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THREE VARIANTS OF ENDOGENOUS GROWTH: AS APPLIED TO THE UNITED KINGDOM 1948-2000

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ABSTRACT

Endogenous growth theory is now fashionable. It seeks to explain why per capita income growth in capital abundant countries is often faster than in capital poor countries and defies the operation of diminishing returns. It also claims to explain the phenomenon of 'increasing returns' which appears to underlie the continuing high per capita income growth in rich countries. Romer (1989) poses the problem thus: "How can one reconcile extraordinary, continuing increases in average per capita income with the notion of diminishing returns?"

The endogenous growth literature, which took off with Romer (1986, 1987) and Lucas (1988), shows no signs of subsiding. Other important contributions in this area are Romer (1989, 1990), Krugman (1990, 1993), Murphy et al. (1989a and 1989b), Shaw (1992), and Aghion and Howitt (1998). This literature often makes Allyn Young's (1928) concept of increasing returns and Marshall's (1890) distinction between internal and external economies its starting point. Since the treatment of the subject by Marshall and Young is considered to be verbal and therefore not rigorous enough, the new growth theorists then claim to explain what they had in mind with greater clarity, rigour and depth.

The objective of this paper is first to examine whether the new growth theory adequately represents Young's views on growth; second to develop alternative models of endogenous growth; and third to test these variants against the UK data for the period 1948-2000. Our view is that growth is best treated as a process in which market size or real demand plays a crucial role. Our starting point is Smith's famous dictum that the division of labour is limited by the size of the market. This demand-based view leads to three variants of endogenous growth consistent, respectively, with the insights of Smith (1776), Young (1928), and Lauchlin Currie (1997), who studied under Young.

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1. Introduction

Endogenous growth theory is now fashionable. It seeks to explain why per capita income growth in capital abundant countries is often faster than in capital poor countries and defies the operation of diminishing returns.[1] It also claims to explain the phenomenon of 'increasing returns' which appears to underlie the continuing high per capita income growth in rich countries. Romer (1989) poses the problem thus: "How can one reconcile extraordinary, continuing increases in average per capita income with the notion of diminishing returns?"

Early development economists such as Rosenstein-Rodan (1943, 1961), Nurkse (1953) and Lewis (1954) emphasised the role of capital accumulation in growth. Given a constant capital-output ratio, the Harrod-Domar model (Harrod 1939, Domar 1947) predicted that the higher the savings rate, the higher would be the rate of growth. However, since capital accumulation was regarded as central to growth, the assumption of a constant capital-output ratio was considered unrealistic, in that the phenomenon of diminishing returns could soon be expected to reduce and finally eliminate all per capita income growth. Based on such models, which emphasise capital accumulation, it is difficult to foresee how growth can continue beyond a few decades given the assumption of diminishing returns. In fact Krugman (1994) in a celebrated article in *Foreign Affairs* claimed that the East-Asian miracle, like the earlier communist miracle, was largely based on input growth. It would therefore not be sustainable:

> Popular enthusiasm about Asia's boom deserves to have some cold water thrown on it. Rapid Asian growth is less of a model for the West than many writers claim, and the future prospects for that growth are more limited than almost anyone now imagines (p. 64).

Neoclassical growth theory (see for example, Abramovitz 1956, Solow 1956 and 1957) regards growth largely as the outcome of exogenous technical progress which effectively offsets the law of diminishing returns to which inputs are subject. From the policy perspective this theory has little to offer since technical change is unexplained and therefore not amenable to policy. The theory predicts a convergence of living standards of different economies to a common level. But the evidence suggests no such convergence.[2] Romer (1989), on the basis of data from Summers and Heston (1984), presents evidence in the form of a scatter plot to suggest that growth rates across 115 market economies show no systematic variation with the level of per capita income. "The absence of any negative slope in this scatter plot is evidence against the assertion that low-income countries tend to grow more rapidly than high income countries and that convergence in per capita income is taking place" (Romer 1989, p. 64). Thus new growth theory has partly emerged to explain this lack of convergence and partly to evolve a theory which has something interesting to say on policy.

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[1] One of Kaldor's (1961) six stylised facts is that output per worker shows continuing growth with no tendency for a falling rate of growth of productivity.

[2] Another of Kaldor's stylised facts is that there are wide differences in the rate of growth of productivity across countries.

