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A Synoptic View of Regional Growth and Unemployment: I — The Neoclassical Theory

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Summary. This paper is the first part of a consideration of the implications of the current controversies in macroeconomics for regional growth theory. It is concerned with the neoclassical explanation of disparities in regional growth and unemployment rates. The one-sector and two-sector neoclassical models are surveyed and it is shown how this approach explains differences in productivity growth in terms of the progressive eradication of an initial misallocation of resources (both interregionally and intraregionally). Involuntary unemployment is ascribed to the classical view that real wages are too high. The effect of the spatial diffusion of innovations on productivity growth is also examined.

Introduction

It is perhaps somewhat ironical that in the United Kingdom there has been a recent diminution of concern with the 'regional problem' as the national unemployment rates have risen dramatically since 1973 (and especially since 1979). Of course, this is for the simple reason that the regional problem has become subsumed in the larger 'national problem' of how to reduce the overall rate of unemployment. An indication of the size of the current unemployment problem is the fact that the national unemployment rate now (1987) stands at a value that was rarely reached in even the most depressed regions in the postwar years prior to 1973.

The difficulty in finding a solution to the regional problem has been compounded by the breakdown in the last decade of the consensus that seemed to have emerged in macroeconomics with the neoclassical synthesis of the 1960s, leading to what Nordhaus (1983) has aptly called the 'macroconfusion'. This has also been mirrored in the disagreements over the causes of regional growth and stagnation since, of course, the region may be viewed as a nation within a common currency area, although largely devoid of internal demand management policy weapons. At present and at the inevitable risk of oversimplification, we may identify two competing paradigms, namely, the neoclassical and the post-Keynesian frameworks.[1] Nevertheless, this shift in emphasis concerning the regional problem has occurred irrespective of the precise views held about the causes of the current recession.

The neoclassical paradigm assumes that an unfettered working of the market mechanism will be equilibrating and any disparities in regional wages will tend to disappear over time. Any differences in regional productivity growth are seen as being fundamentally the result of the gains accruing from a progressive reduction in an initial interregional or intraregional misallocation of resources, or in both. Consequently, any disparities in productivity growth will eventually vanish as the misallocation is progressively corrected and regional growth rates approach the steady state.

Although neoclassical regional growth theory has

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[1] The term post-Keynesian is used here to distinguish the approach discussed in this paper and in McCombie (1988) from the Keynesian-neoclassical synthesis.

not generally analysed the reasons for the existence of regional unemployment, within such a framework the cause must be classical in nature. In other words, unemployment is seen as the result of real wages being too high. The implication is that to reduce unemployment labour must accept a fall in the real wage rate sufficient to price itself back into the regional labour market.

The 'Treasury View' of the 1930s has thus re-emerged as the view of the Treasury in the 1980s. Any expenditure on regional policy is seen as being ultimately ineffective since it will merely lead to 'crowding out' with an offsetting decrease in private investment. While there may be some increase in employment in the region where the expenditure is undertaken, this will simply be at the expense of jobs in other areas.

On the other hand, the post-Keynesian approach stresses the crucial role that the growth of autonomous demand (most notably that generated by the growth of exports) plays in determining regional growth. The present high regional unemployment rates, apart from the small proportion due to structural or frictional factors, are seen as the result of insufficient effective demand and can only be alleviated by a substantial expansion of monetary and fiscal policy at the national level (Moore and Rhodes, 1982). An increase in government expenditure in the regions would lead to a net gain in both regional and national employment; but even a return to the levels of expenditure that were incurred when regional policy was at its height pales into insignificance when confronted with the size of the present problem in the United Kingdom. Another implication of the post-Keynesian theory is that a reduction in real wages, *ceteris paribus*, may only serve to exacerbate the situation by reducing effective demand.

A related, though logically independent, aspect of this approach is that manufacturing industry is subject to substantial economies of scale of both the static and dynamic variety (as demonstrated by the 'Verdoorn Law' — Verdoorn, 1949). This means that there are strong endogenous forces that lead to faster growing regions (countries) experiencing a greater growth of productivity than the more slowly growing areas. Thus, rapidly growing regions benefit from an increasing competitiveness and growth proceeds in the manner of cumulative causation. (However, it is not difficult to construct formalisations of such models that lead to (differing) equilibrium growth rates, or, indeed, to a convergence in the various regional growth rates if supply constraints become binding).

The purpose of this and a complementary paper (McCombie, 1988) is to contrast these two major paradigms with their markedly different policy implications. (We shall be mainly concerned with the broad theoretical issues rather than a detailed consideration of regional policy, *per se*. See Armstrong and Taylor, 1985, for a comprehensive discussion of the latter).

In this paper, the focus of attention is on the neoclassical approach while in McCombie (1988) the post-Keynesian explanation is considered. In particular, it will become apparent that these approaches are not just alternative models of the regional economy whose validity is capable of empirical resolution but rather that they represent distinctive and mutually exclusive views of the way the economic system functions.

The paper proceeds as follows. The one-sector neoclassical regional growth model, which is based on the aggregate production function, is outlined first. Next, we discuss the explanation that one of the causes of disparities in regional productivity growth is the eradication of an initial interregional misallocation of resources. It is also shown why, in the neoclassical approach, the cause of both regional and national involuntary unemployment is ascribed to real wages being too high. Following this, the impact of a progressive reduction in the degree of intraregional misallocation of resources on productivity growth is considered. Finally, we examine the role of the spatial diffusion of innovations in regional productivity growth, although the potential importance of this factor is not restricted to the neoclassical approach.

Neoclassical Theories of Regional Growth

The great attraction of the neoclassical paradigm is that a wide range of economic phenomena can be analysed deductively, often with determinate outcomes on the basis of a small number of axioms. Neoclassical regional growth theory rests firmly within this tradition, relying particularly on the assumptions underlying the concept of perfect competition. The appropriateness of this approach has not, however, been without its critics.

In particular, Richardson (1973, p. 22) argues that:

> 'The background assumptions of neoclassical growth theory are inapplicable to the regional economy. For instance, the full employment assumption is not usually relevant to regional economics since to a marked extent regional problems emerge because of substantial inter-regional differences in the degree of resource (and particularly labour) utilisation. Similarly, perfect competition cannot be assumed in regional economic analysis since space itself and the existence of transport costs limits competition; oligopoly, pure monopoly or monopolistic competition are much more appropriate market structures. Indeed, if we were to adopt neoclassical models in their pure unadulterated form there would be no such field as regional economics.'

