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Endogenous Growth Theory: A Critical Assessment

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1 Introduction

The purpose of this paper is to set endogenous or new growth theory against broader developments within economics as a discipline. As a topic, irrespective of its intellectual antecedents, endogenous growth theory is extremely recent, only dating back in acknowledged published form to Romer's (1986) article which is usually coupled with Lucas' (1988) contribution.[1] Within a decade, the literature has itself taken off into sustained growth. Over the past three years, the number of articles explicitly drawing upon endogenous growth theory almost certainly borders on a thousand.[2] Equally significant, they are spread over fifty or more economics journals. There are textbooks for endogenous growth theory, such as Grossman and Helpman (1991) and Barro and Sala-i-Martin (1995). Surveys and special issues and sections in journals proliferate.[3] In this light, endogenous growth theory would appear to be an excellent point from which to assess the state and momentum of economics as a discipline.

This still leaves open the vantage point from which to make such an assessment. Elsewhere, Fine (1997a),[4] I have argued that economics is currently experiencing a revolution. It is doing so by increasingly colonising the other social sciences from which it had previously been insulated by its assumptions and methods; its axiomatic formalism as in model-building; its methodological individualism with the narrow motivation of economic agents restricted to utility maximisation; the notion of the "non-economic", including social institutions, as exogenously given as in technology and preferences; the heavy reliance upon equilibrium as an organising principle; and the use of econometrics as an unproblematic test of theories not least in lieu of conceptual rigour and depth.

Paradoxically, these apparently insurmountable barriers between economics and the other social sciences have been consolidated rather than weakened as economics thrusts outwards onto new analytical terrains. This is, however, often disguised by the informal, non-technical ways in which notions such as human capital have been deployed across the social sciences without careful regard to their substantive conceptual content and analytical origins. Far from abandoning its traditional methods, mainstream neoclassical economics has extended them in two ways. The first, perhaps most readily associated with Gary Becker,[5] has been simply to presume that individual utility maximisation that had previously been confined to the market economy should be applied as an analytical principle to every aspect of life. The second, in a sense the more revolutionary, continues to be based upon individual optimisation but now takes social institutions as endogenous. In the light of the new microeconomics based on transactions costs and imperfect and asymmetric information, individuals may choose to create social structures, whether in labour, financial or other markets. In this vein is created a new institutional economics, a new political economy, a new development economics, a new financial economics, a new theory of rural institutions, etc.

How does the new growth theory fit into this expanding world of novelty? In the concluding section, the relations between endogenous growth theory and other social sciences will be assessed. For the moment, consider its position from within economics alone. The central factor here is the microeconomic basis of endogenous growth theory. This is apparent in two different respects. First, endogenous growth theory is concerned with the sources of productivity increase. As such, it has drawn upon microeconomic theories, as in the use of resources to produce R&D, economies of scale and scope, the use of human capital as an input, or the externalities that spill over from one firm or agent to another. These theories have nothing to do as such with an economy as a whole, other than in the trivial sense of requiring at least two economic agents in order for exchange to arise. Indeed, often implicitly and sometimes explicitly, the literature takes a microeconomic theory and simply interprets it as macroeconomics.

Second, by the same token, macroeconomics over the past two decades has increasingly been organised around microeconomics and general equilibrium, most notably in the use of representative individuals and the new Keynesian microeconomics in which there is a mixture of imperfections across market competition,

differential access to and use of information, and imperfect market clearing.[6] In short, endogenous growth theory is heavily implicated in the traditional and strengthening microeconomic foundations of neoclassical economics.

In what sense, then, is it new? Clearly, the answer resides in substituting endogenous for exogenous. What was previously taken as given is now explained. It is crucial to recognise, however, that this is a simple moving of the explanatory boundaries outwards although, as will be seen, there is also some countervailing shrinkage in deference to model tractability. This is made especially clear by Hammond and Rodriguez-Clare (1995) who open their survey as follows:

> Progress in economic science often takes the form of explaining what was previously inexplicable. That is, variables which had earlier been treated as exogenous become endogenized. Their values become determined, at least in principle, within an economic model.

In this respect, a standard history is now usually told of old growth theory, presumably to new generations of students. Rarely is reference made to classical political economy or to Marx. Rather, growth theory begins with Harrod-Domar and moves forward to Solow. Here, it stagnates sometime in the late sixties until endogenous growth theory brings the subject back to life both by allowing sources of productivity increase to be explained as well as by addressing the apparent differences in growth rates between countries which ought to have been the same with a free flow of production functions (or knowledge) between countries.

This is, however, to overlook or at least to take as granted and/or relatively insignificant, two developments in growth theory which were prominent in the passage between Solow and Romer. Perhaps I am unduly impressed by them because they were very much in vogue during my own early confrontation with economics as a migrant from mathematics. One is the standard use of intertemporal optimisation instead of the behavioral assumption of a constant saving rate. Although the issue of varying the saving rate over time dates back to Ramsey (1928), and it only became a common technique post-Solow and pre-Romer. It has considerable bearing on the dynamics of growth. The other related intervening development was optimal growth in the presence of exhaustible resources. Clearly a response to the oil crisis of the early 1970s, it breathed a new if short-lived lease of life into growth theory. It was killed off by the limited scope for model development if not by the irregular rhythm of the oil price itself.

The standard incorporation of intertemporal optimisation into old growth theory is of importance for its new version for the simple reason that endogenous growth theory was liable to flourish where such techniques were already in place.[7] This has been so in macroeconomics, where consumption functions have become based on representative consumers optimising over an infinite horizon, but especially in the simplest models of the impact of fiscal and monetary policy in the long run. Section 6 addresses fiscal policy and section 7 covers the way in which financial considerations have arisen in endogenous growth theory.

These were, however, waiting in the wings for endogenous growth theory by virtue of their pre-existing techniques, sharing concern with dynamic intertemporal optimisation and efficiency in common with endogenous growth theory. However, the initiating analytical stimulus to endogenous growth theory derived from the theory of technical change. Romer (1986) argued that there could be technological spill-overs between producers with the result that constant returns for individual producers implied increasing returns for the economy as a whole. Significantly, Romer (1994) confesses to have drawn the inspiration for his model from a microeconomic problem (or a macro treated as a micro problem) - why is that labour should receive a share of income greater than that warranted by its marginal product and capital receive less.

From this starting point, endogenous growth theory has evolved on the basis of two complementary impulses. One has been to model the sources of productivity increase in various ways. Quite apart from technological spill-overs or learning-by-doing which arise spontaneously out of accumulation itself, productivity increase has been modelled by focusing upon the different stages in the generation and use of new knowledge. Private and public resources can be devoted to R&D with greater or lesser benefits to individual capitalists. Productivity increase can accrue through the quality and range of intermediate inputs as well as in the greater output from a given level of inputs. In particular, as a special case, the quality of labour can be enhanced through the accumulation of human capital. This has itself been modelled in various ways, depending upon how it is produced and how it is used - is it attached to work experience, leisure, or public and private resources devoted to education and, once accumulated, how does it affect overall levels of production from given inputs.

A crucial consequence of endogenous sources of productivity increase is that they involve market imperfections. This has provided the second central component of endogenous growth theory. With all agents optimising on the basis of given prices, an associated equilibrium is not Pareto-efficient. This is a simple result of the externalities or socially increasing returns to scale involved. Generally, it follows that the competitive outcome induces a level of saving that is below the optimum since private agents take no account of their knock-on effects. Once, however, there is an endogenous growth mechanism in place, attention can focus on any market imperfection that affects the saving rate and, hence, long-run prospects.

It is now possible to characterise endogenous growth theory in shorthand form as well as in its intellectual thrust. As recognised by many of its practitioners, it is simply a market imperfections theory of technical change in which, in contrast to static general equilibrium or exogenous growth theory, the impact of the imperfections are felt on the rate of growth rather than upon the level of output or welfare for a given rate of growth. The last point, the transformation from level to rate of growth of output, is the only novelty. For market imperfections are now deemed to have cumulative effects over time.[8] Otherwise, endogenous growth theory draws upon two traditions for its conceptual content, the theory of technical change and the theory of market imperfections.

Each source provides a rich vein of raw analytical material. In examining the course of the previously mentioned current revolution in economic thought, I have argued that it has proceeded both by pillaging and simplifying the other social sciences for ideas in order to accommodate them within a framework of methodological individualism and by declaring as new what has previously been well-known to other scholars. Such is the general feature of the contribution of endogenous growth theory to the understanding of productivity change. As shown in section 4, Schumpeter is one of the chief sources in this regard. His work, both for initiating ideas, as in monopoly rents for innovation, and for outcomes, as in clusters of innovations, has been plundered and formally reconstructed on an individualistic basis.[9] More generally, endogenous growth theory has drawn upon the insights on productivity increase attached to Kaldor and Adam Smith, for example, but all of the ideas used in endogenous growth theory are readily invented through casual knowledge of technology invention, adoption and adaptation, and are inevitably to be found in, for example, the literature around national systems of innovation.[10]

As regards the incorporation of market imperfections, endogenous growth theory is essentially cannibalistic. The discipline can plunder itself for the sources of Pareto-inefficient outcomes and translate these into sources for growth as opposed to deadweight losses. Not surprisingly, particularly favoured sources are those that concern imperfect competition, since innovation involves temporary monopoly rents, and any capital market imperfections that affect the level, composition or use of savings and investment.