(1989, 1990), Krugman (1990, 1993), Murphy et al. (1989a and 1989b), Shaw (1992), and Aghion and Howitt (1998). This literature often makes Allyn Young's (1928) concept of increasing returns and Marshall's (1890) distinction between internal and external economies its starting point. Since the treatment of the subject by Marshall and Young is considered to be verbal and therefore not rigorous enough, the new growth theorists then claim to explain what they had in mind with greater clarity, rigour and depth.

The objective of this paper is first to examine whether the new growth theory adequately represents Young's views on growth; second to develop alternative models of endogenous growth; and third to test these variants against the UK data for the period 1948-2000. Our view is that growth is best treated as a process in which market size or real demand plays a crucial role. Our starting point is Smith's famous dictum that the division of labour is limited by the size of the market. This demand-based view leads to three variants of endogenous growth consistent, respectively, with the insights of Smith (1776), Young (1928), and Lauchlin Currie (1997), who studied under Young.

The rest of the paper is organised as follows. In the next section we shall first present Young's view of growth, then explain the ways in which modern growth theory is inconsistent with Young's ideas, and finally develop our three variants of endogenous growth as alternatives to the new growth theory. In section 3 we outline the methodology for testing these variants. In section 4 we put these models to test against UK time-series data taken from the IMF's International Financial Statistics. In section 5 we present our conclusions.

2. Three Variants of Endogenous Growth

2.1 Young's View of Growth

The starting point of our analysis is Adam Smith (1776) who argued that the division of labour was constrained by the size of the market. When Smith talked of the division of labour what he had in mind was job specialisation within a firm. He gave the example of pin manufacture in this context. If one man were to carry out all the operations of pin making – drawing of wire, cutting, head-fitting and sharpening etc. – his output would be minimal. If, however, each man specialised in a single operation only, total output and output per worker would increase dramatically. This was the first illustration of how endogenous growth takes place in response to expanding market size.

Young expanded on Smith's notion of division of labour to include not only job specialisation but also specialisation which occurs among firms and industries (see also Currie, 1981 and Sandilands, 2000). According to him, specialisation at these levels was the main source of increasing returns. A growing market would permit a wider and wider range of specialist firms and industries and this would lead to all-round cost reductions and hence to further increase in the size of the market. In Young increasing returns take the form of pecuniary external economies which are passed on to other firms through the price system. Thus a competitive market system is crucial for the transmission mechanism to take place.

Young's concept of increasing returns is different from the equilibrium notion of economies of scale. In an economy the forces of disequilibrium are continuously defeating those which make for equilibrium, and hence he advocated a disequilibrium approach to understand the phenomenon of growth. Increasing returns in Young must therefore be interpreted from a disequilibrium perspective. He pointed out that if we look for increasing returns under large-

scale production or under production by large firms we are likely to miss them. Increasing returns, more often, took the form of external economies which are passed on to other firms in the form of reduced prices. Thus increasing returns did not necessarily lead to monopoly or the breakdown of competition. What Young had in mind was 'large production' rather than 'large-scale production' in response to expansion of the market as a whole (Young 1928, p. 531), so that increasing returns result from *economies of specialisation* rather than *economies of scale* as conventionally understood. In his LSE lectures, as recorded by his student Nicholas Kaldor, Young remarked: "Most of the advantages of increasing returns can be had in an industry not consolidated... Rather they are those of increased specialisation, those of reorganisation, not mere increase of size in the operating units" (Young 1990, pp. 53-4).

Since the size of the market is determined not by population or geographical area but by the volume of total production, Young suggested that the capacity to buy depended on the capacity to produce. From this he concluded that Adam Smith's dictum regarding the division of labour amounted to the theorem that the division of labour to a large extent depends on the division of labour. Although Young did not use the term 'cumulative causation', which was coined by Myrdal (1957), this was the first enunciation of this principle.[3] According to this principle, change begets change in the same direction so that it is cumulative and mutually reinforcing.

Growth once started has an underlying tendency to be self-perpetuating rather than self-exhausting. Though different industries grow at different rates depending on their elasticities of demand and supply, the endogenous process of overall growth is so full of potential that "even with a stationary population and in the absence of new discoveries in pure and applied science there are no limits to the process of expansion except the limits beyond which demand is not elastic and returns do not increase" (Young 1928, p. 534).

In this demand-based view of growth, inputs of labour, capital and technology are seen more as the outcome of the growth process than its cause. Considerable evidence exists to suggest that growth is indeed not caused by inputs of labour or capital. Currie (1997) gives a useful review of this evidence for the USA. Regarding the relationship between real GDP and non-residential business investment, he finds that GDP precedes non-residential business investment fairly consistently from 1960 to 1992. He also cites supporting evidence from Montenegro (1989), who on the basis of Granger-causality, finds that GDP causes non-residential business investment in the US and not vice versa. Regarding the role of labour Currie finds that there is a negative correlation between per capita income growth and population growth for a sample of 100 countries[4]. In Currie's view therefore there is little evidence to suggest that growth is mainly the outcome of inputs of labour or capital.