Nevertheless, these strictures are analogous to those that are often levelled at aspatial neoclassical economic theory and adherents to the latter approach maintain that, notwithstanding the heroic assumptions, useful insights are still gained into the workings of the market economy from this method of analysis.[2]

It is, perhaps, not very surprising that neoclassical regional growth theory draws heavily on the one-sector neoclassical aggregate growth model, together with the allocation models of the (neoclassical) pure theory of international trade.

It would be unfair, though, to give the impression that regional models have been totally derivative. Although written over twenty years ago, Borts and Stein's (1964) book entitled *Economic Growth in a Free Market* still has claims to being the definitive statement of the neoclassical explanation of regional economic growth. This analysis anticipated a number of developments which were to occur in both growth theory and international trade theory.[3]

The One-Sector Regional Growth Model

The simplest neoclassical growth model uses a one-sector aggregate production function together with the aggregate marginal productivity theory of distribution. It is useful to begin the exposition with the assumption that each region is subject to the same Cobb-Douglas production function which exhibits constant returns to scale.[4]

$$Y_i = A_i e^{\phi t} K_i^{\alpha} L_i^{(1-\alpha)}, \tag{1}$$

where Y, K and L are the levels of output, capital and labour, respectively; A is a constant; ϕ is the rate of exogenously given technical progress, which is assumed to be spatially invariant; α and $(1-\alpha)$ are the output elasticities of capital and labour which are assumed to be the same for each region and under perfect competition equal the relevant factor shares; and i denotes the region under consideration.

If initially it is assumed that there is no misallocation of resources, the growth of regional productivity ($\mathring{P}_i$) is determined by the rate of technical progress and the growth of the capital-labour ratio,

$$\mathring{P}_i = \phi + \alpha(\mathring{K}_i - \mathring{L}_i). \tag{2}$$

[2] It has long been accepted by even the most ardent of neoclassical economists that even in an aspatial context their approach represents a drastic simplification of modern capitalist economies. But it is argued that the methodological basis of neoclassical economics rests firmly on instrumentalism as popularised and simplified by Friedman's (1953) famous essay on 'The Methodology of Positive Economics'. This has been interpreted as implying that the realism or otherwise of a model's assumptions is irrelevant. What is important is the predictive ability of the model and prediction is treated as synonymous with explanation. If this argument is accepted, it presents a very powerful methodological defence of the unrealistic assumptions of neoclassical economics. But see Katouzian (1980, Chapter 3) for a critique of instrumentalism.

It is only necessary to consider the superior predictive ability that 'naive' economic forecasting models (i.e., those based on extrapolating past trends) have sometimes had over those constructed from estimated economic relationships to realise that prediction and explanation are not identical and the former does not necessarily imply the latter.

[3] The intention of Borts and Stein was to develop a dynamic neoclassical theory of resource allocation rather than a regional growth model, *per se*. Their use of United States state data to test their models was, to a certain extent, incidental, being the most suitable for their purpose in that such data minimise the differences in socio-economic factors and trade barriers are absent.

[4] More general specifications such as the CES and translog production functions represent further refinements of the neoclassical production function. However, we shall confine our discussion to the Cobb-Douglas production function since this does not affect the substance of the argument.

In equilibrium, the regional rates of growth of real wages and of the rate of return are equal to the national average and are given by

$$\mathring{w}_i = \phi + \alpha(\mathring{K}_i - \mathring{L}_i) = \mathring{w}_n, \tag{3a}$$

and

$$\mathring{r}_i = \phi + (\alpha - 1)\,(\mathring{K}_i - \mathring{L}_i) = \mathring{r}_n, \tag{3b}$$

where $\mathring{w}$ and $\mathring{r}$ are the rates of growth of real wages and of the rate of return, respectively, and the subscript n denotes the national average.

The following relationships also hold in steady state growth with a given rate of interest;

$$\mathring{Y}_i = \frac{\phi}{(1-\alpha)} + \mathring{L}_i = \mathring{K}_i. \tag{4}$$

The growth rates of factor payments are given by

$$\mathring{w}_i = \frac{\phi}{(1-\alpha)}, \tag{5a}$$

and

$$\mathring{r}_i = 0. \tag{5b}$$

Hence, the growth of wages is determined by the rate of exogenous technical progress. The rate of return is constant and is equal to the rate of interest.

There is no independent investment function and all savings are automatically invested. There is full utilization of all resources. Regional savings are assumed to be a constant proportion of regional output, $S_i = sY_i$, and the propensity to save is the same for all regions. However, regional savings may diverge from the regional level of investment. Following Borts and Stein (1964), let us assume that output growth varies between regions. The rate of growth of capital that can be financed from a region's own savings is given by $\mathring{K}_i' = sY_i/K_i$. Since, from the marginal productivity condition, $r = \alpha Y_i/K_i$, the internally financed growth of the capital stock may also be expressed as $\mathring{K}_i' = rs/\alpha$.

Since the requirement of steady state growth is a constant capital-output ratio, it follows that a region will import capital if its rate of growth of output exceeds rs/α. Furthermore, in a closed economy, the rate of interest will act in the (national) capital market to equilibrate the aggregate demand for, and supply of, the total of the regions' savings. While interregional capital flows will be observed, all regions will have the same growth of productivity and an identical growth rate of real wages. Capital will earn the same rate of return wherever it is invested. Differences in the growth of output are due ultimately to variations between regions in the growth of their labour force.

If regional productivity growth disparities are to be explained in terms of this framework then it is necessary to assume some initial violation of the Pareto optimality conditions. Taking this into account, the growth of productivity may be expressed as

$$\mathring{P}_i = \mu_i + \pi_i + \phi_i' + \phi + \alpha(\mathring{K}_i - \mathring{L}_i). \tag{6}$$

In addition to the rate of exogenous technical progress, ϕ, and the steady state growth of capital deepening, $(\mathring{K}_i - \mathring{L}_i)$, which, from equation (4), is the same for all regions, productivity growth is determined by:

(i) μ_i, which is the growth of productivity due to the improved interregional allocation of resources;

(ii) π_i, which is the growth of productivity due to the improved allocation of resources between industries within a given region (i.e., the improved intraregional allocation of resources);

(iii) ϕ_i', which is the rate of technical progress in addition to ϕ and is due to the diffusion of innovations caused by differences in the level of technology to which the regions have access. In other words, the rate of technical progress will temporarily accelerate in a region as it acquires knowledge of more sophisticated techniques and adopts them. ϕ_i' is, by definition, equal to zero for the most technologically advanced region.

