Knowledge, Capabilities and Human Capital Formation in Economic Growth

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Knowledge, Capabilities and Human Capital Formation in Economic Growth

Abstract

This monograph, which has been prepared as a Research Report to the New Zealand (NZ) Treasury, undertakes three main tasks: (1) describing the various forms of tangible and intangible human capital, their relationship to "capabilities" affecting human well-being, and the channels through which they may contribute to economic growth; (2) reviewing the major theoretical and empirical findings on the microeconomic determinants, and macroeconomic growth effects of investment in human capital; (3) reviewing salient general implications for policies affecting human capital, and indicating measures specifically germane to the situation of the NZ economy. For these purposes, the concept of human capital is defined comprehensively, so that it embraces capacities for interpreting flows of sensory data and structured information required for goal-directed individual actions and inter-personal transactions, and for providing various physical labour service-inputs in ordinary production processes. More conventionally, it subsumes the creative faculties for generating new scientific and technological knowledge, the cognitive basis of entrepreneurship, and the competences for managing market and non-market production as well as household consumption activities. The report is organised in three main Parts that address the three major objectives, taking each in its turn. A detailed Table of Contents and an Executive Summary precede the text, which is followed by extensive bibliographic references.

A unifying conceptual framework is developed to (a) identify the micro-level processes involved in human capital formation; (b) implicitly aggregate the resulting qualities and capabilities of individuals belonging to successive population cohorts; (c) trace the interrelated influences that the forms of human capital have upon macroeconomic performance. The review of empirical evidence at the macroeconomic level features a discussion of the deficiencies of data and methods in many of the international cross-section studies, and contrasts recent econometric findings on the role of education in economic growth among the developed economies with the conclusions derived through more detailed analyses of their historical experiences. Significant policy implications do emerge from the modern macroeconomic growth literature, but these are very broad in nature and not particularly germane to the situation of small, open economies that may lack a substantial industrial base or the extensive human and institutional infrastructure required to generate the knowledge-base needed for their peoples' well-being and their firms' competitive success in international markets. Nor does the received literature adequately treat the implications of

such economies' potential to rapidly alter their respective human resource endowments through differential population migration.

Consideration of human capital policies geared more closely to the specific challenges and opportunities facing New Zealand's economy leads to the formulation of a number of novel proposals. These would reform tax treatment of education and training investments by residents and immigrants alike; subsidise new voluntary institutions developing on-the-job training programs under industry sponsorship; undertake public information infrastructure investments in order to reduce the costs of effective access to global knowledge bases in science and technology. Proposals also are considered for integrated government programmes to accelerate the closing of persistent socio-economic disparities within NZ society, such as those between Maori and non-Maori.

JEL CLASSIFICATION H24, I28, J24, N30, O15, O38

KEYWORDS human capital, capabilities, knowledge, education, on-the-job training, R&D, productivity, macroeconomic growth theory, investment taxation and subsidiesC67 (input output models), L16 (macroeconomic industrial structure)

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Executive Summary

Objectives, Scope and Organisation of the Report

Three main tasks are undertaken in this report:

1 identifying the various forms of human capital and the channels through which these may contribute to economic growth;

2 reviewing the recent economic literature for the main theoretical and empirical findings it offers regarding the factors affecting formation of human capital, and the latter's effects upon long-run processes of economic development and productivity growth;

3 indicating the salient policy implications concerning human capital that are of general relevance, and calling attention to those that pertain more specifically to the present situation of the New Zealand (NZ) economy.

The findings are presented and discussed in three main Parts, which address each of the foregoing objectives in turn, and each of which contains three major sub-sections. This organisational structure is detailed by the Table of Contents. From the latter it may be seen that the headings in this, the Executive Summary, correspond immediately to the report's nine major sub-sections.

An introductory overview of the report as a whole appears in the text at the beginning of Part I, pointing to the limitations as well as the strengths of the particular economic approach that has been adopted here.

Human Capital and Economic Growth: Concepts, Definitions and Taxonomies

The economist's notion of "human capital" refers to a particular set of *acquired human capabilities*. These generally are taken to be *durable traits*, persisting over some significant portion of the life of the person who acquires them, and *yielding some positive effects* upon the person's performance in one or more among a wide variety of socially valued activities.

The concept of human capital is comprehensively defined, and thus embraces:

a the capacity for interpreting flows of sensory data and structured information required for purposive individual actions and inter-personal transactions among economic agents;

b the capacity for providing a variety of physical labour service-inputs in ordinary production processes;

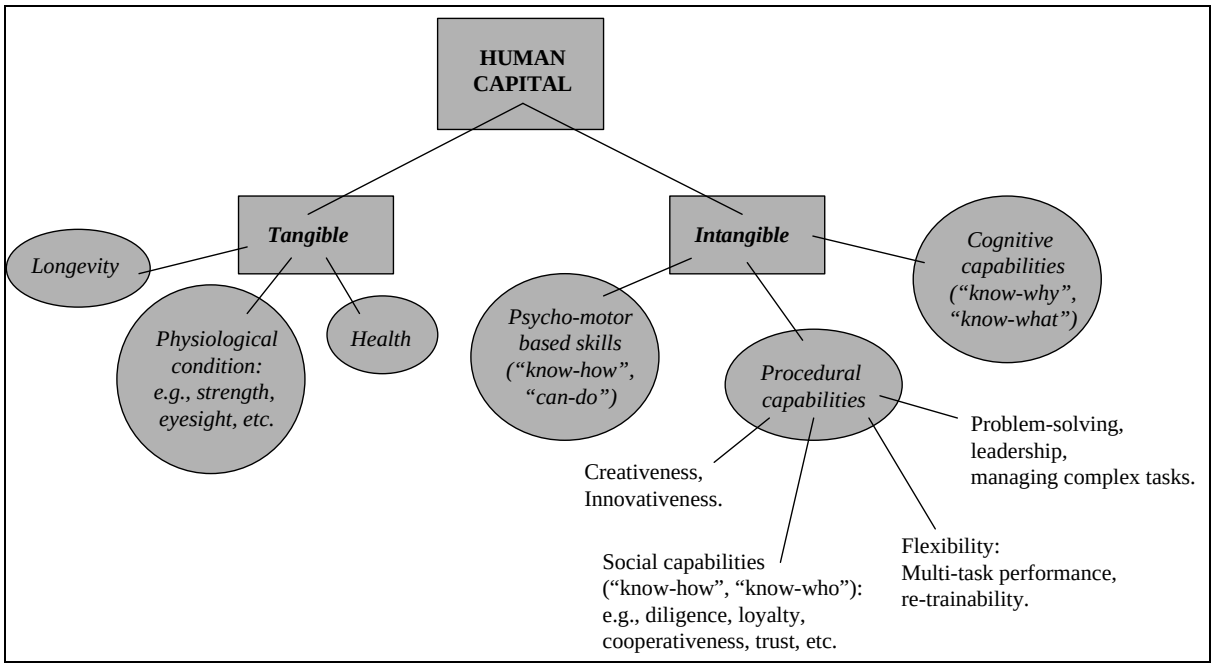
c the cognitive basis of entrepreneurial economic activities;

d the key resource utilised for managing market and non-market production, as well as household consumption activities;

e the creative agency in the generation of new knowledge underlying technological and organisational innovations.

The subject matter's complexity and potential importance should be apparent from the array of distinct and salient roles that "human capital" plays in economic life. The varieties of forms in which human capital may appear are taxonomically organised by Figure 1.

Figure 1: Human capital: A taxonomy



Some human capital traits are classed as *tangible*, because they are directly perceptible in physical characteristics of the individual agent – such as stature, strength, physical endurance; whereas other elements of human capital are *intangible*. Cognitive ability, procedural capabilities, as well as certain psycho-motor based skills usually are taken to be the main categories comprising the individual economic agent's "intangible" (human) capital.

Current usage of the term "human capital" among economists, however, typically refers to those intangible capabilities whose formation or acquisition through study, training and experience is *costly* – either in terms of material resources expended, real income (output of material goods and services) that is foregone, or both.

The quantitative economic importance that human capital thus defined has come to hold in modern advanced societies is suggested by a variety of indicators:

- Estimates of the real stocks of capital in the US (derived by cumulating constant dollar investment expenditures) find that the ratio between the total non-tangible stock and the conventional, tangible stock of capital more than doubled between 1929 and 1990, rising from 0.54 to 1.15.
- At both dates intangible *human* capital (formed by education and training investments) represented about three-fourths of the total non-tangible stock; within the remaining fourth, the stock of R&D capital in 1990 was only half as large as that formed by investments health, safety and human mobility.
- Estimates of the share of gross private business product in the U.S. represented by the imputed real (private) returns on intangible human capital engaged in market production show that it has been roughly constant at 0.25 over the decades since 1929; and almost on a par with the unchanging (0.27) share attributed to the gross returns on tangible business capital.

There is increasing recognition of a wide range of "human capabilities" – only some among which are acquired through formal education – that affect economic agents' performances other than as workers. Consumption activities, including the enjoyment of leisure and recreational pursuits, come under that heading. So does invention, entrepreneurship and related innovative economic behaviours. An understanding of the circumstances that favour successful application of one's own capabilities, and, indeed, self-awareness of the latter, may also be included in the list of economically important human capabilities.

A recent, highly inclusive measure of the capitalised value of the flows of all market and non-market "human" services, is due to Jorgenson and Fraumeni. It places the value of the total stock of tangible and intangible human capital at 10 times the size of the contemporaneous real stock of educational capital.

It is appropriate to draw a distinction between "economic growth", a term now conventionally used to refer to increases in real GDP per capita, and the potentially much broader concept of "economic welfare". The former measure delimits the set of currently available commodities that are counted as satisfying the population's material wants to just those which (typically) pass through market channels.

By contrast, "economic welfare" is a notion that has far greater potential scope. Measures of economic welfare (MEW) impute values to uses of time in non-market pursuits, such as "leisure activities", childcare, and education beyond compulsory levels. But, the growing relative importance of the latter is not correspondingly reflected *directly* in the growth of GDP per capita.

In addition to being seen as an instrumental contributor to the productive resources of society, and therefore discussed under the rubric of "human capital", the "capabilities" of human beings are more direct sources of their satisfactions and sense of well-being.

Many aspects of the human condition are valued ends in themselves, as well as means of achieving material economic abundance. Certain to be included among such "ends" are the following:

- individuals' prospects of health and longevity,
- the ability to comprehend and communicate with others about the events and forces that are affecting one's life,
- access to the cultural and multi-cultural heritages of one's society,
- the capability to express and protect one's own interests through legal and political procedures.

Several further points are required to flesh out the implications of conceptualising human knowledge as a form of capital, and relating it in that way to economic development and growth:

- Knowledge can be viewed as an intangible economic asset, but this kind of capital is even less homogeneous than is the case among tangible capital goods; each and every "bit" of knowledge is truly unique.
- A distinction can be drawn between the kind of knowledge that is manifested in the possessor's specific capacities, or substantive "task competences", and the kind that is reflected in more generically applicable capabilities referred to as "procedural competences".

- Knowledge that underlies "task competence" and "procedural competence" can in many instances be codified and made available as information, but there is also a *tacit dimension* in some types of knowledge that may underlie either task competence or procedural competence. Both forms of competence, whether narrowly task specific or generically procedural, may thus resist being fully codified, but that too reflects the balance between economic benefits and costs.
- "Social capital" is a form of knowledge that is more a *relational* asset than a personal attribute possessed by individual actors. Its properties are akin to those of so-called "public goods", enabling social capital to be concurrently shared and to resist private appropriation. It may be viewed metaphorically as a species of "glue" holding the constituent members of society together, and so permitting them to function more productively in the economic sphere. Social capital must be constructed jointly through direct human interaction, whereas such is not necessarily the case for other forms of human capital.

A Heuristic Framework: Integrating the Micro- and Macroeconomic Perspectives

The unifying framework adopted in this report (a) identifies the micro-level processes involved in "tangible" and "intangible" human capital formation, respectively; (b) implicitly aggregates the resulting qualities and capabilities of individuals belonging to successive population cohorts; (c) traces the interrelated influences that the forms of human capital have upon macroeconomic performance.

"Qualitative" aspects of *tangible human capital* affect the level of potential labour service inputs per capita, and in that way they directly affect an economy's potential level of output per head of population, given the level of potential (full employment) output per unit of labour service input. Underlying compositional shifts, due to demographic-economic interactions affecting the age distribution of the population, may result in changes at the aggregate level.

Substantial changes also occur in the tangible components of average "labour quality", due to forces affecting the physical characteristics of members of the workforce (e.g. nutritional status, stature, strength, susceptibility to illness and disability, etc.). Although these characteristics are governed proximately by physiological processes, the latter are sensitive to environmental conditions and will be affected to a significant degree by past and current expenditures of material resources, as well as by the state of knowledge about how physical well-being can be protected and enhanced.

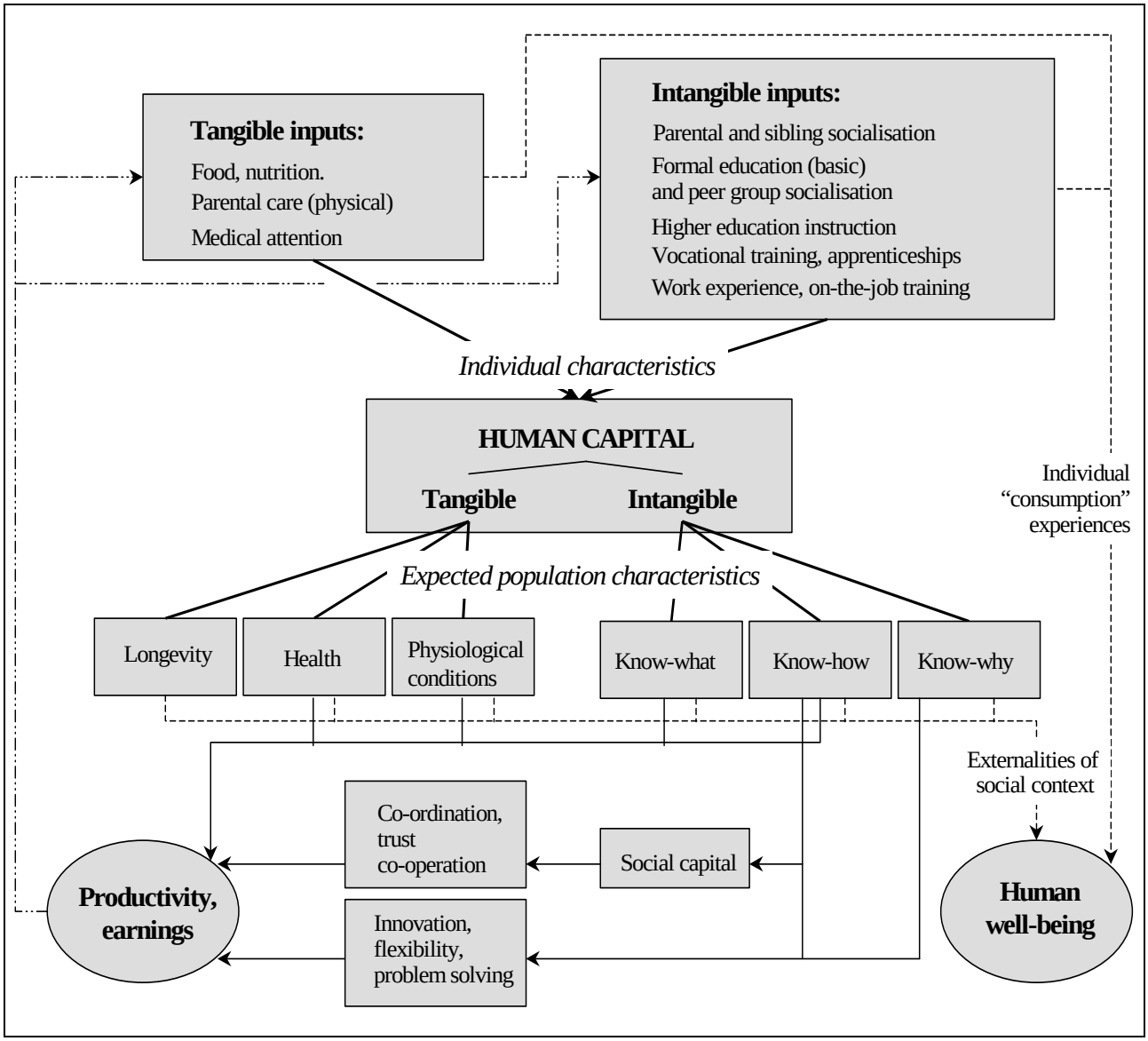
Technological and other developments affecting the codification of knowledge of different kinds shape both the formation of intangible human capital, and the latter's relevance (and value) in economic activities. The codifiability of knowledge carries implications for the institutionalisation of educational processes, and the costs of communicating knowledge among individual economic agents and production organisations of all sorts. It therefore impinges upon the costs of transferring knowledge, and upon the access that agents have to economically useful information.

These microeconomic and macroeconomic perspectives on the relationships between human capital and economic growth may be integrated within a single schematic view, or heuristic framework. Figure 2 (below) depicts these in a simplified form. This schematic has a dual "heuristic" value: First, it indicates the connections between the micro-level determinants, and the macroeconomic effects of the various dimensions of human capital formation. Second, it highlights *the positive feed-back loops* in the dynamic system that connects the micro-level and macro-level outcomes. The latter create the potential for a

self-reinforcing process of growth based upon sustained increases in productivity. But, self-reinforcing dynamics may result in vicious downward spirals, as well as in virtuous upward spirals.

When human capital formation is viewed either at the micro- or the macroeconomic level, it becomes evident that there are structural and institutional features peculiar to the markets for information goods, and for the labour services of free workers, which cause those markets not to function well in terms of allocative efficiency, and to perform less well than the markets for ordinary economic goods.

Figure 2. Human capital formation and growth: Micro- to Macro-level Feedbacks



Various specific micro-level conditions that lead to "market failures" affecting human capital formation, both tangible and intangible in decentralised system of resource allocation, can be identified under the following distinct headings:

- verification problems;
- monitoring problems;
- asymmetric information and agency problems;

- a variety of technical complementarities, which result in “spill-overs” of costs and/or benefits among agents;
- interdependencies among the preferences of decision-agents, which give rise to un-priced welfare effects of individual allocation decisions.

There are really only two broad classes of reasons for the appearance of gaps between private and social marginal rates of return on human capital investments. (1) The existence of non-pecuniary “externalities”, and the interdependence of individuals’ preferences over outcomes, result in some significant portions of the benefits and/or the costs of particular investments failing to accrue to the agents responsible for undertaking those projects; (2) there are persisting “market imperfections” (including incomplete and missing markets) that prevent relative prices from properly signalling relative private marginal costs and private marginal productivities.

Such conditions are likely to result in *persisting* differentials between the social and the private rates of return on investments in human capital. There is thus no automatic mechanism guaranteeing that the dynamic allocation of human resources in a competitive market economy will be socially optimal.

In addition to adversely affecting the society’s overall levels of human capital, the peculiar susceptibility to such “market failures” implies that the *composition* of the resulting human capital stock is also likely to be sub-optimal; in some instances the social rate of return on a given form of human capital investment may fall considerably below the private rate, even though the opposite state of affairs is more typical.

The Microeconomics of Human Capital Formation

Considering the choices that individual agents face over their life-cycle provides a useful framework for reviewing the microeconomic literature about human capital formation. The critical life-cycle decisions are: primary and secondary education, higher education and/or vocational training, on-the-job training, mid-career training and retraining, and retirement.

Due to the complementarities that exist among those forms of investment, and the sequential nature of these choice-points, economic circumstances prevailing at the early stages of a person’s life continue (indirectly) to exercise leverage over the investment decisions that will be made at much later stages in the life-cycle.

Decisions about *primary and secondary schooling* rarely are left to the children, and consequently it is necessary to consider the influences impinging on the choices made by parents and other agents in the educational process. Parental education and income are important determinants of the physical, cognitive and social skills with which the children are endowed.

Parents’ choices are, however, limited by:

- their information about the options available and the consequences of these;
- the control they can exert over the children’s input into the educational process;
- governmental regulations; and,
- other influences on early education that are outside the sphere of the family background, such as the ethnic environment or religion.

The stage of *higher education and/or vocational training* is closest to the main microeconomic perspective established in human capital theory: educational choices will

involve inter-temporal trade-offs between the consequences of finding a job in the labour market now, or investing time and money in additional schooling, in the expectation of gaining higher income opportunities later on.

Under a decentralised competitive market regime, several different sources of "market failure" will constrain and distort individuals' choices with regard to investing in human capital:

- capital market imperfections limit the ability to finance many kinds of human capital;
- the economic benefits from education or training may not be fully appropriable by the agent involved in making the decision or bearing significant parts of the costs;
- the long gestation periods involved mean that decisions will be taken under conditions of fundamental uncertainty rather than calculable risk;
- where human abilities are not readily observable *ex ante*, hiring and related decisions by employers are made on the basis of observable but inaccurate "indicators", including educational "credentials" that thereby may acquire private "signalling" value.

On-the-job training (combining production, learning-by-doing, and mentoring by co-workers) is important for two distinct reasons:

- It is a prime source of specific skills that cannot normally be obtained through formal education or vocational training courses, but firms may have little incentive to pay for the training because: (a) workers cannot be legally constrained from quitting, and (b) there may be conflicts between the worker and the firm about the type of training desired. If workers do not have the resources to invest in training, and there are borrowing constraints, the result is under-provision of specific skills.
- Since a large part of what people know is "tacit", acquired experimentally, and transferred by demonstration, there is a need for workers and firms to use on-the-job training as a mechanism of knowledge transfer in which the knowledge holders actively participate.
- Specificity of certain skills has consequences beyond the under-supply of training: it can also constrain the financing that is made available to entrepreneurs.

The formation of work-based skills that are job-specific but not strictly firm-specific is a potentially important source of labour market externalities, the existence of which has a direct bearing on public policy design. To be able to establish empirically whether or not job-specific human capital accumulation (through learning by doing and formal on-the-job training) was an important feature in particular occupations and industrial sectors, obviously, would be useful. Unfortunately, despite much sophisticated econometric effort to identify various, distinct forms of experience-based "learning" from available panel data, empirically grounded general conclusions about the creation and value of transferable skills formed through OJT have proved frustratingly elusive.

That workers must finance training is not *per se* a market failure, but under-provision of skills can arise when workers do not have the resources to invest in training and there are borrowing constraints. There are serious issues of adverse selection and moral hazard that accentuate the credit constraints upon workers in the absence of third-party loan guarantees, and, indeed, in the absence of state backed lending for such purposes.

In an environment of technological change some skills become obsolete, which raises the matter of *midlife training and retraining*. A problem with retraining is that older workers have less time to recoup the investment in the form of enhanced productivity; as a

consequence, workers above a certain age will not have adequate incentives to learn new skills, nor will firms wish to finance the training they require.

The anticipation of rapid changes in industrial practices and technologies encourages: (a) workers to seek early education and training that allow them to be more flexible, and (b) firms to adopt new industrial practices that can be grouped under the heading of "just-in-time learning". Where technological change is both rapid and disruptive, the induced demand for *broader* general training among the young may conflict with governmental educational policies, especially because the latter often respond to pressures from employers calling for workers with *highly specific* new skills.

The systemic vision of the sequence of educational choices points to the importance of corrective government intervention in early stages of the life-cycle. Because schooling is a foundation for successfully undertaking later investments in education and training, including various kinds of on-the-job training, failures affecting the formation of "educational capital" at the lower, primary and secondary stages will raise the costs or reduce the effectiveness of providing university education.

Human capital's role in *retirement* generally is neglected by the microeconomics literature. Yet, people's intangible capital needs do change when they enter retirement. In view of the demographic trends towards ageing of the population and the growing relative importance of the time and resources that retired individuals are allocating in pursuits other than market work, "education for recreation and retirement" is a subject that would seem to merit more serious attention.

Human Capital and the Macroeconomics of Growth: Theoretical Investigations

The neoclassical theory of growth developed by Solow and Swan centred macroeconomists' attention throughout the 1960's and 1970's on tangible (physical) capital formation as the driver of economic growth. However, the theory showed that, because of decreasing marginal returns in substituting physical capital for labour, the accumulation of capital would not indefinitely support a steady rate of growth in labour productivity.

From this perspective it became clear that technological change, not capital formation, held the key to sustained growth in average labour productivity. Growth accounting studies of the U.S. and other advanced nations in the 20th century confirmed that total factor productivity (generally attributed to technological progress), and not the rate of accumulation of tangible capital per unit of labour (i.e., "capital-intensity") was the proximate source of rising labour productivity.