Blomstrom et al. (1996) express a similar view. On the basis of their Granger analysis as applied to panel data, they find that economic growth precedes capital formation and not vice versa. In a recent study Chandra and Sandilands (2001) show that although GDP and real investment are cointegrated for India during 1950-1996, the direction of causality runs from economic growth to capital accumulation and not vice versa. So investment emerges as a following rather than an initiating factor in India's growth.

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[3] For a useful survey of the literature on main currents in cumulative causation, see Toner (1999).

[4] Studies by Minkiw et al. (1992) and Knight et al. (1993) suggest that population growth has a negative and statistically significant impact on per capita income level and per capita income growth respectively. See also Thirlwall (1999, p. 119) for a summary of six recent studies on the macrodeterminants of growth.

2.2 New Growth Theory and Young

In this section we show how modern endogenous growth literature misinterprets Young in several important ways. First, this literature seems to think that Young was talking about some kind of a competitive equilibrium in the presence of increasing returns. For example, Romer (1986, p. 1004) writes:

> The idea that increasing returns are central to the explanation of long-run growth is at least as old as Adam Smith's story of pin factory. With the introduction by Alfred Marshall of the distinction between internal and external economies, it appeared that this explanation could be given a consistent, *competitive equilibrium* interpretation. The most prominent such attempt was made by Allyn Young in his 1928 presidential address…(italics added).[5]

Young did stress the importance of a competitive market system in making increasing returns possible but his conception was not that of equilibrium. He regarded growth as a disequilibrium process in which "the counter forces which are continually defeating the forces which make for economic equilibrium are more pervasive and more deeply rooted in the constitution of the economic system than we commonly realise" (Young 1928, p. 533). Further: "Every important advance in the organisation of production, regardless of whether it is based upon anything which, in a narrow or technical sense, would be called a new 'invention', or involves a fresh application of the fruits of scientific progress to industry, alters the conditions of industrial activity and initiates responses elsewhere in the industrial structure which in turn have further unsettling effect. Thus change becomes progressive and propagates itself in a cumulative way" (Young 1928, p. 533). Moreover: "Seeking equilibrium conditions under increasing returns is as good as looking for a mare's nest" (Young 1990, p. 45).

In the new growth literature there appears to be much confusion regarding the Youngian conception of increasing returns. The literature seems to suggest that *economies of scale* are the chief source of Youngian *increasing returns*, and therefore, that fixed costs and monopolistic competition are important ingredients of models trying to depict the phenomenon of increasing returns. For example, Romer (1987, 1989) seems to think that increasing returns are based on specialisation arising out of fixed costs and that therefore we need not rely on the beneficial external effects due to spillovers of knowledge.[6] Describing his Marshall-Young-Romer model of endogenous growth Romer (1989) writes:

> The degree of specialisation, or equivalently, the number of different firms that are available at any point in time or location, is limited by the presence of fixed costs…Although Marshall and Young choose to describe specialisation in terms of

[5] See also Robbins (1932), who mistakenly suggested that Young (and Smith) were advocates of equilibrium economics: "[A]lthough Adam Smith's great work professed to deal with the causes of the wealth of nations, and did in fact make many remarks on the general question of the conditions of opulence which are of great importance in any history of applied Economics, the central achievement of his book was his demonstration of the mode in which the division of labour tended to be kept in equilibrium by the mechanism of relative prices – a demonstration which, as Allyn Young has shown, is in harmony with the most refined apparatus of the modern School of Lausanne. The theory of value and distribution was really the central core of the analysis of the Classics, try as they might to conceal their objects under other names" (pp. 68-9).

[6] However, Romer (1990) also presents a model in which monopolistic competition and knowledge spillovers are both allowed in an equilibrium situation. This model emphasises the role of integration into world markets in increasing the growth rate through the way it promotes new research.

competitive equilibrium with externalities, it is now clear that a more rigorous way to capture the effects they had in mind is in a model with fixed costs. In an equilibrium with nonnegative profits, price must exceed marginal cost to be able to recover these fixed costs, so the model must therefore contemplate some form of market power.