These three disequilibrium factors include any effects on productivity growth of a temporary divergence of the growth of the regional capital-labour ratio from its steady state value.

It is useful to examine these factors in greater

detail, commencing with the gains from the improved interregional allocation of resources.

Improvements in the Interregional Allocation of Resources

If factors of production are, for whatever reason, initially being used sub-optimally between regions (so that there are differences in the regional profit rates and real wages), any improvements in the efficiency with which these resources are used will register as an increase in productivity. Over time, with the gradual spatial integration of labour and financial markets and the reduction in impediments to the functioning of the market mechanism, the gains in productivity growth from this source will diminish as the national economy approaches a Pareto optimal allocation of resources between regions. This temporary acceleration in productivity growth is the result of non-optimal growth in the past.

In many countries, the interregional transfer of resources is inextricably bound up with the intersectoral movement of labour, especially from agriculture to industry. The latter has a spatial counterpart because the importance of these two sectors varies considerably between regions. McCombie (1980) found, for example, that, under certain assumptions, well over one-third of the postwar productivity growth of those advanced countries with a large agricultural sector (most notably Japan, West Germany, France and Italy) could be attributed to this movement from the low productivity (agricultural) to the high productivity (industrial) sector. On the other hand, this has proved to be insignificant in the case of the United States and the United Kingdom, since both countries have a highly commercialised agricultural sector exhibiting a high level of productivity. Moreover, in the case of the United Kingdom, agriculture only employs 3 per cent of the total labour force so the relative size of any transfer would be small. Thus, it is likely that any gains from the improved interregional allocation of resources are likely to be minimal in the United Kingdom and it will be argued below that this is indeed true. However, possible gains may be considerably bigger in Japan and Continental Europe.

A simple case of the spatial misallocation of resources may be demonstrated by considering an economy which comprises of two regions designated A and B. It is assumed that the regions produce an identical commodity using the same technology. (There are, of course, other assumptions that could be made such as the regions produce different products and have different production functions. Our intention, however, is merely to outline the main elements of this approach rather than to discuss the various specific results. See, for example, Carlberg, 1981). It is also assumed that the size of the total labour force and the capital stock is fixed and there is no technical progress. Fig. 1a represents the familiar Edgeworth-Bowley box diagram which shows the distribution of the factors of production between the two regions together with the isoquants and the contract curve. Because we have assumed that both regions have the same production function, the contract 'curve' is, in fact, the diagonal between O_A and O_B. Initially, for some reason, there is a misallocation of resources with production occurring at the point a which is off the contract

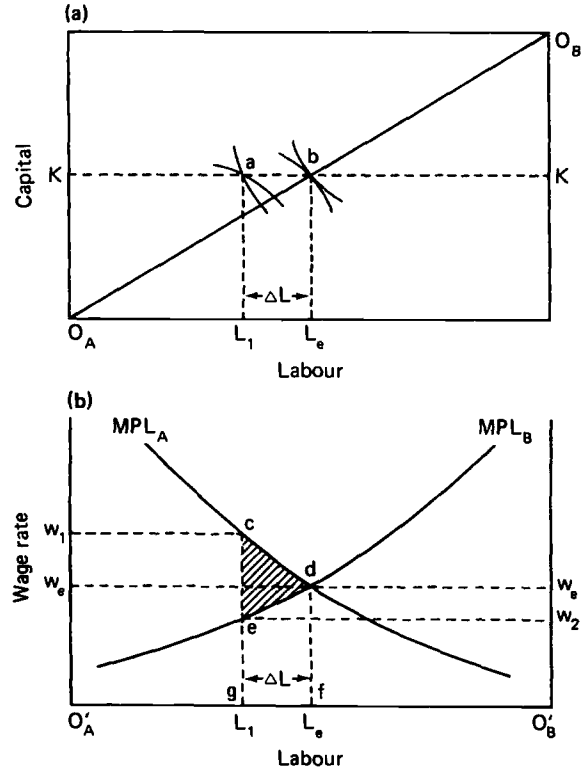

Fig. 1. The interregional misallocation of labour.

curve. Region A has O_AL_1 of the labour force while the rest is employed in Region B. Similarly, O_AK of the capital stock is allocated to Region A with the remainder being in Region B. All factors of production are fully employed.

Fig. 1b is a cross-section of Fig. 1a taken along the dotted line KK. It depicts the marginal product curves of labour of Region A and Region B (namely, MPL_A and MPL_B) given the fixed allocation of total capital stock between the two regions. Because of the fixity of the capital stock, the regional marginal product of labour curves decline as more labour is employed in Region A and Region B, measured from O_A' and O_B'. Under profit maximising conditions, entrepreneurs will employ the amount of labour where the marginal product of labour equals the real wage rate. Initially, the wage in Region A is given by w_1 and this exceeds that of Region B which is w_2. Conversely, the profit rate in Region A is lower than that of Region B. The misallocation of resources is eradicated over time as the wage differential is reduced. It is assumed that the capital stock is immobile so that ΔL of the labour force migrates from Region B to Region A as, in terms of Fig. 1a, production moves from point a to b. Point b is efficient, being on the contract curve. (See Neary, 1978, especially pp. 496–499, for a discussion of the more general case where there are two industries whose production functions have different factor intensities and both capital and labour adjust as the wage differential changes).

In Fig. 1b, the area under the marginal product curve of labour of Region A from O_A' to L_1 is equal to the region's output. The area under the MPL_B curve from L_1 to O_B' likewise measures the output of Region B. In equilibrium, $O_A'L_e$ of the labour force is employed in Region A, L_eO_B' is employed in Region B and the wage rate is w_e. Hence, it may be seen that the net gain in output due to the spatial reallocation of labour from Region B to Region A is the area cde. An interesting question is what is likely to be the order of magnitude of this gain? Some approximate calculations have been made by Brown (1972, pp. 245–249) who suggests that in the case of the United Kingdom the maximum potential gain is likely to be relatively small, a result that is in accord with the so-called 'law of small triangles'. (This 'law' comes from the fact that the losses due to other static misallocations of resources — most notably due to monopoly or tariffs — are also generally an insignificant proportion of GDP.) To estimate the loss, Brown assumes that, in the area of interest, the marginal product of labour schedules are linear and the area of the triangle cde is equal to $1/2\ (w_1 - w_2)\Delta L$.

