CENTRE FOR ECONOMIC POLICY RESEARCH

DISCUSSION PAPERS

The Centre for Economic Policy Research was established in 1980 as one of a number of University initiatives. It was given a mandate to foster policy-oriented studies of the Australian economy. The Centre works closely with other economic research groups - both within the Australian National University and in other Australian universities.

The Discussion Papers of the Centre are intended to make available to a wider audience a series of economic research studies. These studies will have been either commissioned (for instance in conjunction with conferences held under the auspices of the Centre) or undertaken by research staff, and visitors, to the Centre.

The Centre will also publish as Discussion Papers studies of relevance to economic policy which have been undertaken by individual academics attached to other research groups within the University - or where the Centre is able to act as a focal point for such research.

The Centre does not have any views on policy; individual authors do.

Lists of available Discussion Papers, and copies of the papers (which are free of charge) may be obtained from:

The Publications Officer
Centre for Economic Policy Research
Research School of Social Sciences
Australian National University
PO Box 4, CANBERRA ACT 2601, AUSTRALIA
Tel: (06) 2492247 Fax: (06) 2571893

CONFERENCE PROCEEDINGS 1985-1991


Details of earlier conference publications may be obtained from the Publications Officer.
The paper contains the results of research from a project commissioned by the Department of Industry, Trade and Commerce.

ISBN: 0 7315 1602 8

October 1992

Discussion Paper No. 279

Australian National University
Research School of Social Sciences
Division of Economics and Politics
Economic Program

Steve Dowrick

The Implications for Australian Policy
Evidence on Economic Growth:
A Review of New Theories and
270  Applegate, Craig, The Australian Foreign Debt Debate
271  Chapman, Bruce J. and David Pope, Government, Human Capital
     Formation and Higher Education
272  Bourassa, Steven C. and Patric H. Hendershott, Over-Investment
     in Australian Housing: Implications for Tax Policy
273  Hawke, Anne, How Do Australian Part-Time Workers Compare
     to Their United States Counterparts?
274  Chapman, Bruce J. and Cezary A. Kapuscinski,
     Long Term Unemployment: Projections and Policy
275  Dowrick, Steve, A Review of New Theories and Evidence on
     Economic Growth: Their Implications for Australian Policy
CONTENTS

1. Introduction

2. The new theory of endogenous growth

3. Why has a new theory been needed?

4. Human capital models

5. Knowledge as the engine of growth

6. Physical investment and endogenous technological change

7. Policy implications of the endogenous growth literature

8. Empirical evidence

9. References

10. Discussion papers

Papers 1-2: Regional Income Distribution and the Taxation of Labor

Papers 3-4: The New Theory of Endogenous Growth

Papers 5-6: Economic Policy Reform for Regions

Papers 7-8: Economic Policy Reform for Regions

Papers 9-10: Economic Policy Reform for Regions

Papers 11-12: Economic Policy Reform for Regions


Introduction

The purpose of this paper is to study the economic performance of six countries over the years 1950-1966. The data are taken from a number of sources, including official reports, statistical yearbooks, and survey articles. The period covers the post-war years, which were characterized by rapid economic growth in many countries. The results show that there are two clearly defined economic growth phases in the sample period. The first phase, from 1950 to 1960, is characterized by relatively slow growth. The second phase, from 1961 to 1966, is characterized by faster growth. The results are consistent with the theoretical model of economic growth, which suggests that economic growth is driven by factors such as capital accumulation, technological progress, and policy changes.
capital to labour; but it was more a theory of non-growth than of growth in its predictions for the long-run. In its standard form the theory implied that countries should converge to a steady state where capital per head and output per head are constant. There was no theory of technical progress. The empirical research echoed this approach, finding that a large proportion of measured growth was attributable to "the residual" - ie that part of economic growth which was left over after accounting for the contribution of growth in factor supplies.

Because the theory had no explanation for the residual, other than labelling it "technical progress" and treating it as an exogenous factor, neither theory nor evidence had much to say about policies that might significantly influence long-term growth. Indeed, the exceptionally strong growth rates of the 1950s and 1960s that were enjoyed by almost all the industrialised economies may have appeared to make such policy concerns redundant. The ensuing crisis of stagflation in the 1970s saw mainstream economic attention focus almost exclusively on the short-term questions of business cycles, unemployment and inflation - a focus that became the virtual definition of macroconomics. Not until the economic recovery of the mid-1980s - a recovery characterised by growth rates substantially lower than those experienced in the 1950s and 1960s - did mainstream attention start to return to the question of medium or long-term growth (ie growth over a period longer than that of a single business cycle of five or six years). It is in this context that the work of Romer and that of Summers & Heston fell on fertile ground.