However, Young himself never talked of fixed costs or economies of scale or competitive equilibrium or monopoly power in the context of increasing returns.[7] In the Youngian notion, increasing returns are certainly based on specialisation (or the division of labour) which occurs among firms and industries, but these increasing returns are mostly external to a firm and transmitted to other firms through pecuniary external economies. By contrast, Romer suggests that for specialisation to arise significant fixed costs and monopoly power are necessary. In the Youngian notion specialisation does not arise due to fixed costs or monopoly power but due to the expansion of the size of the market. Since Youngian increasing returns are external rather than internal, their presence does not necessarily lead to the emergence of monopoly or to the breakdown of competition.

In a disquilibrium situation where new packagings, new substitutes, new products, new processes, new combinations of factors are continuously emerging in response to a growing market, a representative firm is likely to lose its identity sooner or later.[8] To take an extreme example for illustrating the point, a firm which manufactures a product X to begin with may ultimately end up manufacturing some component of X. Or instead of manufacturing all components of X itself, the firm may just concentrate on assembling the final product and buy components from a number of small intermediate producers. The concept of 'economies of scale' is therefore slippery and problematic, because first, the firm may not be able to maintain its identity for long and second, even if it does it does not often stay on the same cost schedule.[9]

This process of industrial fragmentation or disintegration is a key feature of the growth process. When the external environment in which the firm operates is changing fast, not only is it difficult for it to maintain its identity but also the distinction between internal and external economies becomes meaningless: "With the extension of the division of labour among industries the representative firm, like the industry of which it is a part, loses its identity. Its internal economies dissolve into the internal and external economies of the more

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[7] For example, Young (1928) while dwelling on Alfred Marshall's distinction between internal and external economies warns that "it is, and ought be, a safeguard against the common error of assuming that whenever increasing returns operate there is necessarily an effective tendency towards monopoly" (p. 527). But this distinction, according to Young, is a partial view and may only be true as long as the representative firm is able to maintain its identity. Once one takes into account the changes taking place in the external environment, which are qualitative as well as quantitative, one has to depart from the equilibrium notion of increasing returns which Marshall had in mind. Youngian increasing returns are therefore based on continuous disequilibrium rather than equilibrium.

[8] The notion of a *representative firm* was first used by Marshall (1890) to illustrate how external economies get transmitted and show themselves in average cost. Robbins (1928) criticised this notion on the grounds that it was not merely unnecessary to the theory of value and equilibrium but positively misleading. In Young's (1990) opinion, Robbins "is overcritical and does not seem to appreciate that the notion of a representative firm is an expository device". The question is perhaps one "hardly worth wasting an article in the *Economic Journal*" (p. 45).

[9] The term 'economies of scale' usually conjures up the comparative statics idea that by moving along a given cost schedule, unit costs can fall. The Youngian conception, however, is of 'dynamic economies of scale' in which the cost schedule itself shifts down as the overall market size, in which a firm operates, expands over time.

highly specialised undertakings which are its successors, and are supplemented by new economies" (Young 1928, p. 538).

Further, the concept of returns to scale is based on the idea that all inputs vary at the same rate. This is a very restrictive assumption seldom met in real life. In response to a continuously changing market, inputs vary not proportionately but at different rates. So whichever way one looks at it, the notion of economies of scale as the basis of increasing returns does not appear convincing. If increasing returns have an ambiguous connection with scale economies, it follows that monopoly or some kind of market power is not an inevitable outcome of increasing returns.

Krugman (1993) is another writer who highlights the importance of internal economies of scale. He suggests that economies of scale at the individual plant level are necessary to generate strategic complementarity (or pecuniary external economies) at the level of the economy. In his streamlined presentation of the big push model of Murphy et al. (1989b), Krugman (1993) mentions that two conditions are necessary to generate external economies in the model, namely, economies of scale in production and elastic labour supply in the traditional sector. "It is thus the interaction between internal economies of scale and elastic factor supplies that gives rise to de facto external economies" (p. 20). Further, "As long as there are unexhausted economies of scale in the modern sector, which are crucial to the whole argument, one must face up to the necessity of modelling the modern sector as imperfectly competitive" (p. 20).[10]

Thus, as already stressed, neither economies of scale nor imperfect competition are necessary for Youngian increasing returns to take place because "large production, not large scale production, permits increasing returns" (Young 1990, p. 54). In fact these increasing returns are most fully realised in a well functioning competitive market system.