While data are available directly for the values of w_1 and w_2, ΔL has to be inferred from the elasticity of the wage rate with respect to employment (which is assumed to take the same numerical value in both regions and which is calculated from a Cobb-Douglas production function). If it is assumed that the two regions have a labour force of ten million employees each and wages are 5 per cent higher in region A, the necessary transfer of labour from B to A is three quarters of a million workers and the gain in output is insignificant, being less than 0.1 per cent of GDP.

It may be that the regional wage differential is not due to labour being misallocated relative to capital but occurs because both labour and capital are misallocated with respect to natural resources, broadly defined. This would necessitate both labour and capital being reallocated and the interregional transfer of labour would be larger than in the previous example, perhaps by a factor of three or four according to Brown (1972). This would mean that the gains from the improved allocation of resources would be commensurably higher and may be as much as five times as large as the original estimate. Nevertheless, the gain in ouput would still be small being less than 0.5 per cent of GDP.

However, the gain in output may be much larger in those countries where regional productivity disparities are significantly greater than in the United Kingdom. This is likely to occur especially where some of the regions are dominated by a large inefficient agricultural sector. Moreover, the use of regional wage differences to estimate the gain in output will lead to an underestimate if rural wages are equal to the average rather than the marginal product of labour. (The former often is found to be the case where the production unit is the family farm.)

This situation is depicted in Fig. 2 where it is assumed that Region B is predominantly rural and the wage is determined with reference to the average product of labour curve (APL_B). In Region A, the wage equals the marginal product of labour.

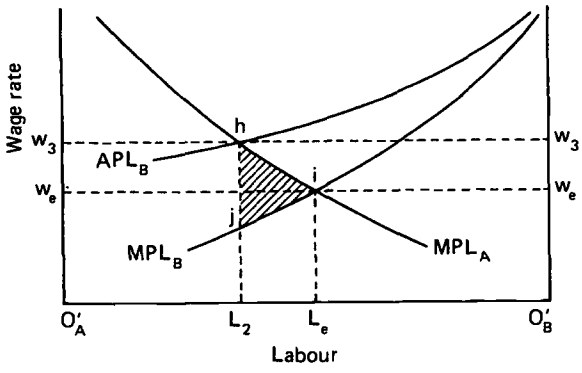

Fig. 2. The interregional misallocation of labour when the wage in Region B equals the average product of labour.

Let us assume that initially the wages in the two regions are identical being equal to w_3. Nevertheless, this does not mean that the gains from the improved allocation of resources have been exhausted.

The initial value of regional output in Fig. 2 is the area under the relevant marginal product of labour curves from O_A' to L_2 in the case of Region A and L_2 to O_B' in the case of Region B. However, in the case of Region B, the total wage bill comprises the whole of the regional output (although the distinction between wages and profits becomes blurred in the case of family farm income).

With the development of a commercialised agricultural sector with labour now being paid its marginal product, it can be seen from Fig. 2 that the equilibrium outcome will be that wages fall in *both* regions to w_e as labour migrates from Region B to Region A. The increase in total output is given by the area hij.

Since 1973, unemployment rates in all regions of the United Kingdom have risen dramatically and it may be legitimately argued that regional unemployment rates are now a more serious problem than regional disparities in wage rates. Within the neoclassical paradigm the explanation for this phenomenon is to assume that the value of the real wage is too high in all regions. (A substantial proportion of the increase in unemployment may also be attributed to an increase in the regional 'natural rate of unemployment'.) This position is shown diagramatically in Fig. 3. The initial loss of output due to the regional wage differential when labour is fully employed is again given by the triangle cde and is associated with regional wage rates of w_1 and w_2. If, for some reason due, for example, to the increased bargaining power of organised labour, the wage rate rises in both regions simultaneously so that the new wage rates are w_4 and w_5, the total reduction in output below the maximum potential is given by the area ndklm. $O_a'L_3$ and L_4O_B' of the total labour force are employed in Region A and Region B, respectively, with the remainder unemployed. (It is assumed that the capital stock is malleable and hence is still fully utilized). If we assume that, as at present in the United Kingdom, the level of output is some fifteen per cent below its potential level then it is clear that these losses are substantially larger than any gains that could be achieved by the improved spatial allocation of resources. (See Brecher, 1974, for a discussion of the impact of a minimum real wage in the context of the pure theory of international trade.)

This brings us to the paradox mentioned in the introduction to the paper that although in absolute (but not in relative) terms regional unemployment disparities have never been greater in the postwar period, the regional problem has become synonymous with the national unemployment problem. The most effective way to reduce regional disparities is to increase national output, which, since we are dealing with 'classical unemployment', must be accomplished through a fall in the real wage. It is implicitly assumed in Fig. 3 that the supply of labour is inelastic with respect to the wage rate, although this does not affect the substance of the argument. The more general case is discussed in McCombie (1988). (In that paper, the neoclassical argument is outline in greater detail and is contrasted with the post-Keynesian explanation of the cause of regional unemployment. The latter holds that such unemployment is due to the level of effective demand being too low.)

Testing the predictions of the single-sector model has suffered, until recently, from the dearth of data on regional profit rates and indices for the capital stock and most tests have been of an indirect nature. However, the early work of Borts and Stein (1964) showed that the single-sector model performed badly. An implication of the neoclassical model is that the low-wage regions should experience the fastest growth rates of both capital and the capital-labour ratio. Furthermore, the low-wage regions should also achieve the fastest growth of wages as a result of the increasing capital-labour ratio. However, statistical tests showed that the theory was refuted in two of the three time periods considered

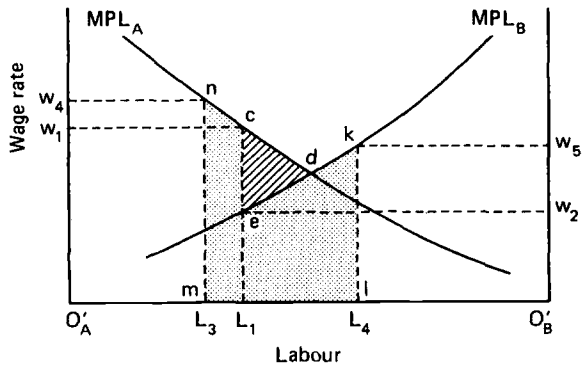

Fig. 3. Neoclassical regional unemployment.

by Borts and Stein, namely, 1919–29 and 1948–53. It was only compatible with the data for the period 1929–48. Given the tendency of both advocates and critics of the neoclassical approach to concentrate on the single-sector model, it is worth quoting Borts and Stein on the implications. 'The conclusion of this statistical section is that the popular aggregative theory has very little predictive accuracy and that one should place little confidence in it as an explanation of regional growth and maturity' (1964, p. 55).[5] Borts and Stein argue that the differential economic performance of the United States states can only be understood primarily in terms of the intraregional improvement of resources within any particular region.