In view of the analytical sources for endogenous growth theory, there are two reasons why it should give rise to conceptual backwardness. Where there is dependence upon other social sciences or heterodoxy within economics, as in theories of technical change, the content is generally stripped of its broader historical and social framework in deference to the requirements of the axiomatic model-building associated with methodological individualism. The limitations imposed by drawing upon previous notions of market imperfections are more technical in nature. As will be shown in section 2, in the context of the multiple equilibria and the dynamics attached to endogenous growth theory, simple extensions of any basic model lead to extremely complex outcomes. On the one hand, limited generalisations of basic assumptions suffice to generate a wealth of outcomes. On the other hand, models become intractable beyond the point of the most simplified models of the economy.

So far, the focus has been upon the analytical content of endogenous growth theory. But it is commonly acknowledged that a major source of momentum to the topic has been provided by the comparison of, and explanation for, differences in growth rates. No doubt, this has been inspired by external events, such as the success of the NICs, for the apparently unacceptable conclusion from exogenous growth theory of equal per capita growth rates is far from new. What is new is that the proposition should be contested in the context of a theory of endogenous technical progress. The capacity to do this has been greatly enhanced by the ready and cheap availability of data sets and computing power.[11] Initially at least, as in what has been termed Barro-type regressions, the convergence of per capita growth rates has been tested by taking them as a dependent variable with per capita income as the independent variable in cross-section analyses. With a negative sign in the regression taken as evidence both of convergence and as supportive of exogenous growth, other independent variables can be thrown in either to correct for country differences or, to the contrary, as indicative of sources of

endogenous growth.

The result has been an explosion of econometric literature around endogenous growth theory. Fischer (1994) reports from Levine and Renelt (1992) that forty cross-sectional studies of the new growth theory had already been conducted with well over fifty different regressors. An issue that tends to be overlooked is that of the stability of the regression - whether particular variables remain significant as others are added or omitted. Levine and Zervos (1994) confirm an earlier analysis of cross-section studies, showing that regression results depend very heavily on what independent variables are included, with financial development and black market exchange premium proving robust, positively and negatively for their effect on growth respectively, but the same not applying to government expenditure, fiscal deficit, inflation and trade. Even these limited results within what, as will be seen, is a flawed statistical approach, leave the direction of causation open to question.

Summaries of results from regressions are provided in Sala-i-Martin (1996a and b), but also Ochoa (1996) in a more critical discussion. These are worth supplementing with a selection of material to give a flavour of what has been done. Engelbrecht (1997) seeks to address spill-overs and technological catch up between countries by incorporating variables for multinational corporations, foreign direct investment, business trips, education and training abroad, migration of skilled workers, extent of purchase of patents, etc. Kocherlakota and Yi (1997) test the US and UK for endogenous growth by lagging it on policy variables whose sum impact should be zero for exogenous growth (which is rejected). Targetti and Foti (1997) seek to test for Verdoorn effects from increasing returns, catch-up from other countries, and capacity for diffusion as measured by investment as a share of GDP. Strawczynski and Dahan (1996) deploy a variable representing permanent as opposed to transitory government expenditure (biased by defence expenditure in their case study for Israel).[12] Cheshire and Carbonaro (1996) run Barro-type regressions on EU countries and across neighbouring city-regions. Lee (1995) suggests that the ratio of imported to domestically produced capital goods is an important factor in raising growth rates. Cardenas and Ponton (1995) examine convergence across regions within Columbia which they perceive to be rapid, with national security and education being important factors rather than labour migration, or composition and trade orientation of output. Savvides (1995) finds that, as opposed to membership of the Franc Zone, initial conditions, financial development, growth of government sector, and political freedom have all contributed to growth in Africa. Tallman and Wang (1994) find that adding a variable for labour quality, along with other appropriate variables, improves the growth regression for Taiwan. Granato et al (1996) throw in cultural attitudes as an explanatory factor. Ben-David (1994) tests for convergence from freer trade for the EU, EFTA and North America in the post-war period.

This all begins to look like statistics without theory other than as an initiating impulse. But such procedures are commonplace in the use of econometrics. A theory is used to derive a simple equation to which a range of modifications, including the addition of error terms, are made prior to statistical testing. There are serious problems with this. First, the independent variables in this context will inevitably be related to one another, since the correlates of growth are systematically connected, quite apart from the mutuality of dependent and independent variables. Education, for example, is both a source and a consequence of growth, as well as of trade performance, etc. Second, the econometrics is highly selective in terms of the relations that it does examine as opposed to those that it does not. In so far as it only focuses on growth rate outcomes as opposed, for example, to the processes by which those outcomes are achieved, there is a neglect of the models' implications which may not be borne out by the data. Simple regressions between growth rates and per capita income, for example, may suggest convergence even though changes in total factor productivity might suggest otherwise with growing productivity differences between countries.[13] Third, it is important to stress how stochastic variation is generated in the model since, for endogenous growth theory, random shocks can have a persistent and varied impact over time depending upon how they arise and how they are transmitted.[14]

These and other issues, as discussed in section 3, are the bread and butter for more sophisticated econometrics which has paid closer attention to time-series and panel data estimation over the most recent period. As a consequence, endogenous growth theory has been a fertile application for advances in econometrics in which complex dynamics and stochastic properties can be more fully examined. The base-line conclusion of such work is that you cannot have your cake and eat it. For the favourable consequences from endogenous growth theory in terms of the richer variety of empirical outcomes for which it allows (differences in growth rates) is necessarily coupled with a dynamics which renders simple Barro-type regressions as irrelevant if not erroneous.[15] Nonetheless, as suggested by other experience within economics, as for the Cambridge controversy over the measurement of capital and total factor productivity for exogenous growth, the presence of unsavoury theoretical and empirical implications for conventional wisdom and practices seems to pose no

impediment. The theory and measurement of endogenous growth and convergence by standard and erroneous methods is almost certainly assured in the class room and will be applied by generations of new students for the foreseeable future.[16]

Mention of the Cambridge controversy provides a trigger for a slightly different discussion - how endogenous represents a continuity rather than a break with exogenous growth theory. Many of the criticisms of the latter carry over, even with greater force, since the scope for generalising endogenous growth theory is limited by the greater technical demands involved in the corresponding models. The standard assumption of a single sector for the economy is open to the devastating consequences of the Cambridge critique. Even where more than one sector is assumed, often surreptitiously as in a separate sector to produce human capital, very special assumptions are made about the production functions or preferences concerned, such as Cobb-Douglas production functions and constant intertemporal discount rates. Otherwise, there are severe problems of multiple equilibria and instability which are, in any case, extremely common.

Endogenous like exogenous growth theory also tends to be organised around steady-state balanced growth. This has a number of drawbacks, although some of this can be accommodated within the more complex dynamics of endogenous growth theory. First, growth is neither steady nor balanced. It is irregular and the composition of output shifts significantly both in the early stages of industrialisation and in the mature stages of post-industrial society.[17] From a technical point of view, the requirement of balance is extremely demanding since many variables must grow at the same rate. The problem is that, in the absence of special assumptions, endogenising the growth rate can readily lead to explosively fast rates of growth or their being eroded to exogenous rates over time, thereby undermining the long-term thrust of the theory.[18]

Second, and again endogenous growth theory does occasionally address these issues on a piecemeal basis, as discussed in section 8 where government policy can be endogenised for example, economic growth is not synonymous with (economic) development which witnesses a whole range of social change with interactions with the economy - proletarianisation, welfarism, urbanisation, demographic transition, etc.[19] In the hands of endogenous growth theory, these can be endogenised by expanding the scope of the model but with two reservations. The model becomes too complex to handle, not least if economic agents have to strategise consistently about the future consequences of their actions in both economic and endogenous non-economic arena. The model is also precisely that - once set in motion from initial conditions, it has a life of its own which can only be changed by random shocks. There is, otherwise, no scope for historical contingency nor for differentiation between one period and another and from one society to another.

Third, quite apart from its fragmented forays into the socioeconomic factors that are otherwise taken as endogenous, endogenous growth theory is built up on the basis of methodological individualism in which agents optimise or otherwise engage in activity according to more or less arbitrary behavioral patterns.[20] Such an approach precludes the endogeneity of social forces, structures and relations, whether these be economic or otherwise, unless derived from aggregation over individuals. This is in sharp contrast to classical political economy with, for example, Smith's emphasis on the interaction between a growing division of labour within the constraints imposed by the extent of the market, and to Marx's theory of the accumulation of capital as the driving force behind productivity increase. In each of these cases, as for Ricardo's theory of differential rent, the value theory constructed is concerned to derive prices on the basis of a changing technology.[21] How is value formed when technology is changing - whether it be due to growing division of labour, movement onto worse land, or the growing composition of capital. A significant continuity between exogenous and endogenous growth theory is that the latter incorporates shifting technology only on the basis of the same principle, even if more complex in practice - that of present value discounting of streams of utility.

2 Opening a Can of Dynamics

As observed, endogenous growth theory has been heavily influenced by microeconomics. Indeed, like much macroeconomics in the most recent period, it can be thought of as microeconomics parading as macroeconomics, especially in the context of representative economic agents whether serving as producers or consumers. Consequently, there is a persistent analytical thrust and logic to proceed by disaggregating the economy in conjunction with whatever market imperfections have already been incorporated. Having treated your economy as if it were made up of a single production function and optimising consumer, it makes sense to generalise or become more realistic by differentiating between sectors or consumers.

