differences; and lastly, for interest, to see how close the model comes to predicting the U.K. growth rate over the post-war years.[2]

The model[3]

The main thrust of Kaldor's argument is Hicks's view [6] that it is the growth of autonomous demand which governs the long-run rate of growth of output. Using the 'super-multiplier' Hicks showed that on certain assumptions both the rate of growth of induced investment and the rate of growth of consumption become attuned to the rate of growth of autonomous demand so that the rate of growth of autonomous demand will govern the rate of growth of the economy as a whole. Kaldor argues that in a regional context the main autonomous demand factor will be demand emanating from outside the region; that is to say, the demand for a region's exports. According to Kaldor, regional growth is fundamentally determined by the growth of demand for exports, to which the rate of growth of investment and consumption adjust. We can therefore write:

$$g_t = \gamma(x_t) \qquad (1)^{4,5}$$

where g_t is the rate of growth of output in time t

x_t is the rate of growth of exports in time t

[1] Of course, even constant persistent growth-rate differences will be sufficient for regional *per capita* income levels to widen if population growth is the same in each region.

[2] Unfortunately the model is not operational at the regional level in the absence of information on vital parameters and variables.

[3] The basis of the model has also been presented and discussed in the context of regional disparities and regional policy in the E.E.C. (see [13]).

[4] Apart from the theoretical considerations underlying this specification there are a number of practical considerations that make export demand for highly specialized regions (or countries) extremely important. In most industries in a region, local demand is likely to be trivial compared with the optimum production capacity of the industries. The viability of regional enterprise must largely depend on the strength of demand from outside the region. There are also a number of important reasons why export demand may be a more potent growth-inducing force than other elements of demand, especially in open, backward areas—either regions or countries. The first is that exports allow regional specialization which may bring dynamic as well as static gains. Secondly, exports permit imports and imports may be important in developing areas which lack the capacity to produce development goods themselves. Thirdly, if the exchange of information and technical knowledge is linked to trade, exporting facilitates the flow of technical knowledge which can improve the growth rate.

[5] In the short term, autonomous investment (e.g. originating from government) may compensate for poor export performance. As far as the model to be developed is concerned, however, the inclusion of two autonomous demand components leads to complications in deriving the equilibrium and dynamic solutions to the model since the weights attached to the two components will vary with the growth rate. This, coupled with the fact that the export component will ultimately dominate the other component if export growth is faster than autonomous investment growth, has led us, like Kaldor, to ignore investment demand in the model. All investment is induced.

and γ is the (constant) elasticity of output growth with respect to export growth (= 1 if exports are a constant proportion of output).

Note that all the growth variables throughout the model are measured in discrete time.

Now let us consider the determinants of export demand and the form of the export demand function. Kaldor is not explicit on this point but seems to be suggesting a multiplicative function such that the rate of growth of a region's exports will be related to the rate of change of 'domestic' and 'foreign' prices and the rate of growth of 'world' demand i.e.

$$X_t = P_{dt}^{\eta} P_{ft}^{\delta} (Z^{\epsilon})_t \qquad (2)^1$$

where X_t is the quantity of exports in time t
P_{dt} is the domestic price in time t
P_{ft} is the competitor's price in time t
Z_t is the level of 'world' income in time t
η is the price elasticity of demand for exports
δ is the cross elasticity of demand for exports
and ϵ is the income elasticity of demand for exports,

which, for discrete changes, gives the approximation[2]

$$x_t = \eta(p_d)_t + \delta(p_f)_t + \epsilon(z)_t \qquad (3)$$

where lower case letters represent rates of growth of the variables.