The recent literature on "endogenous economic growth" emerged primarily as an attempt to encompass the sources of technological progress and hence of sustained productivity growth *within* the general equilibrium framework of neoclassical growth theory. This literature has evolved to provide several distinct explanations of the process of economic growth, each of which carried particular empirical and policy implications:

- Romer's so-called "AK model" generates sustained growth by assuming that technological change is the unintended result of specialising firms' investments. Creation of capacity to produce more and more specialised intermediate products is assumed to work like Adam Smith's division of labour principle, but at the aggregate level.

- The resulting externalities yield increasing returns to cumulative investment, and thus the production of goods can avoid the decreasing returns to rising capital-intensity that the neoclassical model posited.
- These externalities imply that the competitive equilibrium growth path does not coincide with that which could be achieved in an optimally planned economy.

The latter conclusion was reached by virtually all the theoretical analyses based upon successive formulations that belong to the family of "endogenous growth models". It carries the implication that growth performance might be improved by public policy action.

Subsequent endogenous growth models have fleshed out the process of technological change through the *explicit* introduction of human capital and/or knowledge:

- Lucas (1988) considers human capital to be another input in the production function, not fundamentally different from physical capital, but only formed by workers through certain activities (principally education or on-the-job training). By assuming constant returns to human capital formation – on the argument that workers' knowledge "spills over" – the model can achieve a positive steady-state rate of growth rate in labour productivity.
- A second line of analysis shifts attention away from treating human capital as a direct input to the production of goods; instead, it focuses upon modelling other important activities pursued by skilled labour, especially innovation. Technological change resulting from R&D investment that creates a greater variety of goods, or improves the quality of existing is the main form of innovation recognised by the endogenous growth literature following Romer (1986, 1990).

This latter line of analysis brought out the significant point that when human capital is modelled as a factor affecting innovation, the long-run rate of productivity growth is positively affected by the human capital stock's level; whereas, in the Lucas (1988) model, the rate at which human capital is being accumulated, relative to the existing stock, was seen as the critical determinant of productivity growth.

More recent theoretical contributions (e.g. by Acemoglu 1996, 1998) direct attention to the existence of complementarities and reciprocal feedbacks in the dynamic interaction between technological change, conventional tangible investment, and the formation of productive capabilities embodied in members of the workforce. This highlights the importance of the formation of co-ordinated expectations that would support a "balanced" portfolio of tangible and intangible capital formation projects yielding high productivity growth outcomes, rather than leaving the economy on a low productivity growth path.

A final point concerns the debate about convergence of countries to common levels of per capita GDP. The basic neoclassical model held that economies with similar structural conditions would converge to a common level of output per capita. Most endogenous growth models hold out no prospect of automatic convergence: if a country starts at a lower capital and output per capita, it will not grow at a faster pace than a richer country, and differences will persist over time.

This non-convergence result, however, is sensitive to the supposition of the analysis that the economy is strictly closed, i.e., that in addition to there being no factor-equalising international commodity trade, there is (a) no inter-country "spill-over" in the methods of producing human capital and (b) no migration of workers. Both of these assumptions can be readily challenged; when the models explicitly allow for international diffusion of innovations, they tend to predict catch-up by poor countries in the long run.

Empirical Findings on Human Capital and Macroeconomic Growth

In the early 1990's pioneering econometric studies (based on international panel data for a widely diverse array of countries during the post-1960 era) provided empirical support for the conclusion that human capital formation was among the factors that significantly affected the aggregate level rate of economic growth.

- They found that success in the process of catching up internationally in terms of per capita GDP (measured in purchasing power parity equivalents) was positively related to the overall social rate of human capital formation.
- Furthermore, the poor countries that were tending to catch up with the higher income economies were restricted to those that were maintaining levels of investment in formal education which were high in relation to their respective GDP levels.

More recent econometric studies have yielded three robust empirical findings:

- There is only weak empirical support for the hypothesis that changes in the human capital stock affect growth rates.
- There is strong statistical support for the hypothesis that the relative level of the stock of human capital (in relation to the labour force or aggregate output) has a positive effect on growth rates.
- The magnitude of the "level effect" of the human capital stock is itself far from uniform across the distribution of economies; the impact on growth rates does not vary linearly with the relative size of the stock but, instead, becomes proportionately smaller among the economies where the average educational attainment is already high.

The broad interpretation of these findings in the context of recent growth models is that raising the general level of educational attainment interacts positively with other forces -- among them the accumulation of complementary physical capital and the application of new technologies. Higher human capital intensity thus permits countries to accelerate their productivity growth rate and narrow the relative size of the per capita real income gaps separating them from the leading economies.

But, in the near term, at least, the potentials for such convergence are not unqualified. They appear to be bounded by conditions that limit economic integration through trade and capital movements, as well as by cultural and institutional dissimilarities – including differences in political and legal institutions. Such heterogeneities are suspected of impeding easy and effective international transfers of technological and commercial capabilities.

Cross-country economic convergence, in the form of the relative dispersion of productivity and per capita real income levels, has occurred within "clusters" of countries, both historically and in more recent times. The operation of "convergence clubs" had particularly pronounced effects in narrowing the dispersion within the upper income tier of the OECD countries during the third quarter of the 20th century; indeed, this pulled up members from the lower tail so rapidly that some among the former leaders were displaced from their positions in the upper tail (e.g., the NZ economy among them).

The rough rank ordering of national economies by levels of GDP per capita and average labour productivity exhibits considerable inertia over the span of decades. Maintaining a high average level of educational attainments, and correspondingly high rates of investment in other forms of human capital (e.g. health, internal spatial and occupational

mobility), would appear to serve as a *stabilising* force – although not a guarantee – against continuing secular decline in a country's relative per capita income position.

Most of the theoretical literature on economic growth focuses on the role that investment in formal education plays in modern economies. In a broad sense that emphasis is justified by the empirical evidence pertaining to aggregate economic growth performance in recent decades. Notice should be taken, however, of the disparities that do emerge among studies that undertake quantitative assessment of the impacts of human capital formation, by means of econometric and growth accounting studies which are based upon international cross-section data. Several recent studies based upon measures of schooling years per person of working age for the OECD and G-7 economies have obtained results that appear to cast doubt upon the impact of human capital formation upon labour productivity. Closer examination of this work reveals that some of their surprising findings result from inadequacies of the proxy variables that have been employed in lieu of proper measures of the stock of human capital.

Considerable caution therefore is warranted before framing concrete policy recommendations simply on the basis of the findings from international cross-section studies exercises of this kind, if only because of the many subtle international differences in the workings of educational institutions that appear outwardly to resemble one another. By considering the historical growth records of some among the presently advanced economies (even those extending back into the epoch of their proto-industrial development), however, economic historians have obtained a more informative picture of human capital's changing role in long-term growth.

A noteworthy, and perhaps surprising conclusion from historical studies of Europe and the U.S. is that intangible human capital formation contributed comparatively little if anything to labour productivity growth before the latter part of the 19th century. This shows that the strong correlations between human capital and growth found by some modern cross-section and panel-data studies are a phenomenon particular to comparatively modern experience, not a regularity about the process of economic growth that can be expected to hold in any place and period.

Historical studies (by Abramovitz and David, 1973, 1996, 2000) suggest reasons for the rising role played by intangible human capital formation. These reasons are found in the contrasting characteristics of the U.S. economy's growth path over the course of the 19th and 20th centuries:

- In the 19th century increasing labour productivity can be attributed to a high and rising capital intensity (measured by the tangible capital per man-hour worked), a trend that was reinforced by the prevailing tangible capital-using bias of technological progress in the 19th century.
- The main source of labour productivity and real output per capita growth in the 20th century was rising total factor productivity. A crucial aspect of U.S. growth experience in that epoch was the changing bias of technological innovation away from tangible capital-deepening, and the emergence from 1929 onwards of a strong bias towards intangible (human) capital-deepening.
- Biased technological progress has been the long-term force underlying a demand-induced reallocation of savings and the consequent secular relative rise of intangible human capital (vis-à-vis both tangible capital, and real output) during the 20th century.
- The facilitating evolution of both public and privately funded educational institutions, and company financed programmes of on-the-job training, can be seen as having

been *induced* directly and indirectly by changes on the demand side of the labour market.

The foregoing conclusions from the historical experience of economic growth contrast sharply with the assumptions made by growth theory. Neoclassical growth models and the pioneering contributions to the literature on endogenous growth (e.g. Romer 1986, 1990) specify that technological change always is "neutral"; they therefore fail to view "biased" technological innovation as a major force creating pressures for readjustments in the relative supply of skills and other human capabilities.

In reality, however, such pressures exist; in the absence of adequate supply-side responses, they are likely to manifest themselves in rapidly widening pay differentials or increased rates of occupational obsolescence and structural unemployment. A far more desirable outcome, of course, would be the co-ordinated, anticipatory provision of the human capital investments that are required in order to translate new technological opportunities into rising productivity and higher levels of material well-being.

Implications for Public Policies Affecting Human Capital Formation

Generic policy implications, from microeconomics analysis and growth theory:

Microeconomic studies conclude that numerous structural conditions – especially those peculiar to economic transactions involving knowledge, and the services of free persons -- are likely to drive persisting wedges between the private and social rates of return to investing in human capital. These "wedges" signal the existence of mal-allocation, and carry the implication that some corrective public intervention may be warranted.

This is likely to be the case in either of two broad sets of circumstances:

- where technological complementarities give rise to non-pecuniary "externalities", and/or the interdependence of individuals' preferences over outcomes results in some significant portions of the benefits and/or the costs of particular investments failing to accrue to the agents responsible for undertaking those projects;
- where there are persisting "market imperfections" (including incomplete and missing markets) that prevent relative prices from properly signalling relative private marginal costs and private marginal productivities.

However, a strict economic justification for governmental (or charitable institution) interventions directed to raising human capital investment in particular categories is more demanding than the identification of such situations. Public subsidies are called for only where the respective marginal social rates of return on such investments – whether directed to human capital investment among particular population groups, or for specific categories of training – exceed both the corresponding private marginal rates, and the marginal social opportunity cost of the public tax revenues that would be absorbed by the indicated subsidy programmes. Application of this test, as a practical matter, is not so easy.

Nevertheless, the supposition is widely shared among economists that market economies exhibit overall systemic tendencies toward under-investment in human capital, due to the incomplete private appropriation of their contribution to the (external) benefits of having a labour force (and a polity) that is more highly educated and possesses a greater degree and variety of skill. This does not preclude the possibility that in some situations the behaviours of individual when left to themselves will result in a level of educational investment that turns out to be sub-optimal from their own, private standpoint, as well as

from a societal perspective. Such is too frequently the situation of young labour market entrants, whose work habits and educational preparation reflect the limitations of previous interests and judgements on their parents' part.

The condition of overall under-investment also is quite compatible with there being socially *excessive* expenditures of private and public resources for formal schooling, i.e., levels of investment that drive the social marginal rate of return below the marginal private rate. Such a situation sometimes is alleged to be the case in regard to university-level educational credentials that are sought (whether by students or their parents) primarily as "signals of quality" for prospective employers. The source of the putative inefficiency lies in the absence of some alternative institutional mechanism that would perform the socially productive, signal-supplying function of educational credentials – with equal credibility but at lower unit cost.

A systems analysis of the sequence of educational choices points to the importance of targeting policy measures to address tendencies to under-investment during the earlier stages of the life-cycle. Schooling provides intangible capital that is a foundation of the capabilities for successfully undertaking later investments in education and training, including various kinds of on-the-job training. Market failures, or public institutional failures, that result in under-provision of "educational capital" at the primary level, therefore will raise the costs or reduce the effectiveness of subsequent investments in secondary schooling, tertiary vocational and university education, and in on-the-job training.

Corrective interventions by government therefore must be formulated on a case-specific basis, once the nature and seriousness of the existing misallocation has been established. Most corrective policy actions, however, will impose some social costs of their own. These also must be taken into account in judging whether they should be recommended as "second best" solutions, or only as the "n-th best" means of addressing the identified sources of "market failure".

On the question of the means whereby governments may intervene to alter the allocation of private investment in human capital, the literature on the economics of public finance in market regimes points almost exclusively to subsidies and taxes as the instruments of choice for effecting such corrections. A review of the generic implications of applying optimal tax and subsidy principles to the treatment of investments in intangible forms of human capital, however, suggests that existing regimes of taxation tend to be biased in varying degrees against investment in intangible human capital. Thus it is possible to arrive at some general principles for reforms aimed at correcting "government fiscal failures", and these deserve priority of consideration over proposals to introduce specific tax or subsidy measures that would, in any case, need to be tailored to suit the relevant institutional and legal context.

Perhaps the major insight for economic policy design that emerges from the literature on macroeconomic growth models is that in an economy of any reasonable degree of complexity, especially in one where there is decentralised decision-making and competition in many sectors, crucial positive "spill-over effects" are created by technical complementarities and pecuniary externalities of exchange transactions. For these to be coordinated at the microeconomic level in a manner that reinforces growth, it is important that they become mutually aligned through widely shared expectations regarding the positive externalities that will result from investments in a variety of durable productive assets. Such expectational coordination is crucial where the payoff from "investment projects" depends on successfully matching the characteristics of newly developing

technologies, and physical capital that embodies them, with the capabilities of the available labour force, and the projects themselves have long gestation periods.

By working in partnership with the private sector, public agencies may therefore promote growth by facilitating better dynamic co-ordination. This involves increasing the flow of reliable information to shape mutually reinforcing expectations that, in turn will affect private investment decisions. Of course, because financing the necessary human capital components cannot effectively be left to either the household or the business sectors, anticipations of governmental action in the latter sphere assumes critical significance. In this context, what is required to shape expectations is the timely publicising of the state's credible commitments to undertake long-term programmes providing subsidies and/or tax credits for basic education and training investments, as well as assistance with the financing of continuing education and re-training.

From a narrow resource allocation viewpoint, it is obviously important that subsidies in this area should have a two-part structure: in addition to promoting general education in the population, they should aim to elicit further human capital formation that is aligned specifically with indicated broad trajectories of technological development, business reorganisation, and structural reorientation related to international trade specialisation. The latter, of course, ought to be identified on the grounds of being those holding the greatest promise for the economy's future.

The situation of the New Zealand economy, however, presents something of an anomaly in the context of modern generalisations about economic development and macroeconomic growth, and the roles played by human capital therein. Certainly there is little in the macroeconomic growth theory literature that has an immediate bearing upon the circumstances of a small, open economy. Implicitly most growth model assume that the economy is large and diversified, possessing an industrial base and abundant natural resources, as well as being about to support the fixed costs of an extensive human and institutional infrastructure that enables it to be largely self-sufficient in the R&D and human capital formation activities. All of the influential macroeconomic growth models describe the technological situation of a "global" economy, one that is closed even in regard to knowledge flows, and so must invest in R&D activities in order to generate a basis for continuing innovation.

Yet, such is not the situation in which New Zealand – along with many another high income country –finds itself. A number of implications for the design of policies relating to human capital formation (*inter alia*) can be seen to flow directly from that particular disjunction.

Policy Proposals Geared to New Zealand's Special Economic Circumstances:

Although having experienced retarded productivity growth in the past two decades, New Zealand remains a high-income country with a fully developed array of research, education and training institutions. Its overall capacity for expanding the provision of educational services at the tertiary level is not a constraint. Putting aside measures that may be required to correct the supply of specialised training, which in any case might be accomplished by subsidised training overseas, public policies directed to raising the average level of human capital in the population can be focused in the first instance upon the demand side.

Reforming the tax treatment of households' human capital investments

Here changes in existing fiscal measures (taxes and subsidies) are the appropriate instruments with which to start. Considerations of the basic issues involved in determining the proper tax-subsidy treatment of human capital investments can usefully be limited to just those concerned with the degree to which private investment incentives may be distorted (to the detriment of individual well-being) in ways that can be remedied by direct subsidies, or corrected by alterations in the tax regime.

It should be noticed that changing the after-tax rates of return on different categories of assets will generally be easier for the fiscal authorities in an economy that is open to international flows of capital and labour, as well as to trade in goods and services. This is the case because the levels of domestic wages and interest rates tends to be pegged to those in the international economy. Alterations in the relative quantities of different assets (i.e., human intangible capital vis-à-vis tangible inanimate capital), therefore, will not tend to offset the first-order effects of tax rate changes on the structure of after-tax rates of return. This increases the potential potency of the fiscal measures as a policy instrument in New Zealand's circumstances.

Several modifications of the income-tax system could serve to augment New Zealand's human intangible capital resources, without requiring the potentially more disruptive and administratively more costly replacement of income taxation with a consumption tax regime. Application of optimal and second-best tax principles suggests that the principal goal of a partial fiscal reform should be the elimination of the differential tax treatment of human capital investments *vis-à-vis* other forms of investment by households. A secondary, reinforcing objective is to mitigate the disincentive effects of progressive taxation of the interest component of the wage-income streams deriving from private investments in intangible human capital.

The first of these objectives would be met by making all certified *direct* costs of education and training fully deductible from taxable wage income; whereas, the second objective can be reached (without altering the progressivity of existing tax schedules), by the device of shifting to a later point in the life-cycle the date at which such deductions from taxable income can be exercised by private individuals on whose behalf the direct educational expenditures were made.

A new scheme of personal income tax reform that would accomplish both purposes (proposed by David 2001) seems well suited to countries with New Zealand's characteristics. Its essential features are these:

- allow full deductibility for education and training outlays, while restricting the ability of the student/trainee and the household that bore those costs to exercise their deduction claim until some stipulated time period had passed;
- record the nominal value of the educational investment in the current income tax return filed by the student/trainee, and credit the corresponding deduction to a non-transferrable government guaranteed account established in that person's name (identified by a taxpayer number);
- when the initial period of inaccessibility had passed, the account would be available to be liquidated in its entirely, at date chosen by the named holder, and exchanged for a consecutive annual deductions from taxable income over a following span of years;
- for as long as it remained unbroached, the surrender value of this account would grow at the nominal rate of interest on government debt, or alternatively, a fixed real rate of

interest could be stipulated and credits entered in the account could be indexed to the domestic consumer price index.

The novel asset thereby created is an **u**ntaxed, **i**nterest-bearing **e**ducational (expense) **d**eduction account – the UIBEDA (or, phonetically, "we-bedda"). Under quite plausible assumptions about the time distribution of education-associated earnings differentials, and the progressivity of the schedule of tax rates, it would be feasible for the NZ Treasury to use such a scheme to act as a financial intermediary in the market for human capital investments in a way that satisfied an intertemporal balanced budget constraint.

It would be possible for the Treasury to recoup more than enough in extra tax revenues (deriving from the induced additional human capital investments by the resident working population) to make up for the taxes sacrificed by allowing those individuals to exercise their deduction claims. This result can be shown with plausible parameters for the scheme, under which individual account holders would have a strong incentive to defer surrendering their UIBEDA until they reached a point in their life cycle when their earnings were high and they faced correspondingly higher marginal tax rates. The extra tax revenues would then become available for other subsidies.

Further extensions of the proposed reform would apply it also to allow deductibility of the interest costs of government guaranteed loans and scheduled allowances of foregone earnings during periods devoted to education and/or enrolment in certified programmes of on-the-job training. Having such a scheme in place could be beneficial in assisting a shift from universal direct provision of educational services by the state to a mixed programme of student loans and means-tested support for students from low-income households.

The coupling of educational indebtedness arising from such loans with possession of an UIBEDA, might also reduce the resistance among lower income families to having their children borrow from commercial lenders for human capital formation purposes, under the terms of a government guaranteed loan scheme. The effect of the switch in financing would be to release public funds from use for tuition and student maintenance grants in support of general education at the tertiary level, making it available for more selective forms of educational subsidies.

Tax credits and subsidies for cooperative business investments in job-specific training

Providing subsidies for human capital investments that are undertaken jointly by employers and workers does offer the benefit of more immediately realised productivity impacts, compared to the longer term effects of lifting the general quality of the workforce through schooling investments directed to the young. At the same time, OJT investments are less amenable to standardised modes of training, far more heterogeneous in the content of what is to be learned, and less amenable to external monitoring. It is in the interest of employers, as a rule, to make such investments in the most effective form possible if they internalise the benefits – whether they are spending their own money or funds provided by public agencies. Thus there is a case for avoiding government micro-managing, or even certification of the forms of training that will be subsidised.

Nevertheless, survey data as well as casual observation indicates the existence of wide and unjustified inter-firm and inter-establishment variations in training practices. This suggest that there is significant under-investment in information about best practice training methods, and that private incentives to share knowledge about the details of successful training methods remain inadequate. Hence, proactive provisions for information exchanges ought to be made a condition of receipt of public subsidies.

One way in which this latter objective could be realised is by allowing employers to form cooperative training associations whose activities would receive matching public funding according to a pre-determined formula. In effect, such organisations would be "clubs" engaged in the voluntary production of a public good, namely the augmented supply of workers suitably trained for their branch of industry. Because their efforts yielded public goods whose benefits could be shared by "non-club" firms (and their workers), direct subsidisation of private investments through tax credits for *incremental* training expenditures, would be appropriate.

Firms' contributions to these organisations' outlays should be treated as fully expensed, in keeping with general principles of taxing consumption rather than investments. Furthermore, the work of the training association could be reinforced by automatically allowing full deductibility of the foregone earnings costs incurred by the trainees enrolled in these "approved" training institutions. That, of course, would be more immediately feasible were the scheme to be implemented in conjunction with a tax incentive along the lines of the proposed UIBEDA scheme.

Romer's (1993) advocacy of "self-organised industry investment boards" that would sponsor both R&D and specialised training programmes, is similar to the foregoing proposal in spirit. A problematic feature common to both proposals, however, is the need for close monitoring by competition authorities of the internal decision procedures and the actual investments undertaken by these organisation. Lacking such oversight provisions, it would be quite possible for these associations to become vehicles for employers' cartels.

Selective migration policies for increasing the national human capital endowment

The NZ economy's small size in relation to the flows of qualified workers that could be imported from abroad within comparatively short intervals carries an analogous and equally important policy implication. Measures to induce immigration by people that bring special knowledge and skills acquired elsewhere are likely to be more effective than domestic human capital formation in *quickly* shifting this kind of economy between growth paths.

Creating special incentives for selective immigration may be a rather complicated problem in policy design, as there are many different instruments to be considered. Furthermore, the recruitment of highly educated foreign workers and their substitution for those domestically trained may have the perverse effect of weakening the latter group's incentives to invest in acquiring further qualifications for employment in the same areas of occupational specialisation. Nevertheless, there are some special dynamic conditions under which policies to enhance both foreign and domestic sources of labour supply can be complementary, one serving for the short run and the other for the longer run.

The provisions of the UIBEDA scheme also lend themselves quite naturally to its use as an instrument for encouraging selective immigration of workers who have received advanced education and training investments in other parts of the world. The mechanism of selection available to the government in this case is the determination of the list of eligible institutions, and the date of receipt of specified degrees and competence certifications that will be accepted as qualifying them to set up a UIBEDA account when they first enter employment in New Zealand.

As a practical matter it would be necessary to require submission of evidence to establish the direct expenditures incurred overseas in connection with obtaining those (approved) educational credentials. An alternative administratively more straightforward arrangement would permit immigrants to apply to re-finance education and training debts that they had

accumulated prior to their arrival, and to submit evidence of the repayment of these new, domestically financed debts in order to obtain deduction credits in the UIBEDA scheme. In any event, mainly for reasons of administrative convenience, but also to limit the potential for abuse of such provisions, no deduction credits whatsoever would be awarded for immigrants' previous indirect educational investments in the form of foregone earnings.

Targeting human capital formation policies against persisting socio-economic disparities

New Zealand's long history of near universal mass education starting at the primary level in the mid-19th century, and then moving rapidly on to secondary schooling in the first quarter of the 20th century, formed a base for the subsequent high average level of educational attainment in the majority of the population. Over the long run the socio-economic, health and educational status of the indigenous, Maori population has improved, both in absolute terms and relative to that of non-Maori. Nevertheless, recent data document the persistence of substantial disparities between indicators of material well-being for these two population groups, disparities that also appear in measures of educational attainment and professional qualifications.

Dynamic models containing multiple equilibria in human capital formation rates (e.g., Redding, 1996, and Acemoglu, 1996) suggest how an easily identified ethnic or racial segment of the population could become disadvantaged, even in the absence of over ethnic and racial discrimination in the labour market. The existence of strong positive feedbacks that reinforce a culture of poverty, creating vicious cycles that run from lower rates of secondary school completion and poor levels of health care to compromised employment experience, to reduced expected benefits from additional training investments, and weak family and peer-group support for individual efforts to seize opportunities that are likely to yield upward mobility.