To some extent, this has already been implicitly embarked upon in being a growth theory which examines the economy over time. This means that production and consumption at different times do have a different impact on the economy even if they do not represent the supply and demand in entirely different markets as, in a one good world for example, the goods involved are otherwise identical to one another within endogenous growth theory. Consume or produce now or not and you affect not only the resources available in the future but also their productivity.

More explicitly, the economy is liable to be disaggregated by sector. This is inevitably the case where human capital or technical advance is produced with resources devoted to the purpose. The model will then have two or more sectors, those attached to production of goods and those attached to producing productivity however directly. There can also be more than one physical good, whether for capital, consumption, as an intermediate input, or for trade. In addition, it is possible to disaggregate by differentiating between agents, whether as consumers or producer, a point which will mainly be taken up in subsequent sections.

Another factor motivating endogenous growth theory is its capacity to draw upon a wider range of model outcomes, not least in explaining why growth rates can differ even with free flow of technology. Exactly what results the models are supposed to be able to yield is open to question. Before endogenous growth theory, for example, it was found impossible for a single model to generate both growth and cycles, given the limitations of difference equations when applied to Harrod-Domar through the use of a multiplier-accelerator model. Both for analytical and empirical convenience, the short and long runs have been perceived to be independent of one another. For endogenous growth theory, the short and long runs are intimately related since the latter depends endogenously on the former. Put another way, as economic agents choose the growth path, they are also going to choose the path taken to attain it and, of necessity, they will choose a different path if they choose a different growth rate.

It follows that the existence and stability of the endogenous growth path must be determined together. In the first instance, this begs the question of the uniqueness of the endogenous growth path. Not surprisingly, in view of the highly restrictive conditions necessary for a static general equilibrium to be unique and stable, endogenous growth theory is replete with uniqueness and stability problems even with the slightest opening up of its microeconomic assumptions. As will be seen, a very wide range of outcomes is possible even on the basis of simple extensions of basic models.

Consider, first, the issue of multiple equilibria. As Hahn (1990) observes in the context of growth theory, these are always liable to occur in the presence of increasing returns. Even the slightest generalisation of a simple endogenous growth theory suffices not only to allow for different rates of growth but also to generate multiple equilibria. Guevara et al (1997), for example, allow for work-leisure choice as well as for capital to be an input into the production of the education sector. The growth rate that results depends upon the initial ratio of physical and human capital.[22] Similarly, Graca et al (1995) find that if the saving rate is too low, then insufficient accumulation of physical and human capital may occur to provide the incentive to invest in proportionately more human capital necessary to take-off into a high growth path. Once the standard assumptions of a fixed discount rate for intertemporal utility is dropped, Drugeon (1996) discovers the presence of multiple equilibria, with the possibility of local oscillations. In a similar vein, Cazzavillan (1996) allows public goods with positive externalities in both production and consumption. The result is equivalent to increasing returns in utility, and the model gives rise to indeterminacy of the growth path and sunspot equilibria in which any disturbance onto a different growth path is sustained.[23]

A common source in the literature for multiple equilibria is through some form of reinforcement, with the co-existence of virtuous and vicious circles as possible outcomes. In fertility models, for example, parents may choose many children when productivity is low in order to provide for their own present or future utility. If productivity is high, parents can choose to have fewer children and are more than compensated through higher productivity growth. Becker et al (1990) is taken as the pioneering paper in which countries may either converge into a no growth poverty trap or experience divergent endogenous growth rates. Other such models are to be found in Yip and Zhang (1997), Tamura (1996) and Palivos (1995). That fertility models give rise to multiple endogenous growth paths should not be surprising. For, as discussed in Ehrlich and Lui (1997), models of endogenous population growth generate multiple equilibria in balancing the relationships between the incentives for having children in terms of cost, quantity and quality, and the efficiency of inter- and intra-generational transfers (on which see sections 6 and 7). Add some endogenous growth, and this is also no longer subject to unique equilibrium.[24]

In models with research and development incorporated, multiple equilibria have been generated in a number of ways. For Redding (1996), firms invest in R&D and workers in human capital but their incentives to do so are complementary, allowing for low-skill and low productivity traps, as well as their double-high counterparts.[25] Peretto (1996) builds a model of imperfect competition in which a firm's entry is determined by the fixed costs attached to R&D which itself determines productivity along with the (externality) attached to the number of firms. As he concludes, p. 922:

> The number of firms determines the firms' R&D expenditures and the economy's rate of growth. R&D expenditure, in turn, is one component of the firm's total costs and determines entry, exit, and the equilibrium number of firms. Thus, there exists a specific feedback mechanism of economic growth upon itself.

Consequently, the outcome depends upon conjectures that firms have about their rivals' R&D expenditure. These can be self-fulfilling in multiple equilibria. Imperfect competition is also the source of multiple equilibria in Baland and Fancois (1996), where a monopolistic economy allows for high and self-sustaining rents from innovation expenditure as opposed to a competitive poverty trap.[26] On the other hand, for Gali (1994 and 1995), the mark-up in pricing is endogenous and inversely related to the capital stock so that an economy can be caught in a monopolised development trap where productivity is low but unit profits are high.

Multiple equilibria have been generated in a variety of other ways. For Zilibotti (1994), transport intermediation between isolated economic islands becomes more efficient with development but is limited by imperfect competition, leading to high and low level equilibria. Acemoglu (1995) allows a multiplicity of self-sustaining reward structures depending upon whether agents devote their energies to (low growth) rent-seeking or (high growth) productive activity. Palley (1996) provides a post-Keynesian model in which aggregate demand and an investment function mutually condition one another to yield different potential equilibrium outcomes, and You (1994) complements the impact of aggregate effective demand with considerations of class conflict and compromise. Outcomes depend upon degree of demand as well as profitability-responsiveness on the part of capitalists, with both high wages and thriftiness necessary to induce high productivity growth. In de Gregorio (1993), agents are subject to liquidity constraints in investing in human capital, giving rise to multiple equilibria with high and low levels being sustained by corresponding levels of productivity. Laing et al (1995) supplement the complementarity between human capital and on-the-job training with frictional costs in job search, with low and high level outcomes depending upon the "thickness" of the skilled labour market.

A similar dual equilibria model of matching jobs and workers within the labour market according to the level of knowledge endogenously created is provided by Leung (1995) with explicit reference to a threshold level being above or below which ultimately determines the equilibrium growth to which the economy adjusts. Such thresholds are also to be found in Zilibotti (1995), with low and high productivity of social capital, respectively, at corresponding levels of growth, in Futagami and Mino (1995) and in Klibanoff and Morduch (1995), and for King and Robson (1995) through an S-shape of the production function for generating productivity increase. The latter is derivative of Azariadis and Drazen (1990) in which there are multiple stable equilibria, including poverty traps, according to the different levels of productivity externalities at different levels of development.[27]

So far, the discussion has focused on the existence of multiple equilibria. The counterpart is the dynamics to which they, or even unique equilibria, are attached. In a two sector model, for example, Greiner (1996) shows the possibility of oscillations around the endogenous steady state as investments cluster in the presence of sufficiently strong productivity externalities. Using a model of asymmetric information in the labour market in conjunction with productivity growth as a consequence of R&D expenditure, Gatti and Gallegati (1996) derive endogenous cycles around an endogenous trend, thereby undermining traditional divisions between short and long runs. Azariadis and Reichlin (1996) show that growth and cycles are possible as a consequence of the interaction of a positive public debt with production externalities. Greiner and Semmler (1996) review other literature on the dynamics of endogenous growth[28] and develop a model themselves in which human capital accrues more rapidly on more recent investment. The result is not only to generate multiple equilibria and cycles but the transitional dynamics depends upon initial consumption as well as the initial endowment of physical and human capital.[29] Zhang (1994a) provides a multi-sector model of trade between countries that generates multiple equilibria or not and stability properties according to the values of parameters specifying the creation and use of knowledge.[30]

Englmann and Walz (1995) develop a model, nominally attached to growth in and around industrial centres, in which there are two regions, two factors of production (mobile skilled and immobile unskilled labour) and three types of goods only two of which are traded. With various assumptions around technological spillovers and the use of R&D to produce technological advance, they derive a wide range of outcomes for growth as well as for specialisation and migration. In addition, they provide for the possibility both for catch-up and for overtaking or leapfrogging, as new technologies with high potential for endogenous growth become introduced in the low wage, low productivity region.

Apart from dynamics and multiple equilibria, endogenous growth theory has occasionally endogenised the economic structure itself. For Lordon (1997), a formal model is able to allow the rising income attached to standardised production ultimately to undermine itself as a shift occurs towards specialised demand. Structural change and crisis become endogenised in a way that corresponds to the shift from Fordism to post-Fordism. Cornwall and Cornwall (1994) also allow for structural shifts in the economy through the interaction of aggregate demand, distribution and levels of unemployment, with policies to reduce unemployment proving at least as advantageous as economic integration in raising the growth rate.[31]

3 Statistical Conundrums

From the previous section, it is apparent that even the simplest extensions of the models of endogenous growth have readily given rise both to multiple equilibria and to complex dynamics to or around them. If this result had been taken as a starting point for applied work, much of the recent econometric investigation of growth might have been considerably different. However, as observed, the point of departure for the new growth literature has been inspired by two closely related but separate issues. On the one hand, at the theoretical level, there is the shift from exogenous to endogenous growth. On the other hand, there is the apparently empirical question of whether economies have been converging or not in some sense.[32]

From these origins, it has been standard practice to employ Barro-type regressions and to deduce both convergence and rejection of endogenous as an alternative to exogenous growth theory for appropriate and significant coefficients in a simple regression. First, observe, however, that the two theories of growth are not being tested against one another properly. As suggested in different ways by Evans (1997), Leung and Quah (1996) and Eckstein et al (1996), such simple regressions do not necessarily test for endogenous versus exogenous growth. More specifically, Kocherlakota and Yi (1995) nest both exogenous and endogenous growth as special cases within a more general model. Contrary to the conventional wisdom, they find that, dependent upon how persistent are productivity shocks, p. 214:

> In a cross-sectional regression of average growth rates on initial levels of income, a negative coefficient need not imply that growth is exogenous and a non-negative coefficient need not imply that growth is endogenous. To distinguish between exogenous and endogenous growth, convergence regressions should condition on both initial income and capital, and it is the sign on initial capital, not initial income, that is relevant.