The multiplicative demand function is easy to handle, but, as suggested earlier, it leads to some difficulty if one wishes to interpret Kaldor's model as predicting that wage subsidies can raise *permanently* a lagging region's growth rate. On the other hand, there is no reason why Kaldor should be interpreted in this way; he is (perhaps deliberately) vague on this point. Presumably few people would want to argue that a once-for-all currency devaluation, which is analogous to a continual wage subsidy at the regional level, could raise a nation's growth rate permanently. We return to this point later. Returning to equation (3), the rate of growth of income outside the region (z) and the rate of change of competitors' prices (p_f) are both taken as exogenous to the region. The rate of growth of domestic (export) prices (p_d) can be derived from a mark-up pricing equation of the form:

$$(P_d)_t = (W/R)_t (\mathrm{T})_t \qquad (4)^3$$

[1] Alternatively, $X_t = (P_d/P_f)_t^{\eta} Z_t^{\epsilon}$, which is frequently how the function is estimated, which implicitly assumes that $\eta = \delta$. E.g. see Houthakker and Magee [7].

[2] i.e. excluding interaction terms.

[3] Since we specify (in keeping with Kaldor) the mark-up to be on unit labour costs, and not on total *prime* costs (which include raw material costs), any change in imported raw material costs will be included in the last term of equation (5).

where P_{dt} is the domestic price in time t
W_t is the level of money wages in time t
R_t is the average product of labour (in the export sector) in time t
and T_t is 1+% mark-up on unit labour costs in time t.

From equation (4) we can write the approximation

$$(p_d)_t = (w)_t - (r)_t + (\tau)_t \tag{5}$$

where the lower case letters stand for discrete rates of change of the variables.

The third proposition in Kaldor's model, which is the linchpin of the system, is that the growth of labour productivity is partly dependent on the growth of output itself (Verdoorn's Law), i.e.

$$r_t = f_3(g)_t \qquad f'_3 > 0 \tag{6}$$

or

$$r_t = r_a + \lambda(g)_t \tag{7}^1$$

where r_a is the rate of autonomous productivity growth and λ is the Verdoorn coefficient.

Equation (7) provides the link between exports and growth via productivity growth and prices. Combining equations (1), (3), (5), and (7) to obtain an expression for the equilibrium growth rate gives:

$$g_t = \gamma \frac{[\eta(w_t - r_a + \tau_t) + \delta(p_f)_t + \epsilon(z)_t]}{1 + \gamma\eta\lambda}. \tag{8}$$

Remembering that $\eta < 0$, the growth rate is shown to vary positively with r_a, z, ϵ, δ, p_f, and λ, and negatively with w and τ.[2]

Note that the Verdoorn effect is a source of regional growth-rate differences only to the extent that the Verdoorn coefficient (λ) varies between regions or initial differences exist with respect to other parameters and variables in the model such that $0 < \lambda < 1$ serves to exaggerate the effect of the differences. In other words, the dependence of productivity growth on the growth rate *per se* is not sufficient to cause differences in regional growth rates unless the Verdoorn coefficient varies between regions or growth rates would diverge for other reasons anyway.

It is equally clear, however, that it is the Verdoorn relation which makes the model circular and cumulative, and which gives rise to the possibility that once a region obtains a growth advantage, it will keep it. What this

[1] Relating productivity growth in the export sector to the rate of growth of total output, as opposed to the rate of growth of exports, is to treat the economy as if it were a single fully integrated firm in which it is impossible to distinguish between production runs for export and production runs for domestic consumption. On the assumption that $g = x$, however, the equilibrium growth rate is unaffected.

[2] The effect of η is ambiguous since it appears in both the numerator and the denominator of the equation. Whether growth varies positively or negatively with the absolute size of η depends on the other variables and parameters. To determine the effect of variations in η numerical analysis would have to be resorted to.

means is that the Verdoorn relationship plays a sustaining role in the regional growth process, and a sustaining role in the persistence of regional growth differences once they have arisen due to initial differences in the other parameters of the model.