There has been a continuing tradition of interest in long-run growth outside of mainstream economics, principally from those in the diverse schools of Marxist, Schumpeterian and Austrian economics which focussed on the dynamic processes of capital accumulation and competition as the key to economic analysis - schools which had largely been swamped in their influence on both the economics profession and public policy makers by the predominance of static general equilibrium approaches, whether of


constant returns to scale, thereby necessitating analysis of monopoly power and/or externalities - problems which the traditional analysis eschewed. The focus of analysis has also shifted away from the static equilibrium properties of economies, or the short-run dynamics of adjustment, and away from the associated policy analysis of static inefficiencies of resource misallocation or under-utilisation.

In order to understand the new growth theory, and the dissatisfaction with the apparent policy implications of the old theory, it is important to briefly review some of the main features and implications of that theory first propounded by Swan and by Solow in the 1950s and subsequently developed by Shell and Koopmans and many others.

The driving force of economic growth is seen to be investment, the accumulation of stocks of goods - capital - which can be used to generate further capital or consumption goods. The reproducibility of capital over a short period, as opposed to the fixed supply of land and mineral resources, apparently allows economies to grow over time, defining growth here as consumption per head of population. A key feature of these models is, however, that the marginal product of capital - the increment to output which results from adding one more unit of capital to the current stock - decreases as the capital stock gets larger. Such an assumption is typically required to ensure that an equilibrium exists in models of perfect competition. If this marginal product decreases towards zero, or at least below the rate at which economic agents discount future benefits, then there will come a time when there will be no perceived benefit in further accumulation of capital, other than to match the rate of growth in population. In the long-run, therefore, economic growth tends towards zero.

According to this standard neo-classical theory of growth public policy which attempts to stimulate growth by raising investment - perhaps by removing trade barriers or by increasing the rate of domestic saving - will, in the long run, come up against diminishing returns and be unable to influence the long-run rate of growth. Such policy will, in the terms of Lucas (1988) have 'level effects' but not 'growth effects'.
The new heart of endogenous growth

developed economies, despite the rapid expansion of trade and capital mobility (in accord with the prediction of the Storper-Swan model), the divergence for the two countries, especially among the middle-income countries. In the empirical literature, the middle-income countries have been able to explain some of the main phenomena of their economic growth, which have been covered by the traditional growth models, but often because they have

affected on which economic theory can guide policy.

focus which is not measured in economic analysis and is not inherent in the expansion that is measured in economic expansion. The idea that is measured in economic expansion is not the expansion that is measured in economic expansion. However, in the empirical reality, they may not be sensitive to any substantial differences. However, in the empirical

The evidence supports the Delors and Summers ideas that expansion

focus on what policies should be expanded in order to create new jobs with the

impact on a major source of growth. Certainly, economic expansion is not a

focus on what policies should be expanded in order to create new jobs with the

impact on a major source of growth. Certainly, economic expansion is not a
typically consider the case of increasing returns is essentially that such an assumption causes technical difficulties in modelling competitive equilibrium. It is not possible for all factors to be paid their marginal products, because under increasing returns the sum of the marginal products exceeds the average product. Moreover it is difficult to maintain the assumption of many producers to motivate the assumption of competitive, price-taking behaviour. Finally, the optimisation problem for the household choosing between current and future consumption may be unbounded. The new theories solve these technical problems using advances in the mathematical analysis of dynamic optimisation problems (eg Romer, 1986) and by assuming either that there are substantial spillover effects, implying that private returns to investments are diminishing, or that there is monopolistic competition in the sector of the economy where increasing returns are present.

It is intuitively obvious that increasing returns to scale is a possible explanation for long-run growth. If returns to deferred consumption are sufficiently high, and if the returns do not diminish, then there may be sufficient incentive for high rates of saving which can generate continual growth. Jones and Manuelli (1990) show, however, that increasing returns are neither necessary nor sufficient for endogenous growth. The technical condition which they identify as the key to endogenous growth is that the marginal product of capital should never fall too low - that is to say the rate of return on investment (deferred consumption) should never fall below the rate at which households discount future consumption. Rebelo (1991) also argues that endogenous growth can be generated in a model with constant returns to scale as long as there is a "core" of capital goods whose production does not involve fixed factors. These results are foreshadowed in Pitchford (1960) whose adaptation of the Solow-Swan model can generate endogenous long-run growth in per capita output by allowing the elasticity of substitution between capital and labour to exceed unity.