This is primarily a theoretical result concerning what are legitimate tests for the two growth theories.[33] A different point is how to test for convergence irrespective of the sources of growth. Quah (1995), for example, legitimately points out that if changes in growth rates were randomly but identically distributed across countries, then there would, by virtue of Galton's regression to the mean, be a correlation between higher growth rates and lower income. For those countries which had experienced high (low) growth in the past would inevitably tend to grow slower (faster) in the future. This is a simple demonstration that testing growth models in the context of convergence involves some model of growth as well as assumptions about the sources of disturbances both for a representative country and across countries.

At a more complex level, then, convergence cannot be tested without some underlying model incorporating both the sources of growth and the sources and impact of stochastic disturbances.[34] Necessarily, this has led to estimates and comparisons of the properties of the various time series involved. Endogenous and exogenous growth models not only generate different growth rates but also different patterns of growth over time. Jones (1995a), for example, argues that policy variables ought to affect growth rates permanently for which he finds no evidence for the United States. As Evans and Karras (1996) observe, the conventional approach of regressing growth rates on initial per capita income only provides a valid test of convergence if economies have identical first-order autoregressive dynamic structures and all permanent cross-economy differences have been

controlled for.[35] Lau and Sin (1997) apply cointegration tests on growth rates for Japan, the UK and the US, and conclude that the time-series for production are not properly specified, suggesting that the economies might be disaggregated into public and private sectors. In an endogenous growth model, Henriques and Sadorsky (1996) test for Granger causality between exports and growth, find that these are cointegrated with terms of trade and that growth in GDP precedes growth in exports.[36] Loewy and Papell (1996) test for convergence across US states by allowing for an endogenously determined break in the times series.

Most of the studies covered so far in this section have shared three features in common. First, they reject simple Barro-type regressions as a way of testing either for some definition of convergence and/or for endogenous versus exogenous growth, some explicitly recognising that the two hypotheses are not synonymous. Second, they have studied the time series properties of the growth process even if often drawing upon panel data across countries, or from regions within countries, for statistical testing. Third, and not yet mentioned, these studies are often supportive of convergence and exogenous growth when examining time-series properties. This is because the latter need to reveal persistent effects from productivity or other shocks, and these, not surprisingly, are rarely confirmed since it would require any deviation of the economy from a growth path to send it onto another growth path.[37] Fourth, however, whilst the discussion has moved beyond simple Barro-type regressions, even if these remain popular, much of the empirical literature proceeds as if the theoretical results concerning multiple equilibria simply do not exist.

The potential for multiple equilibria gives rise to the idea that economies may be converging into different growth groups or convergence clubs, each attached to its own steady state. In a summary of studies by Sali-i-Martin (1996a and b), it is suggested that a number of OECD economies are converging at a rate of 2% per annum, although it must be borne in mind that this is qualified by a break in convergence for a decade in the mid-1970s over the test period between 1960 and 1990.[38] In response, Quah (1996a and b), also pointing to a growing body of alternative work,[39] argues that these empirical results around 2% convergence are consistent with the stratification of countries into rich and poor without there being catch-up from the latter to the former. The traditional convergence literature is unable to address this question other than as separate economies moving to their unique steady-state. In short, Quah (1996a, p. 1053) concludes:

> With hindsight, the key point ... is obvious. Convergence concerns poor countries catching up with rich ones. What one wants to know here is, what happens to the entire cross-sectional distribution of economies, not whether a single economy is tending towards its own, individual steady state. However, it is the latter that has preoccupied the traditional approach.

But a more general, and slightly different conclusion emerges from this literature. It is that simple models either cannot address simple questions or that they become too complicated even before relatively few explanatory variables are introduced. Endogenous growth theory is in a shambles of its own making as the formal models intended to paint the broad-brush features of growth have become ensnared in unduly demanding statistical issues relative to the original intention.

4 Asset Stripping Schumpeter

Since one strand of endogenous growth theory has been concerned with modelling productivity change, it is hardly surprising that the literature should have rediscovered Schumpeter and, occasionally, Adam Smith for whom a growing division of labour as a source of productivity increase is readily re-interpreted in terms of economies of scale, scope and intermediate product range. Three particular aspects of Schumpeter's work figure prominently.[40] One is the notion of clusters of innovation which are heavily associated with externalities in the production and/or use of knowledge as in technological spillovers. Second, reference is made to imperfect competition and the extent to which the benefits of innovation accrue in the form of rents to the firms concerned. Here, there is a balance of effects. For, if innovation spreads quickly so does the general level of productivity. On the other hand, this means that the incentive to innovate, in terms of temporary surplus profits, are undermined. At one extreme, for example, if diffusion of innovation is costless and timeless, no one would bother to invent. At the other extreme, if all innovations were monopolised, there could be no general productivity increase from spill-over. Third, Schumpeter is a source of dynamics, with waves of creation and, at times, destruction.

Aghion and Tirole (1994a) provide a general framework for interpreting Schumpeterian theory from a neoclassical microeconomic perspective.[41] They distinguish between the financing, creating, ownership and use of innovation. Each of these activities potentially involves separate transactions between imperfectly and

asymmetrically informed agents, and each can be subject to different contractual arrangements, whether in-house or not. Such endogenously treated factors determine the level, ownership, distribution of, and returns to, R&D. Different models generally focus on one or more of the associated market imperfections.

In this vein, King and Levine (1993) examine four roles of finance in Schumpeterian innovation - to evaluate entrepreneurs, mobilise resources, diversify risk over uncertain outcomes, and to reveal the rewards to innovation. For them, each of these functions is enhanced by reducing financial distortions. Baland and Fancois (1996), however, find that a more concentrated industrial structure can be more conducive to growth since higher levels of innovation are induced by high levels of monopoly rents. Smulders and van de Klundert (1995), employing a model of firm-specific innovation, associate faster growth with higher concentration unless monopoly profits from pricing come to exceed those of innovation. They also find that cross-country economic integration speeds growth as rents of innovation are larger,[42] although such enlarged rents have to be set against the speed of imitation from competitors.[43] Cheng and Dinopoulos (1996) distinguish between technological breakthroughs, which occur randomly even if dependent upon resources devoted to produce them, and technological improvements which are subject to diminishing returns. They are able to generate endogenous cycles and growth in which the cycle is shorter the greater is the growth rate. A number of models focus on the skills necessary for innovation, such as Eicher (1996), with Jones (1995b) deploying a scale effect on population size since there will be more workers to take advantage of R&D produced by a given number of scientists,[44] whereas Lai (1995) examines an international product cycle in which skilled labour alone is capable of supplying innovation and imitation whilst it is also necessary alongside unskilled labour in production of goods.

Jones and Newman (1995) model technological progress as a known but random process in which advances give rise to the need for adaptation represented by costs being spent in searching out and learning appropriate matches with other economic agents. Those who succeed in search gain temporary monopoly rents but these are eroded whenever a new technology renders them entirely obsolete. One perverse result is that a technological advance leads to an immediate downturn rather than a boom as existing production is reduced in deference to devoting resources to adapting to new technology.[45] It is also shown that there are two equilibria attached to these periods of creative destruction - one in which technological advance is frequent but matching limited, and one in which the latter is perfected more but at the expense of less frequent innovation.[46]

Stein (1997) constructs a model with firms competing on quality, for which there are spill-overs, and on firm-specific learning-by-doing by incumbent firms in which there are not. This can lead to alternating periods of rapid and limited levels of innovative activity. Otherwise, there is a whole host of different ways of modelling the innovation process. Benhabib and Spiegel (1994) emphasise the role of human capital in catch up;[47] Lombardini (1996) provides a number of complex models including one in which equilibrium is indeterminate with a (Sraffian) trade-off between the wage level and the rate of growth since firms endogenise growth according to returns which depend upon how much human capital has been stored by workers at the expense of consumption; and for Yang and Borland (1991) productivity increase depends upon the level of specialisation of agents rather than the finer range of intermediate inputs.

In short, endogenous growth theory as a theory of productivity increase has two bountiful and overlapping sources for ideas which can be incorporated in one or another way into a formal model and be tested empirically. Either ideas, usually piecemeal and most notably from Schumpeter, can be purloined from earlier literature, or a more or less arbitrary but highly specific source of technical change is casually invented through some economic mechanism attached to human capital, produced R&D, or spill-over. On this basis, the theory is able to broaden its scope of application and even putatively confront a range of policy issues as revealed in following sections.