Improvements in the Intraregional Allocation of Resources

The analysis of the gains achieved from the improved intraregional allocation of resources is very similar to that outlined above except attention is now confined to the allocation of labour and capital between two industries or sectors within the region that are assumed to produce the total regional output. The framework of discussion is again analogous to the neoclassical pure theory of trade except mobility of the factors of production is permitted between regions. It is convenient to use the model of Borts and Stein (1964, Chapter 7) to demonstrate this approach, although once again a modification of the assumptions will alter the exact results derived from the analysis. However, Borts and Stein argue that their model is a plausible explanation of the historical economic performance of the regions of the United States.

We begin by considering an individual region which produces two commodities, X, an export good and Z, a domestic good. There is also an imported good, M, which is not produced in the region. (Capital goods are also imported at a constant price.) Sector X is assumed to be capital-intensive while sector Z is labour-intensive. This assumption is crucial for the results that follow but it is argued by Borts and Stein that it is not unrealistic, since most exports are manufactured commodities which are produced with a higher capital-labour ratio than domestic goods which tend to be predominantly services. The region is small compared with the size of the remainder of the national economy and so the price of X is taken as a constant and is determined outside the region. (Hence, the demand for X is perfectly elastic.) All resources are fully employed. There is, however, a misallocation of resources between the sectors caused by an initial money wage differential, $W_X = \rho W_Z$, where W is the money wage and ρ is greater than unity. In other words, it is assumed that initially the wage in the tradable goods sector exceeds that paid in the domestic sector. (In the United States the value of ρ empirically has often been between 1.2 and 2.0.) 'The differential has been generated by labor market immobilities and by lagged adjustment of labor supply to new job opportunities. The lags are due perhaps to tastes, ignorance, and the lack of training' (Borts and Stein, 1964, p. 130). It is further assumed that there is a perfectly competitive interregional market for capital and there is no technical change. All these assumptions ensure that for sector X, the capital-labour ratio, the wage and the profit rate are constant.

If all prices, the rate of interest and the intersectoral wage differential do not alter, then the region will grow at an equilibrium rate determined by the growth of the labour supply. Growth will be balanced in that the two sectors will retain a constant share of both the labour force and regional output.

[5] A more recent test of the single-sector neoclassical aggregate model by regression analysis undertaken by Smith (1975) finds the model performs better.

However, in order to analyse the consequences of a decline in the wage differential it is convenient to assume that the labour force is constant.

The consequences of an initial wage differential for the allocation of resources may again be seen in terms of the Edgeworth-Bowley box shown in Fig. 4 where the corners of the initial box are given by O_X and O_Z. Production is originally given by the point p which lies on the 'inefficient contract curve' given by the dotted line between O_X and O_Z. On this curve there is the constant intersectoral wage differential, $W_X = \rho W_Z$, while the rate of return is the same in the two industries. The solid curve between O_X and O_Z is the Pareto efficient contract curve.

It is assumed that over time the value of ρ decreases exogenously until it takes a value of unity at which point the regional economy is efficient. It is useful to trace the consequences of this in two parts. First, the economy moves along the rigid capital-labour ray of sector X (namely, the line $(K/L)_X'$) from p to q. At point q the economy is on the efficient contract curve. This reallocation of resources (which Borts and Stein term a substitution effect) has the effect of contracting the output of the export sector while giving rise to an expansion of the domestic sector.

The value of regional output has increased since the region is now on its Pareto optimal production possibility curve. Since the size of the labour force is fixed, regional productivity will have increased as a result of the adjustment process.

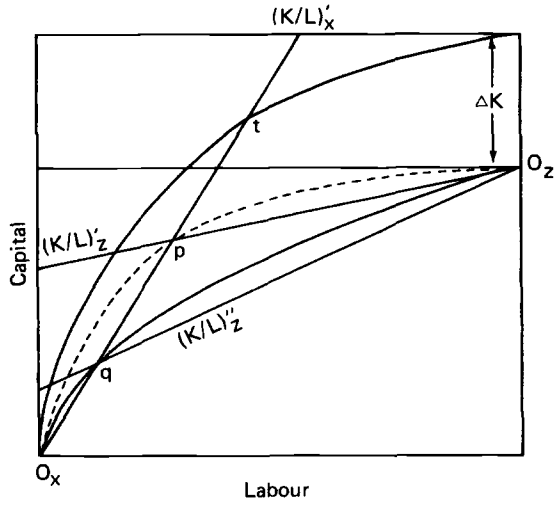

Fig. 4. The intraregional misallocation of resources.

However, this is not the end of the story and we come to the second part, *viz.*, the expansion effect. As the output of Z increases so its price rises and it will be higher relative to the price of the imported capital good. This leads to an increase in the total capital stock of the region (denoted by ΔK in Fig. 4) and an expansion of the dimensions of the Edgeworth-Bowley box. The final equilibrium allocation of resources is given by the point t which is on the contract curve of the expanded Edgeworth-Bowley box. Borts and Stein prove that the share of labour employed in sector Z has decreased while the output of sector X has increased. It will be remembered that there has been no change in the money wage rate of sector X since both the capital-labour ratio of the sector and the price of X are constant. What has occurred is that the wage rate of sector Z has increased until the wages in the two sectors are equal.

An increase in the demand for exports may also be analysed within this framework (Borts and Stein, 1964, Chapter 7, and Armstrong and Taylor, 1985, pp. 59–63). We shall not discuss this in detail but, briefly, the rise in demand is reflected in a rise in the price of the export good. This results in an increase in the value marginal product of both capital and labour. The former leads to an increase in capital accumulation which raises the capital-labour ratio of the export sector. This reduces the rate of return until it again equals the cost of borrowing. The increase in the capital-labour ratio causes a further rise in the value marginal product of labour. If we assume perfect mobility of labour between regions and sectors and no misallocation of resources there will be an increase in the employment of labour until both the intersectoral and interregional equality of wages is re-established.