Suppose, for example, that a region obtains an advantage in the production of goods with a high income elasticity of demand (ϵ) which causes its growth rate to rise above that of another region. Through the Verdoorn effect, productivity growth will be higher; the rate of change of prices lower (assuming w and τ are the same in both regions), and the rate of growth of exports (and hence the rate of growth of output) higher and so on. Moreover, the fact that the region with the initial advantage will obtain a competitive advantage in the production of goods with a high income elasticity of demand will mean that it will be difficult for other regions to establish the same activities. In models of cumulative causation, this is the essence of the theory of divergence between 'centre' and 'periphery' and between industrial and agricultural regions. This is also the essence of Kaldor's view that the opening up of trade between regions may create growth differences which are sustained or even widened by the process of trade.

Notice that an autonomous shock which raises a region's growth rate is not sufficient for its growth advantage to be maintained through the Verdoorn effect unless the autonomous shock affects favourably the parameters and variables of the model (or is a sustained shock). This consideration is important when we come to consider the role of wage subsidies as a device for affecting the growth rate of a region.

The dependence of the equilibrium growth rate on the parameters of the model, and the sustaining role of the Verdoorn effect, is illustrated in Fig. 1 below. For illustration, but without discussion for the moment, the growth rate is shown converging to its equilibrium rate. The disequilibrium behaviour of the model is considered explicitly in the next section.

The distance of the curves from the origin reflects factors affecting each variable other than the variable specified in the functional relation. Fig. 1 shows clearly the link that the Verdoorn relation provides between exports and growth via productivity and prices, and its sustaining influence. The steeper the slope of the Verdoorn relation (i.e. the higher λ), the higher the equilibrium growth rate will be and the greater the divergence between regional growth rates for given differences between regions in other variables and parameters.

Divergent or convergent growth?

We come now to the second purpose of formalizing Kaldor's model which is to consider under what circumstances there will be a tendency for

regional growth rates to diverge. In a two-region model, a necessary condition for divergence is that the growth rate of one of the regions diverges from its equilibrium rate. Whether divergence will take place is essentially an empirical issue depending on the stability conditions of the model in disequilibrium. None of the cumulative causation school, including Kaldor, are clear as to what the stability conditions are in their various models. In order to consider the growth rate in disequilibrium a variety of

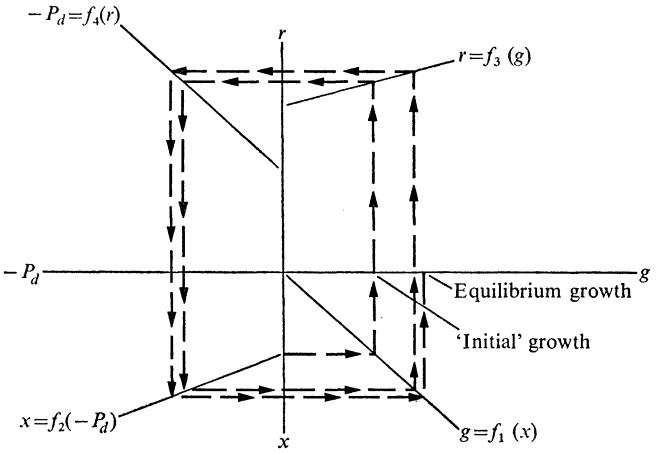

FIG. 1

lag structures could be introduced into the equations which constitute the model. If, for simplicity, we confine ourselves to a first-order system, inspection of the model shows that, since the model is 'circular', a one-period lag in any of the equations gives the same stability conditions, namely that convergence to or divergence from the equilibrium growth rate depends on whether $|\gamma\eta\lambda| \lesseqgtr 1$, as illustrated in Fig. 1.[1] To consider the growth rate in disequilibrium it would not be unreasonable on economic grounds to specify exports in time t as a lagged function of its determinants. It can take time for exporters and/or foreign buyers to adjust to changes in prices and income. Thus we could write $X_t = (P_d)^{\eta}_{t-1}(P_f)^{\delta}_{t-1}(Z)^{\epsilon}_{t-1}$ giving the approximation:

$$x_t = \eta(p_d)_{t-1}+\delta(p_f)_{t-1}+\epsilon(z)_{t-1} \tag{9}$$

where the lower case letters are discrete rates of growth as before.

