SOME ASPECTS OF GROWTH IN THE SPACE ECONOMY

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CONTENTS

PREFACE

This paper is a development of some of the ideas set out in an earlier essay (69). However, a significant difference is that this paper is more eclectic in its coverage of the literature relating to spatial growth. Since the main concern is with long-term growth, such short-run approaches as input-output analysis and interregional income models have been excluded from consideration, as also has been the Growth Pole literature, for reasons explained in the text.

The main theme of this essay is the use of economic theory in explaining spatial growth. It is felt that Meyer's comment in his survey article is as applicable now as it was in 1963 when he wrote that "the bringing to bear (of) certain aspects of conventional economic theory and now often ignored in regional economies can be highly productive of new insights in this field". Consequently, the so-called "non-economic methods" are not discussed, although it is probable that the entropy maximising approach will, in the future, prove to be a useful complementary method of modelling regional growth.

Finally, I should like to acknowledge the help of Professor M. J. Webber with various aspects of this paper.

CHAPTER ONE

Introduction

> "Space is a tyrant and distance enforces his rule. He militates against us, often disposing of what we propose if we ignore his influence".

Thus William Warntz (133) began his presidential address to the Regional Science Association in 1966. He continued,

> "the revolution against him is already begun, however. Among his most disloyal subjects are the Geographers and Regional Scientists".

Yet, inspite of this, throughout the development of Anglo Saxon Economics from Adam Smith to Keynes, there has been a bias against the space economy. Even the oldest branch of Economics, the pure theory of International Trade,has ignored the effect of distance, not withstanding the perceptive comments of Williams (138), Ohlin (85) and more recently, Isard (149). Indeed, much of the post war work in Regional Economics has followed the methodology of International Trade Theory. The national point economy is disaggregated into several regional punctiform economies (often chosen on very arbitrary criteria) and regions are considered to be homogeneous in some respect (such as per capita income). The implication of this approach is that the interrelationship of the region with the rest of the economy is more important than the intraregional spatial structure. Consequently, most of the theories of regional growth are primarily derived from aspatial macroeconomic theory. Even today, as Brown's study (20) shows, the simple neoclassical, structural and regional multiplier models still form the basic theoretical

framework of applied regional economics.[1]

One of the main reasons for this bias can be attributed to the pervasive influence of neoclassical analysis. The existence of agglomeration economies, indivisibilities and discontinuities, which is an integral part of spatial economics, does not lend itself readily to the analysis of marginal substitution. While it is possible to trace the recognition of areal differentiation in the writings of the classical economists, it was mentioned as a fact requiring no further explanation or relegated to footnotes (despite the teleological influence of 18th century rational thinking).[2] Marshall typifies the attitude of most economists today when he commented that "the difficulties of the problem (the mutual relations of demand and supply) depend chiefly on the variations in the area of space and the period of time over which the market in question extends. The influence of time being more fundamental than that of space". Indeed, it would seem that an appropriate motto for the Regional Scientist should be the exact converse of Marshall's,which was *natura non facit saltum.*

It is a truism that every act of production and exchange has spatial coordinates and is influenced by distance. Even though it is perhaps understandable that,in the post war years, the emphasis in economics has followed Marshall and studied the influence of time, it is to be regretted that space has been neglected to such a degree. Although Greenhut (41)

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[1]See for instance, Richardson's highly critical review (102) of the NIER study which was directed by A. J. Brown. Richardson is a forceful critic of the neglect of space in Regional Economics.

[2]The extent to which the importance of spatial elements was recognised in economic thought has not yet been comprehensively studied. Brief surveys may be found in Isard (149), Richardson (100) and Warntz(131).

foresees a time in the near future when introductory microeconomic textbooks will contain three or four chapters on the impact of space on the theory of the firm, on past evidence this would seem to be an optimistic view.

Moreover, even the work that has been undertaken on spatial growth has been overlooked by the economic growth theorists. Hahn and Mathews (42) have complained of "the lack fo empirical discipline" in the theory of economic growth. They argue that one of the major tasks, is "to find theoretical constructs which, without being downright misleading, are crude enough to bear the weight of crude evidence ... we want theories that can be used as plumbers use a spanner - not simply abstract systems". The regional level would seem to be one of the most obvious areas in which to attempt to test some of the formulations of growth theory. The importance of such noneconomic factors,such as differences in entrepreneural dynamism, that have been invoked to explain observed differences in international rates of growth are greatly reduced in a regional context. Indeed, the work of Borts and Stein seems to be the only attempt to test a simple two sector neoclassical model. Yet, if Hahn and Mathews are to be agreed with, this empirical application of a basic growth model is a long overdue step. Furthermore, as will be seen, spatial growth theory clearly brings to the foreground the contrast between the neoclassical and what can be best termed the Kaldorian paradigm.[1] Indeed one regional economist has gone so far as to argue that "the ultimate

[1]This latter paradigm is distinct from the earlier neo-Keynesian models in that the main distinctive emphasis is not on the equilibrating effects of changes in the distribution of income but on the importance of increasing returns as the major *endogenous* growth determinant.

irrelevance (of the neoclassical paradigm) and its gross predictive fallibility are exposed, not in the intellectually respectable and so called 'core' realm of capital theory, but in the upstart and untamed 'fringe area' of regional and urban economics".[1]

However, deeper understanding of the mechanism underlying regional growth is intrinsically important. Olsen (87) has demonstrated the differing conclusions the regional scientist and the international trade theorist may reach on the impact of economic integration on growth rates. Moreover, much of the argument about the case for government regional intervention still remains very much at the intuitive level. This is perhaps epitomized by the existence of two extreme views that are currently held (Cameron (21)). The *national demand approach* asserts that,over the long term the competitive forces of the market create an optimal spatial distribution of economic activity. Thus,any symptons of regional malaise show that the nation has a declining need for this area of the national economic space. Consequently, the logical implication of this view is that the government ought to encourage interregional mobility of factors to strengthen the national activity. On the other hand,the thesis of *planned adjustment* holds that the free market does not automatically create an optimal distribution of activity. While both views are probably to some extent correct, the assumptions and theoretical underpinnings are still often not made explicit. Thus, while this paper is mainly concerned with abstract theory, it is hoped it will help clarify some of the arguments concerning policy questions.

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[1]Richardson (106), p. 23.

The paper may be briefly outlined as follows: The first chapter is concerned with the traditional problem of the effect of scale on spatial modelling and the delineation of regions. Chapter Two discusses the neoclassical model. However, the framework is discussed in considerably more detail than in (69). The reasons for this are two-fold. Firstly, the model is, at the moment, the only one that has been satisfactorily tested. Secondly, previous criticisms of the model have caricatured it, presenting only the simple aggregative model that has been explicitly rejected by the formulators of these models (Borts and Stein). The third chapter considers some of the criticisms of the model.

The alternative Myrdal-Kaldor model is discussed in Chapter Four. Myrdal's seminal work (83) has stimulated a great interest in the process of cumulative causation and the polarization of growth. However, it was not until Kaldor's two pathbreaking papers (59) (60), that the approach has gained a rigorous analytical structure.

Chapter Five examines the attempts that have been made to include the effect of continuous space into growth models (notably through the synthesis of the potential model and the regional production function).

Since spatial growth occurs primarily in an urban matrix, it is through this matrix that the evolving space economy is organized. Consequently the last chapter begins with an examination of some of the theories of urban growth. As Webber (136), p. 71 has noted, "the rationale for this combination (of urban and regional systems) of what have traditionally been regarded as distinct model forms is the essential similarity of the central ideas in the two cases". This leads to what would seem to be the most profitable future line of research - an attempt

to provide the "microfoundations" of spatial growth. On this point, it is difficult to do better than quote Richardson (103):

> "The greatest need in regional economics is for a theoretical framework that simultaneously explains the operation of the interregional system, including the long term growth process in each region and the dynamics of individual decisions. The future of the subdiscipline lies in the integration of inter-regional (i.e., macroeconomic) analysis with intra-regional analysis or more specifically with location theory and urban economics".

Somewhat paradoxically, one of the main conclusions that has arisen through the preparation of this paper is that the most useful approach towards understanding regional and urban growth is not at the aggregate level, which is stressed throughout much of the paper, but at the microlevel.

CHAPTER TWO

THE PROBLEM OF THE DELINEATION OF REGIONS[1]

The problem of how to define and determine the unit most appropriate to apply to regional growth models now consists of an extensive literature, with still no satisfactory solution. This problem will not be considered in detail because, in the final analysis, all that can be said is that there is no unique way of defining a region. There have been some rather empty attempts to define regions from first principles by the use of set theory (Tietz (127), Siebert (113), pp. 16-22). However, in empirical work, the regional scientist is often severely limited in his definition of the area by the data available.

There are two distinct but interrelated problems in the consideration of the regional unit. The first is the problem of scale and the second is what structural elements best determine the limits of the region.

The problem of scale is important in model building because at one level a parameter or assumption that is crucial (i.e., one upon which the conclusions of the model sensitively depend) may often be justifiably ignored at another scale. Thus as Solow (118) so cogently stated:

> "The art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive. Thus transport costs were merely a negligible complication to Ricardian trade theory, but a vital characteristic of reality to Von Thünen".

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[1]This based to a considerable extent on (69), pp. 3-4.

A related point is that a variable at one level of aggregation may be treated as endogenous but at another level becomes, in effect, exogenous Several debates in regional economics may be attributed to the participants arguing about the problem at different scales (probably the most well known was the North-Tiebout debate over the relevance of the Export Base Theory).

However, it is perhaps instructive to consider whether regional growth models can be treated as the same as national growth models but at a smaller scale, or whether there are some fundamental qualitative differences. Thus, given the hierarchy of global, supranational, national, regional, metropolitan and local, is there any reason why there should be a clear dichotomy between the national and regional level.

Probably the major difference is that the national economic space is normally clearly delineated. The existence of a national currency, tariffs, quotas, etc., gives the nation a certain homogeneity, although as Lösch pointed out this does not completely protect it from the effects of price waves or inflation. Thus within the nation, the regions are far more open and factor mobility, both of labour and capital, is much higher. Consequently the degree of interaction between regions is far greater than between nations. Because of this openess, there needs to be a closer specification of the key parameters and much closer attention paid to the "disequilibrium process" as "opposed to what constitutes an equilibrium, and to take account of the greater uncertainty and the much cruder predications of regional economic models" (Richardson (106)). Moreover, Kaldor (60) has recently argued that in aspatial economic theory the concern with equilibrium "has become a major obstacle to the

development of economics as a *science*", so perhaps this is not such a fundemental distinction between spatial and aspatial economics as may be thought. There are also fewer easily implemented and flexible policies for regulating the level of economic activity within regions as compared to the nation. Tinbergen's dictum argues that there must be at least an equal number of policy weapons as there are policy objectives. However the openess of the region means that there are not many policy implements available for spatial objectives (of course policies set with regard to national objectives may have an incidental spatial effect). Gilbert (39), for instance, long ago showed the futility of regional monetary policies even when separate regional banking systems are in existence. Since the region is normally defined to be in a common currency area, the most effective way of operating on the competitive position of a country, through the exchange rate, is not applicable. This raises the interesting point that the nation may not be the "optimum currency area". Mundell (81) basis the criterion for delineating the optimum currency area on the degree of factor mobility and, as his hypothetical example, argues North America's optimum currency area may be smaller than that existing at present. McKinnon (72) has also considered this problem.

However, as Kaldor (59) has shown,regions do have an automatic stabilizing mechanism that is not available to the nation. A region can run an indefinite trade deficit. Thus, when the level of activity falls in a region, so does the tax revenue that the government receives. On the

other hand, the level of government expenditure does not fall proportionally, partially stabilizing the situation.

There are basically three ways in which the boundary of a region can be structurally delimited - viz., by the criterion of homogeneity, nodality and programming. The homogeneity approach assumes that there is one key variable that gives the region its identity. The relations between regions are assumed to be of greater significance than intra-regional differences. However, the mere existence of data at the state level has, paradoxically, resulted in a reverse line of reasoning. This data enables state levels of income and, indirectly, state capital - labour ratios to be calculated. Consequently, theoretical models have been constructed taking the state as a homogeneous unit, not because of the underlying spatial structure, but because the state is homogeneous in terms of the available data (i.e., average or per capita measures can only be easily calculated on a state basis). Of course, it is very difficult to test a model unless it is adapted to reflect the availability of data. However, it can be argued that this has had a deleterious result in directing the attention of work in pure theory away from the continuous nature of space.

Indeed, one of the most obvious features of the space economy is its nonhomogeneity.[1] Population is concentrated into the focii of urban centres, industries are located in locations determined by explicitly

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[1]However, it is surprising to what extent the structure of the space economy is ignored by many urban and regional economists. This is exemplified by the surveys of Meyer (75) and Brown (19) and the exchange of comments between Richardson (105) and Mirlees (77) and Solow (120). Perhaps Harvey (48) when he considers the possibility of a "geographical imagination" analogous to C. Wright Mills "sociological imagination" provides a possible explanation.

spatial forces and cities are not closed systems but are related to each other in hierarchial structures. Industrial and urban interrelations are revealed as flow phenomena which tend to polarize around the dominant nodes, usually large cities. The "principle of dominance" can be used to establish whether a specific peripheral area belongs to a particular region. The *Functional Economic Area* devised by Fox (Fox and Kumar (34) would seem to be an important way of defining the basic unit of any regional classification. The Functional Economic Area is based on an integration of central place theory and commuting distances,the latter being a function of time. In any contiguous area, the Functional Economic Area is delineated for the highest order centre ("primary wholesale - retail trade centres"), and once this has been accomplished, FEA's are next constructed for those areas not included in one of the previous hinterlands, based on the next largest hierarchical centre. Tests by Fox and Kumar show that the FEA's group several similar socioeconomic variables that do not occur when similar sized areas are constructed at random. The great potential for this type of classification is that "economic activities within an FEA can perhaps be described in terms of hierarchies of spatial equilibrium models. Then, the export sectors of all FEA's in the United States may be linked together by means of other spatial equilibrium models into an interarea trading system" (Fox and Kumar (34), p.79).

Other methods based on the concept of nodality include the use of Graph Theory (Nystuen and Dacey (84), Boudeville (17)). This enables the degree of association to be identified between pairs of population centres by identifying the strongest flows of some economic

or sociological parameter. The flows are represented in matrix form and to find the principle nodes all but the strongest flows are removed. The principle of transitivity is adhered to and a node is "subordinate" when its flow that is strongest is to a larger centre, and "independent" if it is to a smaller centre.

A recent study by Huff (52) has attempted to delimit the spheres of influence of the major American cities, designated first order by Berry's (9) principal components analysis. These spheres of influence were calculated using a simple gravity model to determine *isoprobability* lines of trip distributions.

The equilibrium line between any two cities h and k is given by

$$\frac{S_k/D_{ik}^{\gamma}}{\sum_{j=1}^{n} S_j/D_{ij}^{\gamma}} = \frac{S_h \,/\, Dih^{\gamma}}{\sum_{j=1}^{n} S_j/D_{ij}} = P_{ij} \quad , \quad f = h,k.$$

where P_{if} is the probability of an individual located at point i travelling to urban centre f and is proportional to the Urban Size S_f. D_{ij} is the distance from i to f and γ is the usual distance exponent. The boundaries of the spheres of influence are given by the tangent of the two regions isoprobability curves.

In summary, since growth is inevitably concomitant with and transmitted through the development of the urban hierarchy, it would seem that the most appropriate way for studying spatial growth should be based on a regional delineation which is basically determined by the urban system. However most of the work on aggregate growth models has

been based on a broad punctiform regional classification, and one of the major future developments of work in this area must be the construction of models based on a more disaggregated classification, perhaps along the lines suggested by Fox.

CHAPTER THREE

MACRO DYNAMIC THEORIES OF GROWTH I: THE NEOCLASSICAL MODEL

Since regional growth theory is still at a very rudimentary stage, it is not surprising that the initial theoretical work in this field mainly consisted of the adaptation of the highly aggregative models of growth theory to a regional setting. This form of analysis treated each region as a point economy and abstracted from continuous space, in that no account of the influence of spatial interaction between regions was explicitly considered. Nevertheless, these models shed some light on the fundamental determinants of growth.

At this level of abstraction, there are basically two different approaches to the formulation of regional growth models. Indeed, it is probably accurate to say that these approaches represent different paradigms, in Kuhn's interpretation of the concept. The earliest and most fully developed approach was based on the early Keynesian dynamics (Harrod-Domar) and especially the later neoclassical reformulation. The alternative paradigm, based on the Cambridge School, rejects most of the basic tenets of neoclassical analysis, notably the marginal productivity theory of distribution. In this chapter, the neoclassical model will be examined.

However, there is a complementary approach, emphasising the industrial structure, which must be mentioned, especially as it is

introduced into the neoclassical model. This 'industrial structure' approach is basically concerned with differentiating between the *compositional* and *differential* components of a region's growth. The former is the rate of growth that can be attributed to a region specialising in nationally fast or slow growing industries. The differential (or residual) effect is attributable to factors that cause the region's industries to grow faster or slower than their national counterparts (e.g., changing locational advantages or supply constraints).

A commonly used technique to discriminate between these two components is shift and share analysis, but it must be emphasized that this is not a theory of growth *per se*, but merely a scale dependent standardisation technique.[1] Other related forms of analysis include regional input-output techniques (Richardson (104)) and regional multipliers.[2] However, these techniques will not be discussed in this paper because they are more relevant to the medium term, whereas we are concerned with the long term, where the supply side is the more important determinant of growth.[3, 4]

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[1] See for example Brown (19), Mackay (71), Stillwell (125).

[2] The recent revival of interest in regional multipliers is discussed by Gordon (40).

[3] For a discussion of the relationship between the medium and the long term analysis of regional growth see Brown (20), Chapter 4.

[4] Siebert (113) Chapter 3, does distinguish between demand and supply determined growth in the context of an aggregate growth model. The rate of growth of income is specified by the following equation

$$dY = \min(dO, dD)$$

where O and D is output and demand respectively. Most growth models assume full employment so demand is not an effective constraint.

It is perhaps worthwhile to draw the usual distinction between growth and development. Growth models concentrate on the expansion over time of a few given aggregates such as the capital stock, productivity and the labour force. "Development" focuses on those factors that cannot be easily formalised, such as institutional and structural change and the interaction of the social and economic spheres.

The Determinants of Growth in a Neoclassical Growth Model

A simple explanation of regional growth patterns has been to adapt the Solow-Swan model to a regional setting. This procedure has been adopted by Borts (14), Borts and Stein (15) and Romans (107). The basic assumptions of neoclassical economics are adhered to: viz., atomistic competition prevails, factors are paid their marginal products and the capital-labour ratio is determined by relative factor prices. These assumptions are defended along the lines of Friedman's "positive economics" (36). "The theory of growth developed should be evaluated in terms of its ability to explain empirical phenomena and not in terms of the verisimilitude of the assumptions made" (Borts and Stein (15), p. 48).

The basic dogma of this paradigm is that the forces of the market economy tend towards a situation where the rate of growth of per capita income and the profit rate is invariant between regions. Indeed, in its pure form the neoclassical model suggests that no regional disparities should exist. Any deviation from the equilibrium situation is caused by market imperfections and the lack of instaneous movements of factors of production to counteract these anomalies.

This has been most clearly stated by Romans (107, p. 13):

> "The Pareto efficiency optimum is a condition of long run equilibrium under perfect competition. Whenever the efficiency optimum does not exist labour and capital resources should be expected to restore it. Any disequilibrium in the allocation of resources between regions promotes economic forces which react on the flow of capital to achieve an equilibrium. But the equilibrium is a long-run concept and one that is never actually achieved because of continuing changes in demands for the output of particular regions, in technology, in resource availability, and in non-economic forces influencing human migration. Thus capital and labour continue to flow between regions, tending to bring about the elusive equilibrium. The concept of Pareto optimum is static".

Let us first consider the determinants of growth of the neoclassical model. It is assumed that the regions have identical Cobb-Douglas production functions

$$Y_i = A_{ti} K_{ti}^{\alpha} L_{ti}^{\beta} \qquad (1.1)$$

where α, β are the output elasticities of capital and labour respectively. The production function has the property of constant returns, which, with the existence of transport costs, would derive a *uniform* distribution of industrial and service activity, and would prevent town formation. Consequently, in order to remove this highly undesirable property Samuelson's (110) "asymptotic homogeneity theorem" has to be invoked and some initial indivisibilities in the production function assumed.