5 New Trade Theory

New trade theory is little more than old infant industry arguments extended to a broader canvas.[48] Are the benefits of protecting domestic economic activity outweighed or not by the disadvantages of discouraging external economic influences? Of course, in the simplest version of this issue, it is a matter of setting, for example, increasing returns to scale in domestic production against the availability of temporarily cheaper imports. Consequently, all the ingredients of endogenous growth theory are inherently present, given the market imperfections necessarily attached to scale economies.

It is, then, a simple and natural step for trade and endogenous growth theory to flourish together. The

only conceptual issue, one that is rarely addressed explicitly, is how to distinguish one country from another. Traditionally, the answer has been, as in Heckscher-Ohlin theory and its off-shoots, the extent of factor endowments and mobility, with the country or nation-state otherwise treated as an optimising agent or set of agents in so far as the interests of capital and labour, for example, are distinguished. For endogenous growth theory, this has two implications. First, the closed economy model is simply carried over in some form to a trade model, with individual agents designated as countries. Second, the exact nature of the model depends upon market imperfections and the corresponding sources of productivity increase deployed. As a corollary, it follows that a theory of international trade has not been constructed in anything other than name because of the weakness with which separate countries have been specified and distinguished. This is apparent in that exactly the same analysis can be brought to bear upon intra-country growth and trade as in study of uneven regional development.

Despite the link between endogenous growth theory and market imperfections, much of the literature has favoured trade liberalisation. There is, after all, the spread of knowledge and improved input quality and variety to consider.[49] Villanueva (1994), for example, emphasises the gains from trade, deploying simple regression analysis to explain better growth in terms of liberalisation, human capital, and sound fiscal policy. Similar effects can be incorporated by focusing on consumer variety as in Westerhout (1995) who allows firms to exit and enter. With trade liberalisation, consumer prices and costs of production are lower but so is product variety, and this can outweigh the other effects on consumer welfare. For a small open economy, Osang and Pereira (1996) find that all tariffs are damaging to long-run growth but there can be increases in welfare in the short run.[50] In addition, there is no reason to presume that tariffs should be uniform across goods in maximising intertemporal welfare.

With perfect spill-overs of knowledge, innovation depends upon temporary monopoly profits but growth rates are unlikely to diverge over the long run, as Brecher et al (1996) model and find for the US and Canada.[51] Thus, Keuschnigg and Kohler (1996) construct a model of differentiated commodities and monopolistic competition in which trade liberalisation brings substantial welfare gains and export subsidies will even pay for themselves in terms of induced growth. Van de Klundert and Smulders (1996) allow for technology spill-overs between North and South, but the latter's low level of high-tech production limits learning by doing.[52] Convergence or divergence depends upon how openly competitive is international trade. Boileau's (1996) model also allows for international externalities, but with non-traded and non-market production within countries. He is able to generate growth and cycles in which, contrary to most models and in conformity to received wisdom, cross-country correlations on output exceed those of consumption and productivity. Lau and Wan (1994) argue that trade is necessary but not sufficient for poorer countries to converge. For middle-income countries will be able to accrue the benefits of catch-up since the costs of doing so declines with growth, whereas the poorest countries will experience a widening income gap.

A complex model is provided by Fischer and Serra (1996) in which the domestic economy grows faster the greater the level of equality because of higher incentives and returns to investment in human capital.[53] As growth rises, unskilled labour may be rewarded more as it becomes scarcer but inequality may also increase as the wealthier invest more in human capital. With a world economy of rich and poor countries, free trade is in part disadvantageous for the former in raising inequality at once (skilled labour is immediately worth more in opening up to trade) and over time, and in lowering the growth rate as poorer countries converge. Poor countries unambiguously gain from each of these effects. The implication is free trade for poor countries and subsidised education of the worse-off in rich countries. Further, Haque and Kim (1995) advise that subsidising human capital can lead to a brain drain unless confined to those at the lower level of education given relative costs of moving.[54]

Once again, whether tied to more or less sophisticated econometrics, endogenous growth theory in the context of trade is characterised by a proliferation of models based on simplistic microeconomic notions with complex and varied outcomes. Policy implications, especially as regards trade liberalisation, depend upon the mechanisms through which endogenous growth is generated and the market imperfections to which they are attached. It is hardly surprising that free trade tends to be favoured in so far as this will allow for the greatest scope for spill-over and other effects to accrue, although it is possible for either poor or rich countries to lose depending upon the relative impact of scale economies, catch-up and first-mover advantages. Whilst trade and other policy measures can be considered together, as in levels of education expenditure, endogenous growth theory in the context of trade policy rarely considers the portfolio of policies that might promote comparative advantage in particular sectors. Trade policy, more closely associated with productivity increase, tends to be considered in isolation from that other concern of the Washington consensus, fiscal balance, even if this has

itself been a focus for endogenous growth theory in its own right in the context of intertemporal optimisation of the incidence of government expenditure and taxation.

6 Accounting for the State

Fiscal issues have increasingly been set on a microfoundations basis with the state optimising intertemporally in the context of other optimising agents and in the presence of market imperfections. The standard result in public finance is that taxation should not be levied on capital, the accumulable factor of production, since this will reduce the incentive to save, and hence, the level of investment and growth. Instead, taxation should be levied on fixed or unalterable factors of production, such as labour, since the level of supply will not be affected. Such considerations continue to apply, even with greater force, in case of models of endogenous growth since the laissez-faire level of saving is already too low relative to the social optimum because of externalities or whatever.[55] For Ireland (1994), a deficit-financed tax cut can pay for itself in the long run through the endogenous growth generated.

Such conclusions no longer hold once a number of standard assumptions are dropped. First, if human capital is involved, this can be accumulated and is no longer an exogenously given factor of production.[56] Second, there may be imperfections in particular asset markets, especially those for human capital in which it may not be possible to borrow and consume now on the basis of future higher earnings after human capital has been accumulated. Third, this is especially so if individuals are not treated as if they were infinitely long-lived (or "dynastic" in optimising for future generations). In overlapping generation models, children serve both to provide utility directly in the present, in the future and are a source of future earnings. The desired let alone the optimal path of consumption may not be sustainable if it is not possible to borrow on future earnings. In short, prospective productivity increases may lead to the desire to bring consumption forward from the income to be earned later. This may be constrained by the form taken by assets. The exact outcome, however, depends upon how productivity increasing (human) capital is accumulated and passed on, how it contributes to productivity, and how utility is distributed across generations.

In each of these cases, as in static models, there is a role for government subsidies where social exceed private returns and, where there is expenditure, there must also be taxation. In addition, saving behaviour will be affected by how government taxes, and productivity can also be affected directly by government expenditure on education and R&D. Thus, in the context of fiscal policy, Rangazas (1996) argues that infinitely-lived representative agents is an appropriate feature only for a model studying intertemporal substitution in consumption. It is inappropriate for his own model involving redistribution within and between agents where the accumulation and passing on off human capital between generations is based both on constrained bequests and altruism.[57]

In this light, Bertola (1996) finds that taxation on capital may be advantageous if it falls on an older generation with a lower propensity to save than the younger working generation.[58] Turnovsky (1996a) constructs a model in which investment incurs adjustment costs and in which public expenditure affects the level of these as well as productivity of capital subject to "congestion",[59] thereby requiring trade-offs between different taxes.[60] Contrary to real business cycle theory that suggests that fluctuations are the efficient market-response to productivity shocks, Van der Ploeg (1996) argues that stabilisation policy is healthy for an economy irrespective of the source of instability by deploying a model of endogenous growth in a small open economy with overlapping generations, investment adjustment costs, and a premium on interest rates if the ratio of debt to domestic income rises.[61] Greiner (1996) considers a model in which the externality on productivity through learning-by-doing capital depends upon how recent investment has been. Consequently, it is not always advantageous to raise the rate of saving and investment through fiscal policy since low levels of human capital may drag down the level productivity.[62] Palivos and Yip (1995) consider seignorage and taxation as alternative methods of financing public expenditure. In comparisons of steady states, the first is better for the growth rate but the second for tempering inflation. Stokey and Rebelo (1995) argue, in line with earlier work of Lucas, that tax reform would make little difference to the US growth rate, with factor shares, depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labour supply being important parameters but not elasticities of substitution in production.[63] Pecchenino and Pollard (1997) argue that an actuarially fair annuities scheme would not be Pareto-efficient as it would reduce the disutility of dying and hence the level of saving.

Zhang (1996a) assesses the relative merits of subsidising education as opposed to depending upon its public provision, given the externalities involved in an endogenous growth model. He finds that public provision

is less effective at accruing externalities but is redistributional. Consequently, he suggests that inegalitarian economies might start with public provision and then switch to subsidy. Ni and Wang (1994) employ a model to show that education should be provided publicly and financed by taxation. Buiter and Kletzer (1995b) find that intergenerational redistribution policies that discourage saving, and hence investment and growth, may lead to compensating investment in human capital. Caballe (1995) shows that altruistic parents may save too much if they are unable to borrow to finance their children's human capital through borrowing, with the competitive exceeding the optimal growth rate

Palivos and Scotese (1996) find that if desirable social services for children are financed out of taxation, then the fertility rate will be too high since households benefit from the services without bearing their costs. Zhang (1995a) suggests that an unfunded social security programme increases growth by reducing fertility and increasing investment in human capital as long as parents care about own consumption, number of children and child welfare. Otherwise, Zhang (1995b) suggests that the impact on growth of unfunded social security depends upon whether the effect of fewer, better educated children outweighs the lower levels of saving which tend to be associated with compulsory social security. Wiedmer (1996) argues that a fully funded social security system is preferable to a pay-as-you-go system since the saving rate and growth would be higher in an endogenous growth economy. On the other hand, Razia and Yuen (1996) show how difference in tax regimes across countries lead to magnified impacts on growth rates in a model incorporating quality/fertility choice over children and free international capital mobility.[64]

Models of the fiscus, then, in the context of endogenous growth theory are little more than an exercise in intertemporal optimisation, with outcomes dependent upon how productivity is generated and how the welfare of future generations is linked to those of the present so that appropriate taxes and subsidies can be calculated. Such literature, apart from qualifying standard results derived in the absence of market imperfections, is notable for its failure to consider the political and practical issues attached to fiscal policy which seem to have been set aside. As in other applications, and the core models themselves, endogenous growth theory depends upon gross simplification despite the technical complexity that results.