Using equation (9) instead of (3), and combining with (1), (5), and (7),

[1] A one-period lag in two of the equations, giving a second order system, yields two real roots $\pm\sqrt{(-\gamma\eta\lambda)}$. The stability conditions are therefore the same as in the first-order system. This is true however many equations are lagged. This fact considerably enhances the generality of our result.

and assuming the rate of growth of the exogenous variables to be constant, gives the first order difference equation:

$$g_t = \gamma[\eta(w_{t-1} - r_a + \tau_{t-1}) + \delta(p_f)_{t-1} + \epsilon(z)_{t-1}] - \gamma\eta\lambda(g_{t-1}), \tag{10}$$

the general solution to which is

$$g_t = A(-\gamma\eta\lambda)^t + \frac{\gamma[\eta(w_{t-1} - r_a + \tau_{t-1}) + \epsilon(z)_{t-1} + \delta(p_f)_{t-1}]}{1 + \gamma\eta\lambda} \tag{11}$$

where A is the initial condition.

The behaviour of g depends on the value of $\gamma\eta\lambda$. Since $\eta < 0$, $(-\gamma\eta\lambda)$ will be > 0. The condition for cumulative divergence from equilibrium is that $(-\gamma\eta\lambda) > 1$.[1] In our view this is unlikely because: $\gamma = 1$ if exports are a constant proportion of output; the price elasticity of demand for exports (η) rarely exceeds 2, and the Verdoorn coefficient rarely exceeds 0·5.[2] Taking realistic values for the parameters of the model, therefore, the most likely prediction must be one of constant differences in regional growth rates determined by differences in the equilibrium rates; not divergence. Admittedly, our disequilibrium specification is arbitrary but the fact that a one-period lag in any one of the equations gives the same stability conditions, and likewise when more than one equation is lagged, considerably enhances the generality of the result. It also serves some purpose to give a (not unrealistic) specification which suggests on empirical grounds that divergence is not very likely, if only to induce those who adhere to the cumulative causation school to specify more precisely the model they have in mind and to show the conditions under which regional growth rates would diverge through time. In our specification we suggest that diverging regional growth rates would seem to be possible only if the equilibrium rates themselves diverged through time because the determinants of the equilibrium rates were themselves time dependent. For example, the price and income elasticities of demand could change in the course of time as the structure of production changed. This possibility is not pursued further here because of the obvious difficulties it would present for the solution to equation (10).

Regional structure as a determinant of growth

The second term on the right-hand side of equation (11) (i.e. the particular solution to the first-order difference equation) shows that the

[1] Since the equations that constitute the model have omitted higher order terms containing g_t, the stability conditions of the model are necessarily an approximation.

[2] Kaldor has agreed in correspondence that implicit in his argument that regional growth rates may diverge is the assumption that $|\eta\lambda| > 1$ for one region, and argues that he does not regard $|\eta| > 2$ as an unrealistic assumption.

equilibrium growth rate depends on seven main economic parameters and variables that may vary from region to region: η, w, r_a, τ, ϵ, δ, and λ.[1]

If it is assumed that the percentage mark-up on unit labour costs is constant in each region, and that for institutional reasons w is fairly uniform from region to region,[2] we are left with differences in η, δ, r_a, ϵ, and λ as explanations of differences in regional growth rates. The price and income elasticities of demand for regional exports will depend on the nature of the products produced. The rate of autonomous productivity growth, r_a, and the Verdoorn coefficient, λ, will depend on the technical dynamism of productive agents in the region and the extent to which capital accumulation is induced by growth and embodies technical progress. The determinants of r_a and λ are closely related to the determinants of the position and shape of Kaldor's technical progress function [8]. The technical progress function in linear form may be specified as:

$$r = d+\pi(m) \tag{12}$$

where r is the rate of growth of output per man
m is the rate of growth of capital per man
and d is the rate of disembodied technical progress.