The rate of growth of output is given by

$$y_i = \alpha k_i + \beta l_i + g_i \qquad (1.2)$$

[1]

[1] The proof of this is easily obtained by differentiating (1.1) with respect to time. For a particularly clear exposition see Hamburg (45, p. 47). See also the Annex, p. 119.

An equilibrium condition is

$$r = MP_{k_i} = \alpha_i Y_i / K_i \tag{1.3}$$

where r is the national rate of interest and MP_{k_i} is the marginal productivity of capital. Consequently

$$y_i = k_i \tag{1.4}$$

From (1.2) and (1.4) it follows that

$$y_i = k_i = (g/1-\alpha) + \ell \tag{1.5}$$

Assume savings are proportional to output

$$S = sY \tag{1.6}$$

then $I \equiv kK$ and capital imports will occur if kK exceeds sY, i.e., if the following condition occurs

$$y_i > s_{i/\alpha_i} r \tag{1.7}$$

From this it follows that the greater the rate of growth, the more likely it will be that the state will import capital.

The national rate of interest is determined so as to equate total savings with total investment

$$\Sigma I_i = \Sigma S_i = \Sigma r(s/\alpha)_i K_i \quad (i = 1,2,) \tag{1.8}$$

Therefore,

$$r = \frac{\Sigma I_i}{\Sigma (s/\alpha)_i K_i} \tag{1.9}$$

If s/α is invariant regionally, then the national interest rate is proporational to the overall growth of capital;

$$r = (\alpha/s)k \tag{1.10}$$

This is then the general framework that is used to analyse regional growth. It determines both regional growth rates and interregional capital movements. The main determinants of growth are the rate of growth of the labour force and the rate of growth of technical progress. As will be seen, this latter determinant includes gains made through increased efficiency in the intraregional allocation of resources. However, the model abstracts from any spatial impact of innovations. "A new manufacturing process or a new machine is, under competition, available to all. While it may be introduced more rapidly in one place than another, this difference is a result of the alertness entrepreneurship in different places and the possibility of expansion generated by other economic determinants of growth" (Borts and Stein (15, p. 8).

Other noneconomic forces that may be invoked to account for

regional disparities, such as the differential impact of trade unions, variations in entrepreneural dynamism or the exhaustion of agglomeration economies are rejected as important considerations.

A Simple Aggregative Model of Growth

The simplest model that can be constructed assumes that each region produces the same good for the national market. Assuming no transport costs and homogeneous factors, then the model implies that the marginal products of capital and labour are unique functions of the capital labour ratio.[1] Consequently

$$f_L = g(k) \qquad f_c = h(k) \tag{2.1}$$

then if

$$g(k)_A > g(k)_B \tag{2.2}$$

$$h(k)_B > g(k)_A \tag{2.3}$$

where A and B designate the two regions.

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[1] Given a production function

$$Y = LF(K/L,1)$$

$$Y = Lf(k)$$

where $k = K/L$, then it follows that

$$r = f'(k)$$

$$w = f'(k) - kf'(k) \quad .$$

(see Annex, p.123).

Given the assumptions that capital and labour will respond to differentials in the rate of return and wages respectively, the model will tend to equilibrium and it is possible to derive two testable hypotheses.[1]

(1) low wage regions will experience the highest rates of growth of capital and of the ratio of capital to labour because of the inflow of capital and outflow of labour;

(2) low wage regions will experience the highest rates of growth because of the relation between the growth of the marginal product of labour and the growth of the capital-labour ratio.

However, if certain of the assumptions are contradicted, so also will be the implications of the model. For example, it is likely that the natural growth rate of labour may vary regionally. If the rate of growth of labour is fastest in the low wage region and labour is not sufficiently mobile, then the low wage region will experience the higher rate of capital accumulation, but not necessarily in per capita income. This occurs because the internal growth of the labour supply prevents a rise in the capital-labour ratio and may actually cause it to fall (Bjork (11)). Consequently it is necessary to examine the impact of differential factor mobility on regional growth.

Aggregate Regional Growth and Factor Mobility[2]

Let us assume a two region economy, with the standard regional Cobb-Douglas production functions.

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[1] See Borts (14).

[2] This section draws heavily on Siebert (113), Chapter 6 and 7.

$$Y_{it} = A_{it} K_{it}^{\alpha_i} L_{it}^{1-\alpha_i} \qquad i = 1, 2. \tag{3.1}$$

(with the usual notation.)

Growth rate differences may be expressed as

$$\dot{Y}_1/Y_1 - \dot{Y}_2/Y_2 = \frac{\dot{A}_1}{A_1} - \frac{\dot{A}_2}{A_2} + \alpha_1 \frac{\dot{K}_1}{K_1} - \alpha_2 \frac{\dot{K}_2}{K_2} + (1-\alpha_1) \frac{\dot{L}_1}{L_2} - (1-\alpha_2) \frac{\dot{L}_2}{L_2} \tag{3.2}$$

Interregional factor movement is a function of the differences in productivity of the respective factor in the relevant region. Thus the rate of growth of the capital stock may be expressed as

$$\dot{K}_1 \equiv (K_{it} - K_{it-1}) = \dot{K} + {}_j\eta_i \left(\frac{r_i - r_j}{r_i}\right) K_j + {}_j\eta'_i \left(\frac{r_i - r_j}{r_i}\right) \dot{K}'_j - {}_i\eta_j \left(\frac{r_j - r_i}{r_j}\right) K_i + {}_i\eta'_j \left(\frac{r_j - r_i}{r_i}\right) \dot{K}'_i \tag{3.3}$$

where ${}_j\eta_i$ is the mobility coefficient of capital with respect to differences in the rates of return,

${}_j\eta'_i$ is the mobility coefficient of capital accumulated in period t-(t-1).

$${}_j\eta_i = \frac{j\dot{K}_i/K_j}{\frac{r_i - r_j}{r_i}} \qquad \left\{ {}_j\eta_i \gtreqless 0 \,|\, r_i \gtrless r_j \right\} \tag{3.4}$$

Define $U = j\eta_i K_i + j\eta'_i \dot{K}_i$ (3.5a)

$V = i\eta_j K_j + i\eta'_j \dot{K}_j$ (3.5b)

then

$$\dot{K}_i = (r_i - r_j)\left(\frac{U}{r_i} + \frac{V}{r_j}\right) + \dot{K}_j \quad \left\{ U \geqq 0 \,|\, V \leqq 0 \right\} \tag{3.6}$$

Similarly, for the rate of growth of labour in region i we can derive the expression

$$\dot{L}_i = (W_i - W_j)(T/W_i + z/W_j) + \dot{L}_i \tag{3.7}$$

where $T = j\rho_i L_j + j\rho'_i \dot{L}_j'$ (3.8a)

$z = i\rho_j L_i + i\rho'_j \dot{L}_i'$ (3.8b)

where ρ is the elasticity of labour with respect to differences in regional wage rates.

Define

$G = \alpha_1/K_1 + \alpha_2/K_2$; (3.9a)

$E = (1-\alpha_1)/L_1 + (1-\alpha_2)/L_2$ (3.9b)

then it follows from equation (3.1) that

$$y_1 > y_2 \mid a_1 + (r_1-r_2)\left(\frac{U}{r_i} + \frac{V}{r_2}\right)G + \alpha_1 k_1 + (1-\alpha_1)\ell_1 > a_2 + (w_2-w_1)\left(\frac{T}{w_1} + \frac{z}{w_2}\right)\varepsilon + \alpha_2 k_2 + (1-\alpha_2)\ell_2 \qquad (3.10)$$

From equation (3.10) certain inferences may be drawn. For instance, *ceteris paribus*, the greater the rate of growth of the internal determinants (a,k,ℓ) of one region, the greater the difference in regional growth rates. Furthermore the more immobile the internal growth determinants, the greater will be this growth differential. It is also easy to see that the more mobile the scarce factor of a region (which, therefore, commands the higher price) and the less mobile the abundant factor, the greater will be the interregional growth difference. From this the following theorem may be deduced:

> "A growth differential can exist only if differing factor mobilities prevail. A permanent growth differential presupposes some immobility of at least one factor. Historically natural resources can be regarded as this factor".[1]

Consequently, growth differentials may originally be the result of differing factor intensities. Moroney and Walker (79) have indirectly shed some light on the relative importance of these two processes. They attempted to test the Hecksher-Ohlin theorem, which states that a region or country will export the good that uses its

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[1]See Siebert (113), pp. 135-153.

abundant factor more intensively.[1] It is assumed that each region has the same production function, so this logically implies that trade is caused by greater endowments of capital or labour. Considerable empirical work has been carried on this theorem ever since Leontief presented his famous "paradox" paper (this showed, by the use of input-output analysis, that the U.S. exports relatively labour intensive commodities compared to her exports, whereas, a priori, one would have expected the converse).

Moroney and Walker tested two hypotheses:

"(1) There is an inverse rank ordering between capital-labour ratios and location quotients in the south";

"(2) There is an inverse rank ordering between capital-labour ratios and *percentage changes* in location quotients".

However, hypothesis 1 "fails to predict the areas of manufacturing where the south's comparative advantage lies, at least in terms of homogeneously defined capital and labour alone. Indeed, there is some indication that the south experiences a comparative advantage in relative *capital intensive* industries". The reason why the prediction is unsatisfactory, Moroney and Walker argue, is that the model fails to take account of natural resources in the production function (i.e.,

[1]The Hecksher-Ohlin theorem is concerned with the tendency towards factor price equalization cause by *trade* rather than by *factor mobility*. However these are complementary elements. Given complete factor mobility there would be no interregional trade, and conversely, under certain assumptions even with complete factor immobility, trade may cause factor price equalisation (Mundell (80). However, free trade and factor mobility are not *perfect* substitutes. Olivera (86) argues that although both may lead to factor price equalization, it is not guaranteed that they will be equalized at the same level.

the "southern conditions").

Hypothesis 2, on the other hand, was substantiated. Thus, they argue that the pattern of development seems to be that the endowment of natural resources may be of more importance than the relative abundance of capital or labour in determining the initial structure of comparative advantage.

After this initial structure has been established, however, relative endowments of capital and labour become progressively more important in influencing the pattern of industrial growth. It could be argued that Moroney and Walker would seem to provide confirmation of the argument that initially resources are important (cf. North's export base theory), but, as industrialization progresses, so the relative endowment of capital and labour becomes the dominant factor. (This, of course, raises the question of why some regions have greater endowments of capital than other areas. To have to resort to postulating a greater skewedness in the income distribution or varying regional subjective rates of time preference is not very satisfactory.)

Moreover, the above analysis is open to the charge of circular reasoning since the failure of the Hecksher-Ohlin theorem to predict regional comparative advantage is always open to the explanation that there are differing production functions.[1]

It is possible to use equation (3.10) to discuss the implications of external economies on regional growth, although Siebert does not seem to realise the difficulty of reconciling some of the factors he

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[1]See page 60.

introduces with the use of a neoclassical production function.[1] The easiest way to incorporate the effects of agglomeration economies is to treat them as an internal growth determinant. Thus "the more immobile external economies are interregionally, the greater the growth differential. The more mobile external economies, the smaller the growth differential". Consequently, it is possible that the polarization effects of Myrdal and Hirschman may be introduced into the model.

One important distinction can be made with the help of the model. Given an immobile autonomous growth factor, then the mobility of the induced variable, by definition, will be greater. This gives rise to an important policy implication. "If an important growth determinant remains immobile, the increased mobility of other factors reinforces growth differentials and thus moves the economy further away from the desired situation" (Siebert (113, p. 144)). In other words the theory of the second best is appropriate here (Lipsey and Lancaster (66)).

Moreover if there are "levelling effects" such as supply

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[1]One of Siebert's earlier theorems would seem to be incompatible with a Cobb-Douglas production function. He argues that "the greater the weight of a factor in the production function, the higher the growth rate of the region with an increase in that specific factor" (p. 136). Formally, given $k_1 = k_2, l_1 = l_2$

$$\frac{\dot{Y}_1}{Y_1} > \frac{\dot{Y}_2}{Y_2} \qquad \frac{(\alpha_1-\alpha_2)k}{(b_2-b_1)l} > 1, \quad \text{for } b_2 > b_1 .$$

This is simply wrong, since given a Cobb-Douglas production function $(b_2-b_1) = (\alpha_1-\alpha_2)$. Consequently the relative weight of the factors has no effect on the rate of growth.

constraints then, *given a growth differential,* reduced factor mobility will induce a diminishing of regional disparities. However, increased interregional mobility is necessary to reduce the *growth differential* determinant, per se.

As has been mentioned these considerations are not a formal part of the model but a verbal generalization of it. If, however, agglomeration economies, increasing returns and economies of scale are thought to be important then the neoclassical paradigm, with its inability to satisfactorily incorporate these effects, becomes of limited value.

In spite of these reservations econometric work has been undertaken to quantify the effects of resource mobility on regional growth (based on the simple aggregative model). The theoretical framework was developed by Fukuchi and Nobukuni (37),[1] although conceptually it is very similar to Siebert's model.

Assume n regions each with the same Cobb-Douglas production function:

$$Y_{ij} = A K_{i,t}^{\alpha} L_{i,t}^{\beta} \qquad \beta + \alpha = 1 \qquad 0 < \beta, \alpha < 1 \qquad i = 1,\ldots,n \tag{4.1}$$

Similarly, the rate of growth of labour and capital is given by

$$\Delta L_{i,t} = (\rho\pi_{i,t-1} + l)L_{i,t-1} \tag{4.2a}$$

$$\Delta K_{i,t} = (n\lambda_{i,t-1} + k)K_{i,t-1} \tag{4.2b}$$

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[1] See also Renaud (99).

where ρand n are the output adjustment coefficients of the inter-regional movement of labour and capital.

$\pi_{i,t-1}$ is defined as

$$\{\left(\frac{\partial Y}{\partial L}\right)_{i,t} - \left(\frac{\partial \bar{Y}}{\partial \bar{L}}\right)_{t}\} \div \left(\frac{\partial \bar{Y}}{\partial \bar{L}}\right)_{t} \tag{4.3a}$$

$\lambda_{i,t-1}$ is defined as

$$\{\left(\frac{\partial Y}{\partial K}\right)_{i,t} - \left(\frac{\partial \bar{Y}}{\partial \bar{K}}\right)_{t}\} \div \left(\frac{\partial \bar{Y}}{\partial \bar{K}}\right)_{t} \tag{4.3b}$$

From (4.1),(4.2) and (4.3)

$$\dot{Y} = \beta \dot{L}_{i,t} + \alpha \dot{K}_{i,t} \tag{4.4}$$

$$= (\beta\rho\pi_{i,t-1,} + \alpha\mu\lambda_{i,t-1}) + (\beta l + \alpha k) \tag{4.5}$$

$$(\dot{Y}/L) = \alpha(\mu\lambda_{i,t-1} - \rho\pi_{i,t-1}) + \alpha(k - l) \tag{4.6}$$

In a frictionless neoclassical world,a balance growth path (BGP) could be easily identified as the path where per capita is equal in every region.

$$(Y/L)_{i,t} = (Y/L)_{j,t} \qquad i \neq j,\ ij = 1, 2, \ldots, n \tag{4.7}$$

BGP is stable if and only if

$$\lim_{t\to\infty} \operatorname{var}\left(\frac{Y}{L}\right)_t \to 0 \text{ for } \operatorname{var}(Y/L) \geqq 0 \qquad (4.8)$$

It can be easily shown that the BGP is stable if and only if

$$0 < \beta n + \alpha\rho - \alpha(k-1) < 2 \qquad (4.9)$$

[1]

The BGP is therefore a function of the relative share of labour and capital, of their mobility and overall growth rate. In general it can be seen that the greater the mobility of capital and/or labour, the higher the speed of convergence of per capita income.

However, inspite of the degree of work undertaken on the simple aggregative model, empirical tests using Easterlin's regional income data for the United States, showed that the model's predictive power was quite weak. During the periods 1919-1929 and 1948-1953, both the rate of growth of capital and wages was higher in the high wage regions.[2] Borts and Stein adduce several ad hoc reasons to account for this, but all necessitate abandoning the simple one sector model. For instance, it is possible that the rate of migration into the high wage region induced capital formation in the overhead capital sector. The rate of return may therefore be considerably higher in the latter sector, because of capital specificity. It is also possible that the demand for the high wage region's commodities was growing faster than that for the low wage region's goods. Consequently although the *marginal physical*

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[1] For proof see Fukuchi and Nobakuni (37).

[2] Borts and Stein (15), Table 3.1, p. 54).
Bjork (11), Table 1, p. 83).

productivity of capital fell in the high wage region the *marginal efficiency* of capital rose, stimulating a faster rate of investment.

In order to improve the model it is necessary to disaggregate it. The two determinants of growth are the growth of the labour supply and the rate of technical progress. Consequently, following Borts and Stein, it is useful to consider the factors influencing these determinants.

Factors Influencing the Regional Labour Supply and the Intraregional Allocative Efficiency

In the United States during the period 1919-1953, there is a high correlation between the rate of growth and of manufacturing and of ratio of nonmanufacturing to manufacturing employment in the state. We may consider the rate of growth of the employed labour to be a function of two components; (1) the elasticity of the labour supply schedule facing a specific industry (S_i), (2) the degree of shift of this function (v_i). The former may be regarded as a short term effect, reflecting the increased availability of labour at higher wage levels. The latter reflects a long term effect, a function of the rate of immigration, intersectoral shifts of labour and the natural rate of growth of the population.

In long run equilibrium, under the usual neoclassical assumptions, every industry selects a capital-labour ratio (q), so that the physical marginal product of capital, f(q), equals the rental of the capital good per unit of time divided by its price. Formally

$$f(q) = z/P \qquad f' < 0 \tag{5.1}$$

Similarly

$$F(q) = w/P \qquad F' > 0 \tag{5.2}$$

where z is the rental per unit time, P the price and F(q) the marginal productivity of labour.

The labour supply function is given by

$$w = {}^{1}/_{v}\, g(L) \tag{5.3}$$

It can be shown that[1]

$$L_i^* = s_i(P^* + {}^{\mu}/_{e}\, k^* + v^*) \tag{5.4}$$

where μ is the elasticity of the marginal productivity schedule with respect to q and e is the marginal productivity schedule of capital with respect to q.

If we assume identical production functions then v/e will be the same between regions and,given $s_i = s_j$ then

$$L_i^* > L_j^* \quad \text{if } v_i^* > v_j^* \tag{5.5}$$

Thus, interstate differences in the rates of employment, in long run equilibrium, will be a function of the degree of change of the shift factor (In practice, however, it is very difficult to differentiate between s_i and v_i).

From the model it is possible to deduce that the rate of growth of industrial employment will be higher in states with relatively low

[1]For derivation see Borts and Stein (15, p. 80). See also p. 120.

ratios of manufacturing to total employment. Any wage differentials that exist between nonmanufacturing and manufacturing industry will be reduced as intrasectoral mobility (exogeneously) increases.

Moreover, migration occurs from low to high wage areas. Consequently in the low wage areas v_i^* is less, and in high wage areas it is greater, than one would expect on the basis of the rate of growth of the population of the state.

However, the rate of growth of employment will not necessarily be higher in low wage areas. This is because there are two counter-balancing forces at work. On the one hand, capital should move into low wage areas generating a demand for labour. However, emigration tends to reduce v* in low wage areas. Which effect will dominate will depend on which factor is the more mobile (cf.,page 27).

The relative stability of the fast growing areas may be explained by the invariance over time of the ranking of states by the percentage of total employment in manufacturing (i.e., the more heavily industrialised regions had the slowest rates of growth).

This last conclusion suggests that there are two important labour sources. There is the increase in labour due to population growth and additional labour that can be released to manufacturing by a more efficient allocation of resources.

Borts and Stein computed the *hypothetical* growth rates of the regions and found that there was no correlation between it and the *actual* rate of growth. In fact there was a negative correlation between the hypothetical growth rates and the internal (differential) rate. The suggested explanation is the following: states that have a favourable

composition of industries can only draw on labour from other industries. This competition for resources produces a brake on the internal growth rate, thus reducing the actual growth rate. Conversely, in regions with hypothetical growth rates that are unfavourable, the absorption of labour from the other regional industries will not necessarily reduce the internal growth rate but may actually raise it. However, interregional migration may offset this process.