7 Money, Finance and Growth

The same applies to the inclusion of money and finance into endogenous growth theory. Their introduction has been marked by three different approaches - one includes real money holdings in the intertemporal utility function, another requires there to be cash holdings for production purposes, and the third relates money to transactions costs. Whilst each of these reflects relatively crude understandings of money at a microeconomic level, they are readily translated into a macroeconomic context. With inflation resulting from excessive increases in the money supply,[65] the result is equivalent to a tax on future income which places a premium on present consumption serving to decrease the saving and growth rates, as in Zhang (1996b).[66] Money is no longer neutral in the long-run as the growth rate can be affected through inflation. Inflation, ceteris paribus, is also equivalent to a reduction in the real rate of interest, thereby further reducing the incentive to save. However, Smith (1996) shows how higher inflation can lead to a higher interest rate, higher saving and, hence, higher endogenous growth.[67] Further, Roubini and Sala-i-Martin (1995) argue that governments are more liable to use an inflation tax and to resort to financial repression (to increase demand for money) where the level of fiscal tax evasion is high. The consequence is to reduce the rate of growth even for given levels of savings because of the inefficiency of the repressed financial system. For them, there is a spurious inverse correlation between higher inflation and lower growth since both are a consequence of government's attempts to raise the tax base through financial repression. With inflation, Marquis and Reffett (1994) argue that alternative costly payment systems arise for the exchange of goods, with lower growth through the lost resources.

The role of financial intermediation has been modelled in a more sophisticated way with deeper roots in microeconomic considerations, exploiting the role of money as an asset in the presence of market imperfections. Obstfeld (1994) argues that global diversification of finance means the possibility of diversifying into riskier investments, raising the rate of growth. Bose and Cothren (1996) focus upon asymmetry between borrowers and lenders in which costly screening devices can be applied by banks to investment projects as well as their rationing the number of loans that are made.[68] They show, paradoxically, that a lowering of the cost of screening can reduce the economy's rate of growth since the lender may prefer to be much more selective in distinguishing between borrowers rather than targeting an average across them.[69] Once above a threshold of development, however, financial intermediation unambiguously promotes the growth rate. A similar model is developed by de la Fuente and Marin (1996) but with intermediaries emerging endogenously to avoid duplication of monitoring

activities and to negotiate contracts with innovators. They also observe that the case for subsidising innovation, as suggested by spillovers and other productivity externalities, depends upon the capacity and incentive to monitor such supports properly.[70] Galetovic (1996) and Greenwood and Smith (1997) dovetail financial intermediation with specialisation in production, arguing that sustained growth may require financial intermediaries to stimulate specialisation, and such intermediaries are liable to emerge with specialisation and growth as they can be more effective in reducing monitoring costs the finer is the division of labour. Drawing upon Hicks' notion that industrialisation depends upon the capacity to finance large-scale investments, Bencivenga et al (1995 and 1996) extend the notion of lowering transaction costs to allow for a second-hand capital goods market. This can reduce the saving rate and growth as revenue from selling used capital can be devoted to consumption. De Gregorio and Guidotti (1995) model the impact of financial intermediation both on the volume and the efficiency of investment. They suggest that the latter is most important except for Latin America in the late 1970s and early 1980s when a higher volume of bad lending was encouraged by lax regulation and confidence that governments would bail out any financial crisis.

Human capital is an asset which is not only recognised as involving externalities but also capital market imperfections as future earnings cannot always be used as collateral to finance current costs or desired consumption on the basis of future productivity. De Gregorio (1996) argues that this can lead to higher savings to provide for the future instead, and so to higher growth.[71] This is tempered, however, and even outweighed by the reduction of human capital accumulated.

It takes little sophistication, then, in the theory of money and finance to allow each to affect the rate of growth. Any short-run negation of the neutrality of money, as in most macroeconomics, especially in the presence of micro- as macro- imperfections, is readily translated into growth effects through a variety of indirect mechanisms as the level and composition of saving and investment are affected.

8 The Political Economy of Growth

In the last section but one, endogenous growth theory has been linked to fiscal questions in which government is either taken as a benevolent optimiser or arbitrary tax authority. Not surprisingly, models have also been developed in the style of the new political economy in which government policy does itself become endogenous. As such models depend upon the balance of vested interests, they inevitably involve differentiation between individuals.[72] Some analyses are relatively simple, associating lower investment with greater social instability, and the latter with inequality. Thus, Alesina and Perotti (1996) run Barro-type regressions with such sociopolitical and socioeconomic variables included.[73]

At a more sophisticated level, an endogenous growth model is coupled with an endogenous political process, in which heterogenous agents determine policy (for example, by reference to the tax level preferred by the median voter),[74] with such policies subsequently affecting growth and stratification and so on, as in Krusell et al (1997) who show how critical is the initial distribution of physical assets. More generally, it has commonly been argued, as in Persson and Tabellini (1992), that inequality is detrimental to growth in a democracy because resulting redistribution through the fiscus reduces the saving rate (rather than raising the saving rate through higher propensities to save from those on higher incomes).[75] Verdier (1994) surveys such work, pointing to the problem of how agents anticipate the consequences of their strategies given the multiplicity of channels through which their effects are realised, with multiple equilibria inevitably arising. Glomm and Ravikumar (1994) allow public sector R&D financed by taxation to endogenise growth. Despite inequality in initial capital endowments, they find no trade-off between inequality and growth if public policy is decided by majority rule.

Palokangas (1996) examines the impact of trade unions on the distribution of income and on growth. He argues that a higher wage for the unskilled may induce higher, productivity-enhancing investment, raising the rate of growth even if at the expense of unemployment amongst the unskilled. On the other hand, Bertola (1994b) argues that workers may obstruct investments in the presence of adjustment costs where they own fixed factors of production alone (i.e. the unskilled). A similar motivation on the side of capital is developed by Krusell and Riosrull (1996). They provide a model in which innovation is attached to particular vintages of capital which gradually become redundant with the adoption of new technology. The vested interests attached to old vintages can obstruct introduction of the new until they are reduced to a minority.[76] The result is to generate long cycles of innovation and growth. Sturzenegger and Tommasi (1994) model the political process through Schumpeterian entrepreneurs who can either devote resources to R&D or to rent-seeking for government subsidies. The more unequal the competitive access to political redistribution, the less resources are devoted to rent-seeking and the

higher is the rate of growth.

For Garciapenalosa (1995), the costs of education are relatively high in developing countries, so that greater inequality is conducive to growth in such countries whereas the reverse applies in developed economies if externalities are to accrue. Such considerations can be taken into account by essentially combining the two sorts of such economies into a single economy. From relatively minor differences in education or whatever, Benabou (1994 and 1996a and b) is able to show how stratification by education and income is liable to persist across generations, provided the benefits of exclusivity exceed those of integration. This can serve both as an explanation for social as well as geographical polarisation. It also shows how socioeconomic economic, as well as economic structure as discussed at the end of section 2, can be incorporated into endogenous growth theory.

9 Concluding Remarks

From the review to be found in the previous sections, it is obvious to the point of tedium that endogenous growth theory is rapidly expanding its scope both extensively and chaotically, if not arbitrarily, in ways that strongly reflect the established norms of the discipline, both in its formal modelling and in its econometric techniques. The wide variety of models that can be deployed and the different degrees of sophistication with which they can be readily empirically tested suggest that endogenous growth theory has extremely promising prospects into the indefinite future.

In this light, it is worth dwelling on two features of the literature. First, as it has been built upon microfoundations but aims at addressing the macroeconomy, it is always liable to be hopping between the two, with differentiation or disaggregation by sectors or agents to a greater or lesser degree. For Solow (1991), by analogy with the natural sciences and Hawking's A Brief History of Time, it is a matter of getting the balance right between what is taken as exogenous and endogenous and realising the limitations of a partial theory as approximation. There can be little doubt of the exaggerated claims for so partial an understanding as is provided by endogenous growth theory. Solow (1991) is particularly concerned with the long run in which so much is taken as given or in which the grandly endogenous, such as stages of capitalism and shifting social institutions, are tied exclusively to the most simplistic optimising behaviour. Such cautionary notes, even if within the neoclassical paradigm, are most welcome but are equally likely to be ignored as models based on simple intuitions are mathematically worked out and tested empirically against the conveniently available large data sets across regions and time.[77]

Second, endogenous growth theory inevitably leads to policy discussion. As Bertola (1994b) observes, "almost every paper on endogenous growth addresses issues of policy", p. 103. Yet, no policy consensus has emerged nor are the practical implications of endogenous growth theory readily applicable in practice. It is surprising analytically, if not ideologically, that endogenous growth theory should not have been more readily attached to state intervention given its dependence on market imperfections. This is most notable in trade theory, where the advantages of international spillovers have to be set against the benefits of protected markets. Yet, it is precisely the abstract, formal and highly aggregated content of endogenous growth theory, together with its multifarious sources and effects which, in contrast to monetarism and Keynesianism, say, lead to policy ambiguity and imprecision - the more so with the slightest degree of complexity. The movement to detail necessary for policy formulation - levels of education or R&D expenditure - more or less render endogenous growth theory impracticable.