The ABS (1992) have recently published OECD estimates of 1990 relative prices and per capita quantities for broad consumption and investment categories for some OECD countries. Some of the key figures are reproduced here. All quantities are based on per capita indices where the OECD average $= 100$, and prices are indices where the OECD average price $= 100$ (using 1990 average exchange rates compared with purchasing power parities for each item).

<table>
<thead>
<tr>
<th></th>
<th>Per capita quantity indices</th>
<th>Price level indices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Australia</td>
<td>Japan</td>
</tr>
<tr>
<td>Gross fixed capital</td>
<td>109</td>
<td>158</td>
</tr>
<tr>
<td>construction</td>
<td>121</td>
<td>143</td>
</tr>
<tr>
<td>residential buildings</td>
<td>130</td>
<td>116</td>
</tr>
<tr>
<td>non-residential buildings</td>
<td>116</td>
<td>152</td>
</tr>
<tr>
<td>civil engineering works</td>
<td>111</td>
<td>179</td>
</tr>
<tr>
<td>Machinery &amp; equipment</td>
<td>86</td>
<td>171</td>
</tr>
<tr>
<td>transport equipment</td>
<td>72</td>
<td>233</td>
</tr>
<tr>
<td>non-electrical equipment</td>
<td>105</td>
<td>127</td>
</tr>
<tr>
<td>electrical equipment</td>
<td>46</td>
<td>248</td>
</tr>
</tbody>
</table>

These estimates must be treated with some caution since they represent quantities for a single year which is not necessarily representative of recent trends. Moreover some of Australia's investment patterns are explicable by its unusual demographics (high population growth) and geography. Nevertheless, a first glance does suggest that compared with the OECD as a whole, and with the USA, Japan and Germany in particular, Australia over invests in construction and underinvests in machinery and equipment. Australian 1990 prices were at OECD average levels for machinery and equipment, but construction was relatively cheap.
designed for a particular production process. Knowledge can be made explicit through systems that combine the use of expert systems for decision making. In its first use in the field of production, the knowledge base contains only the explicit knowledge of experts who have worked in the particular domain. However, the explicit knowledge is not sufficient to make a fully informed estimate of the requirements for the production process. The knowledge base is expanded by adding more information from other experts or from the production process itself. Knowledge acquisition can be facilitated by using specific methods for acquiring knowledge from experts. These methods include interviews, questionnaires, and other techniques that help to capture the knowledge of experts. The acquired knowledge is then used to improve the performance of the production process. This can be achieved through techniques such as case-based reasoning, which uses past cases to solve new problems. The effectiveness of knowledge-based systems depends on the quality of the knowledge base and the methods used for acquiring knowledge. It is important to ensure that the knowledge base is accurate and up-to-date, and that the methods for acquiring knowledge are reliable and valid. The use of knowledge-based systems for production processes can lead to significant improvements in efficiency and productivity.
patents. But every blueprint is an addition to the stock of common knowledge, an input or preliminary step towards the creation of a new design. Other designers can acquire the preliminary blueprint either through reverse engineering or through examination of the patent application, and they are then free to use it in the development of new designs. It is in this second role of increasing the stock of knowledge that technology is not only non-rival but also non-excludable.

These two features of knowledge as a public good, the non-rivalrous nature of a blueprint and the non-excludability of knowledge as an input into the development of further knowledge, are the keys to Romer’s analysis of the case for policy intervention. If knowledge was purely embodied in specific individuals, or if patent rights could feasibly cover all uses of existing designs, and if knowledge was purchased by competitive firms, then researchers would be able to appropriate the full benefit of their efforts and would not under provide research effort. The existence of research and development activities in the profit making private sector implies that at least part of the returns to research are appropriated by the researchers. It is because benefits spill over to future research activities, and because the users of new ideas have at least a temporary period of market power, that the research sector does not appropriate all the returns and is likely to under supply research activity.