While there is no doubt that this factor does have an important effect on growth rates it is not solely confined to the neoclassical framework (Kaldor (57). Moreover the structural effects are difficult to reconcile with the more abstract model with perfectly malleable capital,[1] which,furthermore derives the rate of growth of labour to be the exogenous *determinant* of the regional growth rate, since the model is essentially supply orientated. If we are to introduce the demand/structural hypothesis, this raises the question of why do some regions induce industries to grow relatively fast? The neoclassical model does not provide a satisfactory answer.

A Synthetic Model of Regional Growth

It is now possible to briefly discuss the two sector model formulated by Borts and Stein,[2] to explain these interrelationships. It is not possible to comment on all the logical implications of this model, and only the broad conceptual issues will be discussed.

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[1] An obvious future development would a vintage regional growth model

[2] Borts and Stein (15), Chapter 7. Since the concern of this paper is with the conceptual issues involved and not with the internal consistency of the model detailed proofs are not presented. These may be found in (15), the Appendix of Chapter 7.

A partial equilibrium approach is adopted, the region being considered in relation to the rest of the economy, but no allowance is made for the feedback of the region's growth on the rest of the economy. Two commodities are assumed, a labour intensive domestic good, sold only in the region and a capital intensive export good. The price of the capital intensive good (P_x), the national rate of interest (r) and the price of capital goods (P_k) are all assumed exogeneously determined by forces outside the region. If we assume that there is an efficient allocation of resources within the region (so that the wage and profit rates are equal between the two sectors) then it may be easily shown that wages, profits and the capital-labour ratios are uniquely determined.

By assumption

$$\bar{r}\bar{P}_k = \bar{P}_x f_k \tag{6.1}$$

Defining the general production function to be

$$Y = L(k_x) \qquad \text{where } k_x = (K_x/L_x) \tag{6.2}$$

then

$$f_{kx} = f'_x(k_x) \tag{6.3}$$

Similarly for the domestic good;

$$f_{ky} = f'_y(k_y) \tag{6.4}$$

$$f_{Ly} = f_y(k_y) - f'_y(k_y)k_y \tag{6.5}$$

Moreover,

$$f'_i(k_i) > 0, \quad f''_i(k_i) < 0 \quad i = x,y \text{ for all } k_i > 0 \tag{6.6}$$

The wage rental ratio is given by

$$w/r = \frac{f_i(k_i)}{f_i'(k_i)} - k_i \tag{6.7}$$

Equation (6.7) determines a unique relationship between the factor price ratio and the technique (i.e., the capital-labour ratio (k_i) used in the sector).

$$\frac{dk_i}{dw} = \frac{-(f'_i)^2}{f''_i f_i} > 0 \tag{6.8}$$

(6.8) is positive in view of (6.6). Thus, a labour becomes relatively more expensive, more capital is substituted for labour in each sector. Consequently, the wage and profit rate of the region and the capital-labour ratio of each sector (given the technologically determined output elasticities) is uniquely determined by (6.1).

If we assume that the space economy is in a "golden age" and there is no technical progress, then the neoclassical model predicts that the rate of growth is equal to and *determined by* the rate of growth

of labour.

However, resource allocation within the region is not initially efficient, there being too much labour in the domestic sector. Hence the wage in sector Y is less than that of the export sector, and this may be expressed as

$$w_x = \gamma w_y \qquad (6.9)$$

where $\gamma > 1$.

γ is assumed to decline, and, pari passu, w_y rise, exogeneously, over time.

The allocation of resources between sectors may be altered only by changing one of the determinants of resource allocation: P_x, P_k, r or γ.

First let us consider the effects of a change in P_x. Short-run analysis in terms of the balance of payments adjustment would lead to an examination of money flows, income multipliers and sectoral price levels. It would lead to the conclusion that the region with the higher export demand would experience an increase in the money stock, inflation and a rise in imports. The final equilibrium would be a position where exports exceeded or equalled imports. However, the position under consideration here is the long-term effect, and it will be seen that the rise in export prices will lead to a growth in the region's capital stock and, consequently, to an increase in the region's rate of growth.

Using equation (6.1), $\bar{r}\bar{P}_k = \bar{P}_x f_k$, it is easily seen that if P_x rises then X must suffer a corresponding fall in the capital-labour ratio. There is, therefore, a substitution effect. The output of X

contracts, the capital-labour ratio of Y also falls and wages rise. The price of both the domestic sector goods and the export goods rise. Thus, the price of capital goods becomes relatively cheaper to the region, stimulating accumulation (i.e., even though the marginal physical productivity of capital falls, the marginal efficiency of investment rises).

Formally, given

$$P_x^* + f_k^* = 0 \tag{6.10}$$

where the asterisk denotes percentage rate of change.

Define

$$\mu = f_{x/(L_x/K_x)}^* \tag{6.11}$$

where μ is the elasticity of the marginal productivity of capital in X

$$P_x^* + \mu L_x^* + \mu K_x = 0 \tag{6.12}$$

$$K_x^* = P_x^*/\mu + L_x^* = 0 \tag{6.13}$$

Let $L_x/L = \varepsilon$, where ε is the proportion of the region's labour in the export sector.

Consequently

$$L_x^* = \varepsilon^* + L^* \tag{6.14}$$

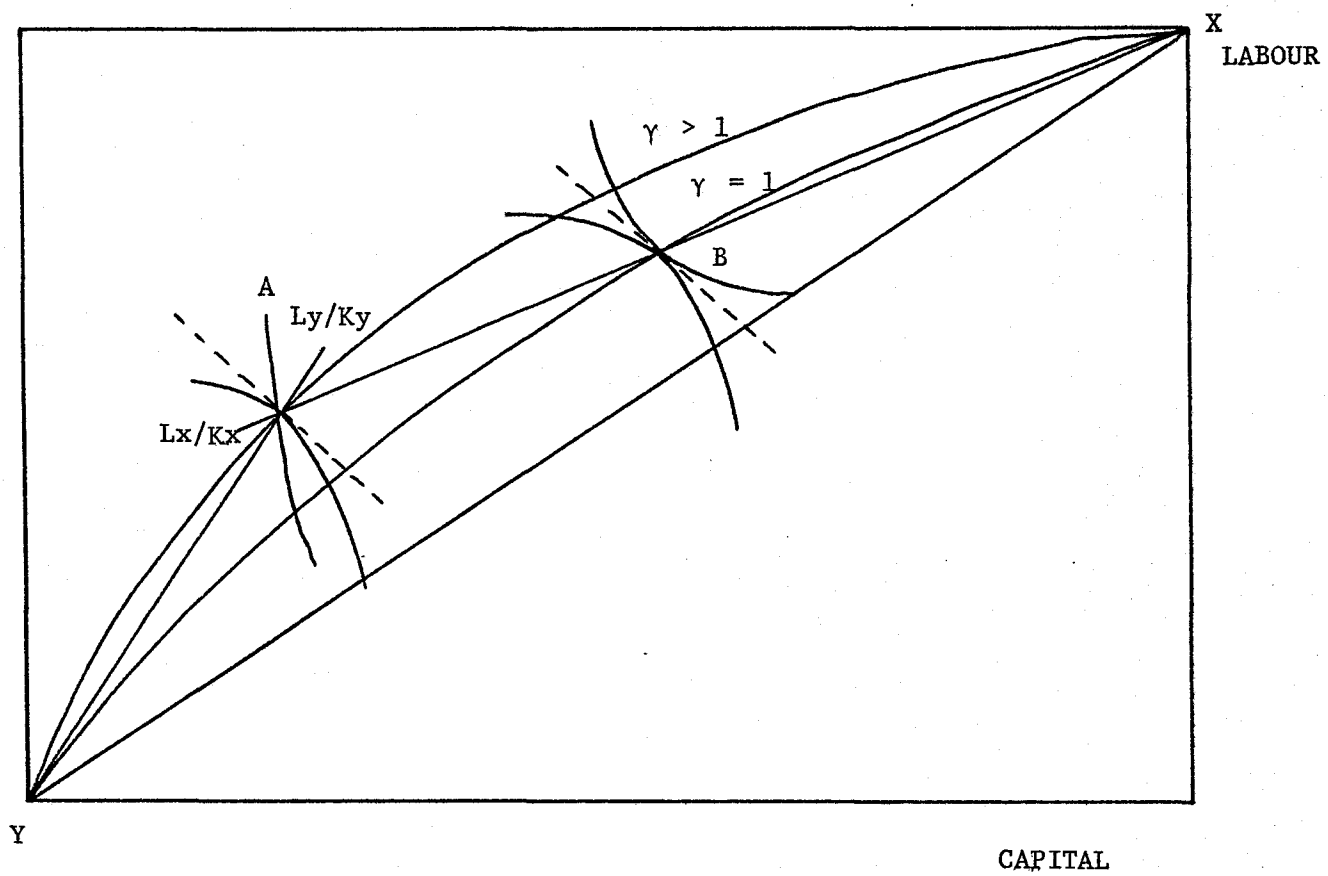

FIGURE 1(a)

Then

$$K^*_x = P^*_x/\mu + L^* + \varepsilon^* \tag{6.15}$$

and

$$\Delta K = K\{P^*_x/\mu + L^* + \varepsilon^*\} \tag{6.16}$$

It is possible to show that the shift of labour into the export sector will be positive if the elasticity of substitution of this sector is less than one. If this occurs factor payments will turn in favour of labour.

In order to consider the effect of this disturbance on the capital flow it is necessary to determine whether the increased capital accumulation will be met by increased savings. Borts and Stein demonstrate that even if the investment level returns to its original level after the discontinuity, there will be no later outflow of capital from the region compensating for the original inflow. Indeed under certain circumstances there may be a perpetual inflow.

The second factor influencing the rate of growth of the region is due to the progressive increase in the efficiency of resource allocation. This increase in efficiency (reflected in the exogenous narrowing of the intersectoral wage differential, γ) is, empirically, a major source of differential regional growth. However, this analysis will demonstrate how the use of the neoclassical model in the examination of imperfections in the market mechanism can produce ambiguous results.

The initial misallocation of resources may be shown in the traditional Edgeworth Box diagram (Figure 1a). At the point A, the wage in the agricultural sector is less than that in the export sector, so that $\gamma w_y = w_x$, where $\gamma > 1$. It is possible to construct an "inefficient contract curve" along which γ is constant.

According to Borts and Stein, as γ declines we move from one contract curve to another. But equation (6.1) constrains the labour capital ratio in the export sector to be constant. Consequently, the movement occurs from A to B along the ray L_x/K_x. The capital labour ratio falls in the domestic sector. Wages are now higher in Y, as also is the price of the domestic good. Thus, the price is now higher relative to the price of the imported capital good. We may regard the movement of the allocation of resources from A to B as a substitution effect, but it will also induce capital accumulation, which will expand the dimensions of the box and the output of X will eventually expand and that of Y contract absolutely.

However,there seems to be some ambiguities in the above economic reasoning. The neoclassical assumption of the returns to the factors being equal to their marginal products is retained. As a logical consequence, if wages are lower in the Y sector at A it follows also that the labour capital ratio must be higher in the domestic sector than at the point of efficient allocation of resources (B). Furthermore, the absolute labour force in agriculture is below the requisite number at B. The amount of capital is proportionally even smaller, so the L_y/K_y ratio is higher. Consequently, contrary to empirical evidence the initial misallocation of resources means that labour, paradoxically, is

below the optimum level. With a decline in the wage differential, in a static context, the profit rate in agricultural rises until at B, by definition, it equals the rate of return in the export sector. If initially this rate of return equals the national rate of interest (as it is assumed to) it is difficult to see why the movement of the regional economy from A to B should *ceteris paribus* stimulate increased capital accumulation.[1]

A more intuitively plausible approach is to abandon the marginal productivity theory of distribution. Consider Figure 1.b which shows the standard isoquant diagram for the output of commodity Y. Relative factor prices only determine the capital-labour ratio if the tangency to an isoquant falls within the "economic region". For instance,given the factor price ratio (marginal rate of substitution) AA', then the relative level of capital and labour is derived to be $\bar{K}$ and L' respectively. However, if the capital stock is given by $\bar{K}$ but the labour supply is given, exogenously, to be L", then the latter's marginal productivity is infact negative and the marginal productivity theory no longer is valid. Kaldor (verbal communication) argues that this latter state of affairs is typical of early homesteading situation in the U.S. and also the agricultural sector of many underdeveloped countries today. The amount of labour in agriculture is not determined by factor prices but by noneconomic factors such as kinship, since even in advanced countries farming remains traditionally a family concern.

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[1]Borts and Stein, however, mathematically derive an expression purporting to show that their geometric interpretation is correct. At the present stage this is left as a mathematical perplexity.

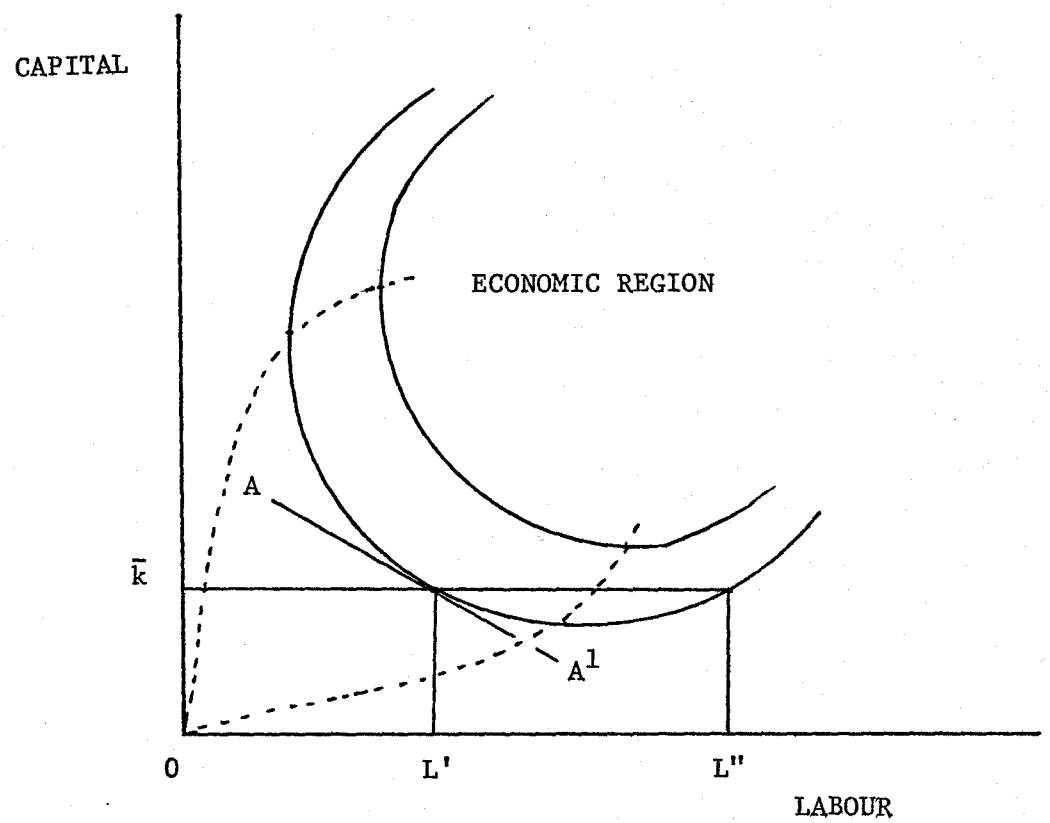

FIGURE 1(b)

Consequently, as the experience of such countries as France clearly show there is *underemployment* of labour in agriculture. This together with the rigid capital specificity, Kaldor argues renders the neo-classical analysis, via the Edgeworth Box, meaningless.

CHAPTER FOUR

A CRITIQUE OF THE NEOCLASSICAL GROWTH MODEL

Although much of the early work on aggregate regional growth models was based on the neoclassical paradigm, the latter has been subject to increasingly severe criticism, notably by Richardson (106). It is useful to consider the criticisms at two distinct, though inter-related, levels. The first concerns the relevance of the neoclassical assumptions to the space economy. These assumptions are felt to be inapplicable in regional analysis since, in effect, they negate space itself. The second level involves the complete rejection of the paradigm, especially the use of the production function and the determination of the capital-labour ratio by the relative factor prices. The rejection of a paradigm necessarily means the adoption of an alternative one, and this will be discussed in the next chapter.[1,2]

Richardson tends to be mainly concerned with the first level.[3] Full employment, perfect competition and constant returns to scale are especially felt to be untenable. Regional problems largely occur because of the differential use of resources (especially labour). Space and transport costs ensure firms have downward sloping demand curves so

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[1]Kuhn (151) provides some interesting insights into the development of scientific thought and the behavioural characteristics of the scientists.

[2]Regional science, perhaps because of its essentially interdisciplinary nature, contains other examples of competing paradigms. Two of the most notable are the utility-entropy controversy and the Neoclassical-Marxian land use theory debate. For a discussion of the latter see (69).

[3]He is content to use the neoclassical production function in his model, even though only for definitional purposes (106,) p. 212.

that they can influence the price of their commodities. Hence, oligopoly, imperfect competition or pure monopoly are more appropriate market structures. The use of linear homogeneous production functions of the first degree abstract from the phenomenon of the agglomeration economies that is an integral part of any explanation of the clustering of firms and population.[1,2] Kaldor's (58) scathing critique of the neoclassical assumptions is invoked with approval. These criticisms are best summarised by the following quotation from Richardson:

> "The working assumptions and abstractions that the neoclassicist uses as a starting point for his analysis could never be justified in a world which recognizes the existence of space as well as time. Space is incompatible with perfect competition, complete certainty, marginal adjustments in prices, outputs and locations and other background assumptions of the neoclassical world. In other words, although a weak case for neoclassical models can be made in aggregate growth theory there is no case at all in regional analysis. However, introducing the spatial dimension reinforces all the other objections to the notion of a homogeneous capital stock and an aggregate production function. The capital stock is heterogeneous not only because it is created in different periods of time (vintage models) and in different sectors each of which embodies a different level of technology (embodied technical progress) but also because it varies with its location. There is little doubt that neoclassicism is succumbing to the gradual accumulation of elegant and sophisticated, though

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[1]See also Mills (76), Chapter One.

[2]The remarkably close fit of data to the Cobb Douglas production function has long been a source of puzzlement to those economists not sympathetic to the neoclassical paradigm. However an important paper by Fisher (33) has demonstrated that this can be explained statistically by the constancy of the relative factor shares and not by the reverse causality based on technological relationships that neoclassical *theory* assumes. Indeed given constant shares, Fisher by means of a simulation experiment, demonstrates that the underlying micro-technological relationship may well show increasing returns to scale. Needless to say "this makes the use of such functions for wide ranging theoretical purposes rather suspect" Fisher, p. 306. At the industry level, Arrow et al.(4) have rejected the hypothesis of constant returns to scale.

> frequently arid intellectual criticism. But its ultimate irrelevance and its gross predictive fallibility are exposed not in the intellecturally respectable and so called "core" realm of capital theory but in the upstart and untamed "fringe area" of regional and urban economics". (106), (p. 23).

However, the high degree of unreality of these traditional assumptions has been long realised in Economics. Discussion of the concept of "Economic Man" may be traced back to Marshall and beyond. Recently, the famous Oxford studies in the mid 1930's also reviewed the controversy as did the Lester Machlup debate in the American Economic Review of 1946.

The traditional line of defence is to argue that merely to criticise the assumptions is to adopt a neo positivist attitude. Since any model, by definition, abstracts from reality, the usefulness of it must be judged by its predictive ability.[1] Indeed, it is argued that these assumptions of the neoclassical model are paradigmatic assumptions and as such are not empirically refutable.[2] Richardson is guilty of epeistomological confusion over this point. He argues, for instance, that as capital flows are the result of the construction of new or the expansion of existing plant facilities, location theory may shed some light on interregional capital movements. However, he considers the profit maximising assumption to be invalid and so, consequently, is the assumption that capital moves solely as a result of

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[1]Friedman (36) argues that the predictive ability should be the *sole* criterion. See also the symposium on methodology in the 1963 American Economic Review.