Now let d and m be functions of the rate of growth of output so that:

$$d = \alpha_1+\beta_1(g) \tag{13}$$

and

$$m = \alpha_2+\beta_2(g). \tag{14}$$

Substituting (13) and (14) into (12) gives:

$$r = (\alpha_1+\pi\alpha_2)+(\beta_1+\pi\beta_2)(g) \tag{15}$$

hence:

$$r = r_a+\lambda(g)$$

where

$$r_a = (\alpha_1+\pi\alpha_2)$$

and

$$\lambda = (\beta_1+\pi\beta_2).$$

The autonomous rate of growth of productivity, r_a, is determined by the autonomous rate of disembodied progress, the autonomous rate of capital accumulation per worker, and the extent to which technical progress is embodied in capital accumulation. The Verdoorn coefficient, λ, is determined by the rate of induced disembodied technical progress, the degree to which capital accumulation is induced by growth and the extent to which technical progress is embodied in capital accumulation. To the extent that the determinants of r_a and λ vary between industries, r_a and λ may also vary between regions depending on the industrial composition of the regions.

[1] Ignoring time subscripts and assuming z and p_f do not differ between regions.
[2] For evidence see [9].

From this analysis, it would appear that the message of Kaldor's model is that raising a region's growth rate is fundamentally a question of making regions more 'competitive' and/or altering the industrial structure so that goods are produced with higher income elasticities of demand and higher Verdoorn coefficients attached to them. [1,2]

Regional 'competitiveness'

To make regions more 'competitive' a policy of wage subsidies to manufacturers in lagging growth regions is sometimes advocated, to achieve the same effect regionally as a policy of currency devaluation nationally. The argument needs to be treated with some caution, however. It is easy to show that a wage subsidy in a regional context is equivalent to a devaluation of the currency in a national context, but the argument that wage subsidies can raise a region's growth rate permanently is less convincing. To show the equivalence of wage subsidies and currency devaluation, let the price of domestic exports in terms of the overseas currency equal P_0. Then $P_{0t} = P_{dt} \times$ exchange rate, or:

$$p_{0t} = \theta_t + p_{dt} \tag{16}$$

where p_{0t} is the rate of change of home prices expressed in overseas currency in time t

θ_t is the rate of change in the exchange rate in time t

and p_{dt} is the rate of growth of prices in domestic currency in time t.

Expressing the domestic price in the same units as the overseas currency, equation (3) becomes:

$$x_t = \eta(\theta_t + p_{dt}) + \epsilon(z_t) + \delta(p_{dt}) \tag{17}$$

and the equilibrium growth rate is:

$$g_t = \frac{\gamma[\eta(w_t - r_a + \tau_t + \theta_t) + \epsilon(z_t) + \delta(p_f)_t]}{1 + \gamma\eta\lambda}. \tag{18}$$

Partially differentiating (18) with respect to θ gives:

$$\frac{\partial g}{\partial \theta} = \frac{\gamma\eta}{1 + \gamma\eta\lambda}.$$

and with respect to w gives:

$$\frac{\partial g}{\partial w} = \frac{\gamma\eta}{1 + \gamma\eta\lambda}.$$

Hence,

$$\frac{\partial g}{\partial \theta} = \frac{\partial g}{\partial w}.$$

[1] And also higher price elasticities of demand if $\partial g / \partial p_d > 0$.

[2] The Verdoorn effect is also an important determinant of the capacity (or natural) rate of growth, g_n. Let $g_n = r + n$ where r is the rate of growth of productivity and n is the rate of growth of the work-force. But $r = r_a + \lambda g$. Substituting, we have $g_n = r_a + \lambda g + n$. The higher λ, the higher g_n. If $\lambda > 1$ there is no constraint on the growth rate. This is the situation of 'increasing returns for ever'.