To the degree that such a cycle can be said to characterise the situation of New Zealand Maori and Pacific Islanders, it is unlikely that the existing pattern of socio-economic disparities will disappear "naturally", or that piece-meal governmental interventions will be able to replace those vicious circles with virtuous spirals leading a large proportion of those disadvantaged populations out of relative poverty.

One may contemplate an integrated programme of support designed to substantially raise average levels of human capital (the tangible as well as the intangible components) throughout these relatively disadvantaged minority groups. But, its resource costs and coordination requirements imply that such an approach would represent a major political as well as an economic commitment. Expanding the coverage of such an approach, so that it addressed the needs of economically and educationally disadvantaged families and youths throughout the NZ population, might raise its political attractiveness on grounds of equity alone. Nevertheless, the added administrative complexities of determining eligibilities for such targeted subsidies, and the potential drawbacks of establishing general programmes of entitlements to resource transfers, should not be underestimated.

Part I: Objectives, Concepts and the General Framework

I.1 Overview of the Report: Purposes, Scope, Organisation and Approach

This report undertakes the following three main tasks:

1 identifying the principal channels through which human capital affects economic activity and so may contribute to economic growth;

2 reviewing the present state of the theoretical and empirical understanding relevant to the formation of human capital, and its linkages with long-run processes of economic development and productivity growth;

3 indicating salient policy implications in regard to human capital that are generic in their applicability, and some that are more specifically relevant to the situation of the New Zealand (NZ) economy.

The three-fold purpose is directly mirrored in the report's three-part organisational structure. Part I develops a general "heuristic framework" within which the complex subject of the role of human capital in economic growth can be grasped by non-specialists, and the interrelationships among its various aspects may be discussed intelligibly. This requires some preliminary attention (in section I.2) to terminology in order to clarify the scope and meaning of the concepts "human capital", "economic welfare", and "economic growth" that have been adopted here. Brief attention is given also to the ways in which these are related to several other concepts which are associated with the less precisely defined but more inclusive terms: human "capabilities", "welfare" and "well-being", and "social capital". A simple taxonomy of human capital is then set out which is useful in identifying its several and distinct connections with economic activities, including the production and distribution of knowledge as well as that of tangible goods and services.

Within the taxonomic and heuristic frameworks presented in the later sections of this Part (I.3), human capital is seen not only to take a variety of forms, but to be able to "contribute" in a number of ways to raising the average level, and altering the distribution of economic welfare within a society. One may appreciate both the complexity and potential importance of the subject from the following enumeration of the distinct and salient roles that human capital plays in economic life as:

a the functional repository of knowledge, i.e., the capacity for interpreting flows of sensory data and structured information required for purposive individual actions and inter-personal transactions among economic agents;

b the capacity for providing a variety of physical labour service-inputs in ordinary production processes;

c the cognitive basis of entrepreneurial economic activities;

d the key resource utilised for managing market and non-market production, as well household consumption activities;

e the creative agency in the generation of new knowledge underlying technological and organisational innovations.

Beyond defining terms and concepts, and providing an overview of the principal relationships among the specific topics that are to be examined in greater detail, the discussion in this Part contains amplifying comments about the handling of several essentially taxonomic points affecting the report's organisational structure. In addition, it has been thought appropriate in these preliminary discussions to interject some qualifying remarks in regard to the emphasis upon "wealth-creation" and economic growth-promoting approaches to the subject of human capital. This approach has featured in the mainstream economic literature, and hence is reflected in these pages. Nevertheless, there are other quite, different, and equally legitimate ethical perspectives that would introduce a range of related and complicating cultural, social and political considerations. These typically are suppressed, or touched upon only implicitly by economic analyses of the issues surrounding "human capital". But their existence and relevance should not be forgotten, especially when considering the particular nature of the policy implications towards which one tends to be most readily led by the dominant approaches that have guided economists' research in this area.

Part II presents a literature-based review of economists' current theoretical and empirical understandings regarding human capital, taking up each body of findings in turn. The discussion in this Part follows the heuristic framework described by Part I. It begins at the microeconomic level, with an examination (in section II.1) of the market and non-market influences that shape individuals' human capital formation behaviours over the course of the life-cycle. Thence it moves upwards to the resulting distribution of human capital "endowments" that emerges at the aggregate population level. The analysis carried out at the macroeconomic level is concerned primarily with the ways in which human capital and the accumulation of assets of that kind affect productivity performance, and hence may alter both the average level of real income and its distribution within the economy as a whole. From the dynamic outcomes at the aggregate level of this idealised system, the consequences of past human capital formation can be followed back down to the microeconomic level. There they will shape subsequent decisions made by households and firms in regard to work, production, consumption, savings, and the various forms of tangible and intangible investment.

To gain insights into the general equilibrium features of this dynamical, "circular flow" process, section II.2 examines the recent macroeconomics literature that has been concerned with "endogenous growth". The material reviewed under that heading is devoted specifically to the formulation and analysis of theoretical models, and the empirical testing of related hypotheses about the channels through which aggregate productivity growth performance will be affected by both the state of the society's "stocks" of intangible human assets, and the rates at which the latter are accumulating. Some conclusions from economic historians' studies of the changing nature of human capital formation and its relationship to the mechanisms of long-run growth in a number of today's high-income societies also figure in the survey of empirical findings presented by section II.2.

These studies have been selected to illuminate aspects of the story that typically have to be left out of the mathematical modellers' abstract, caricature-like sketches of the process of growth. A second purpose served by inclusion of explicitly historical treatments of the

subject is that of imparting a greater degree of concreteness to the proposition that the experience of economic growth only can be understood in terms of the mutual *interactions* and feed-back loops that form among and number of key dynamic processes – including those involved in the accumulation of intangible human capital – even though, for purposes of analysis, economists work hard to formulate models in which these are more easily disentangled. Historical accounts are especially useful in conveying a more realistic appreciation for such interactions, as well as for the complex character and significance of specific institutional details, and the intricacies of sequencing and timing that often matter greatly to the determination of particular economic outcomes.

Perhaps the most notable distinctive feature of the approach adopted here will be found in just that point of emphasis; in the explicit effort to eschew presenting the multiple dimensions and effects of a society's stock of human capital purely sequentially, in isolation from one another. Instead, the discussion seeks to present them within context, by suggesting a comprehensive "systems analysis" of inter-twined processes that sustain endogenous economic growth and human capital formation by continually transforming the characteristics of each process.

This approach also is meant to counteract a misleading impression that has been fostered in part by the large economic literature applying statistical "growth accounting" methods. Such methods have been informative, without question. But, they have incidentally tended to convey the erroneous view that the impacts of the several "factors contributing to growth" can be cleanly separated and treated as independent of one another not merely for heuristic purposes of analysis, but equally when it comes time to evaluate the array of policies options that are available for the promotion of faster economic growth. On the contrary, the appropriate orientation is conveyed by the generalisation that in economic matters "everything depends upon everything else, in at least two ways". The design of effective policies involving human capital is no exception to this rule, and so requires recognition of the pervasive economic interactions among the various modes of capital accumulation and the other sources of growth in aggregate output per capita.

A number of robust implications for policy emerge immediately from the recent literature dealing with human capital theory and empirics, and these are quite naturally given notice throughout the review in Part II. Part III, however, contains a more systematic discussion of the significance that those generic conclusions carry for the formulation of growth-enhancing government policies, including policies that would appear suitable to the general situation presented by New Zealand's economy. In this regard it could be viewed as fortuitous that so much of the recent research on human capital and economic growth has not been directed to the special problems of development in poor countries. Instead, the bulk of the literature implicitly has addressed the range of cultural institutional, political and technological contexts that, broadly speaking, are more directly germane to New Zealand's general situation among the developed, high-income member states of the OECD.

On the other hand, it is evident that a rather unique constellation of challenges for contemporary policy-makers is posed by the small size and the highly open nature of the NZ economy, by the importance that primary production still holds, and the limited extent of the country's industrial base. One should add to those special considerations the historically formed circumstances that are reflected in the disparate economic conditions that distinguish representatives of the indigenous Maori population from their counterparts among the European settlers and their descendants. Unfortunately, neither this particular set of structural circumstances, nor the complications arising from the flows of human capital entailed by international immigration and emigration, have been treated by the

major theoretical contributions found in the macroeconomic growth literature, including those that deal with the role(s) of human capital.

Therefore, to avoid raising expectations which would remain unfulfilled by Part III, it must be made clear from the outset that it is beyond the scope of this report to propose concrete programmes of NZ governmental action. Yet, that does not mean that there is little left to be said in Part III. On the contrary, the conclusions that may be drawn from the material reviewed do form a persuasively robust argument for concluding that unassisted competitive markets do not make a good job of producing and allocating human capital. Consequently, there is an important place for governmental commitments to programmes of public subsidy for education and training, as is true more generally in respect to knowledge-forming activities. This is a broad policy implication which extends to embrace support for programmes devoted to designing and implementing new instruments and institutions that would permit greater selectivity and control in the promotion of educational investments, as well as a variety of complementary forms of intangible human capital.

The last-mentioned point is quite important, inasmuch as the conclusions emerging from the relevant literature constitute a strong case for public sector interventions to promote closer dynamic co-ordination between investments in human capital, technological innovations and other, tangible capital formation projects that are being carried out in the private sector. Furthermore, because the adoption of the systems analysis approach here serves to highlight the diverse forms of interactions and feed-back effects that affect micro-level human capital formation decisions, it indicates that there may be a correspondingly wide array of public policy instruments whose deployment in support of such policies deserves careful consideration.

I.2 Human Capital and Economic Growth: Concepts, Definitions, and Taxonomies

To address the question “How does human capital contribute to economic growth?” it is necessary to distinguish general notions concerning the “capabilities” of human beings from economic agents and their relationship to the concept of “human capital”. Then we must define clearly what is to be understood in this context by “economic growth”, and how our interpretation of the term bears upon the identification of the human capabilities that contribute to the processes that we associate with “growth”.

The introductory material in the remainder of this Part has been left unencumbered by detailed citations to the extensive literature on the many topics that must be touched upon, some portions of which feature variants of the definitions and taxonomic distinctions that are be adopted here. Readers seeking further discussion of these matters are referred to the bibliographic references supplied for Part I. Unlike the selected references corresponding to the text citations in Parts II and III, the background bibliography for each of the remaining sections of this Part is arranged under specific topical headings.

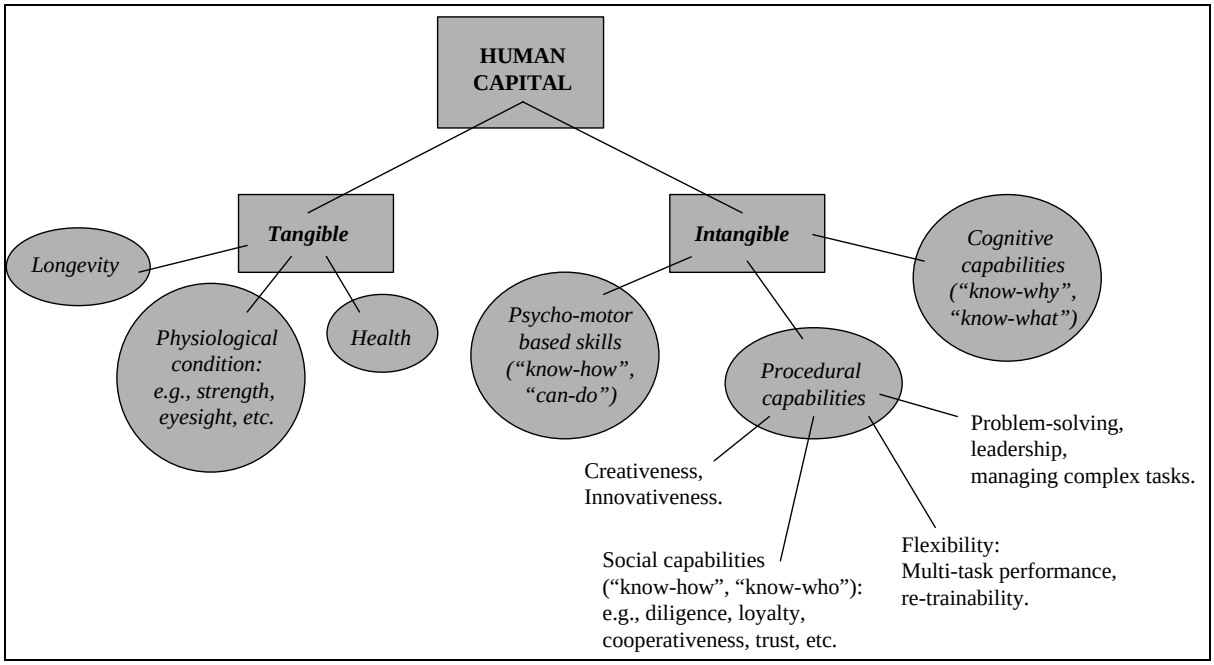
Forms of Human Capital, and Human “Capabilities”

We begin by accepting the working definition of “human capital” that seems widely used in standard microeconomics parlance: human capital refers to the collection of acquired individual abilities that are substantially durable, persisting over some significant portion of the life of the possessor. Furthermore, the personal attributes referred to under this rubric are restricted to positive “abilities” and “capabilities”. In other words, their nature is such

as would normally yield some stream of benefits, by enhancing the possessor's performance in one or more socially valued activities.

A difference can be recognised between *tangible* and *intangible* forms of human capital, although in practice this must rest on what is meant by "tangibility" and therefore is somewhat arbitrary, inasmuch as the latter depends as much upon the fineness of the observer's "touch" as it does upon the inherent nature of the attribute that is being considered. The taxonomic scheme presented in Figure 1 takes a reasonably commonsensical approach to this matter.

Figure 1: Human capital: A taxonomy



Under the heading "tangible" are arrayed a number of macro-level "physiological" attributes: stature, strength, stamina, as well as eyesight, hearing, and so forth. The individual's general health status and susceptibility to debilitating illness also appear here, along with "longevity – an more complex attribute referring to conditional expectations of the duration of the remaining life-span. It is apparent that these are generally relevant to the individual's performance of a wide range of activities in addition to those recognised as falling into the category of "work", with its connotations of physical labour.

The same holds for the "intangible" human attributes that appear on the right-hand side of Figure 1. Three main groups are distinguished there: (a) psycho-motor based skills, (b) cognitive capabilities, and (c) procedural capabilities. The lattermost among them is further elaborated, thereby distinguishing four kinds of procedural capabilities: (i) the attributes of creativity and "innovativeness" are separated from (ii) more routinised qualities such as problem-solving abilities, complex task management, and leadership; (iii) "flexibility", in the sense not only of being able to perform multi-task activities readily, but also to absorb re-training easily, distinguishes another set of procedural abilities". Lastly there are what Figure 1 labels (iv) "social" capabilities": a set of specific personal qualities such as diligence, loyalty, cooperativeness and the capacity for discerning trust in other individuals. These are held to play a particularly important role in forming and maintaining extended networks of cooperative social interactions and coalitional activities; it will be seen that individual *relational assets* of this kind, when regarded from the societal perspective, are requisites for the formation of "social capital".

The critical role of human knowledge in each of the intangible capabilities is emphasised in Figure 1 by the labels that distinguish among various forms of knowledge: “know-what” and “know-why” and “know where” are especially prominent within the sphere of cognitive capability, whereas “know-how” figures in the procedural sphere. “Know-who” has been associated particularly with the subset of social capabilities, although it is obviously also a cognitive matter. Perhaps the main virtue of taking notice of all the foregoing taxonomic distinctions is that it underscores the extremely *heterogeneous* character of human capital. Even more evident than the heterogeneity that appears among the tangible attributes is the implication of the centrality of knowledge in the capabilities that form the intangible dimension of human capital.

Although both the tangible and the intangible forms are subsumed by the term “human capital” in the taxonomic scheme of Figure 1, conventional economic parlance tends to omit a qualifying adjective from discussions of intangible aspects, lumping the tangible attributed under the term “labour”. In the following text, however, this practice will be followed except in contexts where it is important to avoid the resulting ambiguity. In this connection, it is significant that economists take the term human capital to refer particularly to those capacities that have been formed purposively through processes that entail costs of some sort, either pecuniary or non-pecuniary in nature. As the concept usually is defined, human capital formation’s costs include both direct expenditures for material goods and services consumed in the process, and the value that should be imputed to the time and effort that the acquiring individuals must devote to the investment process, thereby foregoing other possible satisfaction-yielding activities.

An important element of individual volition, indeed, of choice, thus, is implicit in the notion of *human* capital – at least as that concept has been developed in modern economic analysis. This gives rise to some subtleties when one must consider the effect upon human capital formation of raising the compulsory school-leaving age. From the vantage point of the situation *ex ante* it would appear that more intangible capital would be formed by extending the duration of the educational processes, and to the extent that there are greater direct resource costs entailed, that conclusion accords with the common view. But as the additional time spent in school by the students is no longer voluntary, the change in the societies’ (legal) norm means that the foregone income (say from employment) costs to *the individual* student will not have increased. Were one to reconsider the same question from the macro-perspective of the social decision, however, the matter could look rather different. The extension of compulsory school undoubtedly does impose costs of production foregone for the society, and these might well be added to the direct resource expenditures that are entailed by the change.

As has been noted, a distinction among intangible capabilities that is recognised in the taxonomy in connection with Figure 1 separates substantive “task competence” from “procedural competence”. This may be thought of as the difference between knowing the answer to a question, and knowing how to arrive at an answer to the question, indeed, to a large class of questions. The point worth noticing here is that the processes of acquiring these different competences, or skills, also are likely to be differentiated. “Learning” particular routines, or skills, is not likely to be the same thing as “learning to learn” – a concept that Stiglitz (1987) developed in its relationship to endogenous technological change. The nub of the issue is the suggestion that whereas certain forms of endogenous learning tended to be “localised” and yield knowledge of the sort whose applicability remained very specific to contexts in which it had been formed, learning by doing also might yield other, more generically applicable knowledge. Meta-learning, or “learning to learn” is one such, and could be viewed as acquired in formal educational experience, yet transferable to a wider class of learning situations. Such considerations carry the

implication that there is little merit to policy recommendations that call for more funding for "education and training" without specifying the nature of the training effort that needs to be expanded, and the modes through which it can and should be supplied and financed.

Capabilities for Discovery and Invention, Entrepreneurship and Innovation

Human capital has an obvious bearing upon the *production of new knowledge* in business practices, as well as of knowledge bearing upon the nature of the material world -- both the world of nature and that of human artefacts. Here one must recognise that there are important positive externalities, as well as potentially destructive effects resulting from "knowledge spill-overs" of a purely cognitive sort. But more recently there has been greater recognition of the point that "human capabilities" -- some of them acquired in the formal process of human capital formation, and others affected by that mode of training -- also have a bearing upon the frequency and ubiquity *of innovative economic behaviour*, and on the supply of *entrepreneurship*.

The latter terms must be clearly defined, if one is to make analytical progress: are they capabilities, or particular metrics of performance success? Does one want to think of innovation activity as a contributor to growth even when such activities often generate business failures? For policy purposes it seems important to make this distinction, and to recognise that the economic context of human action may have as much, if not more to do with the outcomes as it has to do with the attributes of the actors. Thus, one might include among the important human capabilities the understanding of the circumstances that favour successful application of one's own capabilities, and, indeed, self-awareness of the latter. Human capital investments that result in the augmentation of creative and innovative capabilities and entrepreneurial capacities, like those which add to the cognitive knowledge base, are likely to yield economic returns that benefit others and so will not be fully "appropriated" or "internalised" by those undertaking the investment. There may be an implication here that competitive markets will not automatically generate the sort of economic incentives to elicit socially desirable levels of those capabilities in the population. But inasmuch as innovation and entrepreneurship can be economically and socially disruptive, one cannot conclude that there would always be a deficiency in the supply of such abilities.

When it comes to implementing the concept of human capital quantitatively, for example in microeconomic analyses explaining the evolution of the earnings of individuals in market work, or in macroeconomic growth accounting exercises, economists often delimit the range of the processes that are taken to be the constituent elements of "human capital formation". Thus, among the conventionally accepted "sources" of human capital one frequently finds only the following: participation in formal education beyond socially mandated minimum levels, in organised training programs offered by employers, and "work experience" or "on-the-job training" during the early phases of an individual's working life.

For other quantitative purposes, usually those pitched at a highly aggregated level, an attempt is made to capture a broader conceptualisation of human capital by adding items of expenditures for health care, and geographical as well as occupational mobility. In general, however, this is not carried to the point of subsuming all the resources devoted to the bearing and rearing of children under the heading of human capital formation. It will be seen that although economists have shown much ingenuity in constructing aggregate measures of "human wealth", the results invariably rest upon some heroic assumptions for which proper empirical warrant remains lacking.

A variety of quantitative indicators reflect the economic importance that human capital (defined in a less than fully comprehensive manner) has come to hold in modern advanced societies. Abramovitz and David (1999, 2000b), extending Kendrick's (1996) estimates of the real stocks of capital in the US back to 1900-1910, find that the ratio between the total non-tangible stock and the conventional, tangible stock of capital more than trebled between the opening and closing decades of the 20th century; and between 1929 and 1990, this ratio more than doubled, rising from 0.54 to 1.15. On each of the latter dates intangible *human* capital (formed by education and training investments) represented about three-fourths of the total non-tangible stock; within the remaining fourth, the stock of R&D capital in 1990 was only half as large as that formed by investments in health, safety and human mobility (see Abramovitz and David, 1996).

Estimates of the share of U.S. gross private business product represented by the imputed real (private) returns on intangible human capital engaged in market production show that it has held steady at roughly 0.25 over the decades since 1929, and therefore has remained almost on a par with the unchanging (0.27) share attributed to the gross returns on tangible business capital. By contrast, at the beginning of the 20th century the corresponding shares of intangible human- and tangible business capital had stood at 0.10 and 0.44, respectively (Abramovitz and David 1999: Table 2.II). Considering the secular increases observed in the ratio between intangible human capital and tangible business capital, the initial rise and subsequent stability of the ratio between their respective shares is consistent with Abramovitz and David's (1973, 1996) view of 20th century economic growth as having been shaped by technological and organisation innovations that had a strong bias towards physical capital saving and intangible capital-deepening. But it must be noted that the actual macroeconomic magnitudes referred to by that hypothesis are, at best, only roughly approximated by the available empirical estimates.

Many economic realities complicate accurate quantitative implementation of the notion of an aggregate stock of intangible human capital; even at the microeconomic level they create differences between a private measure of "human wealth" and a social measure of an individual worker's intangible human capital. Although the latter might be supposed to correspond to the present value of the differential "quality-adjusted" flows of labour services that the worker can provide in production activities relevant to the economy in question, people rarely work in isolation from others. The acquired "capabilities and qualities" of individual workers affect their interactions with co-workers, and so are likely to have non-pecuniary "externality effects" – directly affecting the productive performance, and the job satisfactions and dissatisfactions of other employees. The simple matter of linguistic compatibilities (including the ability to interpret "standard" symbolic representations, such as that for "hazardous materials") should suffice to make this observation transparent. There is nothing in the workings of actual labour markets that guarantees correspondence between the wage rate or salary paid to an individual worker and the full value of the incremental benefit they provide to the employing organisation: some may collect rents, whereas others are being "exploited".

Human Capital in a Broadened Framework of Growth Accounting

Jorgenson and Fraumeni present a system of real income and wealth accounts for the U.S. that (a) defines human capital wealth in terms of lifetime labour incomes, and (b) includes imputed values of non-market activities. A further innovation is (c) the assumption that the productivity of labour in those non-market uses of time (e.g., recreation, household production) increased *pari passus* with the rise in the "shadow

price" of labour time indicated by real wage rates in market work. Implicitly, this postulates that the "market productivity" effects of changes in the educational attainment (as well as the age and gender composition) of the labour force are paralleled in the sphere of household production and leisure-time activities. This approach to measuring the "sources of growth" therefore departs from the standard growth accounting framework of Denison, and also from the augmented growth-theoretic accounting framework of Abramovitz and David, and Mankiw, Romer and Weil.

The resulting estimates employing this measurement approach show that the estimated real stock of human capital is more than an order of magnitude larger than that found by cumulating real educational investment flow estimates to form ("perpetual inventory" type) measures of the educational capital stock. On this basis Jorgenson and Fraumeni conclude that investments in human and non-human capital together account for virtually all of the U.S. economy's output growth in the post-WWII era. Even if the assumptions underlying these calculations are considered to be rather extreme, the results serve nonetheless to underscore the following important point: by leaving out of the picture the growing proportion of time that modern populations are engaged in non-market pursuits, we undoubtedly understate the quantitative importance of the contributions that educational investment makes to raising average economic welfare, more comprehensively considered.