[2]For a fuller discussion see (69).

differing rates of return, in an equilibrating fashion. "Just at a time when location theory had developed to where it was possible to construct a concrete profit maximising model, microeconomic theorists in general were beginning to display grave doubts about the value of profit maximisation as a rationale for entrepreneural behaviour" (Richardson (101, p. 92).

Machlup (70), for example, argues that this line of reasoning is a case of "misplaced concretness". In the neoclassical theory of the firm (which is really a misnomer) the profit maximising assumption is not a *behavioural* assumption. Indeed 'the firm' is seen as a purely logical construct, analogous to the neutrino in physics. Neoclassical price theory is not designed to examine the reaction of *the firm*, per se, to changes in various variables but to trace effect on the economy. If the former is the object then perhaps the approach of Simon (115) and Cyert and March (26) is, indeed, more appropriate.[1]

To construct a utility function that includes all the possible variables influencing the entrepreneur is a meaningless endeavour. Although entrepreneurs per se do not profit maximise the "natural selection" argument suggests that the environment will constrain firms to profit maximise (Alchian (2), Tiebout (126), Webber (136), pp.105-110), but for a critique see Winter (142), Singh (114)).

It is thus necessary to consider just how successfully the neo-classical model is in predicting regional growth. We will consider the aggregate model and then briefly review the evidence on the determinants

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[1] However, see Marris (74). Marris argues that the most appropriate assumption is that firms maximise their rate of growth - moreover this is seen also as a behavioural assumption and Marris rejects the use

of capital and labour flows.

Borts and Stein's model, which was discussed in the preceding chapter, carefully integrated empirical evidence and the theoretical constructs. The latter was seen to be broadly consistent with the former. Romans (107, pp. 91-98),has also undertaken a rather more direct test.

The neoclassical model predicts that the equilibrium rate of growth is given by

$$I = K\left(\frac{\dot{L}}{L} + \frac{g}{1-\alpha}\right) \qquad \text{(with the usual notation)} \qquad (7)$$

For empirical purposes, Romans defines K as R/r, where R is the net entrepreneural income produced in each region and r is the national interest rate. g was assumed to be regionally invariant and Solow's (119) estimate of 1.5% was used. Investment may be divided into two components - *secular* and *nonsecular* investment. Secular investment is defined to be the amount of capital formation that would be undertaken if there was equilibrium growth and is given by equation (7). In other words "it is that level which maintains the equilibrium of equality of marginal products between regions". Nonsecular investment is caused by disequilibrium (i.e., the existence of wage and profit differentials) and may either disequilibrating or equilibrating. If it is the former,then, by definition, the actual investment would exceed secular investment in regions where the capital-labour ratio was

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of satisficing theories, on the grounds satisficing will tend towards a maximum solution as aspiration levels are raised. Consequently, it is still necessary to understand what this maximand is, even though at any one instance of time an optimum solution is not obtained.

below the national average. If the flows are disequilibrating, in the above case secular would exceed the actual investment. In Romans' analysis the equilibrating movements are taken to be only the capital flows. In so far as labour movements occur, they are reflected in secular investment. For example, suppose migration into a region is one-third of the growth of the internal determinants. Then the secular investment will be greater by the same amount.

If all regions were in long run equilibrium, secular investment, it has been argued, should equal the actual rate of capital formation. Romans tested the hypothesis that this occurred. He found that "for the eight regions secular investment deviated from actual investment by 14%". The greatest deviation occurred in the Far West where the simulated secular investment was 50% above the actual investment. This region, however had the highest income per worker and this suggests that there was a substantial tendency for convergence. The Great Lakes region was the major exception to the expected pattern, since, although there was a 20% excess of actual over expected investment, the region had the highest income per capita of all the regions.

Romans also carried out an alternative test and regressed, using regional rank correlations, the equilibrium growth rate against the observed growth rates. The correlation coefficient was 0.953 (1929-1953) when actual growth was measured in regional income produced and 0.929 (1929-1959) when the measure was growth in personal income. Romans came to the conclusion that "considering the numerous data deficiences, the neoclassical growth model in long run equilibrium explains the pattern of regional investment with considerable precision". It could

be argued that these results vindicate the unrealistic assumptions and that, contrary to Richardson's assertion, the models are not "grossly fallible" in their predictions.

If the neoclassical model is accepted as a reasonable explanation of regional growth, then it follows that space, per se, is of only minor importance. This is a logical consequence of the model, since nowhere is an explicitly spatial variable introduced yet the predictive results are reasonably satisfactory.

However, it is necessary to carefully consider the precise interpretation of these results. The predictions tested are at highly aggregative level and concern such factors as net factor movements and state or regional per capita income and the rate of the growth of the latter. The disaggregation into a Meade type two sector model considerably improves the explanatory power of the model. The main problem, however, in the testing of this model is that, if the plausable assumption that growth is not a purely stochastic process is accepted, then by suitable relaxation or addition of assumptions the model can account for any observed result.

It may be helpful to demonstrate this point with two examples. Richardson has argued that steady state growth implies that the regional growth rates are equal. Suppose that it is observed that there are two regions with the same profit and wage rates (and consequently the same capital-labour ratio) are growing persistantly at different equilibrium growth rates. This can be incorporated into the neoclassical model by simply postulating that the faster growing regions has a proportionally greater savings ratio. Similarly, it is possible to account for

persistant disequilibrium growth (with a high wage region growing persistantly faster than the expected rate or a low wage persistantly slower) by postulating the growth of the internal determinants as being too fast to be offset in an equilibrating fashion by factor mobility. Thus the model can predict both convergence or divergence, which can also be more plausably explained by other models. Consequently, I would argue that the work of Borts and Stein does not constitute a test of the neoclassical model since it is subject to a high degree of circular reasoning.

Romans' simple aggregative test also poses some important methodological problems. The test is concerned with three highly autocorrelated variables, the level of investment, the rate of growth of the labour force, and the rate of disembodied technical progress which is in effect treated as a constant shift factor.[1] However, it is not surprising, given this level of aggregation, there is a very high level of correlation between the rate of growth of the factor inputs. Moreover, high correlations are often obtained between the growth of two variables over time even if there is no theoretical relationship between them.[2]

One of the fundamental questions that any regional growth model must attempt to answer is why do some regions have persistantly different growth rates from other regions. The neoclassical model makes the growth

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[1] As was noted above Romans used Solow's estimate of the rate of growth due to technical progress. However, as Solow himself admits, this estimate is highly suspect. Jorgenson and Griliches (54), estimated the value to be not 1.5% but 0.10%.

[2] On the difficulty in the use of time series see Mendershauser

of labour and technical change the *causal determinants* of growth. While, indeed, it is not surprising that labour growth is highly correlated with regional growth, it is unsatisfactory to regard this as the primary cause of growth and this is implicitly recognised by Borts and Stein when they attempt to introduce industrial structural elements into the model.

The question also arises as whether the predictive ability of a model should be the sole, or even main, criterion for judging the explanatory value of a model. Without wishing to be involved in an epeistomological discussion, it is perhaps worth noting that often *naive* forecasting models produce better predictions than those derived from models consisting of economic functional relationships. However, there is a crucial difference between the ability of a model to predict or forecast and to supply a theoretical explanation of these results. Indeed, it is often the case that many of these theoretical relations are so complex that they cannot be discerned by econometric analysis.

Finally, it is perhaps worth discussing why, inspite of these objections and the empirical evidence (discussed in the appendix to this chapter) that factors do not solely respond to economic forces, neoclassical models have gained such a wide acceptance. One of the major reasons is undoubtably the fact that the model combines a theory of growth *and* factor mobility. Moreover, the main prediction of the model is that there will be a progressive tendency towards regional income convergence (although, of course, this is qualified), which broadly agrees with the United States experience. However, it is unfortunate that the United States is the only country for which there

are regional income estimates available as far back as the 1880's. (Regional income statistics are available for the United Kingdom since 1945). This has encouraged the assumption that the pattern of regional growth of the United States typifies regional development, whereas the converse is more probably true. The U.S. was, in Rostow's phrase, "born free", and was colonized concomittently with the process of industrialization. It consequently had regional population growth rates far exceeding anything experienced in Western Europe or Japan. (From 1910-1950 California's labour force grew by 400%, Florida's by 200% and New York's doubled (Bjork (11), p. 82)).

The recent collation of data on Britain's regional growth experience since the 1880's by Lee (63) suggests a far more complex picture than that assumed by the neoclassical model.

The South East (especially the London Conurbation) has had for the past century persistently above average growth rates, whereas other regional fortunes have been more mixed. At the turn of the century the peripheral regions enjoyed rapid rates of growth and had unemployment levels half the national average. However, since the 1920's these areas have experienced a marked reversal in their fortunes resulting in their lagging growth rates, characteristic of today. What needs explanation is not so much why the peripheral regions experienced this spurt of growth (a simple resource base explanation would suffice) but why (a) this was not maintained, and (b) why the South East, lacking these resources, did not experience a decline in its growth rate. This suggests that any regional growth model must explain why the long run regional comparative advantage, while not easily gained, once sustained

is not easily reduced, even though other regions may experience temporary natural resource advantages. In the next chapter such a model will be considered.

APPENDIX

THE DETERMINANTS OF CAPITAL AND LABOUR MOBILITY

One of the most common objections to the neoclassical (and economic models in general) is that capital and labour do not respond solely to economic forces. Consequently, this appendix briefly reviews the empirical evidence available.

It is generally agreed that capital is the factor of production most subject to economic forces. However, even in this case there are several problems with respect to capital movements that makes the neoclassical model oversimplistic and may prevent complete regional equalization of rates of return to capital. Alternative rates of return in different regions are difficult for entrepreneurs to calculate, even more so than the gains achieved by the movement of labour. The effect of uncertainty involved in investing in the spatially peripheral regions adds a considerable risk premium to the real rate of return (Lösch (67, p. 463), Webber (136, pp. 204-207)). Richardson, (106, p. 308), has developed a simple model that demonstrates how, given the assumption that savings generated in a region will be automatically invested in that region, the need to borrow on the national capital market can cause variations in the equilibrium rate of return on capital (i.e., where the supply schedule of investment funds intersects the marginal efficiency of investment schedule).

However, private investment only accounts for about one-quarter

of the gross regional investment. Investment in social infrastructure, often in indivisible units, is not subject to market forces. Moreover, this investment often involves externalities and, even if the operation of market forces were effective, it would only bring about the equalization of *private*, and not *social*, costs and returns. There is now considerable evidence that the capital market is not as effective constraint on the efficient use of capital (Singh (114), Baumal et al).

Olsen (88) has also found little support for the postulated neoclassical relationship between regional profit rates and capital accumulation. In fact the relationship was the inverse of what would, a priori, have been expected.[1]

Richardson has attempted to relax the simple deterministic assumptions by developing a probabilistic model of regional investment based on the Markov Chain principle (106).

If capital flows are far from satisfactorily explained by the neoclassical model, then this is even more true of the mobility of labour. As Romans (107, p. 90) points out

> "labour, however, is more than just an economic factor of production. Embodied in labour are consumers and political and social human beings, who react to non-economic stimuli and in doing so, may have a dis-equilibrating effect on the regional allocation of resources and on regional income differentials".

There are two main approaches to the econometric analysis of labour migration. The *deterministic* models where the rate of migration is determined by objective economic conditions and the *probabilistic* models which include variations of the gravity and intervening opportunities

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[1]See page 97.

model and often stress noneconomic factors such as information flows. To review even a sizeable part of the literature is beyond the scope of this paper, but there is a comment of Richardson that is worth noting. He argues that from 'the trivial observation' that net migration flows are associated with regional income, "there is often the jump to the conclusion that this fact substantiates the neoclassical model" (104, p. 89).

The mose useful short review of the literature is Weeden's study (134). However, of more importance from the point of view of the discussion in this chapter is a recent study by Hart (47). This work is within the deterministic framework but it is innovatory in that it attempts to analysis the effect of *expectations* of the gains of moving on labour mobility. Since regional economic expectations are found to be unstable than the regional differences, it is probable that a region with persistent locational and/or structural disadvantages may experience temporary rises in economic expectations only to return to their natural level at a future date (Hart quotes the possible impact of North Sea Oil on the Scottish Economy as a case in point). Although as Hart himself admits, the model "while encouraging, leaves much to be desired", it does throw some light on whether labour flows serve to equilibrate regional economic differentials. "If one accepts the expectations hypothesis advanced here, then the answer is probably that they do not" (Hart, p. 280).

In summary, this very brief review certainly suggests the theory of factor mobility derived from the neoclassical model is far from satisfactory.

CHAPTER FIVE

MACRO DYNAMIC THEORIES OF GROWTH II: THE MYRDAL-KALDOR APPROACH

The explanation of spatial growth has also followed a different approach to that of the traditional (neoclassical) analysis and stresses not the tendency towards balanced regional equilibrium growth paths, but rather the converse. This approach consists of such diverse elements as Growth Pole Theory, Myrdal's "Cumulative Causation" thesis, Hirschman's similar polarization theory, and Posner's and Vernon's trade theories, which arose out of a dissatisfaction with the orthodox pure theory of international trade. However, it is only recently that Kaldor (60) has proposed what may be regarded as a satisfactory unifying theoretical framework.

The overall concern of this approach is to explain the phenomenon that is best summarised in Perroux's famous quotation (92)

> "The bitter truth is this, growth does not appear everywhere at the same time; it becomes manifest at points or poles of growth, with variable intensity; it spreads through different channels, with variable terminal effects on the whole of the economy".

In this chapter, a tentative synthesis of these theories stressing the punctiform nature of growth will be presented.[1]

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[1] A notable exception is the literature on Growth Poles. This ignored because, as has been argued elsewhere (68) it does not contribute very much to a theoretical explanation of spatial growth, probably because of its essentially inductive nature. Moreover, it is also an advantage to avoid the terminanological confusion that pervades the subject. One of the best survey of growth poles is Hermansen (50).

The Process of Circular and Cumulative Causation

Myrdal (83) has forcefully argued that the neoclassical paradigm is grossly inadequate as an explanation of growth because it assumes that the economic system will automatically converge to a stable equilibrium. Exogenous parametric shocks may, of course, prevent the actual attainment of equilibrium, but overall the homeostasis effects predominate. However, Myrdal argues that the economic system is characterised by the preponderance of deviation amplifying effects, which give rise to the principle of "Circular and Cumulative Causation". According to Myrdal, the neoclassicists treat the concept of stable equilibrium as if it was of "teleological significance" rather than as "a very abstract, almost crude and usually unrealistic theoretical assumption".[1] Consequently, international trade theory, which perhaps more than any other branch of Economics has been wedded to the equilibrium concept, can shed little or no light on why regional or national income disparities arise and persist. The main tenet of Myrdal's argument is that the dichotomy in neoclassical analysis between "economic" and "noneconomic" forces is spurious, and it is the latter that primarily engenders the cumulative causation process.

Kaldor's reformulation (59), as will be seen, infact argues that it is not necessary to rely solely,or even mainly, on "noneconomic forces" to explain cumulative causation. In fact, the latter is argued by Kaldor to be "nothing more than the existence of increasing returns

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[1]Myrdal's views on the ideological content of neoclassical and classical economics are comprehensively stated in (83).

[2]Myrdal is especially critical of the Hecksher-Ohlin theorem (85, Chapter 10). Ohlin (85), however, argues that many of Myrdal's arguments were anticipated by him. Ohlin's original proposition about the tendency

in the broadest sense of the term". Since the degree of increasing returns is a function of the degree of spatial concentration of industrial activity, a polarization of growth occurs. Once growth has initially started through some chance factor (how this occurs is not really important (Webber (136)), then cumulative causation will perpetuate the rate of growth and development, even though the initial favourable conditions no longer still prevail.

The essential characteristics of the Myrdal-Kaldor approach can perhaps be most clearly brought out when we consider Borts and Stein's criticisms of Myrdal's thesis. They argue that Myrdal's arguments are not general but can be subsumed as a special case of the neoclassical paradigm. Myrdal, they comment, "claims that there will be permanent differences in the rates of growth of per capita output". With the usual notation, the neoclassical model derives an expression for productivity growth such that:

$$y - l = g/(1 - \alpha) \qquad (8)$$

Consequently, according to Borts and Stein (p. 7)

> "In so far as there are permanent differences among regions or countries in the rates of technological change, there will be permanent differences in the rate of growth per capita output. As a result there will be, eventually, a divergence among regions in output. Second he (Myrdal) claims that poor countries will be exporting capital to rich countries and if s/α is not very different among countries, then his conclusions follow logically from our model".

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towards factor price equalization was indeed heavily qualified. Myrdal's criticisms are presumably directed at the more recent formalizations (Samuelson (109)).

However, it is invalid to argue that because the neoclassical model can derive the same predictions as Myrdal's model, then it logically follows that the latter can be encompassed in the neoclassical paradigm. In fact, there is a fundamental difference between the two paradigms as to the main determinants of growth.

If differential growth rates are to be explained by the neoclassical model, there are two alternative approaches than can be taken. In the case of land based economies, or regions in the early stages of industrialisation, the explanation can be couched in terms of the existence of different natural resources. Once this is postulated then there is no need of any further explanation. This is not very satisfactory, for as Samuelson points out:

> "If different production functions are admitted then the theory confronted with evidence contrary to that indicated by factor supplies could always take refuge in the plea: "different production function". Any pattern of trade (and growth) could be explained in such terms. Comparative advantage theory, to be of the slightest analytic value would then require an explanation of when and how production functions come to differ. The problem is to stop the theory from degenerating into a surface explanation, capable of explaining anything ex post and nothing ex ante".

Kaldor (59) makes the same point even more tersely: "After all,no sophisticated explanation is needed why it is better for some areas to grow wheat and others bananas".

Consequently, for processing activities, the neoclassical model generally postulates identical production functions but different regional endowments of capital and labour. It has already demonstrated how, in the Borts and Stein model, since wages and the profit rate are unique functions of the capital-labour ratio, factor mobility will tend to bring about an equalization of factor prices, pari passu,causing regional growth rates to temporarily diverge from the balanced (secular) growth

rate. However, Kaldor argues that this approach is liable to yield "question begging results". It is unsatisfactory to treat capital endowment as an exogeneous variable since "it is as sensible to say that capital accumulation results from economic development as it is the cause of development " (Kaldor). It is meaningless to divorce the rate of growth of output and capital accumulation. Investment is not solely (or even) a function of the subjective rate of time preference but an integral part of output growth, both as a cause and effect of the latter.

Adam Smith's Dictum

The crucial difference between the Myrdal-Kaldor model and the neoclassical paradigm is that in the former the changes making for change are seen as *endogenous* to the system, while in the latter they are *exogenous* (e.g., the rate of growth of the labour force, the number of "Eureka" inventions). Kaldor (60) argues that the existence of increasing returns destroys the whole notion of the economy moving towards an equilibrium path determined by the initial conditions, (which are functions of consumer's preferences and Pareto's obstacles to production).[1]

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[1]Kaldor's paper is primarily a critique of Arrow Debreu General Equilibrium Theory (GET). It is beyond the scope of this paper to consider the admittedly fundamental issues involved. The importance of Kaldor's paper, in so far as spatial growth is concerned, is the stress laid on increasing returns, a feature long realised to be of major importance in the development of the spatial structure but never successfully modelled. Whether the degree of increasing returns are large enough to invalidate GET or whether GET is 'real science' as opposed to being merely a logical construct is another matter altogether.

For an overview of the issues involved see Arrow and Hahn (5), Hahn (43), (44), Kaldor (59), Kornai (61), and Wientraub (137).

There can be little doubt of the empirical importance of increasing returns, if only because of the three dimensionalness of space. Another important aspect is the "break-up" of complex processes into a series of simpler ones. This, of course, was especially stressed by Adam Smith (117) in his celebrated pin factory example. The extent to which capital is used in relation to labour is predominantly a factor of the extent of the market,rather than of relative factor prices (as in the neoclassical paradigm). The third important component of increasing returns is the so called dynamic economies of scale ("learning by doing").

It was left to Young in 1928 to draw the full implications of these three types of increasing returns but the subsequent concern in economics with perfect competition and equilibrium meant that Kaldor nearly half a century later,felt it necessary to reiterate them.