It is precisely the micro/macro bridge and the policy imprecision that will allow endogenous growth theory to prosper through proliferation in models and competing conclusions. By the same token, in the wake of the new revolution in economics discussed in the opening remarks, endogenous growth theory has launched a profound challenge against radical political economy. It has previously done so in two different ways. First, the stumbling block for orthodox growth theory has been taken to be its inability to explain the simplest facts about economic growth whether it be the patterns of convergence and divergence or the stylised facts associated with Kaldor. Now, it is apparent that models can be built which have the potential to accommodate short- and long-run patterns of variables to order.[78] More or less any stylized facts are able to be modelled. Where stylised facts used to be an embarrassment to the orthodoxy, they are now a welcome challenge and invitation. It is clear in retrospect that the conventional wisdom on such matters is an informal counterpart to results derived from ahistorical formal models.[79]

The second challenge to radical political economy lies in that endogenous growth theory has also been

able to incorporate the very variables that neoclassical economics has been criticised for omitting, those relating to shifting productivity, institutions and market imperfections more generally. Of course, it can be argued that this is advantageous to radical political economy since the mainstream is acknowledging the importance of its insights, not least in breaking down the rigid separation both empirically and theoretically between the short run and the long run, and in broadening the scope of the (endogenous) economic. The consequence, however, as has happened in the economics of labour markets for example, is more likely to be the merging of the radical and mainstream which become increasingly indistinguishable.[80] Similar developments can already be observed in endogenous growth theory, in which political economy models of growth drawing upon Kaldor or Schumpeter are explicitly rooted in neoclassical theory and, where they are not, are readily reconstructed as such.

A natural, legitimate but insufficient response by radical political economy to these issues is to appeal to the informality of its own approach and the corresponding ability to deal with historically and socially specific circumstances. The latter, however, have to be wedded to a deeper understanding of socioeconomic processes. At the theoretical level, outcomes must be understood as the complex and contradictory consequences of the underlying socioeconomic processes attached to the accumulation of capital. At the empirical level, this implies that trends or other movements in economic variables should not be seen as the more or less complex balance of mechanically realised socioeconomic processes, as in Verdoorn-type analysis, but as their historically and socially contingent resolution. Simply referring to endogenous productivity, monopoly, institutions, money and finance, the patterns of growth and cycles, conflict, inequality, etc is no longer sufficient to defend radical political economy against the neoclassical orthodoxy. The latter can accommodate them all and more. It is more a matter of going back to methodological first principles, and placing the social, the historical and the forces within the economy at the forefront in order to be able to combat both methodological individualism and the analytical strategy of creeping endogeneity.

Finally, if endogenous growth theory is gobbling up radical political economy rather than deferring to it, how is it relating to the other social sciences? As is apparent from the previous sections, endogenous growth theory is able to incorporate the political (voting) and the social (stratification). Simply renaming the unit comprising the economic agent, as already seen, allows endogenous growth theory to spread to geography. Palivos and Wang (1996) construct a model of urban agglomeration and decentralisation through balancing the positive externality of human capital against the negative one flowing from transportation costs.[81] Zhang (1994b) draws upon an Alonso residential model to define a unique equilibrium for the spatial distribution of households, rent levels, fertility and factor rewards, but finds that it may exhibit permanent oscillations. Krugman (1991) moves seamlessly from international trade to a regional core-periphery model through use of transport costs and increasing returns.

The environment has also provided scope for the application of endogenous growth theory, not least because of its potential association with intertemporal optimisation. Mohtadi (1996) allows for it to enter both production and utility functions, with the optimal growth path requiring both quantity controls and taxation. Bovenberg and De Mooij (1997) find that a pollution tax as opposed to other taxes improves welfare by raising the productive quality of the environment as well as by shifting the fiscal burden onto profits rather than growth generating investment. Bovenberg and Smulders (1995 and 1996) allow for endogenous productivity increase in pollution abatement with the result that a shift towards a more environmentally friendly growth path may only mean lower growth in the short run.[82] Elbasha and Roe (1996) develop a model of trade, growth, imperfect competition and the environment with outcomes depending upon factor intensities, but with the decentralised growth rate potentially faster than the optimum because of the negative impact on the environment.[83]

Despite these forays into the other social sciences, endogenous growth theory advances for the moment only with difficulty, not least because of the extreme formalism with which it is characterised. On the other hand, as observed, endogenous growth theory has already been extended to a political economy of growth in which interest groups, voting, conflict and inequality have been incorporated, and other disciplines have previously demonstrated an interest in the non-economic determinants of growth without necessarily referring to endogenous growth theory.[84] Thus, although endogenous growth theory has yet to cut deep inroads into the other social sciences,[85] and nor has its impact yet been marked in more general discourse,[86] this might only be a matter of time for the technically demanding to filter across - as happened in the case of human capital. In short, as far as the revolution in economics is concerned, endogenous growth theory might not be in the vanguard, but it is certainly liable to be one of the new wave of following colonisers.

Footnotes

1. Solow (1991) marks the origins of endogenous growth theory with Romer's doctoral thesis of 1983 and Lucas' Marshall Lectures of 1985.

2. For the purposes of this review, reference was primarily made to those contributions that were most readily uncovered through the Social Science Citation Index from 1994 onwards.

3. As in, for example, Economics of Planning, vol 28, no 2-3, 1995; Ghatak (1995); Quarterly Journal of Economics, vol 109, no 1, 1994; Scandinavian Journal of Economics, vol 95, no 4, 1993, reproduced as Andersen and Moene (eds) (1995); Oxford Review of Economic Policy, vol 18, no 4, 1992; Journal of Economic Dynamics and Control, vol 21, no 1, 1997; Jones and Manuelli (1997a and b); Verspagen (1992); Journal of Economic Theory, vol 63, no 1, 1994; Journal of Economic Perspectives, vol 8, no 1, 1994; Economic Journal, vol 106, July, 1996; Pio (1994); Economic Journal, vol 106, July, 1996; Journal of Political Economy, vol 98, no 5, Part 2, 1995. See also Buchanan and Yoon (eds) (1994).

4. See also Fine (1997b).

5. See especially Becker (1996).

6. For an assessment of the evolution of macroeconomics in these terms, see Fine (1998, Chapter 2).

7. A significant but less prominent role has been played by incorporation of more complex intertemporal optimising by producers, especially in the context of adjustment costs in investment and, hence, irreversibility of investment decisions. See Pindyck (1991) for a survey and, for the presence of adjustment costs in endogenous growth theory, see Benavie et al (1996), for example.

8. See Matsuyama (1995) for a survey of cumulative processes in the context of monopolistic competition.

9. It is only surprising that it should have taken so long for Schumpeter to have been incorporated within mainstream neoclassical economics, since he is credited with having coined the expression "methodological individualism", and he favoured both it and modelling for analytical purposes. See Machlup (1978).

10. For an exposition and assessment of the NSI literature, see Fine (1993).

11. See Summers and Heston (1988 and 1991).

12. See also Kocherlakota and Yi (1996) who undertake a similar exercise for public expenditure across US states and conclude that military expenditure should be treated separately. Hoon (1996) also separates out the impact of defence expenditure.

13. See discussion in Bernard and Jones (1996).

14. See Faig (1995) and also Ozlu (1996) who allows for stochastic component in the stock of human capital.

15. For a critical discussion, see Strauss and Ferris (1996).

16. In the context of aggregation, a rather different point is raised by Corriveau (1994) who finds that using the range and variety of inputs as an input itself is one way of restoring constant returns to scale in lieu of endogenous growth theory. Thus, in one of the most sophisticated defences of exogenous growth theory, it is suggested that macroeconomic endogeneity may be mistakenly inferred despite microeconomic exogeneity with varying numbers of inputs that are overlooked by macro-data.

17. Of course, the composition, as opposed to the use of output, can scarcely be examined in a one-good model.

18. With Lucas (1988) the production function for human capital, h, for example, is given by $dh/dt = ah^e$ with a and e constants and e taken to be equal to one. Otherwise, for e>1, the rate of growth of human capital, and

hence the economy, is infinitely fast in finite time. If e<1, the impact of human capital declines to zero over time. See Solow (1991 and 1992) and also Stern (1991).

19. See Brinkman (1995) for a critical discussion of the distinction between development and growth as understood by neoclassical economics.

20. For Solow (1991) the choice between optimising individuals and behavioral assumptions is a matter of analytical taste.

21. For a full discussion of this point, see Fine (1982).

22. See also Bond et al (1996).

23. See also Abe (1995) who allows for public goods in production and consumption leading to two equilibria, one a poverty trap with no growth.

24. As an alternative to fertility as an intertemporal link, see Hu (1995) who allows for endogenous retirement, with an aging population increasing the savings and growth rates.

25. See also Caballe and Santos (1993).

26. See also Krugman (1990) as discussed in Solow (1991).

27. Easterly (1994) uses thresholds in a slightly different way, finding that counterproductive government policies will preclude transition to a growth path if they are taken too far.