One particular aspect of human knowledge bears in an important, but nonetheless limiting, way upon the economic conceptualisation of intangible human capital. Knowledge is not homogeneous, despite the conventions followed in formal mathematical modelling, which represent knowledge embodied in human agents as an undifferentiated stock formed by expenditures on education and training activities. Quite apart from the difficulties of dealing analytically with the heterogeneity and the public goods properties of "knowledge", and therefore of treating it as something that could be meaningfully aggregated and thereby reduced to a scalar measure, we have to acknowledge that some forms of knowledge can be transmitted and preserved more readily or at lower unit cost than others.

Economic Growth, Measures of Economic Welfare and Well-Being

Although the term "economic growth" is employed widely and casually in the popular and business press, it carries at least two distinguishable connotations. As those meanings have somewhat different bearings upon the connections between the concept of human capital and that of economic growth", it seems important to be more precise than is usual before proceeding further to discuss the relationship between the two.

The first sense of the term refers to the growth of an economy's productive *capacity*, in either absolute terms or, more usually, in relationship to that of the population; the second sense refers to the growth of per capita *real income*. The latter is potentially distinct from the former meaning because it is given a special interpretation as the pecuniary measure (or counterpart) of the expected level of "welfare", or satisfactions, that is available to a "representative" (i.e., randomly drawn) member of the population in the form of the flow of currently produced material goods and services.

There are some quite special conditions, having to do with the existence of complete and perfect competitive markets, under which quantitative measures of "economic growth" corresponding to each of these two conceptualisations could be held to coincide, so that it would be strictly correct to speak of "economic growth" and the "growth of economic welfare" as though they were one and the same. As a practical matter, however, those

conditions never obtain, and the two meanings should be distinguished. Furthermore, the label “economic growth” has come by common convention to be affixed to the increase shown by either of two particular statistical indicators of national (or regional) aggregate productive capacity: per capita “gross national product” (GNP) or “gross domestic product” (GDP) – the second of them being currently the more popular because it corresponds more immediately with the productive resources that are being deployed within the geographical territory of the country in question.

The widely used income and product accounting concepts, however, are restricted in scope by arbitrary conventions that tend to detract from their appeal as measures of *economic welfare.* Both the GNP and the GDP ignore flows of goods and services that are produced and distributed largely outside market channels, in most instances simply for the reason that to include those would require price and quantity transactions data that generally are not available. But that quite practical consideration masks the more general and deeper issue of where, especially for purposes of quantification, to set the boundary between “economic welfare” and “human welfare” more generally conceived. This question is one that bears quite directly on the nature of the connections that are recognised between human capital (viewed *qua* “capabilities”) and economic growth (viewed *qua* increased average welfare).

“Measured economic welfare” (MEW), being more comprehensive in scope than, say GDP, would also include the imputed value of the time individuals spent engaging in unpaid pursuits, whether or not those involve some components that were market-supplied. Among the prominent items under this heading are leisure and recreational activities, domestic chores such as cooking, cleaning, and clothes-laundering, childcare, and the necessary time engaged in education and training *at levels above those which the society has made compulsory*. (It is true that in GDP and GNP accounting conventions some imputations are made for non-market services, notably that provided by the stock of owner-occupied housing, but economic studies of productivity growth then omit those, by working with real GDBP (gross domestic *business* product) measures.) In contrast with MEW, the narrower-scope measures that most modern discussions of “economic growth” continue to refer to, whether explicitly or implicitly, totally exclude a very substantial part of the real resource costs entailed in forming human capital by means of investments in formal education beyond the secondary school level, and on-the-job training of various kinds.

Aside from several unofficial efforts following the pioneering work of Nordhaus and Tobin in the early 1970s to implement the MEW concept quantitatively for the US case, a wide range of alternative indicators of average “well-being” have been considered, some of which are conceptually narrower than per capital real GDP; per capita real *private* consumption expenditures is one such. Other indicators go outside the scope of the income and product accounts entirely, by introducing indexes of health status, and life expectancy. Still other measures of “human welfare” levels characterising a society at different points in time, or comparing societies, would follow the philosopher John Rawls, by focusing exclusive attention upon the condition of the poorest or otherwise most “disadvantaged” segments of the population(s) in question.

These remarks concerning alternative ways of gauging improvements in human welfare might be regarded as unnecessary in the immediate context. But that view would be unwarranted; certainly the brief attention given to them here seems well-justified by the seriousness of the policy matters that are at issue. The “impacts upon economic welfare” that flow from a given set of exogenous developments which impinge on the rate of human capital formation will depend not only upon the structure of the economy, but upon

the way that "economic welfare" is defined and measured. But further discussion of the policy implications of having settled upon the current association of "economic growth" with increases in real GDP per capita, in preference to some other among the alternative indicator of improvements in economic welfare, will be deferred for fuller consideration in Part III.

"Human Capabilities" and the Welfare Nexus

Yet it seems important at this point to take notice of the distinction that Economics Nobel Laureate, Amartya Sen, recently has drawn between human "capital" and "capabilities". The two terms may be used more or less interchangeably, but there is also an implication for economic policy that is underscored by distinguishing between them. In many contexts the two conceptualisations may have perfectly complementary implications, but in others they might point in rather different directions. Receiving education, for example, may be valued as a direct source of consumption satisfactions, or as a form of investment that generates a future flow of *enhanced* satisfactions – from the consumption of other material goods and service, and possibly from the enjoyments derived in work itself. Alternatively, education may be regarded as the process of creating a productive asset that can have pecuniary and non-pecuniary externality effects upon other members of society, as well as enhancing the productive capacities of the educated person. There are no immediately apparent conflicts among these views of the educational process, save for the difference in the time-distribution of the benefits.

On the other hand, the "human capabilities approach" may be seen as carrying quite different implications in regard to specific economic policy questions -- such as how general or vocationally targeted state subsidies for education should be made. This would become very relevant for a society that was committed to promoting welfare-enhancing "human capabilities" of a generic sort, such as "creativity", "problem-solving", the ability to learn and to lead (all of which appear under the rubric of "procedural abilities" in the taxonomic scheme set out by Figure 1, in Section I.2). The notion of "human capital", by contrast, lends itself to being interpreted much more readily in terms of specific cognitive capabilities and psycho-motor skills that are useful in certain contexts of production and distribution. A widening "portfolio" of such intangible human assets may be accumulated, but the elements are not so "malleable"; they can grow in effectiveness through practice, or become economically obsolete and degraded by lack of practical application. Such satisfactions as their possession may convey to the individual often will be conditional on he or she having access to other, equally specialised productive assets with which those skills are used. In that sense, the job-specific, plant-specific and firm-specific skills that labour economists recognise and distinguish from general human capital, are not completely vested in the worker. As a direct source of human satisfactions, possession of this sort of human capital is more precarious for the persons involved.

The thrust of the foregoing observations can be restated by framing the issue somewhat differently. One might be concerned with the economics of human capital formation because of the immediate significance that investments of that kind would have for people's well-being. Aspects of the human condition such as health and longevity, the ability to comprehend events and forces that are affecting one's life, and to communicate that understanding to others, access to the cultural heritage of one's community, the capability to represent one's views and personal interests, and to protect these through legal and political procedures – each of those human "capabilities" may be regarded intrinsically to be a human *desideratum*. It might well be the case that a complete economic analysis would need to take into account the indirect effects that were

channelled via the impact that expanding those capabilities would have upon levels of material abundance in the society. Nonetheless, there is an entirely coherent purpose to undertaking economic analysis in order to establish whether and in what ways the concomitants of economic growth promoted, or failed to augment these "capabilities" in the population.

Therefore, when considering alternative policy measures for the support for human capital formation", it does matter whether faster "economic growth" is sought primarily because it is supposed to be conducive to the enlargement of valued "human capabilities", or whether it is taken to be the most expedient means of materially enriching the lives of a particular segment within the society, or whether it is desired for altogether different purposes, such as the augmentation of national geo-political power. Furthermore, inasmuch as a narrow qualitative measure of economic growth such as GDP per head reflects not only increases in the productivity of work, but the labour effort expended per capita, the nature of the measurement of "labour effort" would directly affect the answer to the question about human capital's contribution, as well as impinging on the issue of how productivity growth was related to human capital formation.

The preceding remarks might be summed up as calling for us to keep in mind the distinction between "human capital" considered as a productive asset that will yield a stream of input services in material production processes, and "human capabilities" which affect the way human agents design, organise and manage economic activities, and also derive welfare and satisfactions of their material needs in a world of finite material resources. In the first case, human capital is a passive ingredient in production; in the second, human capital is the active, creative element that transforms economic life.

Social Capital

Should the heading "human capital" also subsume the now fashionable concept of "social capital"? "Social capital" involves knowledge about particular *relational* systems among human agents, and about the ways to utilise those relations to mobilise co-operative, collective action among certain members of the larger society. Whatever the satisfactions the participation in such group activities may yield for the individuals concerned, "social capital" is seen as possessing its value as an economic asset because the webs of social interactions that this knowledge supports have the effect of creating trust, placing bounds upon "moral hazards" in economic contracting, and so reducing "transactions costs". Such knowledge must reside in the minds of those who participate in such relationships, and therefore could qualify for inclusion among the attributes possessed by individual agents in the society. It then might simply be regarded as a form of intangible "human capital", which is how it is presented by the taxonomic scheme in Figure 1 of Section I.1, instead of being treated as a distinct and additional analytical entity – which seems to be the way it has entered the literature of development economics.

Of course, because it must be acknowledged that social capital necessarily is *relational* in nature, such knowledge has to be shared with others before it can serve as a basis for action. Yet that is a feature of many other kinds of "socially shared knowledge", which are ordinarily accepted as being part and parcel of intangible human capital acquired through participation in educational processes. Such cognitive capabilities as a mastery of "reference standards" (the metric system, the atomic weights of elements in the periodic table, tables showing the rules for the conjugation of regular verbs, and lexicons containing the conjugations of irregular words), can be acquired as part of a formal educational curriculum. But an important aspect of the instructional process is to impart knowledge that these are "rules" that permit communication and cooperation with others

who subscribed to them. More generally, in the category of "relational information goods" we include "compatibility and inter-operability standards" that specify the designs for complementary components of open technical systems. By analogy, in the case of human social systems, one may view textual codes, graphical symbols and behavioural protocols for the conduct of transactions with other individuals, as learned "standards" whose stability permits the formation of systems of "exchange", economic and otherwise.

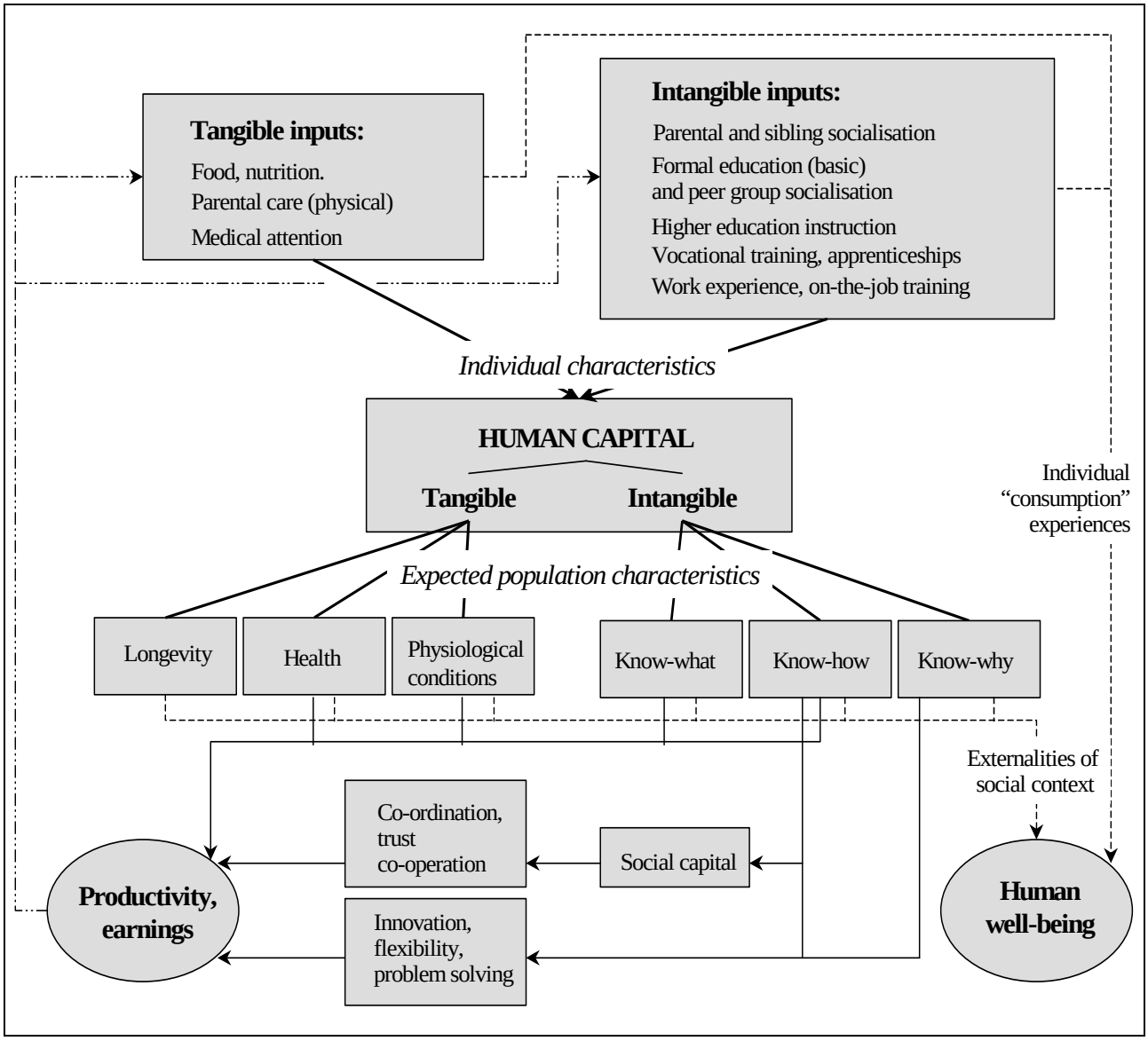
In other words, "social capital" is a form of "glue" that holds the constituent members of society together and permits them to function more productively in the economic sphere, as well as in other inter-personal transactions where trust is beneficial. But, as has been suggested by the sociologist James Coleman, who pioneered the concept, and the political scientists Helliwell and Putnam, whose empirical studies have explored the range of its importance, this "stuff" has to be formed through human experience; it should not be viewed as arising spontaneously, or existing somewhere beyond the realm of the attributes that the members of society acquire by participating in activities that entail tangible as well as intangible resource costs. To be sure, like other learned capabilities, social capital may be developed in interactive processes of socialisation that do not entail significant opportunity costs for the individual. But, equally, there may be substantial foregone "earnings" in pursuing activities that create a basis for trust, and develop the disposition to cooperate with the others – whether they are members of a social club, or a business management organisation, or a production team.

I.3 Integrating the Micro- and Macro-Perspectives: A "Heuristic" Framework

Two main lines of analysis of the human capital-economic growth nexus can be identified as extending from the narrower among the welfare interpretations assigned to the concept of "economic growth". Both of these embrace the instrumentalist view of a nation's population as part of its set of "productive resources", indeed as the most crucial part.

The first branch of the analysis deals with what will be called the "tangible" aspects of human capital, whereas the second focuses upon "intangible" human capital. The simplicity of the taxonomic distinction should not obscure the fact that there are complex interdependencies between the processes that govern the formation and deployment of the two sorts of human capital. One goal of the review undertaken in Part II will be to elucidate these, and show their bearing on policy measures that aim to promote growth by encouraging investment in this general sphere.

Figure 2: Human capital formation and growth: Micro- to Macro-level Feedbacks



Tangible Human Capital Formation

In addition to the purely demographic forces that determine the age distribution of the population and that of the workforce (given the prevailing age-specific rates of labour force participation), various dimensions of the workforce members' physical condition also should be seen as contributing to the society's capacity to generate a higher level of real output per member of the population. When one considers the make-up of the list of such conditions, ranging from nutritional status, stature, strength, susceptibility to illness and disability, it is evident that these impact per capita output levels proximately by affecting the potential flow of physical labour services that will be available from the population.

Quite obviously, "qualitative" aspects of "tangible human capital" must affect the level of potential labour service inputs per capita, and via that channel they will impinge directly on the society's potential level of output per head, given the prevailing level of (full employment) potential output per unit of labour service input. At the same time, however, when more labour service inputs per capita result from greater average work effort, the welfare meaning of the contribution to higher per capita output of goods and services is usually regarded as ambiguous; reductions in involuntary leisure are viewed as likely to be

more welfare enhancing than the sacrifice of leisure in exchange for material goods. Yet, by that logic it could be maintained that if greater labour effort followed from improvements in the nutritional and health status of the workforce, the welfare significance of a consequent rise in real output per capita would not be so problematic, inasmuch as those "human capital" developments would constitute an enhancement of people's capacities to engage more fully in both leisure and work activities.

It is also the case that the physical characteristics of the workforce, including the distribution of its members' ages, strength, ability to learn and remember how to perform complex tasks, will affect the ways in which their labour service potential can be utilised. For example, a workforce characterised by a high rate of absenteeism or inattention due to poor health, is likely to result in complementary fixed production facilities being rendered idle, or under-utilised. That, in turn, may well result in a cost-minimising choice of less capital-intensive methods of production, and reduced levels of average output per unit of labour input.

Each of the human physical characteristics just identified is governed by physiological processes that are conditioned in some significant degree by environmental conditions that respond to prior and current expenditures of material resources that affect people's nutritional and health status. Pursuing this line of analysis in a systematic, growth accounting framework would lead to the consideration that the tangible part of human capital, that is to say, "labour" is simply another "produced resource input". The microeconomic conditions governing its production therefore require explicit analysis, and it therefore would be misleading to implicitly ignore this by treating the tangible human capital stock as a "free" and exogenous factor of production, contributing to the output of the economic system. There are material costs, and opportunity costs in the time spent by parents in the bearing of children and their rearing to an economically productive age. Beyond that, maintaining the health status and longevity of members of a society's workforce (especially against natural and socially created physical insults arising from the organisation of work and the use of particular technological modes of production) entails the continuing diversion of resources into some minimum level of forward-looking (investment) expenditures. These claims on current production would have to be met either by foregoing the current satisfaction of consumption wants, or must come at the expense of other kinds of capital formation.

Therefore, we can say that the solutions to the resource allocation problems affecting maternal and infant care, as well as child care, public health provision, preventive private health care programs, and so forth, all have a direct bearing upon the process of economic growth from the durable (labour) resource input side. It follows that they should be analysed in just the same way as one would approach the resource allocation decisions that govern the accumulation of stocks of tangible non-human assets. Indeed, studies of economic growth in systems that permit humans to be held as chattel slaves, have undertaken such analyses; whatever may be said about the moral character of such economic arrangements, they are further complicated by the peculiar institutions of "ownership", which remove many important allocation decisions affecting tangible human capital from the control of the human beings who are immediately involved. Some parallel complications are present, nevertheless, even in modern societies that forbid reducing people to the condition of chattel slaves. They appear in the form of institutional regulations and contractual restrictions that allow agencies distinct from the persons in whom "intangible" human capital has been purposely formed (through formal education, and training) significant measures of control over the economic exploitation of these acquainted capabilities.

Intangible Human Capital Formation: "Types" and "Forms" of Knowledge

A line of analysis parallel to that relevant in the case of tangible capital formation (of both the human and non-human forms) would begin with an examination of the roles that purposely formed intangible capabilities of human agents play in economic production and exchange. Most recent research pursuing the "knowledge economy" and "knowledge society" themes concurs in the view that the systematic accumulation of human knowledge recently has been gaining in importance among the drivers of economic growth and rising human well-being. It correspondingly calls attention to the ubiquity of modes of "learning" that yield gains in economically relevant knowledge of various kinds. Substantive knowledge about the workings of the natural and social world is identified under the label "know what", whereas a variety of procedural capabilities, artificing skills, and problem-solving capacities are grouped under the heading "know-how". Still another category of knowledge, identified as "knowing who and where" can be recognised as a significant ancillary asset, complementing the other forms. Knowing where to find substantive "facts", and the identity of individuals who possess particular productive assets, or the power to take certain actions, is obviously an important capability that influences the effectiveness of the human actors in any production system.

But, it is not immediately apparent what economic significance such distinctions have, except that they remind us of the point that human (knowledge) capital can be formed through a wide array of experiential processes, and that the cognitive content of such "capital" is far from static. By contrast, if one views intangible human capital formation as the acquisition of "knowledge", and understand the latter to be the basis of an individual's capacities for interpreting "information" and translating it into the performance of symbolic or other actions, then the different forms in which humans acquire and hold such "knowledge" may be seen to carry some important economic implications.

In this regard, the distinction that is becoming more and more prominently recognised in the economics and management literature is that between knowledge which is "codified" and that which is described as "tacit", in the sense of remaining "silent", or not articulated – although not necessarily incapable of being articulated, as Cowan, David and Foray recently have reminded economists. This is because the degree of codifiability, and of actual codification, affects both the feasibilities and the costs of knowledge acquisition, and through that the economic rates of return on various specific kinds of intangible human capital formation. Similarly, those characteristics of the knowledge involved have implications for the conditions and costs of communicating knowledge among individual economic agents and human organisations. It therefore impinges upon the processes of knowledge transfer, and the access that others may have to economically relevant knowledge, whether for direct application in material production and exchange or for use in generating new knowledge and information.

Forming Research Capabilities and the Knowledge-Base for Innovation

The forms of human knowledge, in turn, may affect the ability of private agents and organisations to extract economic rents from the possession of knowledge, or of defined rights to exploit information for commercial ends while restraining others from doing so – through intellectual property ownership and legally enforceable contracts. The bearing of the forms of knowledge accumulation upon the organisation and conduct of research in science and technology, and the impact of science and technology policies and institutions upon the balance between activities that rely primarily upon codified rather

than tacit knowledge, form a sub-topic that is immediately germane both to innovation and diffusion. Such matters warrant closer consideration, even though they may not be thought to be central to the subject of human capital economics because they are situated at the intersection between the latter and the microeconomics of innovation processes.

It is true that science and technology policy tends to be approached – at least within the currently prevailing conventions of mainstream economics – under the heading of "conditions affecting the formation of "intangible non-human capital". Nevertheless, that is a potentially misleading vestige of an older mode of thinking, one that blurred the distinction between knowledge and information, and assumed that all economically relevant knowledge that was the result of costly research or discovery was fully codified. Knowledge reduced to information might be manipulated and processed algorithmically to generate new "knowledge" of that kind; and similarly could be stored, retrieved and distributed without being embodied in human minds.

Being reproducible and transmissible and subject to joint use – all at negligible marginal costs – knowledge of that kind could yield no economic rents to cover the fixed costs of its production. Intellectual property protection, as a device for promoting investment in research and development of knowledge (in codified forms), was thus placed at the centre of science and technology policies aimed at affecting the pace and direction of economic growth. But in view of the extent to which uncodified knowledge is seen as a crucial component of the base upon which innovative economic activities rest, one should expect only limited effectiveness from policies that are directed to fostering the production and distribution of knowledge exclusively in highly codified forms. In reality both innovation and the diffusion of knowledge will be mediated by particular labour market institutions that affect the mobility of skilled individuals among employing firms and regions; and also by the formal education and training institutions, and by more informal organisations and practices which affect the composition of intangible assets embodied in the human agents of production that society has at its disposal.

The nexus between innovation and the human capabilities that may have been developed and elaborated through formal education is quite complex, however, and perhaps it is not surprising that this subject remains very largely unexplored in the vast literature devoted to the economics of (technological) innovation. In modern writings on the role of education in economic development and growth there is a strong tendency to conflate the formation of vocational skills with the acquisition of knowledge via formal schooling. Relating to this tendency is the general disposition to focus theoretic and empirical analysis upon implications of complementarities that may exist between specific skill endowments of the workforce and particular trajectories of technological development. In itself there seems to be nothing very objectionable in that approach, so long as the notion of "skill" is understood to have been expanded sufficiently to embrace more general human capabilities, including generic problem-solving capability and the capacity to master a repertoire of particular skills, and switch among them rapidly with ease. Likewise, one may need to keep in mind a broadened concept of "technology", broadened to include "meta-technologies" constituted from methods of designing and producing a succession of novel and differentiated products, or, distinctly, from collections of the techniques required for mass producing and marketing highly standardised goods and services.