The main tenet has been concisely stated by Kaldor and it is difficult to do better than quote him:

> "The basic consideration underlying Young's analysis is surprisingly the same as underlying Say's Law. If one takes an all inclusive view of the economic process, economic activity ultimately consists of the exchange of goods against goods; this means that every increase in the supply of commodities inlarges, *at least potentially*, the market for other commodities (....). Hence, "the extent of the market" depends upon the division of labour, almot as much, according to Young, as the division of labour depends on the extent of the market, and (quoting Young again) "modified ... in the light of this broader conception of the market. Adam Smith's dictum amounts to the theorem that the division of labour depends in large part upon the division of labour. *This is more than mere tautology*. It means that the counter forces which are continually defeating the forces which make for economic equilibrium are more pervasive and more deeply rooted than we commonly realise".

If "balanced regional equilibrium growth" is read for "economic equilibrium" in the last sentence, then the above quotation provides a revealing insight into the process of regional growth. The interaction of the dynamic and static economies of scale and the extent of the market consequently provides the internal stimulus for a region's growth.

Perhaps the most important aspect of the paradigm is that the capital-labour ratio is no longer uniquely determined by relative factor prices. Instead, we may postulate that the capital-labour ratio depends upon the income potential of the region.

$$(K/L)_{ij} = f(iV_t) = G\Sigma \frac{y_j^{\beta}}{dij^{b}}_{t} \qquad (9.1)$$

where iV is the income potential of region i, Y_j is the income of region j, d is the distance between i and j, b is the distance exponent and β an increasing returns exponent. b is a function of time, since it is postulated b will decrease over time due to exogeneous technical change in the transportation industry. It is also a function of the regions comparative advantage through the regional export demand function. β is postulated to be an increasing function of the capital stock.

The wage and profit rates are also assumed to be an increasing function of the capital stock. Consequently if

$$(K/L)_i = (K/L)_j \qquad (9.2)$$

and

$$K_i > K_j \tag{9.3}$$

then

$$w_i > w_j \tag{9.4}$$

$$r_i > r_j \tag{9.5}$$

This has the important result that, even if we maintain the neoclassical assumption that, *ceteris paribus*, a higher capital labour ratio will be associated with a higher wage and lower profit rate, we can no longer determine *a priori* which of two regions with different K/L ratios and capital stocks will have the higher profit and/or wage rates.

Consequently a fast growing region with a high capital-labour ratio may, if the capital stock is large enough, have both higher wages and profit rates than a peripheral region with a low capital-labour ratio. Thus if capital and labour mobility is the result solely of "*economic*" forces and flows into the fast growing region, given the existence of increasing returns, there is no necessity that this should lead to a tendency towards an equalization of growth rates and factor prices, but may in fact, cause a divergence.

In the next section, a verbal regional growth model along Myrdal-Kaldorian lines will be sketched and then the more formal, but less general, model of Dixon and Thirlwall will be discussed.

The Myrdal Kaldor Approach

The importance of increasing returns as a factor determining trade and growth has long been realised[1] in the pure theory of trade, although the Hecksher-Ohlin theory has tended to dominate any explanation. Posner (95)[2] has expressed doubts as to the utility of the theory as an adequate explanation. For instance, to take the traditional example, why does Switzerland export watches? To argue, à la Hecksher-Ohlin, that it is because Switzerland is differentially well endowed with labour skilled in watchmaking or with watchmaking machinery is open to Samuelson's objection. Moreover as Posner observes "is it possible, even in principle, to measure the existence of such differences (in relative factor endowments) except by the wholly circular method of taking the existence of the comparative cost differences as proof of differences in endowments?" (Posner (95, p. 239)).

The existence of increasing returns, as suggested above, provides an alternative explanation of why trade occurs, and, according to Posner the gains from trade then become the gains from growth. It has been argued that economies of scale may be considered to compose of a static and dynamic element. The former may be defined as

$$C_t = f(Q_t) \quad , \quad (dC_t/dQ_t < 0) \tag{10.1}$$

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[1] For a brief historical review see Chipman (146), pp. 736-749.

[2] Posner's article anticipates much of Kaldor's model (59). However, Posner is more cautious about the theoretical implications: "It is impossible to deny that my simple dynamic model could be expressed as a simple model of Ohlin type trade" (p. 341).

where C = unit costs, Q = quantity produced, t = time.

Exogenous technical progress may be expressed as

$$C = f(t) \quad , \quad (dC/dt < 0) \tag{10.2}$$

The dynamic economies of scale may be defined as

$$C = f(\int_0^T Q_t \, dt) \quad , \quad (dC/dQ < 0) \tag{10.3}$$

This is the "learning by doing" effect. Empirical evidence at the industry level suggest that a firm's unit costs are reduced by 20% everytime output doubles (Hirsch (51), Alchian (1), Fellner (32)). The first attempt to incorporate this effect into a formal growth model was by Arrow (144).

A more useful expression is to weight the more recent contributions to output more heavily than those in the distant past

$$C = f(\int_0^T w_t \, P_t \, dt) \qquad w_t = \phi(t) > 0, \; \phi'(t) > 0 \; . \tag{10.4}$$

An important empirical result that supports the importance of learning by doing is "Verdoorn's law", which states that the *rate of growth* of productivity is a (linear) function of the *rate of growth* of investment or output.

$$\frac{d(Y/L)}{dt} = f\left(\frac{dQ}{dt}\right) \; . \tag{10.5}$$

A cross-sectional regression analysis by Kaldor (57) over the twelve industrialised countries during the period 1953/4 to 1963/4 showed that, apart from an autonomous rate of productivity growth of 1% per year, each increase in output by 1% requires about a 0.5% increase in employment and is associated with a 0.5% increase in productivity. Cripps and Tarling (25) have carried out a more exhaustive econometric analysis, which confirm's Kaldor's emphasis on Verdoorn's law up to 1965 when the relationship brakes down. However, they found that if growth is to be explained in the terms of the neoclassical paradigm, then a large part of the variations in growth rates has to be explained in terms of differential exogenous technical change. At the regional level, Dixon (29) has also found evidence for the existence of the Verdoon effect.

We are now in a position to attempt a verbal explanation of the Myrdal-Kaldor model.

The neoclassical model of growth and trade demonstrates that when trade occurs between two regions, both will gain, although to varying degrees (Bensusan-Butt (8)). However, in the Myrdal-Kaldor model, this is no longer necessarily true. With the opening of trade, the initially more developed region which has a greater degree of increasing returns in the processing industries, may well benefit to the *absolute* detriment of the less developed region.

To demonstrate this, let us assume two "isolated states", each with an agricultural base whence the industrial sector derives the demand for its products. The agricultural sector approximates to the classical position of perfect competition and the producers are therefore price takers. Thus, changes in price serve to equate supply and demand, if

through, for example, a crop failure, they should temporarily diverge.

However, in the case of the manufacturing industries, firms are price makers and long run supply is normally in excess of demand. Consequently, whereas in the case of agricultural commodities a rise in foreign demand will lead to a rise in prices, trade being maintained in equilibrium through changes in the terms of trade, this does not occur in the case of processed goods. Here the increase in demand acts, through the foreign trade multiplier, to increase domestic production and employment. The Hicksian "supermultiplier" determines the degree of autonomous investment which is fundamentally a function of exogenous (i.e., export) demand.

The demand for exports is itself a function of two components; the exogenous rise in world demand and the movement of *efficiency wages* (the rate of growth in money wages minus the rate of growth of productivity). But this latter component is a quasi-endogenous variable, a function of the rate of growth of output. This gives rise to the cumulative causation process. Once trade occurs, the more developed region captures part of the market of the other region, and as the rate of growth of the first region's output increases, the efficiency wage falls (through the Verdoorn effect) and its competitive position further improves, thus enabling it to capture even more of the less developed regions' market.[1] Hence, the initial regional income disparities will be progressively

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[1]This assumes that the rise in money wages is not large enough to completely offset the higher productivity growth. Given nationally bargained wage levels, this is unlikely.

increased by trade.[1]

Posner's model is, to a large extent, complementary to Kaldor's, viewing regional comparative advantage as a function of differential technical progress and innovation, although the model is at the industry level.

Suppose a firm in the "South" produces an innovation in either the production of a commodity, thereby reducing its cost, or in the commodity itself. Firms in the "Northern" counterpart of the industry will find their markets threatened and the southern firm, by virtue of its temporary monopoly of the technical knowledge of the innovation, will expand its markets in the North. This expansion will, via the supermultiplier, lead to increased southern investment. The resulting capital accumulation "will bring about an Ohlin type difference in factor proportions, but this will be the *result* rather than the *cause* of trade" (Posner, p. 331).

If the northern firms are to survive they must imitate, but in contradistinction to Borts and Stein, it is postulated that this cannot occur instaneously, since there are various time lags involved. The first is what Posner terms the *foreign reaction lag* (l_1) and this is the time that elapses between the introduction of the innovation in the southern markets and the time it is perceived by northern

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[1]Salvatore (108) has argued that in the analagous case of factor mobility, free market forces do not *create* regional disparities but merely permit them to occur. Using wages and profits to be a surrogate for the marginal productivities, he argues that, in the case of Italy, the movement of capital and labour did not widen the regional disparities since the relevant factors were unused in the South. Therefore mobility may have raised the rate of growth in the North but it did not reduce that of the South by causing factor shortages and would, under the neo-classical assumptions, have raised southern incomes.

entrepreneurs to be a threat to their markets. There is also a *domestic reaction lag* (l_2) which is a function of the degree of competition in the northern industry. Finally, there is the *learning period* (l_3) which is technologically determined. The *total imitation lag* is defined as

$$L = l_1 + l_2 + l_3 \quad . \tag{11}$$

However, the innovation may not be automatically regarded by northern consumers as a perfect substitute for northern goods, so there may be a *demand lag* (λ), analogous to Nurske's "international demonstration effect". Of course, if the innovation occurs in the production stage and takes the form, not of a new product, but reduced price, the demand lag may be near zero.

The *net imitation lag* is defined to be $L - \lambda$.

Posner invokes Schumpeter, arguing that technical progress is, within an industry, serially correlated, taking a 'clustering form'. To the extent that correlation does occur, the initial advantage need never be lost until the cluster of related innovations comes to an end. "By the time the end comes, the unfortunate competitor may have given up the ghost ... ".

Consequently, to explain persistent growth we must (plausibly) assume that a once and for all gain due to an innovation generates optimism and investment (perhaps through Keynesian "animal spirits"). This additional investment will generate other innovations which will cluster leading to a cumulative effect. "Comparative advantage on these assumptions is caused, not by differences in relative factor

endowment at a point of time, but by differences in the distribution of investment" (p. 340).

This explanation is, to some extent, unsatisfactory in the context of long-term growth because it relies on regionally varying levels of entrepreneural dynamism. However, at this juncture, it is useful to distinguish between two types of technical progress; those that take the form of product innovation (either in producer or consumer goods) and the dynamic economies of scale.

Posner is concerned with the former, which are, subject to the appropriate time lags, interregionally mobile. However, casual empiricism suggests that the "learning by doing" effects are immobile even at the interfirm level. These dynamic economies primarily relate to the progressive introduction of more efficient factory organization and "on the job" training, both functions of experience. Kaldor (57) notes the wide variations that exist in productivity growth between the British and West German car producers, even though both are controlled by the same international corporations and, therefore, have access to the same technical knowledge. Thus we may postulate Posner's innovation diffusion will interact with the Verdoorn effect, generating a sustained increase in comparative advantage that even exogenous innovations in the lagging region may not be able to more than temporarily offset.

At the macro level, since, as Young (143) suggests,neither the representative firm nor the industry of which it is a member is the most appropriate unit to apply Smith's dictum, the fast growth in specific industries will generate *regional* increasing returns and progressively increase the regional comparative advantage.

The importance of Posner's paper is that it conceptually introduces the spatial factor in an attempt to explain growth. While it is very simple, the model has the great advantage that it stresses both the *interaction* element (through the foreign reaction and the demand lag) and the *profitability* element (the domestic reaction and, again, the demand lag).[1]

Much of the geographical literature on diffusion concentrates solely on the interaction element. Consequently, those attempts, such as Berry's (10), that try to explain the impact of diffusion have to resort to such unsatisfactory explanations as "the income effect", where the income generating impact of an innovation is somehow postulated to decline with time.[2] The economic literature has on the other hand often ignored the spatial element.[3]

However, the Posner model needs a mathematical formalisation and there is a vast body of literature on innovation diffusion that may be profitably drawn on (see, for example, Richardson (106, pp. 113-132), Webber (136, Chapter 9)).

A Formalisation of a Kaldorian Regional Growth Model

Dixon and Thirlwall (30), (129), have recently formalised a model of regional growth along the lines suggested by Kaldor (59).[4]

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[1] It is not clear whether the learning period should be regarded as part of the interaction element or as a separate category.

[2] For a fuller discussion of Berry's paper see (68).

[3] For support of this filtering down effect in an urban context see Thompson (130).

[4] See also Richardson (106), pp. 29-34.

Unfortunately they abstract from space, since 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". However, to the extent that it is shown that the Verdoorn effect 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", interregional relations are considered implicitly.

Kaldor argues that regional growth is a function of the export base. Consequently

$$y = \gamma(x) \tag{12.1}$$

where y is the rate of growth of output, x the rate of growth of exports and γ is the constant elasticity of output growth with respect to x. The export demand function is assumed to multiplicative

$$X = P_d^{\,n} P_f^{\,\delta} z^{\varepsilon} \tag{12.2}$$

where X is the quantity of exports,

P_d is the domestic price,

z is the level of world income,

n is the price elasticity of demand for exports,

δ is the cross elasticity of demand for exports,

ε is the income elasticity of demand for exports.

It follows that

$$x = n(p_d) + \delta(p_f) + \varepsilon(z) \quad , \tag{12.3}$$

where $z = \bar{z}$

$p_f = \overline{p_f}$

Moreover,

$$Pd = (W/R)(T) \tag{12.4}$$

where W is the level of money wages,

R is the average product of labour,

T is $(1 + \phi)$ where ϕ is the percentage markup.

Consequently

$$p_d = w - r + t \quad . \tag{12.5}$$

The third relationship, which is the core of the model, is Verdoorn's law.

$$r = f(y)$$

or (12.6)

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

where r is the growth of productivity, r_a is automous productivity growth, and λ is the Verdoorn coefficient.

Combining quations (12.1), (12.3), (12.5), and (12.6) the equilibrium

growth rate is

$$y = \frac{\gamma(n(w-r_a+t) + \delta(pf) + e(z)}{1 + \gamma n\lambda} \tag{12.7}$$

In this model the Verdoorn coefficient (λ) is a source of regional growth rate differences only in so far as λ varies between regions. It only serves to exaggerate existing differences in the other parameters. The Verdoorn effect plays a sustaining role - once the region has an initial advantage it will keep it. The model can be shown graphically in Figure 2.

To consider whether the model will predict convergence or divergence, the model is dynamised by introducing a one period lag and solving the first order differential equation, the general solution of which is given by

$$g_t = A(-\gamma n\lambda)^t + \frac{\gamma[n(w-r_a+t) + \varepsilon(z) + \delta(pf)]}{1 + \gamma n\lambda} \tag{12.8}$$

The time path is determined by $\gamma n\lambda$. Given $n < 0$, this expression must be positive. Cumulative divergence from equilibrium will be given by the condition $(-\gamma n\lambda) > 1$. This is thought to be empirically unlikely by Thirlwall and Dixon, although Kaldor disagrees.

The particular solution to the difference equation shows that differences in n (price elasticity of demand for exports), δ (cross elasticity of demand for exports), r_α (autonomous productivity growth),

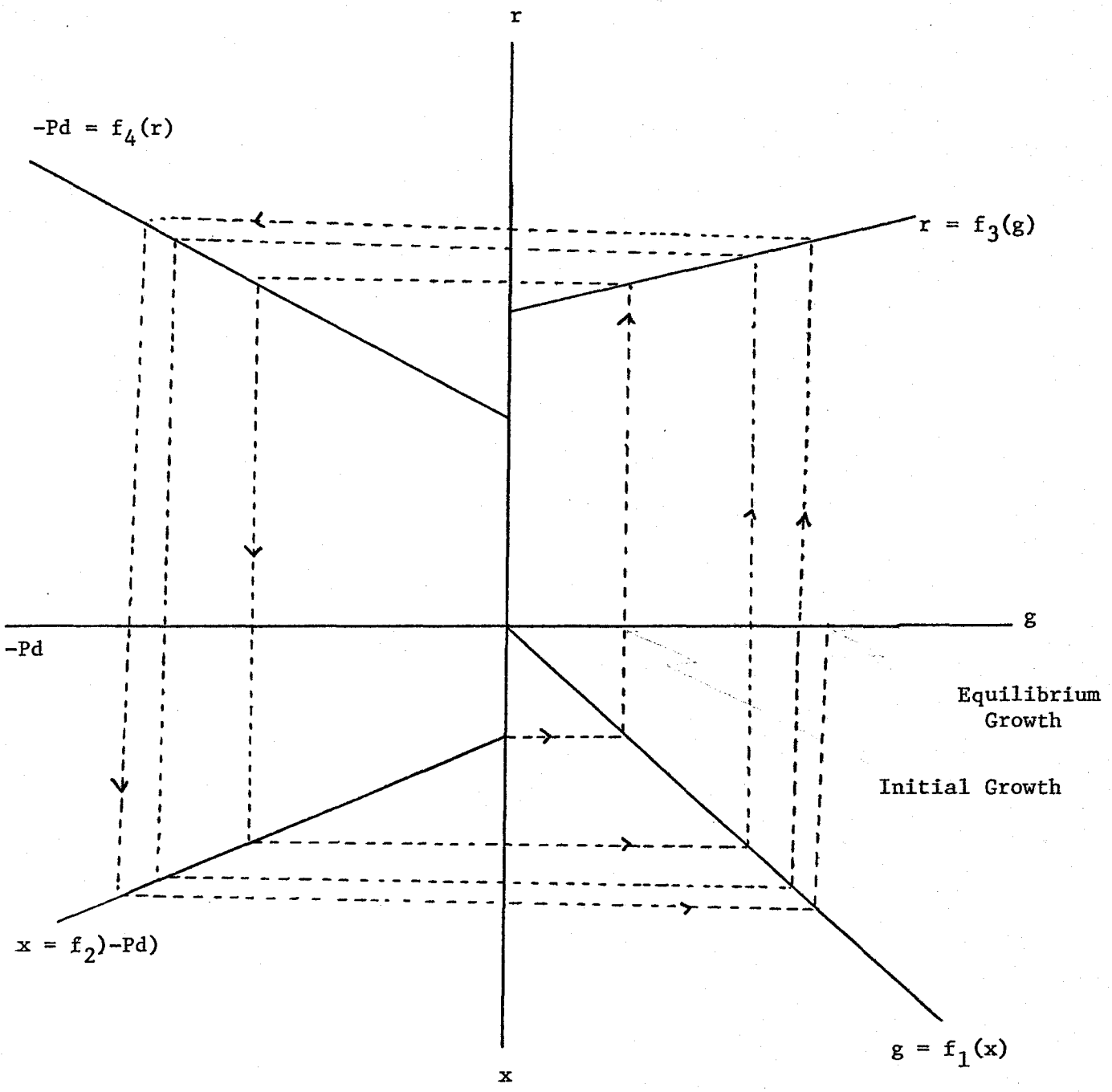

FIGURE 2

THE PROCESS OF CUMULATIVE CAUSATION

(After Dixon and Thirwall)

ε (income elasticity of demand for exports), λ (the Verdoorn coefficient) will generate disparities in regional growth rates.

The Verdoorn coefficient, λ, will depend upon the "technical dynamism of productive agents" in the region and the extent to which capital accumulation is induced by growth and embodies technical progress. Given a Kaldorian technical progress function

$$\frac{dY/L}{Y/L} = \frac{dA}{A} + \frac{dK/L}{K/L} \tag{13.1}$$

let

$$\frac{dA}{A} = \alpha_1 + \beta_1(y) \tag{13.2}$$

$$\frac{dK/L}{K/L} = \alpha_2 + \beta_2(y) \tag{13.3}$$

hence

$$r = r_\alpha + \lambda(y) \tag{13.4}$$

where $r_\alpha = (\alpha_1 + \phi\alpha_2)$ (13.5)

$$\lambda = (\beta_1 + \phi\beta_2) \tag{13.6}$$

The conclusion that Dixon and Thirlwall draw is that 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".