By contrast, the new growth and new trade literature stresses anti-market policies such as patents, copyrights and "strategic trade policy" or protectionism; and monopoly power is justified on the grounds that competition, by driving down the returns, would not provide enough incentive to recoup the costs of R&D and innovation. In Youngian theory increasing returns are achieved through more rather than less competition. The positive effects of competition through diffusion are thought to outweigh its negative impact. While Young was favourably inclined towards copyright laws as "otherwise it would not be possible for

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[10] Krugman (1999) reviewed Bertil Ohlin's seminal work *Interregional and International Trade* (1933) and asks, a propos his own recent contributions to 'new' trade theory based on increasing returns (notably in Helpman and Krugman 1985), "Was It All In Ohlin?" He concludes that Ohlin did anticipate many but not all of the modern insights. For he understood that not only factor endowments but also increasing returns are the sources of trade, insights that are regrettably absent from the Hechscher-Ohlin model as famously formalised by Paul Samuelson. However, while Krugman and Ohlin provide insights into the role of increasing returns as a source of trade, the Youngian perspective suggests that increasing returns are just as much (or more) the result as the cause of trade. By expanding the size of the market, trade acts as a powerful instrument for the realisation of increasing returns as a pervasive, continuing growth phenomenon rather than something that merely generates once-for-all gains. As Young (1924, p.151) put it, before he had elaborated fully on his ideas on increasing returns and economic progress:

> ... in the growth of our economic civilisation it has been commerce, rather than agriculture or industry, that has led the way. Production is limited by markets. It can advance only as markets are increased. Commerce creates markets. The industrial revolution... cannot be ascribed merely to the great invention of Watt, Kay, Hargreave, Arkwright and Crompton. These mechanical improvements were... really called into being by the fact that growth of English commerce... had for the first time made the factory system and large-scale production possible.

publishers to give adequate royalties to authors", he did not favour patents. But in any case the most important improvements in methods of production are not patentable. Young gives the example of the steam engine "which, at first was empirical [i.e., involved trial and observation]; then Joule determined heat expansions [laws of thermodynamics] and engines developed. But Joule's work was not patentable." He also noted: "With the complications of industry, one patent is valueless unless it is used with another (e.g. wireless). The system is hopelessly intricate. We can probably do away with patents and not much retard development" (Young 1990, p. 52).

Finally, new growth theory may be faulted for being too steeped in the neoclassical framework of the aggregate production function – a concept that essentially retains all the properties of microeconomics. It assumes that the whole is simply the sum of its parts, with aggregate output a unidirectional function of factor inputs, albeit the neoclassical exogenous growth theory includes inputs of human capital and R&D. Thus it gives essentially a supply-side view only, whereas Youngian increasing returns are based on macroeconomic real demand in which the whole is much more than the sum of its parts and in which competition, mobility and free trade are the essential mechanics of growth. The Youngian view of growth as a process cannot be easily reconciled with the production-function type models whether of the neoclassical vintage or of the new growth theory variety. We turn therefore to the three variants of endogenous growth based on real demand.

2.3 Endogenous Growth Models: Smith, Young and Currie

In this section we shall try to develop three variants of endogenous growth based on the ideas of Smith (1776), Young (1928) and Currie (1997). The common starting point is Adam Smith's dictum that the division of labour depends on the size of the market. Market fosters specialisation and the division of labour. The larger the division of labour the larger is productivity. Smith in his *Wealth of Nations* listed three gains flowing from the division of labour:

> This great increase in the quantity of work which, in consequence of division of labour, the same number of people are capable of performing, is owing to three different circumstances; first to the increase of dexterity of in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of great number of machines which facilitate and abridge labour, and enable one man to do the work of many (Ed. Cannan 1976, Vol. 1, p. 11).

What role does capital play in fostering the division of labour? It is clear from the above that the role of capital or machinery is derivative. Capital is not desired for its own sake but because it facilitates and abridges labour, which in turn helps produce output which has a market value. Since the division of labour depends on the size of the market, it follows that capital which gives rise to the division of labour is also determined by the size of the market. If the size of the market is measured by the volume of production in an economy, the test of the proposition that the division of labour depends on the size of the market is tantamount to testing that the extent to which capital is employed depends on the size of GDP. Or, in other words, the rate of capital accumulation depends on the rate of GDP growth. In this view, it is not capital accumulation which determines growth, but rather growth which determines the rate at which capital accumulates. According to the first variant of the endogenous growth

theory, therefore, the rate of capital accumulation is determined by the rate of economic growth and not vice versa.