Technology itself is changing in ways that affect the economic significance of different kinds of knowledge, and, via that route may call for adaptations in modes of human capital formation. For example, the progressive codification of production activities is changing the nature of the "skills" required of workers: they are less artificers engaged in repetitive tasks than they are the discretion-using controllers of artefacts and production systems

designed and constructed by others. This implies that the biases in the "direction" taken by technological change, with regard to its factor-saving and factor-using effects, will influence short-run rates of remuneration of tangible and intangible human capabilities, and, over the longer run will be (endogenously) shaped by the effects of past and expected future factor supply conditions. These forces need to be considered when designing policies affecting human capital formation, as the latter typically will be concerned with investments that have long periods of gestation and create (human) assets that are extremely durable.

Gaps Between the Private and Social Rates of Return on Human Capital

In the neoclassical formulations of the human capital concept, its scope tends to be further restricted by efforts to arrive at quantitative measurements of "the human capital stock", especially its intangible component. Two approaches have been pursued which have the attractive property that they ought to yield equivalent magnitudes for the value of the resulting private asset (stock), under conditions in which the microeconomic allocation of investment resources was in equilibrium. One approach is the so-called "wealth" approach, which views an individual's intangible human capital as the (discounted) present value of the stream of differential earnings from the sale of the services of workers in whom different amounts of human capital investment are "embodied". Typically, this approach associates the expected incremental (private) productivity effects of intangible human capital formation with the differences between the life-time full employment earnings profiles of workers belonging to different educational and training attainment categories (but, ideally, who are otherwise identical). The same approach could in principle be applied to compute the "wealth" represented by the incremental private earnings that were attributable to the differential health status that was associated with discretionary medical care.

The other approach is to start from the investment side, by finding the present value of the expected future stream of private costs – in the form of foregone earnings, and direct incremental expenditures (e.g., tuition, fees, equipment, and extra living expenditures) – that are required for an individual to complete a specified programme of education beyond the mandatory schooling age. On-the-job training, internships, and the like may be treated similarly. When reckoning the direct costs of education, the value of publicly provided subsidies should be included, for, even if they are not borne by the individual, they represent the resources expended for his or her education. In the case of on-the-job training, some attribution to costs shared by employers, analogously would be appropriate. With a proper choice of the discount rate – which should allow for a premium above the yield on safe assets that reflects the differential riskiness of investment in human capital – the private "wealth estimate" and the "capital cost" estimate should coincide; at least, they would do so were the agents maximising expected wealth and were the market for human capital in equilibrium.

Measuring a society's aggregate real stock of intangible human capital in either of the foregoing fashions is of interest primarily for purposes of "growth accounting": the proportionate growth rate of that stock, multiplied by an estimate of the elasticity of output with respect to the services of human capital in production, affords a way of gauging the quantitative importance of the "contribution" which human capital formation can be said to make to the growth of real GDP. A rather different way of assessing the economic impact of investments in intangible human capital is to consider the actual or expected internal rate of return on various educational and training "projects". The internal rate of return is the discount rate that will set the sum of the stream of differential net earnings (private

wage earnings net of education-associated outlays) equal to zero. Under certain technical conditions – such as the monotonicity of the net earnings stream – the internal rate of return associated with a specified course of education, such as high school graduation, 2-year college, college completion, etc., will be uniquely defined in each case.

Rate of return calculations of that sort can be used in evaluating the returns to private investments in "educational capital", and even in assessing the conformity of market behaviour to private rationality precepts. Some theory is required for virtually all empirical measurements of economic variables, but estimates that purport to measure the social stock of intangible human capital cannot legitimately presuppose that private and social rates of returns *will* be equated. Nor can it presume the existence of some mechanism that would automatically force marginal social rates of return into equality with marginal social costs of human capital formation. Indeed, there are numerous structural conditions in the relevant markets that are recognised in the economics literature as being likely to drive persisting wedges between the private and social rates of return to investing in human beings. The implication is that the amounts of "human capital" created through private wealth-maximising market behaviours will not be socially optimal.

These signals of the existence of resource misallocation are likely to appear in either of two broad sets of circumstances: (1) the existence of non-pecuniary "externalities", and the interdependence of individuals' preferences over outcomes, results in some significant portions of the benefits and/or the costs of particular investments failing to accrue to the agents responsible for undertaking those projects; (2) there are persisting "market imperfections" (including incomplete and missing markets) that prevent relative prices from properly signalling relative private marginal costs and private marginal productivities – excepting those cases where the imperfections arise from complete market power that accompanies the "internalisation" of all relevant costs and benefits.

Many specific structural characteristics of markets for information goods, and labour market and financial market contracting situations, have been identified by the microeconomics literature as giving rise to difficulties that lead to serious resource allocation inefficiencies in the absence of specifically designed incentive mechanisms, customised contractual arrangements or regulatory interventions. In some cases these will yield socially sub-optimal – and possibly also privately sub-optimal – levels of human capital formation. But in others, the inefficiency may take the form of excessive allocation of resources for such purposes. One cannot start from a general *a priori* position regarding the nature of so-called "market failures" in this field, any more than one can start from such a position in the case of investments in non-human intangible knowledge obtained through R&D.

Corrective public interventions must therefore be proposed on a case specific basis, once the nature and seriousness of the existing mis-allocations are established. But it will have to be considered that most corrective instruments – whether they take the form of subsidies and taxes, or legal and administrative regulations, or the creation and management of special institutions by the public or private sector – will impose some costs of their own. This is so even when they are as well-designed as the state of knowledge would permit. Furthermore, the risks of costly "institutional failures", arising from poorly formulated rules and intra-organisational reward structures and resource pricing conventions, also must be considered where public agencies and governmentally sanctioned institutions are to be deployed. All such costs should be taken into account in judging whether public policy intervention should be recommended as "second best" solutions, or only "n-th best" means of addressing an identified source of "market failure". To be able to move to an ideal world, in which the public and private allocation

mechanisms were subject to none of the troublesome conditions detailed by the following paragraphs, constitute the first-best solution, of course. But more often than not, this remains elusive.

Verifiability problems are especially rife in the case of the formation of intangible human capital. One cannot directly ascertain what is in the "trained" individual's head. The expenditure of resources on such training can be measured and monitored, and so can the individual's performance of certain tasks. But the interactions between inherent human abilities and training confounds the "pure training effects" with unobservable individual attributes, making it difficult to ascertain the degree to which the investment has improved performance. It may be noticed that the literature on labour market screening points to the possibility that even without yielding any payoff in terms of cognitive ability improvements, investment in and completion of accredited educational programs may have a positive social payoff in providing a better bias for selecting individuals with greater inherent ability. This implies, however, that for efficiency, the screening criteria embedded in the design of such screening/training programs should identify the particular abilities that are of interest to those employing the "graduates".

Monitoring problems are closely bound up with non-verifiability. Workers may be provided by employers, or public agencies, with costly forms of training, but it is costly and in some cases impossible to determine whether they are making best use of such capabilities as they acquired in that way. Most solutions involve incentive schemes based upon performance, rather than effort, as the latter is especially difficult to monitor in the case of intangible capabilities. Attribution of performance variations to individuals is difficult, however, when their work is carried out in teams and involves complementary facilities and materials over which they do not have control. A further problem exists with punitive incentive schemes: if bad performance leads to downgrading to less well paid occupational positions, this represents an effective write-off of the training investment.

Asymmetric information and agency problems beset the whole process of producing and selecting individuals who possess "expertise". How can the inexpert judge the quality of experts? Determining the amount of intangible capital possessed by a particular individual is therefore frequently achieved only in an approximate, statistical way, by examining the formal educational credentials and informal learning experiences to which he or she has been exposed. Yet it requires a considerable amount of expertise, much of it involving knowledge of the idiosyncrasies of the individual's history, to accurately interpret those acquired signals. In a parallel fashion, the problems of incomplete and asymmetrically distributed information, and the consequent dependence upon the proper alignment of the interests of principals and agents, are encountered on the side of the purchasers of "signals of competence". The mechanism design literature has a good bit to say about the way to achieve such alignments of interest, but one feature of that body of microeconomic analysis is that the solutions typically will turn out to be very specific to the structure of the problem.

Externality problems constitute the last, but in some respects the most serious category of market deficiencies affecting human capital formation of both tangible and intangible kinds. Labour market theorists have sought to deal with the externality problem that faces those investing in worker education and on-the-job training by drawing the distinction between "general" human capital and "firm'" or "job-specific" human capital. The purpose underlying this taxonomy is to suggest that where firms are able to fully internalise the benefits of training investments, they will provide the correct level of financing for them. Where training is of a "general" nature, making it more immediately

transferable to other employment situations and so enabling the possessor to benefit from higher wages or more secure earnings elsewhere, then, efficiency considerations suggest that the investment costs should be borne by the worker who appropriates the benefits; and, in a world of perfect markets, including complete capital markets, they would be.

But, general and specific forms of human capital in reality are not so simply separated; much "experience-based learning" in solving problems can be generalised by the learning agents, and this creates positive externalities that may be enjoyed subsequently by other employers. Efforts to prevent employers from "free-riding" typically restrict the freedom of workers to take employment in "related" activities, or to migrate to other regions where their experience is more highly valued in the market. These measures, although arrived at in voluntary contracts, clearly introduce new sources of misallocation. One has to ask whether that outcome would be better or worse than having employers levy implicit charges on their workers in exchange for allowing them access to learning opportunities in their respective firms, e.g., by setting workers' wage rates below their marginal value productivities.

All of the foregoing problems arise also in the case of the acquisition of costly forms of human capital by the self-employed. By and large, the literature addressed to the supply of entrepreneurial abilities has been pre-occupied with problems in the financing of innovation in conditions where the human capital "endowments" of would-be entrepreneurs are regarded as exogenously fixed. Yet, the capabilities of the self-employed are no less susceptible to modification by human capital formation than are those of employees, and venture capitalists face problems of asymmetric information, non-verifiability, monitoring and moral hazard from opportunists' entrepreneurial behaviour – all paralleling those encountered by employers who must contract with skilled workers. Making those parallels explicit is useful in that it makes transparent the links between the microeconomics of human capital formation and the microeconomics of entrepreneurial innovation.

To be of practical use economic analyses of the foregoing problems must go further than simply establishing why and how competitive market allocation mechanisms are unlikely to work well even in the developed, institutionally sophisticated market economies. Establishing a theoretical presumption of "market failures" is of course important in providing a cogent economic rationale for public interventions in the affected markets.

Yet, in order to guide such interventions, it is essential to be able to describe the nature of the allocation inefficiencies that arise in specific institutional and technological settings. Analyses that are useful for policy design must establish conclusions about the expected directions, and the comparative magnitudes of the various deviations from a socially optimal pattern of investment in human capital in the absence of public intervention; but also, the pitfalls and perverse results that public agencies would have to avoid in order to achieve interventions that qualify for the label "second best" rather than "n-th best".

Interim Conclusions

The integrative framework that is set out in Part I has been constructed by drastically simplifying many complex and subtle points of modern economic analysis. Justification for it, if one is to be found, must lie principally on the grounds that it serves a dual *heuristic* purpose. Firstly, it indicates the main connections between the micro-level determinants and the macroeconomic effects of the various dimensions of human capital formation. Second, it highlights the presence of several key *positive feed-back loops* in the dynamic

system that connects the micro-level and macro-level outcomes. Feed-backs of that kind are shown to create the potential for a self-reinforcing process of growth based upon sustained increases in productivity.

When human capital formation is viewed either at the micro- or the macroeconomic levels it becomes evident there are a number of structural and institutional features peculiar to the markets for information goods, and for labour, that are likely to result in persisting differentials between the social and the private rates of return on such forms of investment. This implies that there is no automatic mechanism guaranteeing that the dynamic allocation of human resources in a competitive market economy will be one that is socially optimal.

In addition to affecting the overall levels of human capital, the peculiar susceptibility to "failures" of the markets for investments in knowledge, information, and the services of free persons implies that the composition of the resulting human capital stock also is likely to be sub-optimal under such conditions. In some instances the social rate of return on a given form of human capital investment may fall considerably below the private rate, even though the opposite state of affairs is more typical.

The concern this should occasion is heightened, and should be heightened by an awareness of the fact that human capital formation decisions have implications which involve more than the static efficiency of resource allocation. An economy that is characterised by strong positive-feed-backs that generate self-reinforcing dynamic interactions between human capital accumulation and productivity-based growth in real income per capita may find itself spiralling virtuously upwards, but it also may become trapped in a vicious spiral downwards.

To consider more closely what the recent economics literature has to say in regard to those potentials is a central purpose of the material reviewed in Part II.

Part II: Human Capital and Economic Growth: A Review of Recent Theoretical and Empirical Findings

II.1 The Microeconomics of Human Capital Formation over the Life-Cycle: Markets, Families and Social Institutions

To provide a coherent picture of the microeconomics of human capital formation it is helpful to proceed within a simple framework that:

a recognises the various agents involved in this process (families, adult workers, employing firms, public agencies providing education services, teachers, and specialised trainers);

b details the relevant decisions of each agent, particularly with respect to formal education and on-the-job-training; and,

c makes the connection between the personal characteristics – tangible and intangible human capital – resulting from the agents' decisions and the broader technological and institutional environment in which the agents interact.

For this purpose, a natural and convenient way of dissecting the problem is to consider the following critical decisions made in an individual agent's life-cycle:

1 primary and secondary education,

2 higher education and/or vocational training,

3 on-the-job training,

4 mid-career training and retraining, and

5 retirement.

This approach to the educational process is important in its own right, but it is also an essential background with which to assess the strength and credibility of the theoretical and empirical literature that looks at the macroeconomic relationships between human capital formation and growth, which will be examined later in sections II.2, and II.3, respectively.

Primary and Secondary Education

The distinctive characteristic of the decisions regarding primary and secondary education is that others take them on behalf of the agent. In particular, the family and public education institutions both affect the continuance and context of this elemental education, and in turn determine the cognitive knowledge, socialisation, "innovativeness", and other elements of the human capital of the agent. Mincer and Polachek (1974, p. 77) remark how "a major function of the family as a social institution is the building of human capital of children – a lengthy "gestation" process made even longer by growing demands of

technology. (...) Optimal investment in human capital of any family member requires attention not only to the human and financial capacities in the family, but also to the prospective utilisation of the capital which is being accumulated". Since the decision about children's schooling is rarely left to them, it is necessary to consider the influences impinging on the choices made by parents and other agents in the educational process.

Studies have shown that parents', and especially the mother's, schooling is of prime importance in the determination of the "tangible human capital" of the child; by which we mean the health and longevity, and any other concrete elements of a person's human capital, in contrast to "intangible human capital", which is the combination of a broad set of social capabilities and skills. In economic studies, the channel through which women's education operates is: women with higher education have higher opportunity costs of childbearing, therefore they tend to have lower fertility rates, which in turn increases the resources available for every child. Surely as important is the better infant care and diet that educated mothers give to their infants, improving the nutritional standards and so the probability of survival and subsequent health (the literature on this subject is extensive; the following are some recent contributions: Ahn, 1995; Blackburn, Bloom, and Neumark, 1993; Hotz and Miller, 1988; Rosenzweig, 1990; Schultz, 1994; Wolpin, 1984). The socialisation process also is important because it can contribute to children's awareness of health, increasing future investments in health and reducing the possibility of damaging addictions; this is central to Grossman (1999, p. 77), who argues that "in an ever-changing world in which new information constantly becomes available, general interventions that encourage future-oriented behaviour may have much larger rates of return in the long run than specific interventions designed, for example, to discourage cigarette smoking, alcohol abuse, or the use of illegal drugs".

With respect to intangible human capital, the economic literature stresses the link between parents' education and the *value* given to children's education. The well-known paper by Becker, Murphy, and Tamura (1990) concludes that when human capital is relatively abundant, the rates of return on human capital investments are high relative to the gains of having more children, whereas when human capital is scarce, the return from human capital is low relative to having more children. The authors argue that this mechanism accounts for the observation that "societies with limited human capital choose large families and invest little in each member; those with abundant human capital do the opposite" (p. 35). It has been observed that educated parents also make more *informed* decisions about the quantity and quality of education given to their offspring, thus affecting the intangible human capital with which they are endowed.

Naturally, parental income also is important in determining the physical, cognitive and social skills with which the children are endowed: as income increases, the opportunity cost of food, medical attention, and education expenditures is reduced, and so parents invest more. Moreover, the quality of all these "inputs" increases also (Lee and Barro, 1997).

An important caveat regarding these conclusions about the influence of family background, which are central to micro-economic models of fertility and education, is that they assume that parents' decisions about children's schooling are (a) informed about the options available and the consequences of these, (b) "altruistic" in the sense that the expected economic welfare of the children is "embedded" in the parents' own sense of welfare, and that (c) parents have complete control over the *children's* input into the educational process. These may be reasonable working assumptions for some social groups, but it is questionable whether they hold across all groups in society; and especially among the economically disadvantaged in average- to high-income societies.

None of the economist's models treat the notion of a dysfunctional family and its effects on children's performance, although this is central in sociology.

Other influences on early education lie outside the sphere of the child's immediate family. The ethnic environment can influence these capabilities, resulting in more or less productive workers, as discussed by Borjas (1995, p. 388): "[t]his ethnic spillover implies that the skills of ethnic children depend not only on parental skills, but also on the mean skills of the ethnic group in the parents' generation". While this influence works partly through the income of the ethnic group, which may affect the quality of education, it seems that social issues such as the existence of role models (Cutler and Glaeser, 1997) or religion (Tomes, 1985) play a part as well. Tomes (1985) argues that religious knowledge is complementary to other kinds of human capital, and so there is pressure to make educational investments to increase the "stocks of religious capital" in the process.

Parents' choice is also limited by governmental regulations. Attendance at primary and secondary schools is compulsory in countries with high incomes, and so there is a minimum bound to the intangible human capital that a child receives determined by the quality of public schools. Similarly, these countries have laws restricting child labour that eliminate the fertility trade-off that still exists in some developing countries, where having fewer children involves an opportunity cost in terms of less available labour.

Higher Education and/or Vocational Training

This stage in the educational process is the one that most closely conforms with the perspective offered by economics in the theory of human capital. At least in regard to higher education and vocational training, it is not unreasonable to assume that the agent involved is responsible for the investment decision, and there are no legal and institutional impediments that compel participation in educational activities rather than entry into the labour market. Although some younger children may not wish to continue in school, they are not only obliged to remain there until the legal school-leaving age, but, in addition, are restrained by law from holding a full-time, paying job before attaining the minimum working age.

The human capital theory of educational choice (following the work of Jacob Mincer) is based on the inter-temporal trade-off for individuals between the benefits of finding a job in the labour market now, or investing time and money in additional schooling, in the hope of getting a higher wage and a larger (possibly more regular) stream of earning in the future. It is important to include the opportunity costs in the form of foregone earnings in addition to any direct costs of education, such as tuition, because the former actually may be a large portion of the perceived costs of higher education. The distribution of people of different schooling levels is in equilibrium when the supply and demand for workers at each schooling level is equated, and no worker wishes to alter his or her schooling level. This condition requires a particular relationship to hold between the expected incremental lifetime profile of earnings and schooling (for a succinct summary of the theory and the evidence regarding Mincerian earnings functions, see Willis, 1986, and Card, 1999).

While the (simplest) human capital theory is based on a competitive equilibrium with perfect information and no uncertainty, it is widely acknowledged that several forms of market imperfection constrain and distort the individual's choice of education. First, capital market imperfections can limit the ability to finance this investment. The result of a borrowing constraint is that people do not invest as much as they would like in higher education or choose a less-expensive course (for example, a shorter degree or one in an institution with lower tuition rates). Clearly, those who can access alternative resources,

particularly from their families, will be able to get more education for reasons unrelated to personal preferences or productivity, and this suggests a role for government loan guarantees to ease the borrowing constraints.

Cameron and Heckman (1998) present evidence for the US that long-run "family factors" correlated with income, and the initial level of educational attainment shortly after the age of mandatory schooling, positively affect investment in (further) schooling; these factors account for the empirically well-documented correlation between educational attainment and the income level of individual's family of origin, whereas short-term credit constraints are not found to be quantitatively important. The latter evidence, of course, is specific to the modern circumstances prevailing in the US, where both public programs and private banks operating under government loan guarantees provide subsidised student loans. In addition, it should be noted that continuation to college and educational indebtedness are widely established social norms, and US educational institutions typically facilitate temporary interruptions of college careers, readily granting leaves of absence that accommodate students who encounter financial constraints.

Indirect costs of schooling are large vis-à-vis direct costs for basic university education, which often is state-provided or heavily subsidised; professional training has typically been more costly, but it is also true that foregone earnings of college graduates are higher. Estimates for the US in the 1970's and 1980's put the combined direct (tuition, room and board) costs of a four-year college education at a public institution at a mere 8 percent of the total post high school graduation human capital investment costs, inclusive of foregone earnings costs incurred during college and during OJT by college graduates (see Dupor et al, 1996, p. 344). A corresponding notional estimate of the direct cost component for a four-year college education at a private college would be under 32 percent; although the actual tuition charges averages 8 times the size of public tuition/fees, they reflect some degree of subsidy from institutional endowments, while the foregone earnings during OJT for graduates of private colleges may be rather larger.

The question of the relative quantitative importance of direct versus foregone earnings costs of education is important in a number of connections. Financing is one of these, because direct costs need to be financed while at school but foregone earnings do not, so that the former "impose a relatively larger burden on credit constrained students" (Cameron and Taber, 2000, p. 2). The impact of taxes upon human capital investment is a second connection in which this matters, because the foregone earnings are not exposed to income and wage taxation (and so may be viewed as "fully expensed") whereas direct outlays by students and their families are not deductible from taxable income. A further question, whose significance may turn on the relative importance of direct costs in total education and training investments, arises in regard to the government financing of the direct costs of education when there is a possibility of subsequent migration. While migration may not prevent the repayment of loans, there may well be resistance to offering this form of public subsidy if recipients are likely to take their training abroad. (Policy implications of this will be discussed further, in Part III, below.)

A second market failure is that the benefits from education or training may not be fully appropriated by the agent who bears the costs. This will be the case, for example, when the cognitive skills learned are of use to a small number of firms, who then hold the bargaining power with respect to the worker and can offer a wage below the marginal productivity of the educational investment. More generally, there may be important externalities at the level of the firm of having a work-force with a high average human capital, for which the individual workers are compensated unequally or not at all. Thus, more educated workers may be able to more effectively co-operate in teamwork, the

benefits of which will be disproportionately enjoyed by the team-leaders, or managerial staff, or by the owners of the employing firm, because at the margin there are many other individuals who possess the necessary qualifications to permit them to replace an existing team member.

Thirdly, the cognitive decisions are taken with ignorance of the future demand situation. This is one of the most crucial issues in the planning of education, both for individuals and government, since current decisions are to a large extent driven by current payoffs to different *levels* and *types* of education but these investments involve a long gestation period, and the occupational wage structure can be quite different by the time the people conclude the courses of higher education and vocational training and enter the labour market. This uncertainty results in the loss of resources devoted to education for cognitive skills that are not required or fully used; clearly, this implies a payoff for "broad" educational investments in skills that can be used in many occupations. With the notable exception of Heckman, Lochner, and Taber (1998), who study a model of schooling and on-the-job training with heterogeneous human capital, the literature offers few fully specified models of heterogeneous human capital, and none that attempt to account for the feedbacks between wages and the supply of different skills in a context of uncertainty.

That uncertainty raises the possibility that the public sector should intervene in the schooling decision, since government agencies may have better macroeconomic information about demand movements of different skills than individuals, who are likely to respond only to current wages. The same might be said also of individual educational institutions, which periodically have been faulted for failing to adequately respond to changing labour market demands. (See, for example, Romer's 2000 analysis of reasons why traditional university curricula remained unresponsive to the emergence of new, interdisciplinary skill needs, such as those in "bio-informatics", that have accompanied the industrial application of biogenetic research methods). Of course, the centralised decision-making process is more likely to lead to "overshooting", in which the lagged adjustment to skill "shortages" (e.g., in engineers or, more recently, computational biology specialists, described by Stephan and Black, 1998) leads to these being oversupplied when the people enter the labour market.