There are, however, several criticisms that this particular model is open to. The first is that, as has been mentioned, no account is explicitly taken of spatial interaction between the various regions. The whole growth mechanism is primarily a function of the rate of growth of exports. Consequently, the model, in effect relies on the naive export base theory, and is therefore subject to all the well known objections that have been levelled at the latter.

While the model predicts roughly the right order of magnitude of the U.K.'s post war growth rate, it is significantly higher (4.0% as opposed to 2.8%). Moreover the model is disturbingly sensitive to changes in the parameters. Supply constraints, which are neglected in Dixon and Thirlwall's formalism, can be an important factor reducing the equilibrium growth rate (Dixon and Thirlwall introduce the balance of payments as a reason to account for the divergence). Kaldor (57) stressed the supply constraint as one of the major causes of the slow post war growth rate of the U.K. This took the form of the lack of a sufficient labour "reserve" in agriculture and was reinforced by the *premature maturity* of economic structure of the U.K. It was argued by Kaldor that the development of a large tertiary sector (which is not subject to increasing returns to the same extent as industry), prematurely reduced the benefits of increasing returns that could have been gained through the expansion of the manufacturing sector.

This leads to the interesting question as to how far this hypothesis is applicable to the mature regions of the U.S. We may postulate that the decline of the rate of growth in the North East is due, not only to the decline of the agricultural sector, but also to the expansion of the tertiary industries, the latter reducing the Verdoorn coefficient.

The explanation of the long run convergence of regional incomes in the United States is, consequently, in the Myrdal-Kaldor paradigm almost the exact converse of that of the neoclassical model. In the latter, equalization of regional incomes is primarily due to the reduction of the inefficient intraregional allocation of resources (especially the overemployment of labour in the agricultural sector) and interregional factor mobility. The reduction of intraregional inefficiencies in resource allocation is assumed to occur exogenously.

In the Myrdal-Kaldor model, the movement of labour into the manufacturing sector, far from being the *determining factor* of the rate of growth of the region is seen as being, in the long run, the factor *constraining* the rate of growth of the faster growing regions. Consequently, in so far as interregional mobility is not fast enough, convergence will occur as the advanced regions increasingly encounter a labour shortage. Consequently, a profitable development of the Myrdal-Kaldor model would seem to be a combination of the supply and demand aspects, as, for instance, Cornwall (23), (24), has attempted at the national level.

Finally, Dixon and Thirlwall relate the Verdoorn effect to Kaldor's technical progress function. However, as has been pointed

out(45,p108) the technical progress function may be integrated into a Cobb-Douglas production function and Kaldor's 1957 model of economic growth (56) actually derives the same equilibrium growth rate as the neoclassical model.

A Neoclassical Variant

One of the undoubted reasons for the neglect of Smith's dictum in economics has been the pervasive use of perfect competition and the difficulty of reconciling this with increasing returns (Sraffa (121), Marshall (147), Appendix H)). However, drawing on the work of Stigler (124), and Frankel (35), it is possible to incorporate Smith's dictum into the neoclassical model.

Stigler argues that infact perfect competition is not necessarily incompatible with increasing returns as a result of the increasing division of labour. The reason is that as the extent of the market increases and it becomes profitable for a few firms to specialise in those processes subject to increasing returns, the potential monopolistic power of these firms cannot be exploited because "it will be confronted by elastic demands; it cannot charge a price higher than the average cost of the process to the firms which are abandoning it".

Thus, it could be argued that the postulate of perfect competition is not necessarily violated. Consequently we can postulate that the ith industry in region j has a Cobb-Douglas production function

$$Y_{ij} = \alpha H_j K_{ij}^{\alpha} L_{ij}^{1-\alpha} \qquad (14.1)$$

Assuming that each firm produces 1/nth of the regional output the corresponding aggregate regional production function is

$$Y_j = aH_jK_j^{\alpha}L_j^{1-\alpha} \qquad (14.2)$$

Frankel terms H the "development modifier" and suggests that it may be assumed to equal $(K/L)^{\beta}$. H is thus a variable and it internalises all of the effects that are generated by enterprises". It may be assumed to be the function of the extent of the market described in equation

Firms therefore determine the allocation of resources according to the neoclassical theory of distribution. However, the accumulated effect of individual decision making affects the development modifier and the realized growth path is that of the Harrod Domar production function. Thus by incorporating Smith's dictum, this model neatly combines the neoclassical theory of resource allocation and the realistic growth rates derived by the Harrod Domar model, since by substituting $(K/L)^{\beta}$, where $\beta = 1-\alpha$, into equation 14.2 the expression

$$Y_j = a\,K \qquad (14.3)$$

is derived. This is the familiar Harrod Domar function.

A Digression on the Measurement of Increasing Returns

Agglomeration economies and increasing returns would seem to be the Lynchpin of growth in the space economy. The importance of them was stressed by both Lösch (67), and Isard (150). However, while there is a considerable volume of literature on the spatial effect of increasing returns, at least in the context of externalities (for recent reviews see Bird (12), Mishan (78)), there has been little satisfactory empirical work on the estimation of these effects. Indeed Darwent (28), goes so far as to argue that "there is almost no agreement on how external economies are defined and therefore little hope of quantification".

The first tentative attempt was made by Marcus (73) who defined three components of agglomeration economies; viz.,

(1) Economies of Scale,

(2) Economies of Localization,

(3) Economies of Urbanization.

The first element is the traditional form of economies dependent upon the growth in the size of the firm.[2] The economies of localization are a function of the number and degree of specialization of the firms. The last component is the benefit derived from the level of overall

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[1] Lösch's treatment is in many ways unsatisfactory, since it is treated mechanically through the rotation of the market nets to achieve the greatest degree of super-imposition of firms' sites. However, given that agglomeration economies will have a differential impact on the various firms, these will affect the spatial demand curve and hence, ex post, the market areas of the firm which have already been taken to be predetermined.

[2] For details of the extent of these internal economies see Pratten (96) who suggests that they may be considerable.

economic activity and is not dependent upon the size of the industry. Marcus argues that the effects of agglomeration may be determined first by computing the growth of the particular industry under consideration. Then that portion of the growth rate that can be ascribed to growth in the market potential of the area is calculated and is subtracted from the aggregate growth rate. The residual, if positive, indicates the presence of external cost advantages. Hellman (49) has extended this procedure.

Regional external economies are defined by the expression

$$A_1 = f_1(\Sigma N_{j_{t-n}} \cdot \alpha_{ii}) \tag{14.1}$$

where $N_{j_{t-n}}$ is the employment in the supplying industry j at t-n, α_{ij} is the dollar value of input j per dollar output of i. These terms refer to the export industries defined by the use of location quotients.

Localization economies are defined as

$$A_2 = f_2(\Sigma N_{i_{t-n}} \cdot \alpha_{ii}) \tag{14.2}$$

Finally market potential is defined as

$$A_3 = f_3(\Sigma N_i - N_i) \tag{14.3}$$

However, as Richardson has pointed out, Marcus' method is little more than an alternative formulation of differential shift. "At least it is a measure of localization economies not of the more crucial urbanization

and agglomeration economies" (106, p. 176). Hellman's procedure is also subject to these criticisms and inspite of the reasonably high correlation coefficients obtained, it throws little light on the latter phenomena.

An alternative method is to try to estimate an urban production function to the urban areas and, hence, the increasing returns to scale parameter. This approach cannot do any more than give an overall estimate for increasing returns.[1] The most general production function is the CES. It can be written as

$$Y = A(\delta K^{-\rho} + (1-\delta)L^{-\rho})^{-v/\rho} \quad [2] \qquad (15.1)$$

where A is an efficiency parameter which changes output proportionately for given quantities of input, δ, $(0 \leq \delta \leq 1)$, is a distribution parameter which determines the division of factor income, ρ is a substitution parameter and v is the degree of homogeneity parameter. Shefer (112) has tested two variations of the CES production function for the SMSA's. The first was that of Dhyres who showed that the CES function may be expressed as

$$w = AY^{\beta}L^{\delta} \qquad (15.2)$$

where $(1 + \gamma)/(1 + \beta)$ is the homogeneity parameter and $-(1|\gamma) = \sigma$ is the elasticity of substitution parameter.

The regression equation is thus

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[1] However, see footnote 2, p. 44.

[2] For the properties of the CES function see C.F. Ferguson The Neoclassical Theory of Production and Distribution (CUP, 1969), pp. 101-107.

$$\text{Log } L = 1|\gamma \log A + 1|\gamma \log w - \beta|\gamma \log Y \qquad (15.3)$$

The other alternative tested was a variant of Arrow's (144) and Solow's (118) model. Scale is introduced analogously to technical change in Solow's model.

$$Y = F(K, L, S) \qquad (15.4)$$

Thus the scale effects are given by the "residual". If the scale effects are assumed to be neutral, the production function is taken to be cumulative output

$$Y = BoS^{\lambda}(\delta K^{-\rho} + (1 - \delta)L^{-\rho})^{-1/\rho} \qquad (15.5)$$

The estimated parameters of both variations of the CES show the existence of increasing returns. However this procedure is subject to all the usual objections of production function analysis noted above.

Richardson (106, p. 179) assumes that agglomeration economies are a function of the number of urban centres (above a threshold size), their relative size with more weight given to the larger centres and the distances between them.

The agglomeration economies may take the form of the following function

$$A = \alpha_1\left(\sum_{i}^{z} N_i^{\alpha_i}/z\right) + \alpha_2 z + \alpha_3\left(\sum\sum_{ij}^{zz} dij\Big/\frac{z!}{\frac{z!}{2}(z-2)!}\right)(dii = 0,\ dij = 0) \qquad (16)$$

where α_1 and α_2 are positive, α_3 is negative, z = the number of urban centres in the region and d = distance. However as Richardson admits the model is deficient in that there is no appropriate measure of agglomeration economies, *per se*, to estimate the function and since the equation has not been empirically estimated, we do not know the quantitative importance of the various factors.

In conclusion, this brief summary demonstrates that although the importance of agglomeration economies are stressed in spatial economies, the empirical determination of them is still at a very rudimentary level.

CHAPTER SIX

INTRODUCING THE SPATIAL ELEMENT INTO REGIONAL GROWTH MODELS

In the last chapter an attempt was made to divorce the capital labour ratio from being uniquely determined by the factor price ratio, and this was accomplished by defining it as a function of the income potential of the region under consideration. It was also seen that it is possible to incorporate Adam Smith's dictum into the neoclassical model at the macro level, while maintaining the neoclassical distribution theory at the micro level. In this chapter the various attempts that have been made to explicitly incorporate space into a regional growth model will be discussed. The few rudimentary attempts to accomplish this have drawn on the use of potential models (with the notable exception of Richardson's model). These concepts have the advantage that they are essentially macro models and they were originally derived from Social Physics.

The Social Physics School

The income potential model has already been defined, and the gravity and demographic energy models may be expressed as:[1]

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[1] The earlier literature relating to these models has been exhaustively surveyed in Isard (150).

$$I_{ij} = \frac{G\, P_i P_j}{(dij)^{\beta}} \tag{15}$$

$$E = \frac{G\, \frac{P_i P_j}{dij}}{} \tag{16}$$

where P_j is the population at point, or area, j (income or some other surrogate may be used and a weighting attached), dij is the distance (physical or economic) between i and j, β is the distance exponent and G is a constant.

These concepts were primarily introduced into Geography by Stewart (123) who explicitly regarded them as a physical analogy, considering members of society as spatially interacting in a comparable way to that of gas molecules or physical masses. However, these models have long been used in the Social Sciences and may be traced back to Comte (1830) who coined the term "Social Physics".

However, an important development has occurred in the last decade when the use of the entropy maximising approach has provided a firmer theoretical support for the derivation of these models than the simple probability explanation of Isard. Indeed the statistical mechanics approach may be viewed as largely superseding the Social Physics analogy. Although such Economists as Beckmann (7) and Hansen (46) argue to the contrary, the entropy approach using the Jaynes Tribus formalism is not an analogy from physics. Although entropy was first developed in the physical sciences, it does not logically follow that it is only legitimately applicable there. The major contribution

of Jaynes was to show that the use of entropy in physics is only one *particular* application of the concept, and the latter is no way dependent upon physical laws.

One may speculate that the hostility of many Economists to the entropy approach is due to the teleological emphasis of Economics that was derived from the early influence of Newtonian Mechanics. That this emphasis is still pervasive in Economics is perhaps epitomized by Samuelson's (110) scathing attack on Marshall's conception of the biological approach providing the economists' 'mecca'. Samuelson argues that the post war development of Economics have been fundamentally influenced by mechanics. However, as Georgescu-Roegen (38) has shown, Economists seem to be ignorant of the development of modern physics since Boltzman and the subsequent integration of mechanics and biology through the entropy concept.

However, while the entropy approach seems potentially a useful way of aggregating individual decisions and thus blurring the traditional dichotomy between micro and macro economics, it will not be discussed in this paper. The main concern of this chapter is how the spatial element may be incorporated into the traditional economic models. An indication of the potentialities of entropy in regional and urban modelling may be found in Wilson (140).

The Importance of Space in Interregional and International Trade Theory

In the two sector neoclassical model of Borts and Stein, the standard theorems of (spaceless) international trade theory were incorporated. However, there is now an extensive body of empirical

work, concerned with explaining the *direction* of international trade, that unequivocally stressed the importance of space and distance. Moreover, these studies are of relevance to spatial growth, since as Posner emphasises, regional growth and trade are closely interrelated.

The early studies of Isard and Peck (148) and Beckerman (7) merely noted that the volume of trade declined with distance. The first regression analysis was undertaken by Pöyhönen (94) who used the simple gravity model in the form

$$Iij = GG_iG_j \frac{((Y_i/P_i)^{\alpha}((Y_j/P_j)P_j)^{\beta}}{(1 + hdij)^b} \qquad (17)$$

where Iij = value of the exports from i to j,

$G_i(G_j)$ = export (import) parameter of i (j),

$Y_i(Y_j)$ = income of i (j)

h = transportation cost coefficient per unit of distance.

The multiple correlation coefficient of the function, when the latter is used to explain the pattern of world trade in 1958 was 0.94. Subsequent work by Pöyhönen (94) and Tinbergen (128) confirmed the magnitude of the coefficient.

However, the most important empirical study was that of Linnemann (65) since he based his interpretation of the analysis on economic theory. Linnemann considers that trade occurs because domestic patterns of production and consumption diverge. Countries have developed comparative advantages in different fields of production which makes it profitable to engage in trade.

It has been seen that in the neoclassical paradigm, trade and growth are explained in terms of differences in factor endowments (Hecksher-Ohlin) or natural resources (Ricardo). However, Linnemann's explanation is more similar to Kaldor's, since he stressed the importance of economies of scale and national differences in technology. Like Kaldor,Linnemann argues that the theory of international trade should be built around man-made phenomena and those created by nature should be considered as exceptions. Trade is therefore argued to be a function of the potential export supply and the potential import demand of the various countries and the "resistance to trade". This last factor is of particular interest here.

Linnemann defines the potential foreign trade ratio as the ratio of exports and imports to the GNP. It is Linnemann's hypothesis that this varies solely in relation to population size differences between countries, since trade is a function of economies of scale and the diversification of demand increases with higher income levels.[1]

The basic relationship postulated by Linnemann is very similar to Pöyhönen's

$$Iij = G \frac{(Y_i)^{\alpha}(Y_j)^{\beta}}{(P_i)^{\gamma}(P_j)^{\delta}(d_{ij})^{b}} (PR)^{\varepsilon} \qquad (18)$$

where PR is a dummy variable for trade preference. The regression coefficient obtained was 0.80. Consequently these studies demonstrate

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[1]Cf.,Linder (64).

the importance of space in determining the degree of trade and therefore growth. It is now necessary to consider the way the spatial element has been integrated into regional growth models.

Potential Models of Growth

Two of the earliest studies introducing these concepts into regional analysis were undertaken by Warntz (131), (132). His first work, 'Toward a Geography of Price', examined the effect of the divergence of spatial demand and supply for agricultural commodities on the price of these commodities. The study confirmed that the friction of distance does lead to spatial variations in the prices paid to farmers. Prices were, infact, shown to vary directly with gross economic population potential and inversely with product supply potential and product supply time potential.

Warntz's conception of the importance of space is far reaching:

> "Going even further, one might conceive of the General Price Theory restated in potentials in which all commodity and factor prices are mutually interrelated and simultaneously determining and determined, meaning, then, that all potentials contribute to mutually interrelated and simultaneously determining and determined prices in a time space continuum". (p. 104)

However, it is the second study, "Macrogeography and Income Fronts", which is of more relevance here. This work was far more unorthodox and controversial and may be interpreted as an attempt to introduce a dynamic element into the potential concepts, and to try to explain the observed long run convergence of regional income in the United States over the period 1880-1956. In other words, the main tenet of the study is that there were originally large per capita income differences between regions but there has been a slow convergence

towards spatial equilibrium, the rate of convergence being a function of the friction of distance.

It is postulated that these initial regional disparities arose because of two major disturbances that occurred in the mid 19th century, viz., the mineral discoveries in the Far West and also the Civil War, which created a low income area in the south. Since there have been no more recent comparable disturbances, the regional income disparities have been slowly reducing through the action of the equilibrating forces.

Warntz assumes that there is a positive correlation between per capita income and income potential (because of the effect of increasing returns). By plotting state per capita income against income potential, Warntz finds that it is possible to discern three regression equations. These equations delineate spatially contiguous states into high, medium and low income regions, which occur in the Far West, the Central and North East (the "main sequence") and the South respectively.

To explain the progressive convergence, Warntz, influenced by Stewart, draws an analogy with the macroscopic gas laws. The per capita income levels are regarded analogous to temperature and per capita income equalization is seen as equivalent to the dissipation of warm and cold fronts, (hence the term 'income front', which is defined to be the use of discontinuity between the sequences).

However, Warntz also gives an economic interpretation of this process. This is couched in terms of the equalization effects of migration (although the unrealistic assumption is made that the marginal productivity of the emmigrants is zero), the equalization of factor prices through commodity trade (Hecksher-Ohlin) and the spatial

redistribution effect of government fiscal policies.

Thus, it is difficult not to totally agree with Richardson when he argues that "it is merely the neoclassical theory in disguise. The neoclassical model is the counterpart in economic theory to the inductive income front model, a main feature of which is the dissipation of these fronts". Consequently, the original disturbances are "explained" by exogenous factors and instantaneous attainment of equilibrium is prevented by the friction of distance.

Peaker (91) has developed a simple neoclassical model that more formally incorporates the potential concept. He assumes a two region system, the identical production functions, which, with the usual notation, may be expressed as:

$$Y_i = AK_i^{\alpha} \qquad i = 1, 2 \tag{19.1}$$

The rate of capital accumulation is defined to be

$$k_i = a_i Y_i + b_i(\varepsilon P_i - \varepsilon P_j) \qquad i,j = 1, 2, \; i \neq j \tag{19.2}$$

where εP is the economic potential and is given by

$$\varepsilon P_i = Y_i/P + Y_j/(p+q+r) \qquad i,j = 1, 2 \;\; i \neq j \tag{19.3}$$

where p and r are the intraregional transport costs for regions i, j respectively and q is the interregional transport cost.

In the model, therefore, investment is deemed to consist of two elements,

an autonomous component which is a function of the regional income and an induced component which is a function of the relative increase in the regions economic potential.

By simple substitution it is shown that

$$k_i = a_i AK_i^{\alpha} + a_j\left[{}^{1}/_{p} - \frac{1}{p+q+r}\right]\cdot AK_i^{\alpha} + a_j\left[\frac{1}{p+q+r} - \frac{1}{r}\right] \times AK_j^{\alpha} \qquad (19.4)$$

Thus induced investment is primarily a function of changes in transport costs. While the model is useful beginning, like most neoclassical analysis, it ignores the importance of agglomeration economies. While further work along these lines is disirable, the most fruitful approach would seem to be that suggested in Chapter 5, and to treat economic potential not only as a function of changes in transport costs but also on increasing function of the capital stock.