As we noted, Young made use of Say's Law to suggest that capacity to buy depends on the capacity to produce. He combined this with Smith's famous dictum to conclude that "the division of labour depends in large part upon the division of labour" (Young 1928, p. 533). In Young capital, by enhancing roundaboutness in production, greatly facilitates the division of labour:

> The first point is that the principal economies which manifest themselves in increasing returns are the economies of capitalistic or roundabout methods of production. These economies…are largely identical with the economies of the division of labour in its most important modern forms…The second point is that the economies of roundabout methods, even more than the economies of other forms of the division of labour, depend upon the extent of the market – and that, of course, is why we discuss them under the head of increasing returns (*ibid*, p. 531).

Thus to test the proposition that the division of labour depends on the division of labour is tantamount to testing whether the rate of capital accumulation depends on the rate of capital accumulation itself. According to the second version of endogenous growth theory, therefore, capital accumulation leads to further capital accumulation.

Coming to the third version of endogenous growth, due to Currie (1981, 1997), growth begets growth, that is, growth depends on growth itself. In other words, the cause of growth is growth itself. According to Currie, given the institutional framework, as well as the absence of exogenous shocks, the same rate of growth tends to perpetuate itself.

Note that the Smith version is common to all three variants as Smith is the common starting point. That means that if the Smith version holds, the weak versions of the remaining two also hold. For the strict Young version to hold, in addition to the Smith version the proposition that the rate of capital accumulation depends on the rate of capital accumulation itself should also hold. Similarly, for the strict Currie version to hold, not only should the Smith version hold, but in addition the proposition that the cause of growth is growth itself. To test these propositions one has to go into the question of causality. We shall use cointegration and error-correction modelling for this purpose. In the next section, therefore, we take up the methodological issues.

3. Methodology

In Granger's (1969) concept of causality the dependent variable Y depends on its own past values as well as the past values of the independent variable X. Which of the two past values are significant in explaining the dependent variable can be tested by using the standard F test of joint significance. In Sim's (1972) test, in addition to the past values, some lead values are present as well. So it has the disadvantage of using more degrees of freedom as compared to the Granger test. Both tests have been criticised on the ground that they do not check for the cointegrating properties of the concerned variables, and therefore may miss some of the causality which becomes available through the error-correction term (Granger, 1988). In what follows, therefore, we shall use the Engle-Granger (1987) approach which makes use of cointegration and error-correction modelling.

Before cointegration is applied the time-series variables have to be tested for stationarity[11] or for the presence of a unit root. There could be several ways of doing this, such as the Dickey-Fuller (1979), Augmented Dickey-Fuller (1979) and Phillips-Perron[12] (1988) tests. Augmented Dickey-Fuller (ADF) tests are the most popular and we shall use them here to test for stationarity as well as the order of integration of a series[13]. If the two variables are integrated to the order one, i.e., I(1), then the next step is to find whether they are cointegrated.

Let Y be per capita income and I the investment to GDP ratio. We take the log of these variables so that the first differences can be interpreted as growth rates. LY and LI are cointegrated if, first, they are I(1), and second, the residuals u and e of the following cointegrating equations are stationary or I(0):

(1) $LY = a + b\ LI + u$

(2) $LI = \alpha + \beta\ LY + e$

Once it is established that LY and LI are cointegrated the next issue is which variable causes the other. This can be established by estimating the following error-correction models:

(3) $\Delta LY = \text{lagged}\ (\Delta LY, \Delta LI) + \lambda u_{t-1}$

(4) $\Delta LI = \text{lagged}\ (\Delta LY, \Delta LI) + \phi e_{t-1}$

where the error-correction terms u_{t-1} and e_{t-1} are stationary residuals from the cointegrating equations. By introducing error-correction terms an additional channel of causality is opened up. In these models causality can be manifest through lagged changes of the independent variable, or through the error-correction term, or both. For example, in equation 3 if growth of investment causes income growth, either the coefficients of the lagged ΔLI are positive and jointly significant (F-test), or λ is significant (t-test), or both. Similarly, in equation 4 if growth of income causes growth of investment, either coefficients of ΔLY are positive and jointly significant, or ϕ is significant, or both.

In the above analysis two issues need to be settled. The first concerns the number of lags to be included in the model, and second the distinction between short-term and long-term causality. For the choice of the number of lags to be included in the causality analysis, we follow Engle-Granger (1987). Their procedure involves starting with fewer lags and then testing for added lags. This process is carried on till there is no autocorrelation in the estimated equation. The advantage of this method is that it gives a parsimonious model fairly quickly; i.e., if white noise residuals are achieved with fewer lags then that model is preferred to the one with more lags. Another advantage is that keeping our sample size in mind, it does not involve overparameterising the model and thus preserves degrees of freedom.