A different type of uncertainty can be important also in the demand for education: if ability is desired by employers but unobservable to them, then sorting of potential workers may be made on the basis of observable educational credentials when firms perceive a correlation between ability and education. This is the central idea of the signalling and screening hypothesis (see, e.g. Weiss, 1995). There is disagreement as to the "distortion" caused by sorting: early studies focused on the over-investment in education caused by the private return to education – the direct effect of education on productivity plus the value of signalling *innate* ability – exceeding the social return to education, which only takes into account the direct effect; more recently, however, it has been recognised that sorting can result in better matches of workers to jobs that increase productivity. A dynamic process of increasing demand for education may be envisaged as people seek to differentiate themselves. This will be the case if the number of new tasks is growing slowly, because it forces people to get education if they aspire to a good salary.

On-the-job Training

On-the-job training (combining production, learning-by-doing, and mentoring by co-workers) is important for productivity because it supplies *specific skills* that are normally not obtained by formal education or vocational training courses – in fact, it has been suggested (Mincer, 1997) that post-school human capital investment is the primary factor

underlying the observed wage structure. The distinction between general and specific skills was first made by Becker (1962): general skills increase the productivity of workers with many employers, while specific skills only increase their marginal productivity in the current job. The distinction is crucial because firms are willing to share the cost of specific investments, as workers can only recoup these in the current job, and therefore have no incentive to quit and work in another firm. But employers will not finance general skills, since the worker can leave after the investment is made and gain the benefit from the general human capital elsewhere; therefore workers must finance general skills (for a formal derivation of these results, see Hashimoto, 1981).

The specificity of a given skill may change as the industrial structure evolves, thus affecting the incentives for firms to provide and pay for training; e.g., knowledge of computer programming may only have been useful to one firm at the outset of the computer industry but it is now valuable across a wide range of firms. “Distortions” in the wage structure in imperfect labour markets – in particular, compression of the wage distribution resulting from institutions such as minimum wage laws or from matching and search frictions – can also affect the specificity of skills: the labour market imperfections mean that workers do not get paid their full marginal product when they change jobs, making general skills effectively specific (Acemoglu and Pischke, 1999a, b). Another reason why some training for general skills may be provided by firms is if these skills are complementary to specific skills.

If training is used as a screening device to discriminate between workers with unobservable characteristics, then firms may have an added incentive to provide nominally free general skills training. For screening to be feasible training must be more productive and therefore valuable to high ability workers; Autor (2000) develops a formal model that shows how “firms may be able to offer a package of wages and up-front general skills training that induces self-selection by ability, generating short-run monopsony profits”. The importance to the firm of gaining the private information will determine the demand for training as a screening device; in this respect, note that the increasing number of standards reduces the “signal” from each and can lead to increasing monitoring periods.

Obviously, it would be desirable to be able to establish empirically whether or not job-specific human capital accumulation (through learning by doing and formal on-the-job training) was an important feature in particular occupations and industrial sectors. The formation of work-based skills that are not strictly firm-specific is a source of labour market externalities, the existence of which has a direct bearing on public policy design. Unfortunately, empirically grounded general conclusions about the creation and value of transferable skills formed through OJT have proved frustratingly elusive. This is the case despite the considerable ingenuity and effort on the part of labour economists that has been devoted to econometric attempts to establish whether individual, job-experience based “skill acquisition” (rather than selection effects) was the main source of the putative “learning effects” that have been observed widely in wage-*tenure* profiles and labour force turnover data.

It is important to separate the effect of greater on-the-job experience from the effect of lengthened tenure upon wages, because wages will not rise with the accumulation of job-specific human capital unless the workers are able to share some of the benefits that employers expect to capture from enhancing their productivity through training investments. This is a point recently underscored by Felli and Harris (1996), who also notice that even after controlling for worker experience, a positive tenure effect upon wage rates is observed quite widely in industry. This pure “tenure effect” can be interpreted as

reflecting the wage-structures designed by firms that seek to retain workers to whom they have provided firm-specific training. Thus, Topel (1991) views the widespread presence of a pure tenure effect as evidence that "accumulation of specific capital is an important ingredient of the typical employment relationship".

Nevertheless, the latter conclusion is merely an inference, and one that may be quite unwarranted. It is quite possible, instead, that such a tenure-graduated wage structure could be established simply in order to reduce the firm's (random) job-turnover rate. Because hiring and quits impose fixed costs on the employer, tenure-graduated pay has a rationale independent from that of sharing the productivity gains that derive from experience-based job-specific learning. Consequently, its appearance need not signal the presence of job-specific learning. Indeed, McHugh (1988) concluded that employer concerns over rising labour turnover rates lay behind the appearance of positive wage-experience profiles among US southern textile mill workers, including those in occupations that left little or no scope for extended job-specific learning.

If employers adopt tenure-associated wage increments to protect their returns from firm-specific investment in human capital, then one would expect to find lower average turnover rates in firms where the wage-tenure (and within-firm-experience) profiles were steeper. A more demanding test, however, would need to control for the complementarity that is thought to obtain quite generally between formal education and subsequent on-the-job training investments. Turnover rates tend to be lower in occupations dominated by college educated workers, and empirical studies for the US find a strong association between the recruitment of workers with higher educational attainment levels and steeper wage-experience profiles. There are few empirical studies that have been able to make the sort of controlled inter-firm comparisons that are required to convincingly infer the existence of job-specific learning simply from the observed positive effects of tenure upon wages.

There is a second empirical implication, however, which labour economists have sought to exploit in testing for the presence of job- or firm-specific human capital accumulation as a source of positive wage-tenure profiles: the workers' conditional separation also should be observed to decline as tenure lengthens. In other words, the presumed "sharing" of the returns on learning investments with the workers should be seen to have the effect of depressing quit rates among the (putative) specifically-trained workers. Negative duration effects on the hazard rates for separations – both quits and layoffs – are observed quite generally in US data (e.g., Parsons, 1972, 1978; Topel and Ward, 1992; Farber, 1994). But this is far from conclusive evidence: the problem with this test is that it does not eliminate the influence of other tenure-related processes affecting job separation rates. The empirical hazard rate for quits (voluntary separations) might decline due to the presence of unobserved heterogeneities among the workers.

One form of such heterogeneity might be the initial dispersion in workers' beliefs about the nature of the job, or of the firm, and the goodness of "the match" it represents for each of them. Workers with the most grossly optimistic "priors" would be likely to be quickest to "learn" by revising their beliefs downward, and so would tend to exit early; they would leave behind those whose expectations conformed more closely with the "realistic" job-quality appraisal – towards which they would converge as their tenure lengthened.

Another selective attrition process may be envisaged, which would likewise give rise to negative duration effects on the hazard rate for separations: suppose that among the workers there is a distribution of standards for job matching, and some of these pertain to dimensions of the job about which credible information is available only to those actually

employed by the firm. Those with the most demanding standards are likely to discover that they have a “poor match” and so will exit first, leaving behind those who regard themselves to be well-matched in their jobs and are therefore less likely to quit. Such workers are “learning”, but they are learning *about* the job, rather than learning to be more productive on the job.

Although the remaining workers would be “better matched” with their employer, and it is conceivable that the average performance of the (surviving) workforce might tend to rise with tenure, *ex hypothesis* the productivities of the individual workers would not have been enhanced by the accumulation of tenure in their respective jobs. Lacking some collateral observations such as individual productivity indicators, or differential treatment of “better matched” and “better skilled” employees by the firm, empirically identifying situations of true “on-the-job training” is difficult indeed.

There are parallel forms of “learning” that could be said to improve the average productivity of a given cohort of workers without generating human capital. The existence of unobserved heterogeneities in the traits of the workforce leaves scope for selection-type *learning on the part of the firm*. Screening by employers on the basis of “signals” such as educational attainment will not suffice to remove all the variability in worker ability, attitudes and interpersonal capabilities, so, within any cohort of new hires, average performance can be improved through selective retention. Such a policy can be implemented readily enough without forced separations: it may be sufficient to inform workers with “sub-par” traits that they “do not have a future” with the firm, at least not one that involves promotion to higher wage positions. The firm in this situation is in a position to capture all of the benefits of the “knowledge” it gains about the qualities of retained workforce, and so there is no reason to expect average wages to rise with tenure on account of the “learning process”. Correspondingly, once one controls for the effects of selective promotion to higher-paying (occupational) job-slots within the firm, positive wage-experience and wage-tenure profiles would not be observed at either the individual or the cohort levels.

Therefore, it remains hard to come by econometric findings that distinguish conclusively between the formation of non-transferable job-specific human capital, on the one hand, and investments that, on the other hand, yield a preponderance of either general human capital, or occupation- and industry-specific human capital, the benefits of which are not fully internalised by the trainees or the training firms, respectively. This difficulty is encountered not because policy-relevant conceptual distinctions are difficult to draw, nor because such distinctions cannot be operationalised for purposes of quantitative analysis. Quite the contrary. The core of the problem is empirical: the data requirements for such analysis are very demanding, and applied labour economists have been waiting to be provided with very large panel data sets, pertaining to wages, job-titles, hires, quits and layoffs for a sample of firms that are following a variety of policies in regard to training investments and labour turnover.

It is likely that they will have to go on waiting. Systematic collection of complex data sets of that kind is an expensive, long-term undertaking, and the immediate applicability of the material to current labour market issues is exposed to the risk of obsolescence by sudden shifts in technological, institutional or international trade conditions. Consequently, resort to the use of focused employer and employee surveys would appear to offer a more immediately practical empirical basis for informing the design of public policy aimed at encouraging private sector investment in job-specific training.

Concretely, what one needs to ascertain is information about the extent of the gaps that exist in a given range of industries between average practice and what might be viewed as "best practice" training policies. The latter can be gauged by inter-firm comparisons as to the scale, per worker costs, the nature and modes of training: codified material vs. demonstration of tacit skills, training that is conducted off-site vs. on-site, training activities that are out-sourced vs. those provided by firm personnel). Such comparisons can identify the effects on workers' performance (average proportional change, and variance within- and between-trainee cohorts), and worker retention rates among the trainees.

Information of that kind is costly, yet not impossible to obtain. Black and Lynch (1996), for example, report findings on the business revenue productivity impact of human capital investments among medium and large size manufacturing firms in the U.S., based on data from the National Employers' Survey conducted by the National Center on the Educational Quality of the Workforce (EQW). This was a telephone survey administered by the U.S. Bureau of the Census in August and September 1994; a national sample of 4633 eligible private firms employing 20 or more workers was contacted (over-sampling firms with 100 or more employees), and a 72 percent response rate was obtained. The survey questions replicated those on the Annual Survey of Manufacturing in regard to plant characteristics, sales, materials and capital during 1993. That data was supplemented with information on educational attainment, training and job tenure characteristics of the workforce, the types of training programmes in use (computer-, teamwork- and supervisor-training), the percentage of formal training provided outside working hours, the use of other managerial practices (TQM and "Benchmarking"), and so forth.

It is unfortunate that the intra-industry variability of these training practices, and their correlates does not appear to have been made the subject of systematic investigations. Instead, Black and Lynch (1996) sought to use this unique data to estimate a more sophisticated set of cross-section production functions – which differed only in a scaling parameter among the array of industries included in their survey sample. It might be noted that their concentration on establishing productivity effects, although entirely understandable, was nevertheless a rather dubious undertaking in view of the failure of this study to deal satisfactorily with the number of serious econometric problems.

Numerous pitfalls await casual statistical analyses in this area, and among them the following trio are particularly troublesome: (a) the bias introduced by the endogeneity of the inputs and training investments selected for the establishments, (b) the problem of uncorrected sample (self-) selection biases, and (c) the potential bias due to correlation between establishments' labour training investment choices and (unobserved) product mix differences that affected levels of *revenue* productivity through relative product price differences, rather than through physical productivity differences. The main point to be noted here, however, concerns the possibility of gathering pertinent data by survey methods.

In addition, however, it is worth noticing a number of subsidiary points that appear among Black and Lynch's (1996) results, as these reinforce the argument that detailed data are well worth pursuing in this connection. First, like replacements in physical capital that reduce the average age of the machinery stock, worker training has negative concurrent effects on organisational performance due to disruption of work routines. As a consequence, positive effects are likely to appear only with some lag. To bear this in mind would be especially pertinent when seeking to elicit survey responses from employers and supervisors as to the performance effects of OJT, as distinct from out-of-work hours, off-site training. This is quite consistent with observations regarding the apparent adverse productivity effects of organisational and individual learning entailed in taking up

successive vintages of personal computer hardware and software during the "PC revolution" of the later 1980's, a point emphasised by David (1991a), among others seeking explanations for the so-called "computer-productivity paradox".

A second noteworthy finding is that there appear to be significant differences among sectors in the impact of different types of training on establishment productivity, although the clearest evidence on this point concerns the association between "computer-training" and establishments' revenue productivity levels in the non-manufacturing sector. The supposed complementarity of information and computing technologies with worker-skills has been a staple in recent discussions of the unexplained rise in wage dispersion in the US and UK, and to a lesser extent in other industrial economies (see, e.g., Krueger 1993).

A third observation suggests the importance of obtaining further detail from interviews on the content, timing and implementation of programmes such as employer-provided training and TQM (total quality management). Black and Lynch (1996) cite an unpublished 1993 study by Columbia University researchers, in which it was found that the productivity effects of high-performance work systems vary significantly with the actual manner of their implementation. This conclusion emerges also from Levy and Murnane's (1996) study of the effect of computerisation of a given business activity (a bank that had expanded into financial custodian services) upon the specific kinds of worker skills for which demand was increased. Where the workforce is expanding, it is found to be important to redesign the firm's training programmes, and worker recruitment criteria, not simply to meet the skills requirements of the new information technology, but to take into account the characteristics of the new workers who are being recruited to fill the jobs. (In the case of the bank that was expanding and upgrading its information technology, the larger number of college graduates being employed called for fewer routine work assignments.)

The upshot of these considerations is that providing subsidies for human capital investments that are undertaken jointly by employers and workers does offer the benefit of more immediately realised productivity impacts, compared to the longer-term effects of lifting the general quality of the workforce through schooling investments directed to the young. In that connection it seems important to bear in mind that the substantive content of OJT investments, i.e., the nature of the knowledge imparted to or acquired by trainees, is likely to be a matter of interest, and potentially a subject of some conflicts between employers and workers. The content of training is no less relevant for decisions as to whether, and where this form of human capital investment should be promoted by means of public subsidies. The following sub-sections elaborate upon these observations.

(i) Further training and financing

The fact that workers must finance training is not *per se* a market failure, but under-provision of skills can arise when workers do not have the resources to invest in training and there are borrowing constraints. There are serious issues of adverse selection and moral hazard that accentuate the credit constraints of workers. Of course, even if workers have liquidity constraints, they may be able to self-finance training that is useful across many firms, by accepting a wage cut while training. Elbaum (1989) discusses the benefits of the British apprenticeship system to employer financing of skills that are transferable between firms, but modern examples of trainees with wages below their marginal productivity abound.

A different problem is that there may be a conflict in the type of training desired by the worker and the firm; the firm will generally want the worker to get specific skills while the worker will prefer to get general ones for insurance reasons. If there are contracting

difficulties because of unobservability or nonverifiability of the type of training (so that the worker and firm can observe the training, but a contract specifying the characteristics of the training would not be enforced in a court), then there will also be under-provision of skills. The economics literature has studied some labour market mechanisms that seem to alleviate this problem, focusing particularly on the role of promotion to reward employees for certain kinds of training and the possibility that firms can build a reputation for not appropriating all the benefits derived from workers' specific skills.

The specificity of certain skills has broader consequences than the undersupply of training: it can also constrain the financing of *entrepreneurs*. A bank may not lend to an entrepreneur who wishes to start a business, because it (rationally) perceives that the entrepreneur will take decisions in the running of the firm that go against the lender's interest. In particular, Goddard (2000) shows that the entrepreneur has an incentive to get more general skills than the bank desires when starting the firm, to insure herself against the possible bankruptcy of the firm. Not only is financing limited, but the probability of firm failure is higher than could be achieved with the appropriate skills.

(ii) Training and the nature of specialised knowledge

The need for on-the-job training to learn specific skills is vital, but there is another, equally important, motivation for training workers on-the-job rather than in formal education related to the *nature of knowledge*. The intangible capital of individuals is not only composed of explicit and codified methods and procedures – what is referred to as codified knowledge; a large part of what people know is "tacit", acquired experimentally and transferred by demonstration. Tacit knowledge is costly to codify for transmission and use by individuals (and organisations) who work under conditions that differ markedly from those in which the knowledge originated (see David and Foray, 1995; Cowan, David and Foray, 2000). It should not be supposed that reliance on knowledge that remains tacit (as distinct from "secret") is a characteristic only of traditional, "low-tech" activities, or artisanal trades. Tacit and codified knowledge are complements at the microeconomic level, as studies of tacitness in scientific work-groups have observed. As David (1998, p. 8) puts it, "it is embodied in the craft-knowledge of the researchers, about such things as the procedures for culturing specific cell lines, or building a new kind of laser that has yet to become a standard part of laboratory repertoire".

Some intangible capital remains un-systematised in a compact and easily transferable form simply because its nature resists codification. But the incentive structure and technological elements affecting the cost of codification (for example, new electronic information systems) determine the level of effort devoted to codification: where big payoffs exist, then more knowledge tends to be expressed in forms that make it easier to transmit to others. Since formal schooling is based on the transmission of systematised information, there is a need for workers and firms to use other mechanisms of knowledge transfer in which the knowledge holders actively participate.

On-the-job training is key in this respect because tacit knowledge cannot readily be expressed outside the production context in which it is generated; it is an integral part of the work practices of research and production units. (For further discussion on the economics of tacit knowledge and codification, see: David and Foray, 1995; Cowan and Foray, 1997; Cowan, David, and Foray, 2000.) Of course, on-the-job training is not the only way in which people can acquire the tacit knowledge needed for production. "The circulation of post-doctoral students among university research laboratories, between universities and specialised research institutes, and no less importantly, the movement of newly trained researchers from the academy into industrial research organisations, is

therefore an important aspect of "technology transfer" -- diffusing the latest techniques of science and engineering research" (David, 1998, p. 8). Such transfers, of course, occur also in industry, but where firm-specific knowledge is involved efforts usually will be made to minimise such "knowledge spill-overs".

(iii) Formal schooling and further training

A final point regards the positive relationship between the formal schooling undertaken and the equilibrium amount of on-the-job training. Schooling provides intangible capital that is an essential preparation to undertake certain kinds of on-the-job training and, more generally, facilitates the acquisition of skills. This is even true of a great deal of codified knowledge, since "successfully reading the code in this last sense may involve prior acquisition of considerable specialised knowledge" (Cowan, David, and Foray, 1998, p. 9). Moreover, it provides a signal to firms about the worker's ability that increases their willingness to provide training.

As a result, people with more schooling tend to invest in more on-the-job training, and people with greater ability or better schooling tend to engage in job training more than others with the same nominal schooling (see Mincer, 1997, for evidence of this using US data). This positive relationship is a mechanism that perpetuates differences in schooling in later stages of the life-cycle, leading to permanent differences in perceived and real productivity and earnings. Therefore, market failures in the provision of higher education, or even earlier, can lead to permanent and increasing stratification of workers.

Midlife Training and Re-Training

Training becomes particularly important in situations of rapid technological change, because skills become obsolete more rapidly; this is compounded by the fact that the new skills required may not be available in the labour market but must be developed within the firm. This is emphasised by recent OECD documents (1996, 2000). Helpman and Rangel (1999) formalise this argument to show that specific skills from on-the-job training will be substituted for more formal education in times of rapid technological change, because the intangible capital gained from the latter can be transferred more easily between firms, industries, and occupations. There also will be an incentive to get more schooling and delay entry into the labour market if experience is technology-specific and people anticipate that a new and different technology will appear soon.

Another consequence of the rapid obsolescence of job skills is the need for continuous training. This is emphasised by Pischke (1996) in an analysis of the German experience. He argues that "initial vocational qualifications are not enough for workers to remain productive when work environments change quickly or when structural change necessitates switching jobs or occupations", and that retraining – through formal firm-based continuous training or informal mentoring and learning-by-doing – is crucial. More generally, it can be argued that the anticipation of rapid changes in industrial practices and technologies will induce workers to seek early education and training that allows them to be more *flexible*.

This induced demand for broader general training among the young (usually through formal education) tends to conflict with the educational policy thrust of governments that are responding to current, short-run conditions. The accelerated organisational and technological changes create the perception that employers require highly specific new skills; public authorities come under pressure from business complaints that formal education institutions are "failing to deliver what the economy needs". Although in the

short-run general and specific training necessarily will be substitutes, human capital policy for a context of rapid technological and commercial innovation must recognise that over the longer run their complementarity emerges in the lowered cost of retraining.

Rapid technological change also should create incentives for firms to adopt new industrial practices that can be grouped under the heading of "just-in-time learning"; these seek to minimise the further training costs required to yield the right mix of skills at all times. Specifically, such practices include the cross-training by co-workers, job rotation, skill-based pay, formal or informal groups, and suggestion systems that reward contributions to improve work processes or products (see Stern, 1996, for a more detailed characterisation of these practices).

The distinction between tacit and codified knowledge is germane to these technological transformations, since it has been recognised that the knowledge about new technologies is likely to be highly tacit, held only by a small group of individuals engaged in practical application of the technology in question. As a consequence, the scope for easy and inexpensive transmission of uncodified knowledge beyond the confines of such work groups remains quite restricted. The process of codification is lengthy, requiring these agents to make their discoveries and inventions manifest in physical artefacts or in published papers; this knowledge will then slowly diffuse into learning institutions. While codification is under way, practical work-based training and other forms of learning are essential for workers to understand and use the new technologies.

On the other side of the coin, it is found that modern industrial technologies have become based increasingly on science-based knowledge, and so are more amenable to codification and "embodiment" in highly automated plant and equipment. Industrial workers therefore have come to operate as the vital discretionary controllers of ("open loop") processes involving physical, chemical or electrical transformations, whereas previously they were important direct instrumentalities in such transformations. The training of such workers continues to be undertaken within these industrial facilities, but its "craft aspects" are greatly attenuated. Formal instruction imparting highly codified knowledge of both the scientific foundations of the engineering principle embodied in the technology with which they are to work, and of the computer hardware and software they must understand in order to perform their tasks properly plays an increasingly important part in the new training routines (see, e.g., Balconi 1998, 2000).

One evident implication of this trend is that the costs facing firms who must undertake this kind of plant-specific, on-the-job training are becoming more sensitive to the availability of industrial job applicants who come with not only "basic" literacy and numeracy, but also have a reasonably strong quantitative and technical grounding. The continuing penetration of codified knowledge into industrial practice is therefore creating a stronger cognitive knowledge basis for complementaries between formal educational investments and eligibility for employment in "blue-collar" manufacturing, paralleling the connections that were formed in an earlier era in regard to "white collar" employment.

Retirement

The issue of retirement generally has been neglected by the human capital literature. Nevertheless, a strong argument may be made that people also require certain types of intangible capital in their old age. People who have retired increasingly need to participate in sophisticated markets (e.g. for pensions or medical care), for which they are unprepared; clearly financing the training required to learn about these issues is even more difficult for this group of the population. Further, it can be observed that the

underprovision of human capital of kinds relevant for old age has become even more acute: in previous eras young people lived and cared for their older relatives directly, and in the process learnt the problems faced by older generations. Today, however, the increasing desire for independence by both the younger generation and their elders (when they can afford it) translates into residential and often (retirement) community segregation. Such trends raise the likelihood of a greater number of people entering the ranks of the elderly having had comparatively little experience of the realities of that stage of the life-cycle. In view of the demographic trends toward ageing of the population in the economically advanced countries, and the growing importance of the time and resources that individuals devote to activities other than market work, the economics of "education for recreation and retirement" is a subject that would seem to merit more serious attention.

Conclusions

Different stages in the process of human capital formation can be affected by market failures. While these market failures may be independent from one another, it should be emphasised that the feedbacks between family socialisation, formal education, and the work environment can lead to initial differences in human capital persisting in later stages of the life-cycle. The reason is that at each stage of the life-cycle there appear to be mechanisms that perpetuate and amplify differences in human capital and contribute to stratification. Differences in intangible human capital from the early socialisation process and the quality of primary and secondary education modify the desire and the access to financing for higher education. The better off can make better use of (government financed) education through complementary investments; people with less college education tend to get jobs for which experience and learning-by-doing is less relevant, thus reducing their future wage increases, and are offered fewer opportunities for skill acquisition by firms that use schooling as a proxy for innate ability; et cetera.

A systemic vision of the sequence of educational choices therefore points to the importance of corrective government intervention in early stages of the life-cycle, rather than in later periods. Some institutions, such as the prohibition of child labour and universal schooling, have been very important in affecting the initial level of capabilities. In general, however, it seems that parts of the process which greatly shape future possibilities are determined within the family setting of early childhood, where outside social agencies have quite limited effective leverage. Thus, seemingly "neutral" policies can yield very "biased" outcomes through these cumulative life-cycle effects.