Olsen's Simulation Model

One of the more sophisticated spatial growth models is that devised by Erling Olsen (88). Because of the lack of adequate regional data with which to test regional growth models, a simulation approach was followed. Historical data was used to calibrate the model and then the United States' regional growth was modelled through the use of a recursive computer programme, with not altogether satisfactory results.

Although Olsen explicitly regards his model as an attempt to synthesise the diverse aspects of Myrdal's work, the Hecksher-Ohlin

Theorem, and the Social Physics School it remains fundamentally a neoclassical theory. Thus, even though Olsen deems Myrdal's disequilibrating forces important they are handled in a similar way to the approach adopted by Borts and Stein. It has been argued above that the Myrdal-Kaldor approach is more than the stressing of the disequilibrating effects of factor mobility responding to 'non economic' signals. In fact it has been argued that differential growth rates occur even if market signals are correctly followed.

Olsen assumes a CES regional production function, with constant returns to scale.

$$Y_i^t = \gamma_i[\delta_i^t(K_i^t)^{-\beta_i^t} + (1-\delta_i^t)(L_i^t)^{-\beta_i^t}]^{-1/\beta_i^t} \qquad (20.1)$$

where, as before, γ is the efficiency parameter, δ is the distribution parameter and β is the substitution parameter. The capital stock is defined to be at time t+1 in region i

$$K_i^{t+1} = K_i^t \, e^{\pi}(y_i^t/y^t)^{\zeta}(r_i^t/r^t)^{n}({}_iv^t/v_t)^{\vartheta} \qquad (20.2)$$

where y_i^t is per capita income of the ith region,

r_i^t is the regional rate of return,

${}_iv^t$ is the market potential. e is the base of the natural logarithm.

(π, ζ, n, $\vartheta > 0$; constants)

The labour force at time t+1 in region i is also defined to be

$$L_i^{t+1} = e^{\phi}\left(\frac{y^t}{y_i^t}\right)^{H}\left(\frac{W_i^t}{W^t}\right)^{\lambda}\left(\frac{{}_iv^t}{v^t}\right)^{\mu} \qquad (20.3)$$

where W_i^t is the wage level in the region

(ϕ, H, λ, μ > 0 constants.)

The efficiency parameter from time t+1 to t+2 is

$$\gamma_i^{t+1} = \gamma_i^t \, e^{\Lambda \left(\frac{\varepsilon_i^t}{\varepsilon^t}\right)^{v} \left(\frac{U_i^t}{U^t}\right)^{\pi} \left(\frac{iv^t}{v^t}\right)^{T}} \tag{20.4}$$

where ε_i^t is the average number of years of schooling completed by the labour force at time t in region i (i.e., a surrogate for labour skills, and investment in human capital), and U_i^t is an urbanization index and is the percentage of the population living in urban centres above a certain threshold size.

A functional relationship for ε_i^t may be defined as follows:

$$\varepsilon_i^{t+1} = \varepsilon_i^t \, e^{\Xi \left(\frac{y^t}{y^t}\right)^{v} \left(\frac{U_i^t}{U^t}\right)^{\theta} \left(\frac{iv^t}{v^t}\right)^{X}} \tag{20.5}$$

(Ξ, v, θ, x > 0; constants).

Olsen defines the urbanization index to be

$$U_i^{t+1} = U_i^t \, e^{\Omega \left(\frac{y_i^t}{y^t}\right)^{\psi} \left(\frac{iv^t}{v^t}\right)^{w}} \tag{20.6}$$

(Ω, ψ, w > 0; constants).

Regional income differences are seen as the "net result of a complicated interaction between equilibrating and disequilibrating forces".

The elements of the Hecksher-Ohlin theorem are to be found in equations (20.1) (the CES function) (20.2) (the capital stock equation) and (20.3) (the labour force equation). The disequilibrating forces are contained in (20.2) (20.3) (20.4) (the efficiency equation)(20.5) (the human investment function)(20.6) (the urbanization function). Equation (20.2) incorporates the tendency of capital to accumulate fastest in the rich regions, and the remaining three equations show how the levels of productivity, education and urbanization may increase more rapidly in the rich regions.

However, in estimating the parameters Olsen finds seven of the 19 parameters to be negative, contrary to what one would expect, *a priori*. Two of the results left unexplained were the fact that the level of education and urbanization has a negative effect on productivity.

However some other crucial parameters were also found to be negative and Olsen does attempt to advance possible reasons for this. For instance, in the capital stock equation,

$$K_i^{t+n} = K_i^t \, e^{n\pi} \left(Y_{i/Y}^t\right)^{n\zeta} \left(r_{i/r}^t\right)^{n\eta} \left(\frac{iv^t}{v^t}\right)^{n\vartheta} \qquad (20.2)$$

η and ϑ were found to be negative. Even with a little explicit "fudging", by rejecting some of the regions to get a better fit, the parameters still remained negative.

That η should be positive is based on the assumption that capital moves from regions where the rate of return is low (under neoclassical assumptions, where the K/L ratio is high) to regions

where it is high.

Olsen argues that the neoclassical assumptions hold but the friction of distance "limits the interregional capital movements so much that the capital stock, despite the capital exports, grows relatively faster in the rich regions". The alternative is to abandon the Hecksher-Ohlin theorem and to assume that capital flows from poor to rich regions. Moreover, empirically it seems that rates of return are higher in the rich regions, a fact easily explained by the Myrdal-Kaldor model but harder to account for in the neoclassical model.

The fact that γ is negative is attributed to the preference investors have for investing in the rich countries (i.e., due to the uncertainty factor, poor regions require a risk premium over and above the physical rate of return).[1]

The simulation runs of the model also produced very unsatisfactory results. The fact that the runs for the earlier period of the study were better than the later period has lead Richardson to speculate that the poor results may be due to a cumulative effect of initial errors. Nevertheless, Olsen's pioneering effort has shown that spatial growth is probably considerably more complex than either the simple neoclassical or Myrdal-Kaldor model suggest.

Richardson's Model

By far the most thorough study of spatial growth is Richardson's recent work (106). Like his other books, it displays his considerable erudition and reviews nearly all of the literature relevant to regional

[1] See Chapter Seven.

growth. However, in spite of his severe criticsms on the relevance of neoclassical assumptions for the space economy he is still, paradoxically, prepared to start from the familiar neoclassical growth equation

$$y = [\alpha k + (1-\alpha)l]^{v} + t \qquad v \gtreqless 1 \tag{21.1}$$

The rate of growth of capital stock, instead of being a function solely of the rate of growth of the labour force and technical change, is defined to be

$$k = b_1 A + b_2 y - b_3 K - b_4 \overset{z}{cv}(K_i/\pi d_i^2) + b_5(R-\bar{R}) \tag{21.2}$$

where A = regional agglomeration economies,

K = regional capital stock,

$\overset{z}{cv}(K_i/\pi d_i^2)$ = coefficient of variation of the capital stock per unit of area in each city of the z urban centres in the region,

R = rate of return in the region,

$\bar{R}$ = the national rate of return.

The labour supply function is given by

$$l = b_6 n + b_7 A + b_8 \bar{P} + b_{14}(w-\bar{w}) \tag{21.3}$$

where n = rate of growth of the population,

$\bar{P}$ = measure of locational preferences

w = regional wage.

The technical progress function is assumed to take the form

$$t = b_{15}A + b_{16}k + b_{17}G_{N_1} + b_{18}q\bar{t} \qquad (21.4)$$

where G_{N_1} = rank of the region's leading city in the national,

q = a connectivety measure of the region,

$\bar{t}$ = the national rate of technical progress.

The major deficiency of this model is, as Richardson readily admits, the fact that by its nature, its value depends upon the results obtained from testing the model, and because of the present data deficiencies this is, at the moment, impossible. Thus the model remains a mere formalization of the factors Richardson intuitively feels are important in explaining growth.

Moreover, in spite of Richardson's constant criticisms of the neoclassical model, if we agree that the assumptions made by Borts and Stein concerning the importance of continuous space etc., are correct, then the following familiar results are obtained

$$y = [\alpha k + (1-\alpha)l]^{v} \qquad (21.5)$$

$$k = b_2 y + b_5(R-\bar{R}) \qquad (21.6)$$

$$l = b_6 n + b_{14}(w-\bar{w}) \qquad (21.7)$$

$$t = b_{18}\bar{t} \qquad (21.8)$$

Thus Richardson's model is open to the objection that it is merely a sophisticated neoclassical model. The use of the regional production function suggests that Richardson accepts the neoclassical theory of distribution. However, while the neoclassical model derives, as the internal determinants of growth, l and t which are determined exogeneously to the system, this is not necessarily true of Richardson's model, since it is formalized by a series of regression equations taking account of other factors.

CHAPTER SEVEN

Towards the Microfoundations of Spatial Growth

The growth models discussed above have been at a very high level of aggregation, concentrating on such factors as homogeneous labour, capital, market potential and the "stylised fact", Verdoorn's Law. However, it is felt that a greater understanding of spatial growth can be obtained through a greater emphasis on individual decision-making (i.e., through the application of microeconomic analysis, especially location theory). This line of approach is in the tradition of the recent work of such economists as Clower and Leonhufvud (who have attempted a reconciliation of Keynesian and Walrasian economics) and Phelps et al. (who are trying to provide a microexplanation of inflation).

Neoclassical growth theory, is, of course, based upon micro-economic theory in that the former necessarily incorporates the assumptions of complete certainty, perfect competition and individual profit maximisation. However, as was discussed in Chapter Three, these are perhaps not the most appropriate assumptions in analysing the space economy.

Consequently, recent developments in location theory, describing processes of town formation as a result of individual firm's actions, provide insights into differential spatial growth rates. While it is probably true that, as Jones (53) comments "it is probably idle to search for a theory of location which may be used to explain the present distribution of industry and industrial formation", location theory can

contribute to the explanation of those forces affecting the growth of industrial activity.

However, the first level of disaggregation is to consider growth as it relates to the urban economy, *per se*. Casual empiricism suggests that initially growth occurs in a few regions, but, progressively, this secular growth is accompanied by a dispersion of growth into neighbouring regions as the integration of the space economy occurs. Concomitant with this spread effect, to use Myrdal's terminology, there is an *intra-regional* polarization of growth as the urban hierarchy develops. Moreover, within the urban area a dispersion trend, away from the CBD, occurs. Hence, any general theory must satisfactorily explain these related phenomena.

Growth in an Urban Context

The literature on urban growth is considerably more diffuse than that of regional growth, since the subject has attracted a greater degree of interdisciplinary attention. Indeed, the city is far more than just an economic phenomenon but a cultural and territorial identity (Harvey (48). However, from the point of view of urban economic growth, we may identify four approaches: the historico-inductive approach, aggregative urban growth models, the planning models and mathematical land use models.

Much of this literature on urban growth, especially that of a planning nature, is not of direct concern here. Typically, the urban area is assumed to be growing at a given rate and the model is designed to trace the implications of this growth for urban structural change.

However, this type of modelling does not attempt to explain the determinants of growth per se, or why some urban areas grow faster than other centres. Consequently, it is perhaps useful to draw a distinction between models relating to growth and those concerned with the effect of growth on the urban structure. As far as this paper is concerned, the former models are of more interest.[1]

The historico-inductive approach is concerned with describing the broad historical sweep of urbanization and development. It basically consists of verbal models at a very high level of generalisation. Although this approach will not be considered in detail, it provides a historical perspective from which to view the economic models that abstract from chronological time, and perhaps provides some evidence as to whether factors deemed important in the more formal models are also emphasised in a timebound framework.

In fact, a brief perusal of the literature in this field provides considerable support for the Myrdal-Kaldor model. Schnore (111), Pred (97), and Lampard (62), for example, all stress the importance of the increasing division of labour and cumulative causation.

Schnore emphasises the division of labour as reflected in the sociological writings of Durkheim and Weber, rather than Smith. However this reinforces the importance of Smith's Dictum not only in the narrow economic context but as a major influence of the development of society. Pred's work is heavily influenced by Myrdal and attempts to relate the latter's approach to an explicitly spatial setting, although the model, like Myrdal's original formulation, is at a very intuitive descriptive level. Lampard provides a very useful discussion of economic models

[1]For an excellent short review of the latter models see Mills (76, Chapter 4)).

from the viewpoint of an economic historian and again the theme of the importance of deviation amplifying forces is apparent. The second category, the macroeconomic urban growth models, would seem to be of the greatest immediate relevance to a consideration of spatial growth, being structurally similar to the regional growth models. However, as has been emphasised above, it is felt diminishing returns may well have set in with regard to the use of this format.

These macro models again fall into the dichotomy of demand and supply orientated models, although in contradistinction to the regional counterparts, the emphasis has been on the demand side. This arose through the legacy of the simple export base theory, and its later reformulation using Keynesian concepts.

The early urban base theories argued that the growth of an urban centre is a function of the base-service ratio. The basic industries were defined as industries producing goods for sale outside the urban area (although some definitions include import substitution production). However, in the 1950's concern arose over the mechanistic use of the base-service ratio to predict the growth of the urban population. For instance, Pfouts (93), (incorrectly)[1] hypothesised that if the economic base was the sole determinant of growth, then as the base-service ratio falls "we would expect a diminuation of economic activity and population because of the relative shrinkage of the economic base, or because of the shrinkage of the growth potential of the city".

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[1]It is incorrect because it neglects (1) the effect of the higher income elasticity of demand for services and (2) the fact that, as Baumol (6) demonstrates, since services are not subject to increasing returns to such an extent as manufactured goods, the service industries require a greater proportional increase in employment for a given increase in in output in *value* terms.

Not surprisingly, subsequent testing of this hypothesis lead to its rejection, but this had the beneficial result of leading to the Keynesian variant. In its simplest form, this model may be formalised as follows:

Define the balance of trade identity as:

$$B \equiv E - M \tag{22.1}$$

where M = urban imports,

E = urban exports.

The import function is given by

$$M = \alpha + mY \qquad (0 < m < 1) \tag{22.2}$$

where Y = urban income,

m = marginal propensity to import ($m = \partial M/\partial Y$).

Similarly define the consumption function

$$C = \beta + cY \qquad (0 < c < 1) \tag{22.3}$$

where c = marginal propensity to consume ($c = \partial C/\partial Y$).

The urban multiplier is derived as

$$dY = \frac{1}{(1-m)c} B \qquad (1/(1-m) > 1) \tag{22.4}$$

Consequently, an increase in the trade balance will increase income subject to the leakages of income into imports (a function of m) and savings (a function of 1-c-m). This model may infact be regarded as the standard economic base theory.[1]

More sophisticated demand models have been recently developed by Czmanski (27) and Paelinck (90). Czmanski introduced a city's comparative locational advantage as a determinant of urban growth. These location advantages are a function of not only Weberian least cost advantages, but also of urbanization and localization economies.

The model may be summarised as follows

$$P = \alpha_1 + \beta_1 L \tag{23.1}$$

where P is the urban population and L the total employed labour force.

$$L \equiv Lg + Lc + Lu \tag{23.2}$$

where the labour force is defined to be composed of Lg, the labour force employed in geographically orientated models, Lc, the labour force in complementary industries and Lu, the labour force in industries related to the urban economy.

$$Lc = \alpha_2 + \beta_2 Lg \tag{23.3}$$

$$Lu = \alpha_3 + \beta_3 P \tag{23.4}$$

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[1]For a regional economic base model see Sirkin (116).

Consequently

$$P = \frac{\alpha_1 + b_1(\alpha_1+\alpha_3)}{1 - b_1 b_3} + \frac{b_1(1-b_2)}{1 - b_1 b_3} Lg \quad . \tag{23.5}$$

Urban size is therefore functionally related to the employment in geographically orientated industry. This latter's growth depends on how much mobile export industries can be attracted to the urban area. This is a function of the static urban comparative advantage.

Czmanski's model has been further developed by Paelinck (90) who incorporated an input-output component to represent the influence of the structure of the urban economy. From a solution of the various difference equation models, Paelinck identifies four phases of urban development. The first phase commences with the growth of the population induced (tertiary) industries. The second phase is associated with the expansion of the complementary industries and this is followed by the expansion induced by agglomeration economies. The last phase is designated as the policy phase. Paelink concludes that "the urban development function is subject to built in cyclical processes that can be easily triggered off due to the interplay of certain strategic studies".

These urban models have received a good deal of conceptual criticism. The models neglect the spatial juxtaposition of other competing urban centres and also the existence of the urban hierarchy. Winger (141) has forcefully argued that while the demand models may have been significant in explaining growth a hundred years ago, with

the increasingly footloose nature of industry, supply orientated models are of now more explanatory value.

Indeed the demand-supply dichotomy has been viewed as a function of the short and long run. Blumenfield (13), in 1955, pointed out that the attraction of the export industries to the urban centre is, to a large extent, a function of the availability of services and the quality of the social overhead capital. Consequently any simple monocausal explanation relying on the growth of exports is likely to be misleading.

As Thompson (130) more recently argued

> "as we move from local cycles to local development... the lines of causation are then turned inside out to the degree that comparative costs rest on the efficiency of local transportation systems, public utilities...and a host of other critical supporting services" (p. 44).

Winger (141) argues that there is a need for a neoclassical production function analysis at the urban level.[1] The standard growth expression is used

$$y = a + \alpha k + \beta l \qquad (24.1)$$

However, we must concur with Winger when he comments that "this obviously oversimplifies the process by which productivity capacity is expanded, partly because it provides little insight into changes taking place in total factor productivity. This deficiency is serious since changes in total factor productivity, a, are an important element in the

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[1] This approach has also been used in the production oriented land use models, though not explicitly to trace the effects of growth.

explanation of growth in developed economies over time" (p. 5).

The existence of increasing returns is included by the assumption that $\alpha + \beta > 1$. We may postulate that this varies with city size. The rate of capital accumulation is a function on the degree of agglomeration economies. Following Baumol (6) the latter may be assumed to increase approximately as the square of population

$$k = f_1 N^2 \tag{24.2}$$

where N is the urban population.

More generally we may define

$$k = f_1 N^{\phi} \tag{24.3}$$

where $\phi = F(N)$.

This allows for the degree of agglomeration economies to vary with population size.

The rate of technical progress may similarly be expressed as a function of urban size

$$a = f_2 N^{\psi} \tag{24.4}$$

where $\psi > 1$.

Consequently

$$y = f_2 N^{\psi} + \alpha f_1 N^{\phi} + \beta l \quad . \tag{24.4}$$

We may consider the rate of growth of labour to be a function of the rate of growth of the urban population (n) and net migration (m). Hence

$$l = d(n+m)$$

where d is a measure of the activity rate.

However, although the model may be disaggregated in a manner analogous to that adopted by Borts and Stein, the model is open to all the criticisms discussed in previous chapters. The treatment of increasing returns and *dynamic* comparative advantage is very unsatisfactory and, in spite of Winger's comments, it does not seem to be very useful to try to explain urban growth within the neoclassical framework.

Microeconomic Theory and Regional Growth

Ultimately, regional growth is a function of entrepreneural decision-making, especially in respect as to whether to replace capital depreciation and expand investment in situ, and whether to invest, de novo, in a region. Consequently, it would seem that location theory should be able to shed some light on the spatial growth process and in this section a brief overview of the possible approaches will be given.

Apart from the usual aggregation problems, the reconciliation of location theory and the macrodynamic theories of growth is handicapped by the fact that regional growth theory is based on puncitform regions while location theory is essentially spatial. Moreover, most models in location theory are essentially static and it is difficult to relate this to dynamic growth theory, except through a comparative

static approach.

As was noted in Chapter Four, there are two main ways in which location theory may be considered. The first, which will not be discussed in any detail here, is to abandon optimization theory and assume that, because of conflicting goals, imperfect information and environmental changes, entrepreneurs can only be treated as satisficiers. This approach assumes that location decisions do not yield deterministic outcomes. (Pred (98), Pred and Kibel (152), Olsson and Gale (89)). The major disadvantage of utilizing this approach in the explanation of growth is epitomized by Pred's behavioral matrix, where, to derive more than trvially obvious results, the method becomes exceedingly complex.

The other alternative is to retain the maximization hypothesis[1] as a paradigmatic assumption.[2] However, the use of perfect competition as an analytical tool is clearly untenable and this invalidates the, albeit simple, process of aggregating individualistic profit maximising decision-making under conditions of perfectly elastic demand to derive the neoclassical macro growth model.