But neither devaluation, nor wage subsidies, can have a permanent effect on the *rate of change* of the exchange rate or money wages, only on the *level* of the exchange rate or money wages. The effect of devaluation and wage subsidies on the rate of change of the exchange rate and the rate of change of money wages is once-for-all. Unless the export pricing function, or the export demand function, is additive the effect of devaluation, or the introduction of flat-rate wage subsidies, on the growth rate cannot therefore be permanent.[1] θ and w become zero in the periods after wage subsidies have been introduced and devaluation has taken place.[2] As far as an additive export demand function is concerned, it is not at all clear what demand function would generate the argument that the *rate of growth* of exports is related to the absolute difference between domestic and foreign prices.[3] It seems unfortunate that the success or otherwise of government policies with respect to regional wage subsidies will depend on the (unknown) form of the pricing and export demand functions. The relation between export prices and the growth of output is a subject which seems to be treated far too casually in the theory of trade and growth. We believe that it is much more satisfactory to regard the level of exports as determined by relative prices in a multiplicative demand function than by the absolute difference between domestic and foreign prices in an additive demand function. If this argument is accepted wage subsidies at the regional level are equivalent at the most to an autonomous shock which, as we argued earlier, could only affect the growth rate permanently if the structural parameters of the growth model were thereby affected favourably. If anything, however, policies of 'devaluation' tend to ossify a region's or country's industrial structure, impeding structural change. Export promotion and import substitution properly directed offer a much more hopeful solution to lagging growth caused by unfavourable price and income elasticities of demand for exports and slow autonomous productivity growth. At the regional level, this policy conclusion points to the need to relate regional taxes and subsidies to activities with particular structural characteristics rather than to particular factors of production,

[1] However, regional devaluation could have a permanent effect on the percentage level of unemployment ($\%U$). The initial effect of devaluation will be to lower $\%U$. Since $\%U$ is the outcome of the difference between the growth of labour demand and supply, and the growth of demand is unaffected by devaluation, the lower level of $\%U$ can persist. Moreover, the cheapening of labour relative to capital could induce the use of more labour-intensive techniques. Interpreted as a weapon to combat unemployment, therefore, regional devaluation may have merit. As a means of stimulating regional growth, however, its value is doubtful.

[2] In fact, if money wages are rising through time, a *flat-rate* wage subsidy per man will actually raise the rate of increase in money wage costs after the initial introduction of the subsidy since the percentage effect of the subsidy is smaller in the next period.

[3] Beckerman [**5**], who has used an additive function in a national context, is not clear on this point.

either capital or labour. We believe the income elasticity of demand for exports to be a particularly important parameter at both the national and regional level. Regional policy for stimulating regional growth could usefully direct its attention to identifying activities with a high income elasticity of demand and encouraging these to locate in depressed regions by policies of capital incentives and labour subsidies.