In the view of the literature discussed, the solution for market failures is straightforward. In the case of externalities, there is a presumption that the government can intervene to force actors to "internalise" the consequences of their decisions on others. For example, if the private returns to a firm of implementing a new technology differ from the social returns – because of costs of adapting the educational curricula or other external costs, then the government could "tax" firms that adopt this new technology until the optimum adoption rate was chosen. If the technological changes are geographically localised because of the tacit nature of this new knowledge, this is certainly possible; in this respect, governments have an advantage over individual firms, which can do little to accommodate technological change.

But, again, the scope for effective government interventions will be constrained when externalities extend across national boundaries – unless very costly policy measures also are imposed to isolate the economy from foreign trade and factor movements, and the flows of information that emanate from the rest of the world. In particular, a small, open economy may not be able to influence the flows of knowledge that affect its educational

system and industrial structure. Unlike a firm, the government may be further limited by its inability to sign contracts with people to take decisions about their education and training to rapidly adjust the supply of skills to the industrial restructuring resulting from the introduction of new technologies.

It is in the light of such real-world constraints on government action that one should read the macroeconomic growth literature (surveyed in the next section) for the analytical insights it can provide, rather than as a source of practical policy prescriptions.

II.2 Human Capital and Macroeconomic Growth Theory

We must now seek to pass from the preceding examination of market and non-market processes, which impinge upon intangible human capital formation at the micro-economic level, to an assessment of their macro-level impacts. The analytical gateway through which this passage can most readily be effected is provided by the theory of economic growth. Formal growth models present a simplified version of general equilibrium analysis in which changes in the quantities of outputs and inputs in the aggregate economy, and the associated relative prices, are seen to be determined simultaneously under conditions that maintain full utilisation of the economy's growing productive potential.

Explicit treatments of the role of human capital within formal economic growth theory are of comparatively recent origins, dating from the seminal papers of Romer (1986) and Lucas (1988) in the so-called "endogenous growth theory" literature. Before that, the prevailing neoclassical theory of growth developed by Solow (1956, 1957) and Swan (1956) had centred macroeconomists' attention throughout the 1960's and into the 1970's on tangible (physical) capital accumulation as the driver of economic growth. (For a full description of this theory see Barro and Sala-i-Martin, 1995, or Aghion and Howitt, 1998.) To appreciate what the recent contributions to growth theory have to say about the role of intangible capital formation, it will be helpful first to review the main features of the preceding generation of models.

Growth with Tangible Capital Accumulation: The Neoclassical Background

The basic neoclassical modelling approach envisages the growth of output per capita (and per worker) as dependent on the process of (tangible) "capital-deepening". Average labour productivity levels are depicted as dependent solely on workers' access to co-operating inputs of physical capital services, and not on the level or distribution of education, experience, or other characteristics. The economy saves part of its current production and invests it in additional capital goods. In the simpler, one-sector formulation of these models it is assumed that the output can be used equally well for consumption or for investment in non-human physical assets, whereas the "two-sector" neoclassical models recognised distinct consumption- and investment-goods and determined their relative price endogenously, along with the quantities of each. The supply of labour to the market is assumed to depend only on the exogenously determined population size, and so labour input growth cannot arise from either "quantity" changes (such as alterations in the labour force participation rate, the length of the employed work-year, and the intensity of physical work efforts), or from alterations in the "quality" of the workers.

Since the neoclassical model of growth assumes the existence of decreasing returns to physical capital, positive growth rates of output cannot be supported indefinitely by physical capital accumulation. As the capital stock grows, the marginal productivity of

investment is reduced, leading to less capacity expansion; in the limit, the capital-output ratio is constant and growth in output per worker can only be maintained by the efficiency-enhancing effects of technological change. The latter source of sustained growth is thus exogenous and its productivity raising effects are treated as separable from those of capital accumulation. This separability feature is a consequence of the specification that technological change is "neutral", in the sense that it does not alter the *relative* marginal productivities of the factors of production, when the proportions in which labour and capital used remains unchanged (standard growth models assume what is referred to as "Harrod neutrality, " or technological progress which is purely labour-augmenting: given an unchanged capital-output ratio, such technological changes will not disturb the marginal productivity of capital inputs). The existence of this kind of technological change, and its effects in raising labour productivity, are therefore compatible with the maintenance of a "steady state" equilibrium path, along which the capital stock and output will be growing "in balance" with each other, i.e., maintaining a constant capital-output ratio, and a constant real rate of return on capital. When the model includes population growth, there is a positive steady-state rate of growth of aggregate real output which equals the population growth rate plus the exogenous technological change.

Cass (1965) and Koopmans (1965), building on Ramsey (1928), extended the Solow-Swan model to allow for an endogenous savings rate by incorporating an intertemporal consumption decision. Competitive firms rent capital and hire labour to produce and sell output, and a fixed number of infinitely lived households supply labour, hold capital, consume and save. The optimal savings rate from this model depends on the capital stock per worker, adjusting as the economy develops. In the Solow-Swan model the fixed savings rate implied that the economy could "oversave", but this is no longer possible when the savings rate is endogenous. Note that the representative household assumption precludes discrepancies between private and social discount rates. Hence, in these models, there can be no intertemporal misallocation.

Aside from the issue of savings, both these models of exogenous technological change predict that a country with a capital-output ratio below that of the steady state will invest in physical capital until it reaches the optimal ratio; if the country has an excessive capital-output ratio then it will disinvest until the right level is reached. The speed of convergence to the steady state capital-output ratio will be greater the further away the economy is from this balanced growth path. Moreover, if the countries have identical preferences (time discounting and risk aversion), population growth, depreciation (of physical capital), exogenous technological change, and initial technological levels, then they will end up in the *same* steady state. This result is called conditional convergence since the convergence requires that the economies share the same structural conditions – versus absolute convergence, which implies that poorer countries will always grow faster than richer ones. If the conditions differ, then it is possible for different countries to have different rates of growth of output in the steady state.

The two most important contributions of the Solow-Swan model are that it can (1) quantify the effects of different factors on economic growth, and (2) distinguish between *growth* effects, when changes in the parameters alter the productivity growth rates along the steady state paths, and productivity *level* effects. In the case of the latter, changes in the rate of growth of labour inputs, or in the savings supply function and the rate of depreciation of the tangible capital stock, can raise or lower the level of the capital-output ratio and labour-productivity on the balanced growth path. But the slope of the steady-state path will not be affected thereby.

This result has been seen as an unsatisfactory feature of the theory, inasmuch as it presents the long-run source of sustained labour productivity improvement (and hence growth in per capita real GDP) as dependent entirely upon exogenous technological change. The model therefore offers little guidance for public policies designed to promote faster, sustainable growth. A related criticism of the neoclassical theory is that it completely abstracts from any market failures resulting from externalities, asymmetric information or problems of monopolistic competition, and therefore presents a picture in which the competitive equilibrium coincides with the social optimum, leaving neither scope nor guidance for governmental policies.

While addressing these deficits in the neoclassical theory of growth has been an important contribution of the more recent literature, some other, more generic shortcomings remain largely unaddressed. It is important to note some of the more serious among these persisting legacies from the "old growth theory", before going on to examine the "new growth theory" in which the role of human capital has come to be discussed. Perhaps most prominent among the caveats to be mentioned in this connection is the fact that the exclusive supply-side orientation of virtually all the model-building work in this area has led to a narrow focus on the characteristics of "balanced" (or steady-state) growth paths.

Although the notion of steady state growth is a very useful analytical construct, in permitting the study of "comparative equilibrium dynamics", the growth theory literature is not empirically well-grounded in representing the experience of long run growth as a "steady-state equilibrium" process. Nor has it provided an adequate characterisation of the observed behaviour of the economy when it is away from its steady-state path; indeed, the maintained hypothesis of "real business cycle theory" is that the economy never gets pushed far from its supply-determined equilibrium path.

The two prongs of the foregoing criticism should be understood to be quite different in their implications. The first point accepts that the long-term historical record of macroeconomic performance in the US and other advanced economies can legitimately be read as a reflection primarily of supply-side developments that gave rise to the trends in potential (full-employment) real output and productivity. But within that framework, economic historians have shown that careful reading of the evidence rejects the view of growth as movement along an unaltered steady-state path, in favour of interpreting it as a sequence of extended transitions, or "traverses", between steady-state growth paths (see, e.g., Abramovitz and David 1973, 1999; David 1977, 2000).

The second point of criticism focuses on the question of whether it is legitimate to separate the trend from the cycle for purposes of analysis and explanation (see, e.g., Duesenberry 1958, for an alternative approach). The neglect of the economy's *disequilibrium dynamics* – which is entailed in thus abstracting from shorter-run macroeconomic responses to exogenous demand shocks, and endogenous fluctuations in the involuntary employment rate and the rate of utilisation of fixed plant and equipment associated with the business cycle, cast doubts upon an important presupposition common among those engaged in modelling economic growth.

Specifically, it calls into question the validity of the claim that the steady-state growth path solution(s) found for these models are locally as well as globally stable; that convergence to all such paths will be sufficiently rapid to provide a reasonable description of actual dynamic behaviour (see Fisher, 1983). In other words, if one cannot offer a good account of the economy's movements when a disequilibriating "shock" takes it away from a steady-state growth path – there may be no sound basis for assuming that the ensuing disequilibrium dynamics takes the form of simple convergence back towards the pre-

existing growth path, or in a smooth traverse to a newly defined steady-state configuration.

A message of caution to take from the preceding remarks is that, like the models cast in the neoclassical mould, the recent wave of endogenous growth models tell us about the contrasting (dynamic) equilibrium configurations that are implied by different constellations of their underlying structural relationships and parameters. Comparisons among those equilibrium states, however, in most cases can tell us very little about the actual time path of reactions that would ensue from particular policy interventions that altered one or another parameter of the macroeconomic system.

Endogenous Growth Theory

The current literature on endogenous economic growth emerged primarily as an attempt to encompass the sources of technological progress, and hence of sustained productivity growth *within* the general equilibrium framework of neoclassical growth theory. As the focus of this critical review is restricted to the recent economic literature, our treatment of economic growth theory is essentially co-extensive with the body of work on formal, or mathematically formulated growth models. It is therefore appropriate to draw initial attention to the existence of earlier contributions to the modelling of endogenous technological progress based upon the accumulation of learning and wealth-related investment in education.

In particular, the mathematical growth models developed by Haavelmo (1954, pp. 24-44) recognised the endogeneity of the growth of knowledge and its role in modern economic growth: output growth depended on “the accumulation of knowledge” and the state of knowledge was represented as an index of “education and know-how” that cumulated the “educational effects” of physical capital investments that matched the savings supply along the full employment growth path. This “learning by doing” specification anticipated Arrow’s (1962) model of growth with endogenous technological change. Haavelmo also sought to represent the growth of the population, and hence the labour force, as endogenous, by specifying a negative relationship between the birth rate and an index of “the level of education” for the population that was dependent upon per capita real wealth. Alas, Haavelmo (1954) worked out his models using specifications of the aggregate production function that proved less mathematically tractable, and yielded less intuitively appealing results than those provided by the models of Solow (1956)-Swan (1957) formulation. The latter, elegantly simplified formulation rapidly established itself as the dominant paradigm in the theoretic growth literature.

(i) Increasing returns due to externalities of specialised tangible investment: The “AK model”

The principal initiator of the new fashion in growth theory, Romer’s (1986) “AK model”, generates sustained growth by assuming that technological change is the unintended result of the firms’ investment decisions. Firms decide their investment without considering the positive effect that the additions in the capital stock will have on the productivity of all the other firms in the economy. The result of this externality is that the production of goods can avoid the decreasing returns to physical capital that prevent steady rates of labour productivity growth in the Solow-Swan and Ramsey models when there is no technological change. Mankiw, Romer, and Weil (1992) and Barro and Sala-i-Martin (1995) argue that another interpretation of the existence of constant returns in the AK model is that capital may be viewed broadly to include physical and human components.

When the production function has constant returns to capital, the model implies a constant growth rate, but when the externality is so large as to produce increasing returns, growth becomes explosive. Solow (1994) criticises the AK model for its knife-edge character, which makes the model unrobust: any infinitesimal deviation away from constant returns to physical capital either eliminates sustained growth or makes it explosive. A different and perhaps more fundamental criticism of the AK model is that it assumes technological change to be an accident of other productive enterprises, rather than an economically valuable activity decided on by rational agents.

The AK model implies that there is no convergence among economies: if a country starts at a lower capital and output per capita, it will not grow at a faster pace than a richer country, and differences will persist over time. (We may note that an analogous result is found by Lucas, 1988, where differences in the initial educational level of the labour force are shown to persist, as will be seen.) The existence of the externality, however, implies that the competitive equilibrium of the AK model does not coincide with that which could be achieved in an optimal socially planned economy, thereby introducing a role for government policies designed to enable poorer economies to close the gap with those that were initially at higher per capital output levels.

(ii) Increasing returns due to externalities of investments in intangible assets

The endogenous growth models that followed Romer (1986) fleshed out the process of technological change through the *explicit* introduction of human capital and/or knowledge. The literature can be separated into two separate strands, depending on the role played by human capital in promoting economic development. The first, pioneered by Lucas (1988), considers human capital to be another input in the production function, not fundamentally different from physical capital, although it can only be accumulated by workers through certain activities – principally education or on-the-job training. A second line of analysis, originating in the work of Nelson and Phelps (1966), is formalised by Romer (1990). It recognises the role of human capital as an input to conventional production but doesn't regard this as its most important function, emphasising instead the part it plays in innovation. In this perspective, human capital has the inherent capacity to modify itself and the other inputs also, and it is this property that leads to a permanently dynamic economy; human capital is the only factor of production capable of creating new and improved production processes and goods, in addition to promoting their diffusion through the economy. In the following sub-sections, these two different kinds of endogenous growth models and their implications are described in greater detail.

(iii) Growth with human capital as a factor of production

Lucas (1988) includes human capital as an additional input in the production of goods, while retaining the other features of the neoclassical growth model. In the model, the labour force can accumulate human capital, which is then used together with physical capital to generate the output of the economy. In one version of the model, human capital is acquired through time spent in an (non-productive) educational process, introducing a trade-off for workers between employing time to produce output and using it to gain further human capital that will increase their marginal productivity when working in subsequent periods. In another version of the model, human capital is gained by the workers through on-the-job training, and so the time employed working increases their productivity later on. The accumulation of human capital involves a sacrifice of current utility in the form of less current consumption in the case of education, or a less desirable mix of current consumption goods when on-the-job training is considered.

In the Solow-Swan and Ramsey models, the equation describing physical capital accumulation is sufficient to determine the dynamic evolution of output. To specify the growth path when human capital is included, it is necessary to consider an additional sector where the growth of human capital takes place. Given that physical capital still has diminishing returns, the required assumption for the model to exhibit a positive growth rate of output per worker in the steady state is that the "technology" for generating human capital has constant returns. This means that the growth of human capital is assumed to be the same for a given level of effort whatever the level of human capital attained. With this assumption, the rate of output growth (per worker) is positive and increasing in the productivity of education or on-the-job training in the creation of human capital.

Note that linearity in the production of education or on-the-job training is a strong assumption, not warranted by either theoretical or empirical literature on the microeconomics of human capital formation. In fact, human capital theory normally specifies that the marginal return from each extra year of education is decreasing, both because the skills gained have less impact on the worker's productivity and because the worker has less time left in which to recoup the investment made before retiring. Lucas (1988), however, justified his assumption on the argument that (at the societal level) constant returns to human capital formation are the consequence of a social feature of the human education and training processes, whereby each generation of workers is able to inherit part of previous generations' knowledge. But the way in which this came about was not specified.

Azariadis and Drazen (1990) and Redding (1996) undertake to model the mechanism of human capital transmission across generations in the more plausible framework of an overlapping generations model (Lucas followed Ramsey in the simplifying assumption that households, as well as firms, are infinitely lived). In these models agents inherit the human capital accumulated by the previous generation; they then decide how much time to devote when young to a training technology that increases labour quality, thereby affecting their marginal productivity when older. Since a given generation deciding its *own* human capital investment does not take into account the intertemporal spill-over effect upon the human capital endowment of *future* generations, there is a technological externality that can result in constant or increasing returns to human capital at the social level. This state of affairs could be ascribed to the impossibility of contracting with the future generations, and sometimes is described as an allocational inefficiency due to "incompleteness of markets". The source of this problem affecting human capital investment is therefore rather different from the set of conditions previously seen to impair the allocative efficiency of markets that do exist.

With respect to on-the-job training, Lucas argues that while there may be diminishing learning by doing on a particular good or production process, the additional productivity is also inherited within a "family" of goods. Stokey (1988) and Young (1991) formalise this idea in a model of economy- wide learning-by-doing. In their models, there are positive spill-overs from any individual firm's experience in production to the rest of the firms' costs, and from the experience of the firm in the production of any one good to the production of other goods. Stokey's and Young's models of knowledge spill-overs, however, differ from the structure of Lucas (1988); they conceive growth as driven by the enhancement of product quality through the introduction of new goods, rather than by human capital accumulation. That is, the focus is on "un-embodied" knowledge regarding skills and technology, rather than knowledge embodied as human capital via a costly educational process. In this regard, the approach of Stokey and Young is more closely related to the growth theory literature focused on the connections between human capital formation and innovation, which will be examined below.

Lucas proposes, much as Romer (1986) did in presenting the AK model, that there may also be a contemporaneous externality between workers such that a rise of the average skill level in the economy would increase the marginal productivity of all the factors of production. The rationale for this externality, which was originally envisioned in the work of Arrow, is that agents benefit from others' human capital but do not take this into account when deciding on their allocation of time between production, leisure, and education. Incorporating an "external effect" of human capital results in equilibrium growth rates that do not coincide with the efficient growth rates, once again indicating scope for welfare enhancing public policy measures. In the model with education, this would require a subsidy to schooling that offsets the inability of agents to internalise the benefit their own investment in human capital will convey to others in their own generation. In the model with on-the-job training, the intervention requires "picking winners", in the sense of subsidising the production of those goods where there is a high return to on-the-job training.

Acemoglu (1996) has offered a formal demonstration of how positive spill-over effects (pecuniary externalities) created by workers' educational and training investment decisions can give rise to macro-level increasing returns in human capital. His model supposes that workers and firms make their investments in human and physical capital, respectively, before being randomly matched with one another. The direct consequence of random matching is that the expected rate of return on human capital is increasing in the expected amount of (complementary) physical capital with which a worker will be provided; similarly, the return on physical capital is increasing in the average human capital that the firms expect the workers to bring to the job. Hence, an increase in education for a group of workers induces the firms to invest more in tangible assets, thereby increasing the return to all workers in the economy. Through a similar argument, the model is seen also to imply that there are "social increasing returns" in physical capital.

The importance of Acemoglu's (1996) analysis lies in the attention it calls to the interactions between the two forms of investment, and the dependence of this source of social increasing returns upon some measure of co-ordination being achieved between them. In the model the high level co-ordination equilibrium is attained because, in effect, both firms and workers are implicitly assumed to be "risk neutral" and willing to commit to irreversible investments on the basis of the expected payoffs from probabilistic job-matching. By the same token, the analysis has two limitations that are worth noting. First, the externality results derive crucially from the presumed difficulties, if not the impossibility, of firms and workers contracting with one another *ex ante*, in advance of their investment decisions. In some situations, where the duration of the "training investments" is very extended, this may be quite realistic. But even there, where legal provisions for "bonding" trainees exist, co-ordinated decisions to train and to employ may be arrived at, and so "internalise" the potential investment externalities. The special arrangements used by the armed services to furnish themselves with a trained medical corps constitute a familiar illustrative case.

The second limitation is related to the point noticed previously concerning risk-neutrality. If random matching results in some workers ending up in the wrong jobs (i.e., in jobs that require a different level of skill than the one they have obtained, not to mention different skills altogether), they will find they have wasted some of their human capital investment. This is so especially when, as the microeconomic evidence cited by Acemoglu (1996) indicates, the higher costs of job search once workers are installed in a job lead to considerable persistence even when the match with the employing firm is not close. Symmetrically, firms would wind up with unsuitable workers who required to be further

trained before being trusted to use the specialised facilities in which capital had been sunk, or possibly with over-qualified workers who were discontented and adversely affected the morale and performance of others.

In other words, there is a worrisome "down side" to probabilistic matching, and the consequences of that would surely be considered by rational agents. It is only reasonable to suppose that in a dynamic environment both firms and workers would learn from these matching mistakes, and would try to devise selection rules to reduce the costs of future mismatches. But if the economic losses involved were large, and if such remedies proved largely ineffectual in avoiding them, the response to the uncertainties surrounding the payoffs surely would militate against the probabilistic investment strategies assumed in Acemoglu's model. In other words, there is also a low-skill, low capital investment co-ordination equilibrium in this model. That would suggest a significant role for public agencies: providing better information that would reduce the degree of uncertainties, and so prevent the economy from being pushed into co-ordination on under-investment strategies that lead to a low productivity growth path.

(iv) Human capital externalities and international convergence

Lucas's (1988) analysis predicts that economies which start with a poor endowment of physical and human capital will remain poor relative to richer countries; even though the growth rates will be the same in all countries when they reach their respective steady state paths, on which the fraction of labour time devoted to education is unchanging and the marginal products of physical and human capital are also stabilised. This non-convergence result, of course, is sensitive to the model's specifications that there is (a) no inter-country "spill-over" in the methods of producing human capital and (b) no migration of workers.

Both of these assumptions can be readily challenged. Consider not only the international dissemination of codified and uncodified knowledge used for instructional purposes, but the diffusion of educational institutions and institutionalised organisational practices – such as systems of external examinations, local, regional and national school systems with supervisory bureaucracies, school inspectors, etc. In addition, many examples of the international spread of pedagogical techniques may be cited; such as the "Montessori method" in infant schools, computer-based remote instruction at the university level, the "case method" in M.B.A. programmes. But it is another matter as to whether these outwardly similar "technologies" of instruction can be used with equal cost effectiveness everywhere, even within broadly homogeneous societies, let alone across fundamentally different cultural milieus.

Although spill-overs of "knowledge about conveying knowledge" could be a significant promoter of convergence, and therefore ought not to be assumed away, neither should they be supposed to operate automatically and costlessly. Indeed, it is likely that such knowledge transfers require significant complementary local investments and managerial abilities. Differential organisational "absorption capacity" becomes relevant in this context, as it is in the case of technology spill-overs. Yet, where formal educational infrastructures are concerned, the all but universal dominance of public sector financing and state provision of schooling implies that market mechanisms on the supply side will not have much leverage; differences in the organisational knowledge-borrowing capacities of government bureaucracies may therefore be a more critical source of international differences in the educational levels attained by the mass of the population.

In a subsequent article, Lucas (1993) presents a growth model with human capital spill-overs, but the human capital in question is not embodied, and therefore is more closely akin to technological knowledge. As might be expected, the possibility of cross-country spill-overs substantially alters the convergence conclusions of the previous model of "informationally isolated" economies: if each country's evolution of human capital is driven by the world average, then convergence will result. On the other hand, it may be that the average human capital stock differs between groups of countries, in which case each group would converge to a different steady-state determined by the relevant average human capital stock (so-called convergence-club dynamics, studied by Quah, 1997, and Durlauf and Quah, 1998).

(v) Intangible capital, innovation and growth

Since the work of Romer (1990), Young (1991) and Aghion and Howitt (1992), the endogenous growth literature has stopped modelling human capital as an ordinary input to the production of goods and considered the *other* important activities pursued by skilled labour, concentrating especially on innovation and its diffusion through the economy. Two separate types of innovation are considered: first, innovation as the creation of a greater variety of goods and production processes; and, second, innovation as the improvement of existing goods' quality. Romer (1990) emphasises the creation of new capital goods by a fixed, exogenous number of skilled workers; unlike Lucas, where the capital goods are unchanged and the human capital is determined within the model. Romer argues that workers with human capital can be allocated to the design of new intermediate products that are subsequently used in a final product market production or to production itself. The new "knowledge" generated is nonrival, partially excludable, and can be accumulated without bound on a per capita basis; contrasting with human capital, which is rival and excludable, since it is incorporated in the workers, and for which there is an upper bound to accumulation determined by the finite lifespan of an individual.

A consequence of the nonrival, partially excludable nature of knowledge is that there is incomplete appropriability of the profits generated by an innovation; while the designs for the production of capital goods cannot be used freely to produce output, they can be used to develop new designs that erode the other goods' profits. This in turn implies that knowledge cannot be paid its marginal product under perfect competition without negative profits for the firm. An important contribution of Romer's model is to introduce imperfect competition in the intermediate goods sector, which then generates a stream of rents to the firms when they innovate, partially circumventing this problem.