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[11] A time series is stationary, in the sense of weak stationarity, if its mean, variance and covariances remain constant over time.

[12] Perman (1991) suggests that if the diagnostics statistics (such as normality, autocorrelation etc) from the ADF regression are not in order a prima-facie case exists for adopting non-parametric adjustments proposed by Phillips and Perron.

[13] If a time series has to differenced once before it becomes stationary, it is integrated to the order one or I(1). In general if a time series has to be differenced d times before becoming stationary, it is integrated to the order d or I(d).

The second issue concerns the need to distinguish between short-term and long-term causality. Following Jones and Joulfian (1991), Bahmani-Oskooee and Alse (1993), Doraisami (1996), and others we interpret the lagged changes in the independent variable to represent short-term causal impact, while the error-correction term is interpreted as representing the long-run impact. It may be noted that the lagged changes in the independent variables are lagged growth rates, while the error-correction term is based on the long-term relationship between the level variables.

Now coming to the hypotheses to be tested, the Smith version will hold if, in equation 4, the coefficients of lagged ΔLI are positive and jointly significant (F-test), or ϕ is significant, or both. At the same time equation 3 should not show any reverse causality. If Smith's version holds, weak versions of Young and Currie automatically hold as Smith is the common starting point. For the strict Young version to hold, then in addition equation 4 should also show positive and significant ΔLI coefficients (F-test). For the strict Currie version to hold, in equation 3 the coefficients of ΔLY should be positive and jointly significant (again F-test).

If Smith's version is supported by the data, as also any of the two strict versions, we shall conclude that in general the data support the endogenous growth theory that is based on real demand. The results are presented in the next section.

4. Results

The results of our analysis are shown in Tables 1, 2 and 3. Table 1 shows the unit root test for stationarity. It can be seen that ADF test statistic for the level variables is marginally more negative than the respective 95% critical values. From this it can be interpreted that the level variables are I(0) or do not contain a unit root. Such tests have been shown to lack power at the borderline between stationarity and non-stationarity. Since we are dealing with marginal cases here, i.e., both LY and LI are I(0) at the margin, we shall interpret that they are in fact I(1).

Table 2 shows the results of ADF and CRDW tests for cointegration. It can be seen that CRDW statistic is too low, even lower than 10% critical value of 0.69. As a first approximation this shows that LY and LI do not cointegrate. Even the ADF statistics is not lower than the 95% critical values in both the level variables. So we conclude that LY and LI do not cointegrate.

Since LY and LI do not cointegrate we cannot use the error-correction models for finding the direction of causality. We shall use the standard Granger procedure which leaves out the error-correction terms from the estimated models. That is, equations 3 and 4 are estimated without the error-correction terms λu_{t-1} and ϕe_{t-1}. The results of Granger-causality are shown in Table 3. It can be seen that the growth of the investment ratio (ΔLI) is caused by growth in per capita income (ΔLY) as the sign of this relationship is positive and jointly significant as shown by the F value (second equation in Table 3). Since the F value of 14.539 is highly significant, we conclude that growth of per capita income Granger-causes the growth of the investment ratio. In the reverse causality (first equation in Table 3), it can be seen that F value of lagged ΔLI is only 1.391 which is not even significant at 10% level. So we conclude that growth of investment does not Granger-cause growth of per capita income. It is obvious therefore that while growth of per capita income causes growth of investment, the reverse causality is not true. We can conclude that Smith's version of endogenous growth holds.

As the Smith version holds, the weak versions of Young and Currie also hold. Now it needs to be tested whether the strict Young and Currie versions also hold. Let us first take up the strict Young version. In the second equation of Table 3 it can be noted that the F value for lagged ΔLI is 0.519 which is insignificant at even the 10% level. Turning to the strict Currie version, the first equation of Table 3 shows that the F value of lagged ΔLY is positive and significant at 4.4% level of significance. The conclusion which follows is that while the strict Young version does not hold, the strict Currie version holds.

A few words on the possible reasons why the data seem to be rejecting the strict Young version. First, capital accumulation may not be the only factor influencing the division of labour. There may be other important factors such as improvements in organisation and management practices which also have a bearing on the division of labour (and which Young himself recognised). In such cases improved division of labour may occur while using no more capital. Second, the division of labour may depend on the improvements in the *quality* of capital. For example, a firm or an organisation using computers may be able to accomplish much more work, using in fact less aggregate capital (in physical and value terms) than earlier. In this case, capital accumulation does not fully capture the extent of the productivity gains due to the division of labour. Third, the expanding market may make capital goods industries more productive in the sense that less capital is required to produce a given level of output. The capital-output ratio in that case may fall, at least for some industries. The benefits of increasing productivity of the capital goods sector are likely to be transmitted throughout the economy through the cheapening of capital goods.