Application of the model

It is hard to apply Kaldor's model at the regional level without being able to identify regional exports and to estimate such crucial parameters as the price and income elasticities of demand for exports, let alone the other parameters of the model. The model is general enough, however, to be applicable to a nation as well as to a region within a nation. Indeed, a similar model to Kaldor's has been developed by Beckerman to account for differences in rates of growth of European countries over the post-war years [5]. It is interesting to see what equilibrium growth rate for the British economy is predicted over the post-war period when equation (11) is applied to the data. We restrict the period of analysis to 1951 to 1966 to avoid the more recent years of high inflation following devaluation of the pound in 1967, and to achieve consistency with the study of Houthakker and Magee [7] which estimates the price and income elasticities of demand for British exports over the period 1951 to 1966. Their estimate of the export demand function, $X = A(P_d/P_f)^{\eta}Z^{\epsilon}$, is $X = A(P_d/P_f)^{-1{\cdot}24}Z^{1{\cdot}0}$. Since η and δ are not estimated separately, as specified in our model, we shall apply the coefficient on relative prices to the difference between the rate of increase in domestic and foreign prices, implicitly assuming that $\eta = \delta$.[1] Our feeling is, however, that their estimate of the price elasticity is on the low side. Junz and Rhomberg [11] have estimated it at between $-1{\cdot}86$ and $-2{\cdot}29$, and most forecasting of the British economy takes a somewhat higher figure. As a compromise estimate we take $\eta = -1{\cdot}5$. The best estimate of the rate of increase in prices of major competitor countries is 2·0 per cent per annum.[2] From the United Nations National Accounts Statistics, G.D.P. growth of Britain's major export customers averaged approximately 4·0 per cent per annum over the period. Domestic wage inflation averaged 6·0 per cent per annum so that, assuming the percentage mark-up on labour costs remained unchanged, $w+\tau = 0{\cdot}06$. Estimates of the Verdoorn relation for Britain from regional cross-section data gave $r_a = 0{\cdot}02$ and $\lambda = 0{\cdot}5$ [12]. Lastly, assuming exports to be a

[1] The parameter estimates are those obtained after adjustment of the equation for the presence of serial correlation in the residuals. Before adjustment, $\eta = -0{\cdot}44$ and $\epsilon = 0{\cdot}86$.

[2] See index of export prices of manufactured goods for major industrial countries in National Institute of Economic and Social Research, *Economic Review*, Quarterly.

constant proportion of output, $\gamma = 1$. The full list of parameter values used in equation (11) is: $\eta\ (= \delta) = -1{\cdot}5$; $w+\tau = 0{\cdot}06$; $r_a = 0{\cdot}02$; $\epsilon = 1{\cdot}0$; $z = 0{\cdot}04$; $\lambda = 0{\cdot}5$; $\gamma = 1$, and $p_f = 0{\cdot}02$. Solving for the equilibrium growth rate gives $g = 4{\cdot}0$ per cent per annum. This is above the actual and natural (capacity) rates of growth experienced over the period 1951 to 1966 of 2·8 and 2·9 per cent per annum, respectively [**10**]. One reason for the over-prediction of g could be that the estimate of r_a is too high, based as it is on the use of data for manufacturing industry only. Autonomous productivity growth of 1·8 per cent per annum ($r_a = 0{\cdot}018$) would be consistent with the actual growth rate experienced of 2·8 per cent. This would also be closer to the autonomous rate of productivity growth actually experienced in the economy as a whole if the Verdoorn coefficient for all industry is also 0·5. We conclude that the application of Kaldor's model to the British economy is not inconsistent with the evidence; on the other hand, it should be stressed that the calculation of g is very sensitive to small changes in the parameter values of the model.

Conclusion

Our attempt to formalize Kaldor's model has the pedagogic virtue of bringing into the open the structure of the model and the main determinants of regional growth-rate differences. Whether or not we have done justice to Kaldor and represented his views faithfully, we believe that the model presented captures the main elements of an open economy growth model which has relevance to regions within countries and to open developed and developing countries alike. At the national level, a built-in balance of payments constraint would make the model more realistic.[1] No attention is paid in the present model to the fact that the rate of growth of output may generate a level of imports in excess of exports, necessitating demand contraction. At the regional level, it is difficult to conceive of a balance of payments constraint on growth, except to the extent that there may be a constraint on the regional money supply. There is certainly no requirement that exports and imports must balance to preserve the value of a currency in the foreign exchange market, which may be required at the national level. We have neglected here the consideration of balance of payments constrained growth in order to concentrate on the basic model. To incorporate such a constraint, however, may be a useful addition to the model, especially for application at the national level.

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[1] The absence of a balance of payments constraint may be another reason why the model is tending to over-predict the actual U.K. growth experience.

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