Romer’s model of growth is far from the only one based on increasing returns to knowledge. Grossman and Helpman (1991) suggest that knowledge may contribute to expanding product variety or to rising product quality. In the latter case, where entrepreneurs race each other to bring out the next generation of products and enjoy the fruits of a temporary technological lead, it is possible that there may be excessive quality upgrading. Super-optimal research activity can occur because research success for one firm has a negative spillover effect on other producers.

Other new growth models differ from Romer’s 1990 paper in their focus and in their treatment of the technical problems of defining equilibrium in the presence of non-forward economies. Grossman & Helpman point out that there may also be an advantage in a strategic trade policy which successfully captures increasing returns activities and/or captures supernormal returns from certain R&D projects.

The emphasis of the new growth theories on the importance of investment implies that tax policy can play an important role in distorting or encouraging investment in those areas which generate the spillovers of knowledge and technology. A simplistic conclusion is that governments should simply aim to minimise any form of taxation which acts as a disincentive to forego current consumption in favour of future returns. But more complex models are needed to analyse the range of taxation instruments open to government.

Perhaps the most clear-cut policy implications can be drawn from the empirical work of DeLong & Summers and Aschauer who make out strong cases for subsidisation or direction of equipment investment and public infrastructure respectively. DeLong & Summers conclusions are worth quoting:

"... The social rate of return to equipment investment is 30 percent per year, or higher. Much of this return is not captured by private investors. If these results stand up to scrutiny they have obvious implications. the gains from raising equipment investment through tax or other incentives dwarf losses from any non-neutralities that would result. A 20 percent wedge between the social return to equipment and other investment has implications for all policies affecting saving and capital allocation.

Our finding ... suggests an explanation for the striking differences in economic performance realized by nations with "interventionist" governments that have tried to jump start growth ... We suggest that the poor performers have confused support for industrialization with support for industrialists. Policies that try to increase the health of the equipment sector by enriching
Physical Investment and Expanded Technological Change

Growth in the economy is partly due to the expansion of the productive capacity of the economy. This expansion is facilitated by technological change and increased investment. The role of technological change in the economy is crucial, as it determines the rate of growth.

The second major component of growth is the improvement in the efficiency of production. Here, it is important to recognize that the efficiency of production is not only a function of the number of factors of production but also the quality and productivity of labor.

...
Finally, there are various theories which emphasise the possibility that new ideas and techniques are typically embodied in machines and equipment, with returns to the investment made by one firm spilling over to benefit rival firms and firms engaged in related production activities. The implication of such models, as in Scott (1989), is that private incentives alone may lead to under-investment.

Empirical evidence

Before examining the policy implications it is important to look at whether there is any empirical evidence which might back up the new growth theories. If so, can the evidence help us to distinguish between the various versions of the new theory in order to establish which of the policy implications are likely to be relevant? Or is the new wave of growth theory merely empty theorising?

There is actually very little published empirical work which addresses these questions directly. Until the empirical and theoretical streams of research interact more closely, a process which should occur over the next two or three years, any conclusions on the relevance of endogenous growth theory will have to be highly circumspect.

Two studies just published by Barro and Sala-i-Martin (1992) and Mankiw, Romer and Weil (1992) examine the evidence for endogenous growth indirectly by testing for convergence in income levels across regions and countries. Decreasing returns to capital, as in the Solow-Swan models, imply that incomes should converge, whereas endogenous growth models typically suggest that income gaps may stay constant or even converge. Both sets of authors do find evidence that some convergence occurs but they draw rather different conclusions. Barro and Sala-i-Martin conclude that the rate of convergence is much slower than that typically predicted by the neoclassical model, and suggest that the evidence may be consistent with constant returns to capital investment. The standard use of the "representative household" abstracts from issues of income distribution.

The general tenor of the new growth models is that where there are externalities or market failures which make private returns to innovation and investment in physical or human capital less than social returns, then market provision is likely to lead to under investment and sub-optimal growth and there may be a case for public intervention. It is worth listing some of the more important contributions. But it is important to note that very few of the models can yet claim to have been validated by thorough empirical testing.

Lucas (1988, p. 31) finds that where investment in education has a spillover effect on the productivity of others, there is a case for the subsidisation of schooling. Where there are differential externalities from learning by doing, greater externalities in, perhaps, the production of high-tech goods, then Lucas comments that "... an 'industrial policy' focused on 'picking winners' .. would be called for. In the model, 'picking winners' is easy. If only it were so in reality!" The problem of course is knowing in advance, without the benefits of either hindsight or a modeller's choice of parameters, which are the sectors that will produce the greatest learning externalities. Nor, at the level of generality at which Lucas is theorising, is it possible to identify those types of education and training which might generate significant spillovers.