Finally, there is an important difference between the predictions of the single-sector regional model, where it is assumed that there is one product produced for the national market, and the two-sector regional economy. In the former, an increase in the regional capital-labour ratio will be accompanied by a fall in the rate of return and a rise in the real wage.

However, this does not necessarily follow in the two-sector case. Even when all resources are efficiently allocated, it is possible that an increase in the overall capital-labour ratio of the region may not lead to a rise in the capital-labour ratio of the

two sectors, and, hence, to a rise in the wage rate. For example, an increase in the stock of capital may be accompanied by an increase in the share of regional output produced by the capital-intensive sector such that there is, in fact, a decline in the capital-labour ratios of both sectors. In this case, an increase in the aggregate regional capital-labour ratio would be accompanied by a fall in the regional wage rate.

In the two-sector regional model, it is no longer the case that capital and labour will necessarily flow in opposite directions, as in the single-sector model, with capital moving to regions with a low capital-labour ratio and labour migrating to where the capital-labour ratio is high. For example, it is possible that, under certain circumstances, both capital and labour will move to the same region.

As in the case of the interregional misallocation of resources, the two-sector model may be extended to incorporate regional unemployment by introducing a wage rate that is above the competitive value in both sectors, although this argument will not be pursued here.

Regional Productivity Growth and the Spatial Diffusion of Innovations

Once an allowance has been made for the contribution to regional productivity growth of improvements in the allocation of resources and the impact of the growth of the capital-labour ratio, a 'residual' remains. In the 'Growth Accounting' exercises this is usually interpreted as 'exogenous technical progress' although it also captures the effect of measurement errors. (See, for example, Denison, 1967.)

If at any moment, however, there are regional differences in the level of technology, part of technical progress may be the result of the diffusion of new techniques from the relatively advanced to the more backward areas. The explanation for this is as follows. In the early stages of the development of a particular country when the space economy is not fully integrated, the friction of distance prevents equal access to the same 'blue-print' of techniques. If there are economies of scale in invention, then the prosperous regions which are able to devote a large volume of investment to research and development may have been able to develop a progressively more advanced technology than the poorer, often peripheral, regions. This advantage, however, tends to disappear with the development of a single national market. The increasingly oligopolistic nature of industry results in the relatively backward regions gaining increasing access to this advanced technology. This leads to the backward regions experiencing a temporary increase in their rate of productivity growth with a resulting convergence in regional productivity levels.

This argument assumes that there exist techniques of production which, if known in the peripheral regions, would immediately be adopted and raise the level of productivity. In other words, the effect (in a simple malleable capital model) would be to shift the production function upwards and act as an increase in technical progress. In a vintage model, this new process would be embodied in investment and so the increased rate of technical progress would be a function of the level of gross investment.

While the hypothesis of the importance of the spatial diffusion of innovations in explaining regional growth disparities is by no means confined to the neoclassical paradigm, it will be noticed that the cause is similar to market failure. In this case, the failure is due to the supposed fact that information is not instantaneously available everywhere but takes time to diffuse. As this is corrected over time to the extent that the rate of diffusion increases, there will be equilibrating effects similar to those generated by the improved allocation of the more tangible inputs. Hence, it is convenient to discuss the diffusion of innovations at this juncture.

At the moment, there seems to be little agreement as to just how important empirically the diffusion process is in regional growth, at least so far as the advanced countries are concerned. For example, Dixon and Thirlwall (1975, Chapter 6) find no evidence of regional differences in exogenous technical progress for the United Kingdom. Borts and Stein (1964, p. 8) consider that a 'new manufacturing process or a new machine is, under competition, available to all'. Brown (1972) in his detailed study of the United Kingdom regional economy did not consider that the topic was of sufficient importance to warrant discussion. Richardson (1973, p. 113), on the other hand, thinks this neglect is misplaced. 'The assumption that new technical knowledge is freely available to all except for the barriers imposed by imperfectly competitive markets runs contrary to empirical observation. Instead, the diffusion of innovation over space occurs according to

predictable patterns which fail, at least so far as entrepreneurial as opposed to household innovations are concerned, to penetrate all conceivable locations.'[6]

Certainly, ever since Hägerstrand's (1952) influential study of agricultural innovations, substantial evidence has accumulated to show that many innovations do not appear randomly over the space economy. Rather, they both take a contiguous pattern with diffusion from a centre into the surrounding area and also flow down the urban hierarchy with the time to adoption inversely related to city size. One problem, though, with many of the earlier studies is that the phenomena for which it was possible to obtain data on both the time of appearance and the spatial co-ordinates have very little relevance for the process of economic growth. In other words, they tended to be product rather than process innovations. Typical examples included television stations, shopping plazas, and Rotary Clubs. More recent studies have, however, concentrated on the diffusion of innovations that are of greater relevance for economic growth. See, for example, Gibbs and Edwards (1983), Thwaites (1983) and Thwaites and Oakey (1985).

At the aspatial level, there are numerous studies of industrial processes that also show that new inventions are not immediately adopted by every firm. Often the percentage of firms which have innovated follows a logistic curve over time, a path that is replicated in many spatial studies.

At this point, it is worth emphasising a matter that does not always seem to have been fully appreciated in the literature on the spatial diffusion of innovations. This is that the existence of differences between regions, countries or firms in the speed of adoption of best-practice techniques or the fact that there are regional disparities in the age-structure of machinery does not necessarily imply differences in the knowledge of best-practice technology.

It is possible (indeed, likely) that innovations will diffuse over time as a result of profit maximisation even if there is perfect information concerning the availability of all possible techniques.