One of the most comprehensive attempts to synthesise micro and macro location theory has been undertaken by Greenhut((41), part III, pp. 209-325). However, the fact that this section of the book is basically a review of land use theories with the objective of demonstrating that interurban and intraurban locations are analogously determinable, shows

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[1]In location theory, this has been the traditional profit maximising assumption, although the Baumol Marris growth maximising function may provide an interesting alternative.

[2]For a defence of this approach see Webber (136, pp. 105-110).

that the reconcilation of location and macro spatial theory is still at a very elementary stage.

Greenhut begins with an orthodox review of the early interurban land use theories (Hoyt, Harris and Ullman, inter alios), which is followed by a survey of the "micro location"-theory of the firm (the Weberian minimum cost approach and the market area approach). The transition from micro to macro location theory is achieved by the use of standard microeconomic theory and the use of household and firm bid rent curves. The urban hierarchy is derived by the use of Beckmann's extension of the Loschian system.

While much of this section will be familiar to the geographer, Greenhut provides some interesting insights into the effect of growth on location. By using Churchill's firm stock flow production function analysis (which has the advantage of allowing for noncompetitive factor and product markets), the possibility of the reversibility of efficient location sites as demand grows is demonstrated.

However, the main conclusion of Greenhut is more controversial. Greenhut conceives of the space economy originally consisting of randomly sited firms, their location a function of the distribution of natural resources. As growth occurs, there is progressively greater interaction and a tendency towards oligopoly - competition (Greenhut (41, Chapter Seven). However, while Greenhut argues that oligopoly is the most appropriate market structure of the space economy, he views it as a transformation of perfect competition into space. Consequently, he claims to have demonstrated that spatial competition results in an efficient market solution. At the risk of overgeneralisation, the

justification of this conclusion is Alchian's natural selection thesis, an epeistomological stance hard to justify (Winter (142)).

The various attempts to construct urban hierarchy models, following the pioneering work of Tinbergen (128) and Bos (16) provide an alternative way of reconciling individual location decisions based on a consideration of differential agglomeration economies with the spatial hierarchical structure. However, like Losch's model, while this derives varying urban sizes, it is within a static framework and so the dynamic impact of agglomeration economies is not made explicit.

Attempts to explain the existence of the urban hierarchy through Gibrat's Law reject the need for an examination of economic forces, per se since the distribution of city sizes is deemed to be a product of stochastic forces. This explanation is unsatisfactory in that recent evidence does suggest that there is a relationship between growth and city size (Stanback and Knight (122)). Moreover, a necessary condition for Gibrat's Law to be valid is that there is no significant difference in the variance of growth rates in each city size class, a fact refuted by Thompson (130). This implies that it is necessary to provide an economic interpretation and it is not sufficient to rely on the existence of random forces.

Two recent attempts to provide an explanation have been put forward by von Boventer (18) and Evans (31). von Boventer, assuming that the numbers and sizes of all business units are given, attempts to answer the question of "where will these enterprises locate, what kind of city size structure will evolve, and what will the optimal spatial distribution of cities be?"

Following Losch, it is assumed that firms have differing spatial

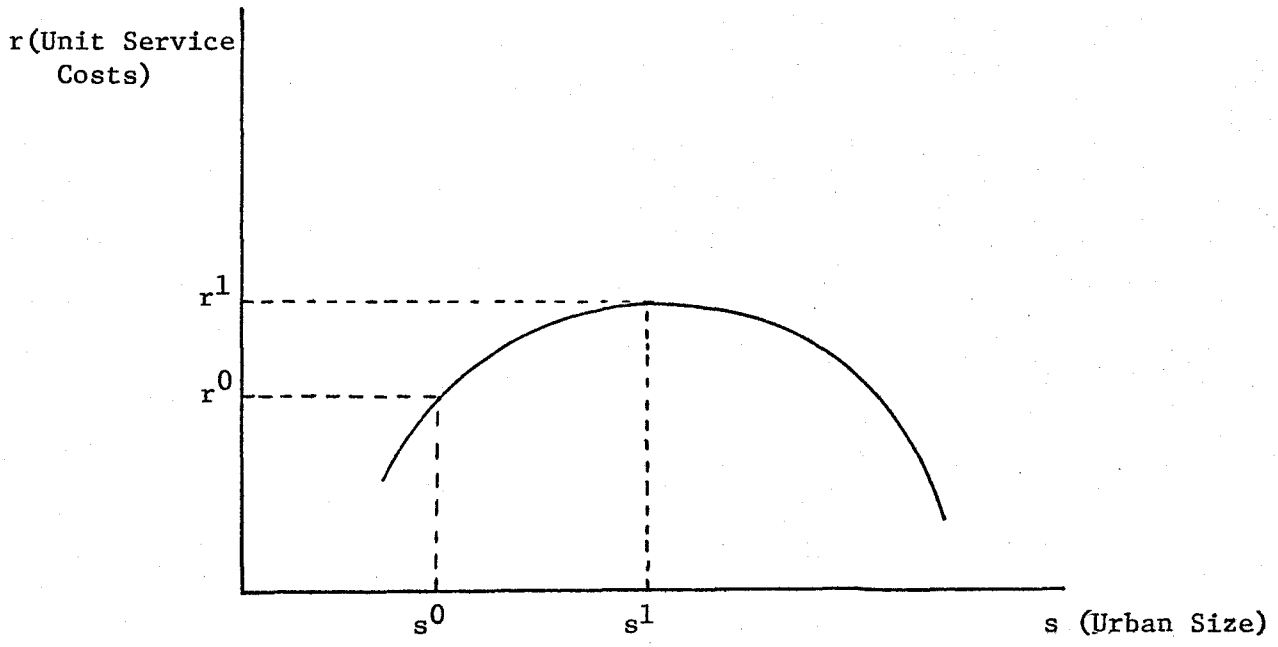
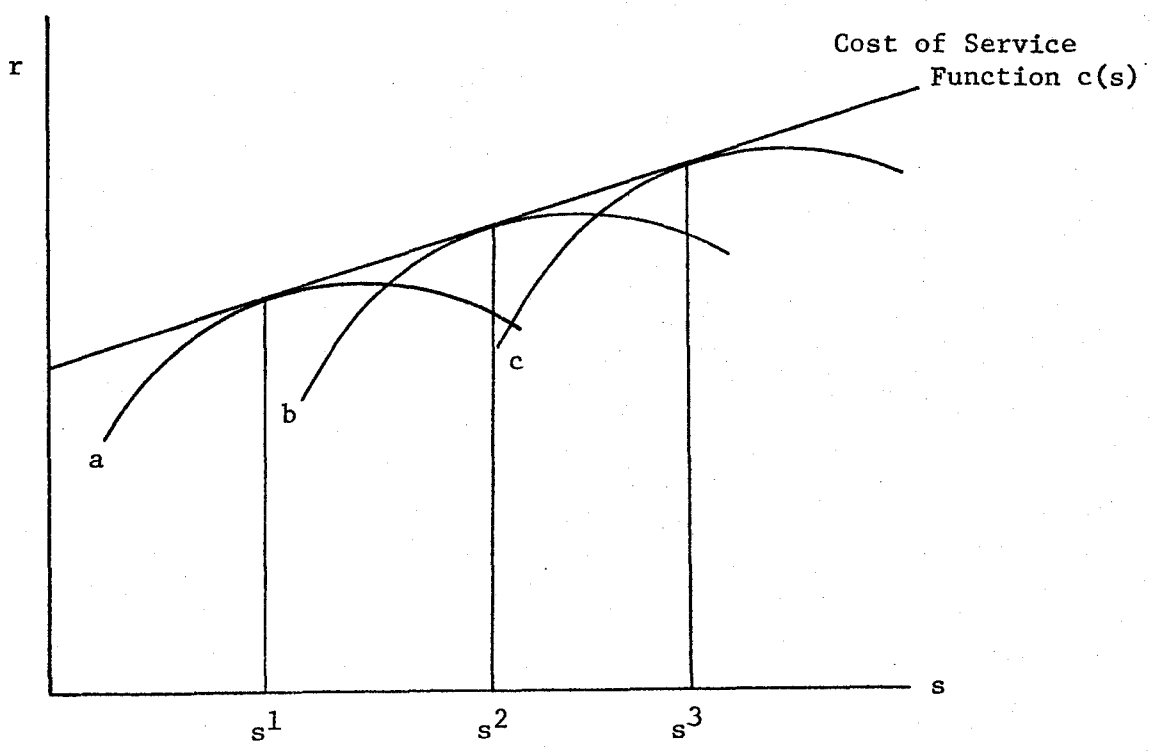


FIGURE 3



(After von Boventer)

FIGURE 4

markets and the distribution is some form of Pareto or lognormal function (the exact form is unimportant). The problem arises that given some tendency towards an optimal spatial solution, how will these firms be located. From the work of Christaller and Losch,it may be assumed that some form of central place network will be envolved. However, the additional information that is required is knowledge about the agglomeration economies of an urban centre on the one hand and the cost of urban inputs on the other. The infrastructure costs and agglomeration economies will determine the optimal size of a centre analogously to the way that supply and demand determine the market optima in the commodity market. As an expositional assumption, it is postulated that the unit cost of urban services rise monotonically with the increase in size of cities. One may consider this, in fact, to be the supply curve of the urban centres. The corresponding demand curve is theprice that firms are willing to pay for this "representative bale of urban services" at given profit levels.

The question then is posed as to why firms should be willing to pay different prices in different cities for these same services. The answer is to be found in the fact that if a firm is able to derive agglomeration advantages from locating at a bigger centre (and, consequently, increase its profits), it will be willing and able to pay a higher price per unit of urban services, if it is assumed competition equalizes profit rates. Consider Figure 3. A firm in city size s^o will pay pay r^o for each bale of urban services. It is now necessary to determine what is the maximum price per unit service the firm could

pay as it fully responds to increasing returns engendered by city size. In Figure 3, these agglomeration economies rise to a peak at s' and decline thereafter.

The analysis can easily be extended to derive relative city sizes. Let us suppose we have 3 firms a, b and c. The firm with the greatest propensity to benefit from agglomeration economies will locate in the largest city (see Figure 4) and so on. Consequently, for each particular firm there is an optimum city size where it will locate.

Evan's paper similarly derives the urban hierarchy. However, Evans develops the argument further and considers the determination of the urban hierarchy from a general, rather than partial, equilibrium viewpoint. This is accomplished through a game theoretic approach.

> "Each city can be viewed as a 'club' or 'coalition' of which manufacturing firms are members. The firms in the economy can be viewed as players in an n person game in which each firm acting independently can join coalitions of other firms and usually cannot be barred. The pay-off to each firm is a function of the size of the coalition of which he is a member and the pay-off functions are not the same" (Evans(31)).

Finally, it is necessary briefly to consider the implications of the relaxation of the assumption of perfect knowledge. The deleterious effect of uncertainty on the ability of atomistic competition to derive a Pareto optimum is well known, and, in development economics, has long been realised to be of major significance by such Economists as Nurske. The foundation of Growth Pole Theory, as originally formulated by Perroux (92) was based upon Scitovsky's concept of pecuniary externalities and the fact that the absence of ubiquitous

information channels destroys the validity of the concept of balanced spatial growth. More recently, Komai (61) has argued that the price mechanism is not even the *major* source of information in the economic system and has proposed an analytical framework taking cognizance of this fact.

The first study to examine the effect of uncertainty on location theory was by Greenhut (41). However, Greenhut was primarily concerned with the impact of uncertainty of location decisions rather than the effect of on the spatial structure, per se. The latter was more the interest of Webber (136), who demonstrates that uncertainty reinforces the tendency towards spatial concentration and accentuates the polarization nature of growth. Moreover, if information is not costless, there "is a definite and limited area within which it pays firm to gather information". Webber shows that ex ante and ex post optimality of location decisions may diverge and a profit maximising search procedure on the part of the firm may not result in a socially optimal location pattern.

In conclusion, as has been argued above, a greater understanding of spatial growth may be achieved through the greater use of micro-economic theory, especially location theory, to study the macrophenomenon of growth. The Myrdal-Kaldor paradigm provides a more appropriate framework for this analysis than the orthodox (neoclassical) paradigm, and what is required in the future is a synthesis of the model to incorporate space.

Moreover, in spite of the greater mathematical sophistication, and elegance of the neoclassical growth models, they provide little

satisfactory theoretical explanation as to why growth rates differ between advanced countries. Consequently, the Myrdal-Kaldor may not only be useful in explaining the stylised facts at the regional scale but also at the national level, where the microfoundations may be provided, not by traditional location theory, but by Vernon's International Product Cycle Theory (153).

ANNEX

(a) To Prove: The rate of growth of output of the simple neoclassical model is given by

$$y = n + g/(1-\alpha)$$

With the usual notation, define

$$Y = e^{gt} K_t^{\alpha} (Lo\ e^{nt})^{1-\alpha} \quad (1)$$

Therefore

$$\log Y = gt + \alpha \log k + (1-\alpha)Lo + nt \quad (2)$$

Differentiate (2) wrt time

$$y = g + \alpha k + (1-\alpha)n \quad (3)$$

((3) is, of course, the same as equation (1.2) in the text.)

But $S \equiv I \equiv sY$, therefore $i = y$ where i is the rate of growth of I

$$i = g + \alpha k + (1-\alpha)n \quad (4)$$

But for balanced growth $i = k$ (5)

Therefore

$$i = g + \alpha i + (1-\alpha)n \tag{6}$$

$$i = y = g/(1-\alpha) + n \qquad Q.E.D. \tag{7}$$

(b) To Prove $L^* = s(P^*_t + \mu/e\ k^*) + s.v.^*$

Borts and Stein derive the proof for this using a general production of the form $Y = L\ h(K/L, 1)$

However we shall derive an alternative proof using a Cobb-Douglas function

$$Y = K^{\alpha} L^{1-\alpha} \tag{1}$$

$$\frac{\partial Y}{\partial K} = \alpha(K/L)^{\alpha-1} = z/p \text{ (with the notation in the text)} \tag{2}$$

$$\partial Y/\partial L = (1-\alpha)(K/L)^{\alpha} = w/p \tag{3}$$

Differentiate (2) wrt time

$$z^* - p^* = (\alpha-1)\left(\frac{1}{K/L}\right) \times \frac{d(K/L)}{dt} \tag{4}$$

However we may define μ (the elasticity of the marginal productivity schedule wrt K/L) as

$$\mu \equiv \frac{d \log (K/L)}{d \log \alpha (K/L)^{\alpha-1}} \tag{5}$$

$$= \frac{1}{K/L} \cdot \frac{K/L}{(\alpha-1)} \cdot \frac{d(K/L)}{d(K/L)} \tag{6}$$

Substituting (6) into (4)

$$z^* - p^* = \frac{1}{\mu} \left\{\frac{d(K/L)}{dt}\right\} \div (K/L) \tag{7}$$

$$= 1/\mu (K/L)^* \tag{8}$$

Similarly

$$w^* - p^* = \alpha \left\{\frac{d(K/L)}{dt}\right\} \div (K/L) \tag{9}$$

Define e as

$$e \equiv \frac{d \log K/L}{d \log (1-\alpha)(K/L)^{\alpha}} \tag{10}$$

$$e = 1/\alpha \tag{11}$$

Therefore substituting (11) into (9)

$$w^* - p^* = 1/e\ (K/L)^* \tag{12}$$

Turning now to the supply of labour

$$v^* + w^* = \frac{g'(L)}{g(L)} \dot{L} \tag{13}$$

$$s \equiv \frac{g(L)}{g'(L)} \frac{1}{L} \tag{14}$$

(where s is the elasticity of labour wrt to the wage rate.)

$$w^* + v^* = 1/s\ L^* \tag{15}$$

The rate of increase in the *real* value of the capital goods is given by

$$K^* = z^* - p^* \tag{16}$$

$$z^* - p^* = 1/\mu\ (K/L)^* \tag{17}$$

Therefore

$$\mu K^* = (K/L)^* \tag{18}$$

$$w^* - p^* = 1/e\ (K/L)^* \tag{19}$$

$$= \frac{\mu}{e}\ (K/L)^* \tag{20}$$

$$w^* = \mu/e\ K^* + p^* \tag{21}$$

But from (14) we know

$$L^* = s_y{}^* + sw^* \tag{22}$$

Substituting (21) into (22)

$$L^* = sv^* + s(p^* + \mu/e\ K^*) \qquad Q.E.D.$$

(c) To Prove $f_K = f'(k)$

$f_L = f(k) - f'(k)k.$

where f_K = marginal physical product of capital

f_L = marginal physical product of labour

$k = K/L$

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

$$Y = L\ f(k) \tag{2}$$

Let us determine π/P

$$\pi/p = \frac{\partial\{L\ f(k)\}}{\partial Y} \tag{4}$$

$$= L[f'(k)\ \frac{\partial k}{\partial K}] \tag{5}$$

$$= L[f'(k)]\ \frac{1}{L} \tag{6}$$

$$= f'(k) \qquad Q.E.D. \tag{7}$$

Similarly

$$w/p = \frac{\partial[Lf(k)]}{\partial Y} = f_k + L[f'(k)\ \frac{\partial K}{\partial L}] \tag{8}$$

$$= f(k) + L[f'(k)\left(\frac{-K}{L^2}\right)] \tag{9}$$

$$= f(k) - f'(k)k \qquad Q.E.D. \tag{10}$$

Let us demonstrate this using the Cobb-Douglas.

$$\frac{\partial L}{\partial K} = f'(k) = \alpha(K/L)^{\alpha-1} \tag{11}$$

(i.e., differentiating $Y = L(K/L)^{\alpha}$ wrt K.)

$$\frac{\partial Y}{\partial L} = (1-\alpha)(K/L)^{\alpha} \tag{12}$$

From (10)

$$(1-\alpha)(K/L)^{\alpha} = f(k) - f'(k)k \tag{13}$$

$$= (K/L)^{\alpha} - \alpha(K/L)^{\alpha-1}(K/L) \tag{14}$$

$$= (1-\alpha)(K/L)^{\alpha} \qquad Q.E.D. \tag{15}$$

(d) To Prove $K^*_x = \frac{P^*_x}{1-\alpha} + L^* + \varepsilon^*$

Proof

It is assumed r, P_k and P_x are exogeneously determined

$$\bar{r}\bar{P}_k = \bar{P}_x f_k \tag{1}$$

Consequently

$$0 = P^*_x + f^*_k \tag{2}$$

$$-f^*_k = P^*_x \tag{3}$$

$$f^*_k \equiv \mu Q^*_x \tag{4}$$

where $Q = L_x/k_x$

$$\equiv \quad (1-\alpha)Q_x^* \qquad [1] \qquad (5)$$

To show this

$$\text{Define } Y \quad = \quad (L/K)^{1-\alpha}K \qquad (6)$$

$$\frac{\partial Y}{\partial K} \quad = \quad (1-\alpha)\left(\frac{L}{K}\right)^{-\alpha} \cdot -\frac{L}{K^2} \cdot K + \left(\frac{L}{K}\right)^{1-\alpha} \qquad (7)$$

$$= \quad -\alpha\left(\frac{K}{L}\right)^{1-\alpha} \qquad (8)$$

$$\left(\frac{\partial Y}{\partial K}\right)^* \quad = \quad (1-\alpha)\left(\frac{L}{K}\right)^* \qquad (9)$$

But

$$Q_x^* \quad = \quad L_x^* - K_x^* \qquad (10)$$

From (5) and (10)

$$K^* \quad = \quad \frac{-f_k^*}{(1-\alpha)} + L^* \qquad (11)$$

---

[1] *Nota bene,* $(1-\alpha)$ is defined here as the output elasticity of labour from the production function $Y = K^{\alpha} L^{1-\alpha}$.

Borts and Stein term $(1-\alpha)$ as α, which may be a potential source of confusion if the two approaches are compared. It was thought appropriate to retain the conventional notation, above.

$$K^* = \frac{P_x^*}{1-\alpha} + L^* \qquad \text{(from 3)} \tag{12}$$

But there is a shift of labour into x defined to be ε^*.

Therefore

$$K^* = \frac{P_x^*}{1-\alpha} + L^* + \varepsilon^* \qquad Q.E.D. \tag{13}$$

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