Romer's (1990) analysis of the spillover effects of research activities and the monopolistic nature of firms using research implies that too little human capital is devoted to research. His analysis leads to a clear call for the subsidisation of research, especially for research of a fundamental nature. Again there is little surprising here for policy makers and others not weaned on the neo-classical growth model.

There is as yet little analysis in this stream of economic theory which helps us to distinguish what types of fundamental research should be subsidised and how this might relate to industry policy. Nor does this analysis help us as yet to decide whether
One of the pillars of the standard growth accounting framework has been the role of the factors of production in explaining economic growth. However, recent evidence suggests that this may be a simplification.

In a world of imperfectly competitive industries, a factor of production, such as labor, is not always mobile. The assumption of perfect mobility of factors is a simplification that may not accurately reflect the dynamics of economic growth. It is important to acknowledge that factors of production are not perfectly mobile, which means that changes in factor endowments can affect economic growth.

The policy implications of the new framework are significant. The feedback from the real economy to the financial system is crucial for understanding the sources of economic growth. It is not enough to focus solely on the financial sector; the real economy also plays a significant role.

In summary, the new framework provides a more nuanced view of economic growth, highlighting the importance of factors of production and the role of imperfect competition.
observed variation in growth rates, whether the variation is examined across time or across countries. Compared with the unexplained differences in rates of technological progress, the impact of physical investment is relatively trivial. This finding is puzzling in the face of the popular view amongst economic historians and others that it is the development of new physical means of production that impelled the first, and subsequent, industrial revolutions.

In the conventional growth accounting approach where the elasticity of output with respect to capital stock is assumed to equal the share of profits in national income, the marginal effect of a one percent rise in the stock of capital is to increase output by only 0.3 percent or so. Putting it another way, if the real rate of return on capital is ten percent and the capital output ratio is three, then a rise in the share of GDP devoted to investment from twenty percent to twenty-one percent would increase the growth rate of the capital stock by around one third of one percentage point and raise annual GDP growth by only 0.1 percentage points. These growth accounting estimates are supported by econometric estimates of cross-country aggregate production functions as in Barro (1991) and Dowrick (1992) where real annual rates of return to physical investment are found to be between seven and ten percent. Differences in rates of aggregate investment across countries and across time go some way to explaining differences in GDP growth, but the unaccounted differences are apparently much greater.

There is, however, some recent evidence that the contribution of capital to growth may be severely underestimated by failing to distinguish between different types of investment. Inappropriate aggregation has the effect in regression analysis not only of averaging out the effects of high return investments with low return investments, it also is likely to bias downwards the estimate of the average effect. For example, if investment in A has a five percent return and investment in B has a fifteen percent return, econometric estimation of the return to aggregate investment AB is likely to yield a figure below ten percent.

DeLong and Summers (1991) argue very forcefully that the key to growth is investment in equipment rather than investment in structures and transport. They find evidence that the real rate of return on equipment may be as high as thirty percent. They suggest that much of this return is in the form of external effects on productivity growth in related sectors, citing studies by Jorgenson as supporting evidence. Their academic and institutional pedigrees (both are eminent in US academic circles and Summers is Chief Economist at the World Bank) suggest that their findings should be taken seriously - albeit subjected to further rigorous testing.

One plausible interpretation of the DeLong and Summers results is that equipment investment is the principle channel through which advances in technology are diffused both within a country but also, perhaps more importantly, across countries. This interpretation is strongly supported by the finding in their Table V that amongst the high productivity group of 25 countries the impact of equipment investment is strongest in those countries lagging furthest behind the technological leaders. DeLong and Summers are, however, reluctant to come to such a conclusion because such a relationship does not appear to hold for their larger sample of 63 countries. But that failure to hold across a sample of high and low productivity countries is perfectly consistent with the findings of Dowrick and Gemmell (1991) that technological diffusion does not extend to the poorest economies who lack the physical and human capital infrastructure to exploit new techniques and new products.

There is also evidence that the importance of investment in public infrastructure is down played in conventional measures. Aschauer (1989) presents evidence that public investment in core non-military infrastructure is highly productive. His core of public investment includes streets and highways, airports, electrical and gas facilities, mass transit, water systems and sewers.