The pioneering study that modelled the economic forces affecting the adoption of new techniques is the vintage capital approach of Salter (1966). The rationale of his analysis may be summed up in Jevons' dictum that 'in commerce, bygones are forever bygones and we are always starting with a view to future utility.' Thus, once a piece of equipment has been purchased, the only costs related to this machinery relevant to the decision of the entrepreneur as to whether or not it should be scrapped are, after installation, the variable costs of running the equipment (i.e., the cost of labour and materials, etc.). On the other hand, *ex ante*, the decision whether or not to buy the machine is a function of the total costs of production with the equipment (i.e., including amortisation and interest payments). A new technique will be only introduced if the total costs involved in its use are less than the variable costs of producing with the machine it is to replace; and an important element of such costs is the real wage rate. At any moment, there will be a difference between the average productivity of an industry and the productivity of the best-practice technique. The lower the regional wage relative to the price of investment, *ceteris paribus*, the greater this difference will be; the average age of the capital equipment will also be older. Even substantial differences between the average productivity of an industry in different regions do not imply that one area has access to a superior technology if there are exogenous differences in the regional wage rates. Likewise, if it is found that a region has a larger proportion of firms adopting a particular innovation, it does not necessarily mean that it is in any sense more aware of the existence of this particular technique.

It should be noted that if there are, indeed, regional differences in the level of technology, this is likely to be reflected in differences in the level of productivity and in real wages. The Salter argument, however, shows that the existence of such differences in productivity or real wages does not necessarily imply that some regions (or nations) have access to a more advanced technology compared with other areas.

Generally speaking studies by economists have tended, perhaps not surprisingly, to emphasize the economic reasons for diffusion, while others, such as geographers, have placed greater emphasis on the informational causes of diffusion. Griliches (1957), for example, in his classic study of the diffusion of hybrid corn in the United States attributed the date

[6] Richardson (1973) provides a useful if now somewhat inevitably dated survey of the literature.

of the introduction of hybrid varieties of corn in a particular state and the speed of adoption to the degree of profitability and economic forces.

Berry (1972), on the other hand, provides a good example of a non-economic model (there is no role for profitability or relative prices in his approach) that seeks to explain differential growth rates in terms of the filtering of information down the urban hierarchy.

Berry's analysis is interesting, perhaps not so much for its specific results as for the method it typifies.

After generating a rank-size hierarchy of city sizes through a maximum entropy procedure, Berry proceeds to consider a probabilistic model whereby innovations diffuse down this hierarchy until a threshold level is reached. The adoption lag at a particular city is postulated to be a function of the information flows between it and other cities in the hierarchy which have already received (adopted) the innovation. The mechanism draws heavily on diffusion models borrowed from the physical sciences including the gravity model. A city's (or a region's) growth is a function of the length of time before it receives the innovation because the impact of an innovation in increasing income, and productivity, is assumed to decline with time. (If this were not the case, a constant lag with a steady stream of innovations would not cause differences in growth rates.) The benefits of the innovation are also assumed to spread out contiguously from the adopting centre. The implication to be drawn from this approach is that in order to raise a region's growth rate the length of the innovation lag should be reduced and spread forces encouraged.

An indirect empirical test of the model is undertaken by examining the diffusion of television stations (and TV sets) through the United States over the period 1940 to 1965. The proportion of cities adopting a television station follows the familiar logistic pattern over time. The model is tested by the use of regression analysis to determine how successfully the date of adoption is explained by a number of variables proxying information flows. These include the population size of a city (to capture hierarchical diffusion) and the population potential (to capture contiguous diffusion). A number of other explanatory variables representing demand factors are also included. The model is successful in that there is a significant statistical relationship with the smaller cities opening TV stations at later dates than larger cities as predicted by the theory.

This analysis, however, clearly demonstrates the problem outlined above in distinguishing between the effects of non-economic and economic forces. A similar pattern could equally be explained by economic factors even though information about the availability and costs involved of operating a TV station were not spatially restricted. A logistic adoption curve could also be generated by assuming that over time the cost of operating a TV station falls because of technical progress. Consequently, immediately after the initial development of TV stations with their high costs, only those cities with a large population (and, hence, a sufficiently large advertising revenue) were able to support a station. However, with both costs falling and *per capita* income rising over time, TV stations became progressively economically viable in smaller and smaller cities leading to the observed diffusion pattern.

This example clearly shows that it is not sufficient to assume that the observed existence of the diffusion of innovations necessarily means that they are a significant factor in explaining differences in regional growth.

McCombie (1982) attempted to test the importance of the diffusion of innovations on regional productivity growth by developing an approach suggested by Gomulka (1971). Gomulka argued that, in an international context, the part of a country's productivity growth that is due to the diffusion of advanced technology will be a function of what he terms the 'technological gap'. This is defined as $(P^* - P_i)/P_i$ where P^* and P_i are the levels of productivity in the most advanced country (which, in the postwar period, is the United States) and the country under consideration. The hypothesis is that, for the advanced countries, the larger the technological gap, the greater the potential for the diffusion of innovations. Hence, if diffusion is an important factor then productivity growth should be positively related to the technological gap.[7] However, the

[7] In an earlier stage of development (or in the case of the present less developed countries) diffusion lags may well increase and lead to greater regional disparities in productivity levels. In the case of the less developed countries, the dual nature of the economy may encourage this since the small modern industrial sector may be based on highly sophisticated techniques of production imported from the advanced countries. The traditional sector will not have the capacity to learn of and adopt these methods of production, with the result that differences in regional productivity levels will increase over time.

reservations expressed above about the use of such a proxy for the level of technology should be borne in mind.

McCombie (1982) used growth rate data for total manufacturing industry drawn from the United States states for the period 1963–1973. Various specifications of a production function, expressed in terms of growth rates, were estimated using these cross-regional data, and a proxy for the differences in the level of technology was included as a regressor to test the diffusion hypothesis. (The proxy was an index of the ratio of the level of total factor productivity of a particular state to that of the technologically most advanced state. The ratio of the relevant levels of labour productivity was also used but this made little difference to the interpretation of the results.) The coefficient of the 'technological ratio' proved to be statistically insignificant in all the estimated specifications. Thus, within the limitations of the model, it appears that the diffusion of innovations is not an important determinant of productivity growth in an advanced country.

A related weakness of this type of empirical approach is that it is within a malleable capital rather than the vintage (Salter) framework mentioned above. The former suffers from the disadvantage that any new technique will, in practice, be embodied in investment and may have little, if any, impact on the efficiency of machines already installed.