28. See Benhabib and Perli (1994) and Benhabib and Farmer (1994), for example, who provide models with multiple, even a continuum of, equilibria and correspondingly complex dynamics.

29. See also Cartigny and Venditti (1994).

30. See also Riverabatiz and Romer (1994) and Devereux and Lapham (1994) for potential instability for endogenous growth in the context of economic integration.

31. See also You (1994) and Driver (1996) for a more informal account.

32. Note that there are different understandings of what constitutes convergence - for example, if poorer per capita countries grow faster than richer ones or if the dispersion of real per capita income across countries declines over time.

33. See also Tzanidakis and Kirizidis (1996) who test, and reject, exogenous growth theory by transforming the equation to be estimated, with the growth rate becoming dependent upon initial growth rate alone.

34. See Bernard and Durlauf (1996) who also, along with many others, point to the different definitions that can be attached to convergence. In addition, they observe that cross-section tests of convergence tend to assume that the economy is far from, and adjusting to, a steady-state whilst time-series are used on the basis of economies being close to equilibrium. In other words, the time-series approach to testing convergence requires, in case of multiple equilibria, that the economy be close to long-run equilibrium. Otherwise transitional adjustment will be conflated with the steady state.

35. See also Evans (1996).

36. See Ghatak et al (1995) for a similar exercise for Turkey. See also Bernard and Durlauf (1995) for a study of common trends across fifteen OECD countries over a hundred years.

37. As Bernard and Durlauf (1996) demonstrate, convergence is more likely to be accepted in cross-section than in time-series testing.

38. In other words, convergence only materialised for two-thirds of the period under examination. In any case, at this rate of convergence, it would take thirty-five years for half of the difference between steady-state per capita incomes to be closed.

39. See also Galor (1996).

40. Solow (1991) significantly entitles a section, "Formalizing Schumpeter".

41. See also Aghion and Tirole (1994b).

42. See also Thompson and Waldo (1994) who model trustified capitalism as one in which innovating firms do not entirely drive incumbents out of business. Consequently, they find that the growth rate is unambiguously suboptimal as the profit motive for innovating is weakened. Thompson (1996) models trustified capitalism by expected profits from R&D expenditure and provides production function estimates for R&D for thirteen industry groups.

43. See also Soete and Verspagen (1994).

44. On the other hand, Roy (1997) models a negative externality across the R&D sector given that the same invention cannot be made twice - overlap rather than spill-over.

45. See also Corriveau (1994) for whom innovations are random within a one-sector model. Recessions do not result from negative shocks on technology as such, as in real business cycle theory, but from the use of resources in the short-run to exploit advances as they occur.

46. Such models of creative destruction derive originally from Aghion and Howitt (1992). See also Aghion and Howitt (1994) who point to learning from, as well as choosing to, invent, with innovation depending upon systematic and serendipity effects; trade with liberalisation increases rents of innovation from larger markets but decreases them through competition. Consequently, p. 123:

> The tendency for temporary shocks to become embedded into the economy's long-run growth path calls into question the by now traditional division of macroeconomic theory between trends and cycles.

47. See also Easterly et al (1994) where adoption depends upon level of human capital, and Young (1993) for whom R&D expenditure and learning by doing on new technology mutually condition one another. For Keller (1996), the success of trade liberalisation to absorb technology is dependent upon human capital to sustain it.

48. See Fine (1996) for a simple model and some reference to the literature. See also Krugman and Smith (eds) (1994), Edwards (1993), Kitson and Michie (1995), Dornbusch (1992) and Rodrik (1992), for example.

49. For an overview of trade, growth and knowledge, see Zhang (1994a).

50. See also Kaneda (1995) who shows in presence of increasing returns that the country with lower time preference is liable to industrialise first.

51. See also Feenstra (1996) who finds that growth rates do not converge with no diffusion of knowledge but that this can be tempered by trade in intermediate products and by multinational corporations.

52. See also Walde (1996) who suggests that, with perfect international technical spill-over, convergence will depend
upon conditions of competition.

53. See also Gould and Ruffin (1995) for the case that human capital is crucial to growth and trade.

54. However, Walz (1995) finds a non-monotonic relationship between tariff reductions and growth in a model of regional international development, with the possibility of core-periphery patterns of development arising in case of factor mobility.

55. See King and Rebelo (1990) who argue that taxation can lead to underdevelopment traps, with large families with low human capital if incentives to accumulate the latter are eliminated.

56. See Milesi-Feretti and Roubini (1994) and Jones et al (1997) for rejection in the context of human capital of the Chamley-Judd proposition that taxes should only be on labour. Mino (1996) shows that policy effects depend upon relative capital-labour intensities in a model with more than one sector, such as output and produced human capital.

57. See Xiu (1994) for the idea that the effect of taxation depends upon how human capital is generated and used, how endogenous growth is generated, and how taxes are raised and spent. See also Glomm and Ravikumar (1997) for a survey of endogenous growth theory in which government expenditure is productive in one way or another.

58. See also Uhlig and Yanagawa (1996) for an identical result.

59. Congestion is where the productivity of public goods declines with use.

60. See also Turnovsky (1996b and c) and Cashin (1995) for a model of congested use of public capital in conjunction with taxes to fund it.

61. See also Martin and Rogers (1997).

62. This is perceived to divide developed from developing countries, with NICs in-between because of relatively high levels of human capital.

63. In a two sector model in which labour is allocated between work, leisure and human capital accumulation, Devereux and Love (1994) find that the effect of taxation on the growth rate depends upon how labour responds to higher tax rates.

64. See also Xiu (1994) for an account of taxation and endogenous growth in the context of international capital mobility.

65. Bagella and Lo Cascio (1994) highlight six potential (indirect) effects for growth through changes in inflation: a real balance effect; a real interest effect; an impact through lagged expectations; labour supply responses; changes in flows of foreign capital; and differences in risk as an investment premium.

66. See also Jones and Manuelli (1995) and Marquis and Reffett (1995). In a model in which money is an element in the production function, Pecorino (1995a) shows that inflation is equivalent to a tax on the income of reproducible assets, reducing saving and sources of endogenous growth.

67. See also Mino and Shibato (1995) who place real balances in the utility function in an overlapping generations model but with infinitely-lived agents. The growth rate is affected by monetary policy through reducing saving rates. A similar model is developed by van der Ploeg and Alogoskoufis (1994) who also consider the different effects of different ways of financing government expenditure.

68. See also Ho (1996).

69. See also Mauro (1995a) for whom saving for precautionary purposes can be reduced with the development of financial markets, as in the substitution of the stock market for family business finance. The same applies to Jappelli and Pagano (1994).

70. See also Boyd and Smith (1996).

71. See also de Gregorio (1993).

72. Models do not appear to have arisen much in which vested interests within the state itself are taken to be important. Presumably, these cannot survive the long run.

73. See also Alesina and Perotti (1994) for a review of the literature and the conclusion that political instability is more of an impediment to growth than fiscal imbalance.

74. See Perotti (1992) for example.

75. Alesina and Rodrik (1994) also argue that inequality in income and land ownership is an impediment to growth because of the higher taxation and conflict to which they are attached. See also Bertola (1993) and Saint-Paul and Verdier (1993). For the latter, redistribution takes place through growth-enhancing public education.

76. This has resonances with Domar's idea in the Harrod-Domar model that the warranted rate of growth needs to be reduced by a capacity factor in view of the need for output to be transferred from the reluctant old to the more productive new vintages.

77. For a brief critical assessment of the limitations of endogenous growth theory, see Pasinetti (1994).

78. Thus, for example, contrary to exogenous growth models, and in conformity to a acknowledged cyclical movements, the share of consumption in employment is shown to be pro-cyclical in Marquis (1996), through allowing for the allocation of time to formal training. See also Basu (1995) who explains the smoothness of consumption relative to fluctuations in income on the basis of tax uncertainty in the context of non-separable utility function over time.

79. See Wulwick (1993) for the notion of endogenous growth theory as the excessive formalisation of Kaldor both mathematically and statistically. In a long footnote, Stiglitz (1994, p. 79) pays homage to the anticipation of the new growth theory to be found in the older growth theory of the 1960s, including the contributions of Kaldor.

80. See Fine (1998, Chapter 4).

81. See also Boarnet (1994) and Premer and Walz (1994) who allow for migration. They acknowledge the longstanding tradition of studying agglomeration in economic geography. Referring to the work of Perroux, they observe, p. 708:

> Although his considerations were primarily sectoral oriented, they became widely accepted in regional-development theory. Unfortunately, his analysis was not successfully embodied in a rigorous theory that would have clarified its assumptions and arguments.

82. For a contrary view, see Ligthart and van der Ploeg (1994).

83. See also Vanewijk and Vanwijnbergen (1993 and 1995), Smulders (1995) and van den Bergh and Nijkamp (1994).

84. As in Haggard and Webb (1993).

85. In the context of the industrial revolution, Crafts (1995, p. 772) judges that:

> Growth theorists have ... found useful ways of formalizing ideas long discussed by economic historians, and the way may now be open for some fruitful interaction between economics and economic history.

86. As Crafts (1996, p. 30) observes:

In a speech in the autumn of 1994, the Shadow Chancellor, Gordon Brown, referred to "post-neo-classical endogenous growth theory". The press seized upon this phrase and lampooned Mr. Brown.

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