To sum up, UK data for the period 1948-2000 support the Smith version of endogenous growth. The data also support the strict Currie version as also the weak Young version. The strict Young version is rejected by the data, however. Overall, the UK data give strong support to the endogenous growth theory based on real demand.

5. Conclusions

Models emphasising capital accumulation cannot deal with the observed phenomenon of increasing returns in rich countries where rates of per capita income growth have not only been maintained but are often higher than in capital-poor countries. The neoclassical theory tried to explain this in terms of exogenous technical progress which effectively counters the law of diminishing returns that factor inputs are subject to. But the technical progress or the residual itself was left unexplained. Also, the neoclassical theory did not have anything interesting to say about policy, as whatever the governments may do is not expected to have any influence on the exogenous technical change. Nor could the neoclassical models explain the lack of convergence between capital-abundant and capital-poor countries.

The new growth theory entered the scene partly to explain the residual left unexplained by the neoclassical theory and partly to garner a policy role for the government. Within the production function framework, it succeeded in introducing certain innovations designed to yield increasing returns to scale rather than the neoclassical constant returns to scale. Despite these achievements, the new growth theory could not break free from the supply-side view of the growth process emanating from the neoclassical production function approach. As we noted, although the new growth theory claimed to explain Young with greater analytical clarity, rigour and depth, actually it missed his central message that the division of labour and the size of the market are dominant influences. To its credit the new growth theory talks about

integration with world markets but only because larger markets induce more research inputs, which in turn contribute to faster growth. Thus the new growth theory suggests that growth arises primarily due to the application of new knowledge. But the role of larger markets in making more effective use of existing knowledge or technology is largely neglected. As we noted, even with no advances in pure or applied sciences there are no limits to increasing returns in Young. Also, the new growth literature suggests that the presence of fixed costs and some sort of market power are crucial to growth. In Young neither fixed costs nor market power nor economies of scale are necessary for the operation of increasing returns. They are better realised with more rather than less competition. Therefore, the new growth theory misrepresents Young in important ways.

Finally we developed three variants of endogenous growth theory based on Smith, Young and Currie and put them to test against UK data. We found that the data support Smith's version, the strict Currie version, and the weak Young version of endogenous growth. The strict Young version was rejected, however. On the whole, the UK data for 1948-2000 seem to lend strong support to demand-based endogenous growth theory.

Table 1 ADF test for unit root				
variable	**Test statistic**		**95% critical value**	
	Levels	**first differences**	**Levels**	**first differences**
LY	-3.547 (1)	-5.916 (1)	-3.509	-2.927
LI	-2.998 (1)	-5.468 (0)	-2.926	-2.927

Notes:

1.Computations are performed by using Microfit 4.0 (Pesaran and Pesaran, 1997).

2. Terms in the parenthesis show the number of augmentations or lags (k) in ADF regressions.

3. k is chosen with the help of a model selection criterion such as Akaike Information Criterion (AIK), Schwarz Bayesian Criterion and Hannan-Quinn Criterion (HQC).

4. Microfit 4.0 uses critical values from Dickey and Fuller (1979).

Table 2 ADF test for cointegration				
regression	$\overline{R}^2$	**CRDW**	**ADF**	**95% CV**
LY=f(LI)	0.202	0.038	0.285(0)	-3.466
LI=f(LY)	0.202	0.197	-2.267(1)	-3.466

Notes:

1. Critical values are from Mackinnon (1991).

2. The critical values for CRDW in the vicinity of 50 observations are 0.78 at 5% and 0.69 at 10% levels of significance respectively (Engle and Yoo, 1987). CRDW is a useful test for cointegration if the disequilibrium errors of the cointegrating regression are generated by first-order AR process.

Table 3 Results of Granger-causality				
regression	**lags**	**Signs of independent varables**	**F(lagged ΔLY)**	**F(lagged ΔLI)**
ΔLY=lagged(ΔLY, ΔLI)	1	(+) (-)	4.273(.044)	1.391(.244)
ΔLI=lagged(ΔLY, ΔLI)	1	(+) (-)	14.539(.000)	0.519(.475)

Notes:

1. In the third column the first sign is for lagged ΔLY and second for lagged ΔLI.

2. In the last two columns the terms in the brackets are the probability values or the exact level of significance.

3. Error correction terms have not been included since LY and LI do not cointegrate as shown in Table 2.

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