Gomulka and Sylwestrowicz (1976) have developed a vintage approach which attempts to quantify the gains in productivity growth, in an international context, resulting from the use of technologically more advanced imported capital equipment. The model is used to estimate the benefits of the 'direct effect of embodied diffusion' which is the additional productivity obtained by using an imported capital good over and above what the productivity would have been if domestic machinery of the same vintage had been used. They also calculated the extent to which the use of imported machinery in the domestic capital goods industry leads to domestically manufactured machinery of better design. This is termed the 'indirect effect of embodied diffusion'. If the estimates of Gomulka and Sylwestrowicz are largely correct, diffusion would seem to explain much of the international disparities in the growth of productivity.

In principle, a vintage approach to diffusion may be applied to the regional case. As a simple example, consider the case of a peripheral region that has a stock of capital of various vintages which is comprised of domestically produced equipment and more efficient imported machinery.

Two crucial assumptions of this approach are (i) the existence of constant returns to scale and (ii) any differences in the productivity obtained by using machines of a given vintage requiring the same labour input are due solely to differences in the level of technology embodied in the equipment. These are not innocuous assumptions since they rule out, *ab initio*, all other major explanations of disparities in productivity. These include differences in the degree of overmanning and restrictive practices, in the efficiency of management and in the effect of dynamic and static increasing returns to scale.

Regional output from capital equipment of vintage t is assumed to be given by

$$Y_t = (\theta_t K_t)^{\alpha} L_t^{(1-\alpha)}, \tag{7}$$

and the level of productivity is

$$P_t = (\theta_t K_t / L_t)^{\alpha}, \tag{8}$$

where θ_t is a measure of the technical efficiency of the capital stock of vintage t. (It is assumed that there is no disembodied technical progress.)

The capital stock of vintage t consists of domestically produced and imported capital goods, namely K_{Dt} and K_{Mt}, respectively.

Thus,

$$\theta_t K_t = \theta_{Dt} K_{Dt} + \theta_{Mt} K_{Mt} \tag{9}$$

and, by assumption, $\theta_{Mt} > \theta_{Dt}$.

Equation (9) may be written alternatively as

$$\theta_t K_t = \theta_{Dt}(K_{Dt} + K_{Mt}) + (\theta_{Mt} - \theta_{Dt}) K_{Mt}, \tag{10}$$

where $(\theta_{Mt} - \theta_{Dt}) > 0$.

Consequently, the productivity obtained using machinery of vintage t may be expressed as

$$P_t = \left\{ \left[\frac{\theta_{Dt}(K_{Dt} + K_{Mt})}{L_t} \right] + \left[\frac{(\theta_{Mt} - \theta_{Dt}) K_{Mt}}{L_t} \right] \right\}^{\alpha}. \tag{11}$$

If there was no difference in the level of technology of the imported and the domestically produced capital goods, the level of productivity would be a function of only the expression in the first square brackets in equation (11). The additional productivity resulting from the diffusion effect due to the more advanced level of technology of the imported machinery is thus a function of the expression in the second square brackets. It is possible to use this framework, with suitable aggregation of the various vintages, to calculate the contribution that embodied diffusion makes to regional productivity growth. It is necessary to have data on the size of the imported capital stock and proxies for the technological indices of the domestically produced and imported capital goods so that the relevant growth rates may be calculated. One measure of the level of technology of the imported machinery is, for example, the observed level of labour efficiency obtained by using this equipment in the advanced region. It must be assumed that, for this to be the case, the same level of labour efficiency would be achieved with the use of this machinery in the less advanced region.

The difficulty, in practice, is, of course, that there are no data sources comparable to international trade statistics from which estimates of the value of capital goods imported from other regions could be made. Nevertheless, equation (11) is useful in not only theoretically incorporating the diffusion process but also enabling us to clarify further the implications of a crucial assumption underlying the diffusion explanation of productivity growth.

It is implicitly assumed that the superior efficiency of the capital goods imported into the region is not captured in their value. In a competitive situation, however, this greater efficiency would be capitalized into the price of the imported capital equipment. Under these circumstances, there would be no difference between θ_{Mt} and θ_{Dt} and the component in the second square brackets of equation (11) would be equal to zero. The difference in technology would be reflected in the value of K_{Mt} in the first square brackets of equation (11). Any increase in the amount of capital imported from the advanced region would only increase productivity to the extent that it augmented the value of the regional capital stock and would not represent a costless increase in efficiency. This, of course, merely substantiates the earlier argument that the existence of the diffusion of new techniques does not necessarily mean a costless increase in regional productivity growth. Any observed differences in the regional level of productivity obtained using the same value per worker of capital of a given vintage would thus be due to the efficiency with which this capital equipment was used in the various regions rather than differences in the level of technology, *per se*. Given the highly oligopolistic nature of modern economies with the hundred largest industrial firms typically producing about half of the output, it would be surprising if imperfect information with regard to production techniques could account for anything but a small part of regional differences in productivity growth. However, this surmise must, to a certain extent, await the results of future research.

Evidence from the work of Schmookler (1966) suggests that much of the pattern of invention (at least in so far as it is reflected in patents) is demand-led. A faster rate of growth and a greater confidence in expected growth rates leads to both a greater willingness to undertake research and development and to an increase in risk-taking. A faster rate of growth of output will, through the impact of learning by doing and dynamic economies of scale, cause a greater growth of productivity. The latter is thus to a large extent endogenous to the growth process being determined by the growth of output. Such models that stress the process of cumulative causation are considered in the complementary paper (McCombie, 1988).

Concluding comments

In this paper, it has been shown how the neoclassical approach explains disparities in regional productivity growth as the result of the progressive eradication of both interregional and intraregional misallocation of resources. These are caused by market imperfections that resulted in differences between regions (and also between industries within any one region) in wage rates and/or profit rates. The implication is that the free play of market forces should lead to a general convergence in the level of regional productivity. Likewise, substantial differences in regional wage rates should not persist indefinitely.

The existence of regional unemployment may be incorporated into this approach by assuming that

the real wage is too high and this is again the result of market imperfections such as the excessive bargaining power of organised labour. The policy prescription that may be derived from this approach is that a necessary and sufficient condition for a reduction in the regional level of unemployment is for the real wage to fall towards its market clearing level.

It was also suggested that, for the advanced countries at least, it is not clear that the diffusion of innovations has necessarily been a major cause of differences in regional productivity growth.

The most effective way of assessing the explanatory power of a particular paradigm is to compare it with an alternative. In a subsequent paper (McCombie, 1988) we discuss one such competing paradigm, namely, the post-Keynesian theory of regional growth and unemployment, which provides a marked contrast to the approach discussed here.

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