Positive long-run growth is sustained in Romer's model by the accumulation of knowledge, thought of as an expansion in product varieties. The necessary assumption for permanent growth is for the research sector to have a constant returns technology, such that increases in the "knowledge stock" do not reduce the marginal productivity of further research. Since knowledge accumulation is responsible for growth, it is the fraction of the skilled labour force in the research sector and the productivity of this pool of labour that determines the growth rate of output in the economy's steady state. In addition, since the model assumes that the human capital required for research is the same as that for the production of output in the final goods sector, the rate of output growth is ultimately determined by the size of the skilled labour force in the economy. This result is very significant: when skilled labour is considered solely as an input for production, the growth of output can only be affected by different rates of human capital accumulation, but when human capital is thought of as a factor of innovation, growth is sensitive to the level of the human capital stock.

In Romer's analysis, there is suboptimal human capital accumulation and growth resulting from, first, an externality arising from the effects of knowledge on future productivity, and, second, the effects of monopoly pricing in the intermediate sector, which results in suboptimal levels of acquisition of new vintage capital goods. These market failures are seen to justify government intervention; as a consequence of the model's structure, government subsidies to the production of human capital can increase growth and welfare somewhat, but only a subsidy to knowledge creation can reach the social optimum. Similar results were derived by Grossman and Helpman (1991c, Ch. 3) by considering an expansion in the number of consumer products, rather than intermediate capital goods.

Stokey (1991, 1995), Grossman and Helpman (1991a) and Aghion and Howitt (1992) model innovation as a process that increases product quality; Aghion and Howitt stressing the obsolescence of capital product designs and knowledge generally, which both Lucas and Romer ignore. In these models, innovation is generally modelled by embedding a patent race into the Romer framework, whereby the firms must spend human capital resources in R&D to gain a certain probability of discovering an enhanced quality product. This good then yields a stream of monopoly rents to the successful firm until the next innovation appears. As in Romer, there is an inefficient outcome because of an (intertemporal) spill-over, as each innovation permanently raises the productivity of future goods, and the monopolistic appropriability effect. In addition, obsolescence introduces a "business stealing" effect, as researchers do not internalise the destruction of rents to the current holder of a production patent when deciding on the amount of R&D to invest.

The stochastic nature of innovation in these models means that output follows a random walk with drift such that the *average* growth rate is increasing in the size of the skilled workforce and in the productivity of research. Therefore there is no prediction of convergence. Young (1993) and Stokey (1995) generalise the previous literature to show that the equilibrium rate of R&D, and therefore the growth of output also, depends on the degree of substitutability or complementarity among goods, the nature of competition, and the properties of the innovation technology.

The interaction between the investment, training, and R&D decisions is crucial to these recent explanations of endogenous economic growth with human capital. This systemic feature of the relation between human capital and R&D is most clearly exhibited in a growth model developed by Redding (1996), in which Aghion and Howitt's (1992) assumptions are modified to allow for an explicit choice by workers of the time to devote to education, whilst the entrepreneurs decide on how much to invest in quality-enhancing R&D. Since these decisions are taken separately, and the workers are then assumed to be matched randomly to entrepreneurs, their optimal investment depends on each other's *expected* investment. In particular, if workers expect entrepreneurs to invest in R&D they will invest more in human capital because of the increased marginal productivity of human capital that would result. Similarly, entrepreneurs will invest more if they expect workers to have acquired human capital. The result of this strategic complementarity is that growth depends very much on the expectations of the agents' investment decisions. Redding proves that there may be a high-growth equilibrium for which both make high investments, but the possibility of a low-growth equilibrium exists also. Moreover, this raises the issue of government intervention to co-ordinate expectations of the agents in the economy, perhaps by giving a subsidy to either R&D or to human capital accumulation in order to induce the economy towards the high-skills and high-growth equilibrium.

The diffusion of innovations, be they the result of an expanding product variety or quality improvements, is the other essential contribution to growth of human capital considered by the endogenous growth literature. Young (1991) studies the diffusion of innovation

within an economy, while other authors (Grossman and Helpman, 1991b; Barro and Sala-i-Martin, 1995, 1997) study the problem in an international context by dividing the world into two groups of countries, generically named “leaders” and “followers” depending on their relative technological advance. A key assumption in these models is that the follower finds imitating the leading economies cheaper than innovating when the technological distance is very great, but that the cost of imitation increases as the technological gap is shortened; this assumption implies a form of diminishing returns to imitation. As a consequence of that condition, the followers prefer to copy than to invent and the relatively lower cost of imitation implies that they grow at a faster rate than the more advanced countries, for otherwise identical economies. These diffusion models therefore predict catch-up by poor countries and convergence of output per capita in the long run.

Under the assumed conditions of such a model, copying is possible because of the public-good character of technology and limited property rights. These elements, accentuated by imperfect competition, imply that the outcomes are not optimal: the leading economies generally have insufficient incentives to innovate and the followers have excessive incentives to imitate. The models with diffusion have other interesting implications. First, they too (like Lucas, 1993) can generate clusters of countries with different output per capita in the steady-state if there is more than one relevant technological leader. Second, the models encompass the possibility of “leapfrogging”, whereby the technological leadership shifts from one country to another (Brezis, Krugman, and Tsiddon, 1993).

Leapfrogging will occur when there are major technological changes in the context of imperfect knowledge spill-overs across countries – due to national specificity of learning, justified perhaps by the imperfect codifiability of technological knowledge. Brezis, Krugman, and Tsiddon (1993) argue that more developed countries will have accumulated more experience (learning-by-doing) in older technologies, making them less inclined to change to new technologies that are initially less productive because they can’t transfer their previous production experience. Lagging economies have greater incentives to adopt the new production techniques and will overtake the leaders when these prove to be more productive than the older ones; the result is that “economic leadership will tend to be the source of its own downfall”. More generally, the existence of any sunk costs produces inertia in the techniques of production utilised, because the firm or country must compare the marginal cost of the old system to the (higher) average cost of the new one.

Stiglitz (1987) makes a more comprehensive statement about the selection of technologies. He suggests other mechanisms can lead to the dominance of one technology besides learning-by-doing. There is what he calls “learning-to-learn”, which means that experience in learning increases the productivity in *learning*, just as experience in production increases productivity through learning-by-doing; this explanation focuses on learning as an activity, similar to producing in that it too requires a process of specialisation, but it begs the question of the nature (codified or tacit) and whereabouts (e.g., in the “know-how” of organisations) of this capacity to learning. Following the analogy a step further, the author asserts that there are some spill-overs from learning-to-learn, just as there are from the knowledge about one technology itself; but these spill-overs are not complete: there is partial localisation in the learning process, so that learning to perform a set of tasks is useful to learn how to perform another, related set of tasks.

Stiglitz’s analysis carries at least two implications for the present discussion. First, unlike Brezis, Krugman, and Tsiddon (1993), the lagging economies may not be able to adopt the new production techniques and “leapfrog” because they are not only behind in production: they also lag in the capacity to absorb and adapt the technologies, especially

so if the knowledge about the new techniques is not fully codified or the technology is very specific to the context. Therefore economies can become "locked-in" to a technology that traps them in a low output growth equilibrium, and thus convergence would not be expected. Secondly, firms' and nations' "ability to learn, as well as their state of knowledge, is critically dependent on past history". For example, a "labour shortage may induce firms to shift to a less-labour intensive technology; but subsequently, when the labour shortage is eliminated, the new technology may dominate the one previously used" (Stiglitz 1978, p. 134). This viewpoint of economic growth diverges markedly from the *ahistorical* exogenous and endogenous growth models discussed earlier; it also points to the importance of dynamic elements in policy consideration rather than just an analysis based on static comparative advantage.

(vi) Dynamic interactions: human capital investments and technological innovation

Among the more interesting recent developments in the analytical treatment of the role of human capital in macroeconomic growth has been the effort to recognise the existence of reciprocal influences in the dynamic interaction between technological changes and the formation of productive capabilities embodied in members of the workforce. The key insight into this is the existence of technical complementaries between the two classes of assets, both of which require irreversible (costly) resource commitments. On the one side are specific technological and organisational practices, intangible knowledge-assets, which result from deliberate inventive activities, or arise as a by-product of experience gained in actual production operations. On the other side is an array of physical production facilities and human capital assets that yield flows of productive services, and in which technological and organisational knowledge can be embodied.

As has been recognised in the theory of factor demand (since Hicks, 1932), changes in the state of technological knowledge may alter the relative marginal productivity schedules of the primary factor inputs (labour and tangible capital). Thus, the derived demand implications link the relative rates of accumulation of productive assets to expectations about the future marginal productivity relationships, and consequently to the expected future structure of relative asset prices. "Non-neutral" trajectories of technological and organisational innovation are those that imply an alteration of the expected relative input prices, in the absence of any intervening change in assets' relative availability in the economy. Within the class of productive assets there are complements as well as substitutes. Concretely, machines may substitute for repetitive, low-skill labour services, such as those of a trench-digger, whereas the mechanical back-hoe requires a skilled driver to operate it without tearing up water-mains and electricity cables; numerically controlled lathes may dispense with some of the skills of the machinist, but nonetheless demand the services of operators who are capable of programming and reprogramming them on the shop floor.

On the other side of the picture, however, the theory of induced innovation points to the reciprocal influence that expectations about the future value of that knowledge in production applications will exert on decisions to invest in creating new technological knowledge. It thereby highlights the role played by the future availability and prices of the necessary productive inputs in establishing the anticipated, privately appropriable returns to those creating new knowledge of that kind (see, e.g., Binswanger and Ruttan, 1978). Consequently, the direction of deliberate, profit-motivated R&D investments (i.e., their "neutrality" or "biasedness" with regard to relative input usage) will respond to changes in

expectations about the relative rates at which the various forms of tangible capital stocks and intangible human capital are accumulating, and to whatever alterations may be expected to occur in the pattern of (technical) complements and substitutes among the array of specific physical capital and labour service inputs.

A recent paper by Acemoglu (1998) directs attention to the potential complexities in the dynamic interactions between those two processes. Because human capital formation typically has a rather long gestation period, and the same is true of physical capital in many cases, the adjustment of prices in the markets for these productive assets tends to occur much more quickly than the quantity adjustments; moreover, induced changes in the direction of innovation depend upon the expectations of future relative input prices and the anticipated scale of application. Expectations about the extent of the market for a new technological innovation, of course, should be reflected in (and hence signalled by) the expected future real unit prices of the technologically-specific inputs, i.e., the ratio of the inputs' price to the price of the end products.

Motivated by the experience of the US economy since the early 1970's, when the college-graduates belonging to the baby-boom cohort flooded into the labour market, Acemoglu's model traces a dynamic sequence in which an exogenous (or, equivalently, an endogenous but lagged) increase in the availability of workers having particular higher level skills/capabilities at first depresses the relative skill-premium; but the expectations that this situation will persist then induces "directed" innovations that are biased towards making more intensive use of just those skills. The eventual arrival and adoption of these innovations (loosely associated with "information technology" in Acemoglu's discussion) then generates a sufficient increase in the derived demand for workers with complementary capabilities to reverse the previous trend towards compression of the skill premium. Indeed, as there is no further supply increase comparable to the initiating (unanticipated) labour supply "shock", the induced technologically-driven demand for skilled workers is sufficient to produce a trend towards greater wage and earnings inequalities.

There is a critical supposition underlying this analysis, although not one that is explicitly developed by Acemoglu (1998): expectations that the biased trajectory of (IT) innovation will continue for some time into the future are quickly formed and shared by the household sector, as well as among the firms. This is so because the household sector's opinion about the desirability of undertaking investments in training for future employment involving the supposed technology-related skills must underpin the allocation of private and public resources for such purposes. Lacking that, there is nothing in the picture to prevent the human capital formation process from being slowed, or halted by initial experience of the collapsing skill-premium. Thus, it is not enough that the firms know they are making R&D investments premised upon the future availability of the right kind of (complementary) capabilities in the workforce. The firms need to know that this is known and understood by the agents who must make the necessary forward-looking decisions as well, if those premises are to be fulfilled.

This is essentially the same kind of co-ordination problem that was recognised and made central in Acemoglu's (1996) model of the role of labour-capital complementaries and externalities in creating social increasing returns to human capital investment. Remarkably enough, that earlier paper is not mentioned or even referenced by Acemoglu (1998), yet its main results are quite critical in the present connection. Indeed, the different characteristic speeds of adjustment in the markets for the different types of intangible knowledge-assets (skills and technologies) only further complicate the fundamental difficulties of achieving the appropriate intertemporal co-ordination equilibrium. It is useful,

of course, to show that one can formulate a growth model in which there exists an equilibrium path characterised by high rates of human capital formation and technological progress. Yet it is unwarranted and potentially misleading to completely gloss over the disequilibrium dynamics of such a dynamic system, thereby creating the impression that the unassisted market always could be depended upon to find that path automatically and stay on it.

This is so particularly in the case of this model, because "the reality" more likely would entail periods of skill-shortages, under-utilised production facilities, over-commitment to training programmes; alternated with episodes of labour-market congestion, lengthening job-search durations, over-qualified workers, and – for a growing portion of the cohort of labour-market entrants – rising debt-burden and disillusionment with the institutions of further education and professional training. A critical issue that this raises is whether such episodes would also seriously interrupt, and even re-direct, the trajectory of technological change. In the context of Acemoglu's (1998) model that would seem to be very much a possibility, given that its specification of the innovation process represents the latter as lacking any inertial components and therefore sensitive to current changes (expected) input prices and quantities. In this connection we may notice the rather different conclusions that would be suggested by an alternative, non-neoclassical theory of technological change that also allows for "non-neutrality" in the effects of endogenously directed innovation (see David, 1975, esp. Ch.1, for further treatment of neoclassical and non-neoclassical macro-models of induced innovation).

The immediately relevant difference between the two theoretical formulations lies in recognising that some important part of "directing" comes from the rear – that is, from the constraints created by the cumulative nature of technological progress, and not only from inventors' expectations about the state of relative factor prices that will prevail in the future. Thus, past choices of technique, and the sunk costs associated with them will exert persisting ("hysteresis") effects upon both the rate and direction of technological improvements that are generated along established trajectories of innovation. This is especially relevant where technological progress takes the form of a more-or-less continuous stream of incremental, highly localised innovations (Antonelli, 1995).

Such "localisation of technological change" may result from either (a) unplanned knowledge generated essentially as a by-product of production activity, including the formation of new, plant-specific workforce skills, or (b) knowledge gained in previous production as a result of deliberate efforts to enhance the efficiency of existing production facilities within the engineering and labour management constraints that those impose, or (c) conscious R&D strategies of elaborating and extending established "families" of products that exploit a common scientific knowledge base or a specific set of perfected production methods.

Under those conditions, a bias of technological and organisational change towards intangible human capital-deepening methods might become established and persist for a protracted period, imparting more or less steady, upward pressure on the demand. Although lags and the effects of disturbances on the supply side of the labour market – due to demographic developments and public policies affecting funding and provision of training – might well result in episodes during which the expectations of high private rates of return to investments in further education and training will be disappointed. Yet, where the underlying technological trajectory has become established and the co-evolution of institutions and political commitments supporting the extension of mass education has acquired strong momentum (from the sunk costs and individual professional and

commercial interests it involves), the emergent dynamic properties can become increasingly robust.

But a rather different state of affairs exists elsewhere, especially for economies that face the challenge of initiating a major technological and structural reorientation, calling for complementary changes in the capabilities of its labour force. When considering the latter context, perhaps the most significant point to note is the one that emerges when Acemoglu's 1996 and 1998 contributions are read in conjunction: it is quite a delicate matter for a market system to establish a smoothly virtuous dynamic of positive feedbacks that will continue to drive growth at the macroeconomic level. The reason, simply put, is that the spill-over effects required must be underpinned at the microeconomic level largely by *mutually aligned expectations* regarding the positive pecuniary externalities that will result from investments in a variety of technically complementary durable assets.

Such will be the case especially where the "investment projects" that are required to achieve complementarity between the characteristics of newly developing technologies and matching worker capabilities are those which can entail unusually long periods of gestation. For a free market economy to arrive spontaneously at an automatically sustainable set of such expectations is difficult, and therefore highly unlikely. The good news – or, perhaps one should say, the less discouraging news – is that the important initiating and guiding function that exists to be filled in such situations is one that lies well within the scope of established national government agencies in most countries, save for the poorest and smallest.

II.3 Empirical Findings on Human Capital and Macroeconomic Growth

The Modern Cross-country Evidence

The literature of endogenous growth theory has stimulated economists' interest in the empirical evidence available from cross-country comparisons, bearing on the main-level relationships between human capital formation and the growth rate of real output per capita. The growth models that view human capital as a simple input to production predict that growth rates will be positively associated with changes in the stock of education, whereas models in which human capital has a role in the development of innovations and its diffusion throughout the economy imply that it is the stock (rather than the flow) of human capital that affects the overall productivity growth rate of the country.

(i) Measuring the stock and flow effects of human capital on output growth

Early studies of the effects of human capital on growth, such as Mankiw, Romer, and Weil (1992) or Barro (1991), were based on data sets pertaining to a very diverse array of (more than 100) countries during the post-1960 era. They used narrow flow measures of human capital such as the school enrolment rates at the primary and secondary levels, which were found to be positively associated with per capita growth rates. Barro reported that the process of catching up was firmly linked to human capital formation: only those poor countries with high levels of human capital formation relative to their GDP tended to catch up with the richer countries.

Later studies by Barro and Lee (1993) criticise the school enrolment measures of human capital used for measuring the flow rather than the stock of human capital, and tackle this by constructing new indicators based on educational attainment of the population. The

new indicators measure the number of years of school attainment, categorising it into those with no schooling, some primary, some secondary, and some higher education. While the Barro and Lee (1993) indicators can capture a measure of the stock of human capital, they can do so only crudely, because they omit the possibility of differing quality of this stock. Barro and Lee (1996) extend their previous indicators to consider a proxy of quality based on the school inputs using measures such as the public expenditure per student, teacher-pupil ratios, estimated real salaries of teachers, and the length of the school year.

Inputs to schooling may be too narrow a measure of human capital quality, and measures based on student cognitive performance could be better in accounting for the other non-school inputs to human capital, such as family influence, and differing ability or motivation. Hanushek and Kim (1995) analysed data derived from tests of academic achievement, concluding that the quality of the labour force has a consistent and strong influence on economic growth, and that, together with the quantity of schooling and initial income, 40% of the variation in growth rates can be explained. Barro and Sala-i-Martin (1995, Ch.12), among many others, have also included life expectancy and infant mortality in the growth regressions as a proxy of tangible human capital, complementing the intangible human capital measures derived from school inputs or cognitive tests considered; their finding is that life expectancy has a strong, positive relation with growth.

A recent survey by Krueger and Lindahl (1999, 2000) of the findings from these econometric studies of cross-country growth equations characterises the more robust results. First, changes in the human capital stock do not seem to affect growth rates, as would be implied by the model in Lucas (1988) or a macro-extension of the Mincerian human capital theory. This contrasts with the robust evidence from the micro literature of education on income (recently reviewed by Card, 1999), and leads Krueger and Lindahl to suggest that because of measurement errors in the estimated human capital data in many studies, the educational variables have essentially no “signal” after conditioning for physical capital investment rates. When allowances are made for these measurement errors, the change in stock measures of education is positively correlated with economic growth (see also Topel, 1999). Secondly, the evidence with respect to the positive effect of the level of human capital stock on growth rates is much stronger. But the size of this effect varies across countries; and it is not linear as has been generally assumed by the endogenous growth model literature. In particular, among countries that have attained a high average level of education (e.g., the OECD economies), the initial level of education appears to be unrelated to their subsequent growth performance.

Two other well-established results that emerge from the cross-country studies examined by Krueger and Lindahl are: (a) the greater effect of secondary and higher education on growth, compared with primary education, and (b) the seemingly insignificant, or even negative, effect of female education on the growth of output. With respect to the latter, they follow Barro (1999) in suggesting that the insignificant effect of female education may be a result of gender discrimination in some countries’ labour markets. The argument is that females receive education in these countries but are discouraged from participating in the labour market, and thus cannot contribute directly to the growth of output. This may explain part of the problem, but it seems that other mechanisms also are at work: in countries with high female labour market participation, variations in the extent of female education have an insignificantly small positive effect on output growth rates.

While there is persuasive evidence about the positive relation between initial human capital levels and output growth and (weaker) empirical support for the relation between changes in human capital and growth, it is not at all clear that this implies a causal

relationship running from human capital to growth. Motivated by the fact that schooling has increased dramatically in the last 30 years at the same time that the "productivity slowdown" became manifest in many of the higher income economies, Bils and Klenow (2000) suggest that the causal direction may run from growth to schooling. That relationship would be predicted by a Mincerian model in which high anticipated growth leads to lower discount rates in the population, and so to higher demands for schooling. Of course, both variables might be driven by other factors. From the results of different empirical tests, Bils and Klenow conclude that the channel from schooling to growth is too weak to explain the strong positive association found by Barro (1991), and Barro and Lee (1993), as described above. But, they argue, the "growth to schooling" connection is capable of generating a coefficient of the magnitude reported by Barro. An alternative explanation is suggested by Glaeser (1994): current schooling need not *directly* impinge on future output growth, but it decreases the cost of future schooling, and it is this indirect effect through increasing returns to scale in nation-wide schooling that works to raise long-run per capital output growth rates.

In summary, there appears to be no single formal theoretical model of growth that is wholly consistent with the empirical results reported from cross-country studies. The evidence broadly sides with both the augmented neoclassical models of growth, and models of endogenous growth with spill-overs that also predict (conditional) convergence. Yet, there are more complex patterns underlying the variation in output growth rates across countries that would qualify those broad findings and favour models with multiple steady-states (e.g. Azariadis and Drazen, 1990). With respect to the effects of human capital on growth, the weight of the cross-country evidence is in favour of a level effect. This implies that the stock of human capital reflects many other differentiating factors that influence the growth process, and should not be seen as simply another source of service inputs to production. The importance of the role of human capital as a critical factor for innovation and the diffusion of knowledge thus appears to emerge from this literature as deserving closer analysis.

(ii) Convergence, catch-up and the role of human capital

For some economists (e.g., Easterlin, 1981) the answer to the question "Why isn't the whole world developed?" lies mainly in the international disparities in levels of education. Does the evidence suggest that human capital formation is the route through which the gap between rich and poor nations can be closed? As explained in the review of recent growth theory, different models have dissimilar implications regarding the ability of relatively poor countries to catch up with richer ones. The neoclassical growth model predicts absolute convergence in the per capita real GDP levels among countries with similar structural characteristics (referred to as "conditional convergence"). Most endogenous growth models, on the other hand, do not predict that countries will end up with the same output per capita in the long run; instead, they predict that the long run outcome will continue to reflect the initial conditions of the economy.

An important exception to be noted in this literature, however, is the set of endogenous growth models that do predict eventual convergence because they explicitly recognise the effects of international spill-overs of knowledge (as in Grossman and Helpman, 1991, and Lucas, 1993, for example). Quite clearly, the existence of neoclassical and non-neoclassical models that yield the same prediction makes it difficult to discriminate between these formulations solely on the basis of the empirical evidence regarding convergence. Consideration of that evidence nevertheless may prove helpful, in enabling us to eliminate still others among the contending array of growth models.

The main finding from a wide range of cross-country studies is that absolute or so-called "unconditional" convergence is not manifest in the international data pertaining to the post World War II era (see Summers and Heston, 1991; World Bank, 1991). But conditional convergence is evident. The "conditioning variables" change from study to study, but tend to include indicators of: the educational characteristics of the population, government consumption, the importance of trade, the rate of population growth, investment ratios, and the degree of political instability (see Barro, 1991 and 1996, Barro and Sala-i-Martin, 1995, and Durlauf and Quah, 1998, for a review).

These studies point to a low rate of convergence, approximating 2% per year. Although that in itself is not an implausible estimate, the slow convergence speeds found in these studies does pose a problem, in that they imply that the share of physical capital in total income should be around 0.9, whereas national income accounts show that the share is closer to 0.4. In turn, this would suggest that labour is being paid more than its marginal product, and that physical capital is paid less. To counter this implication (which is anomalous within the framework of the neoclassical theory of distribution), an influential article by Mankiw, Romer, and Weil (1992) proposed that capital should be interpreted broadly to include human capital in addition to physical capital. The addition of a proxy of the rate of human capital accumulation as a conditioning variable leads to an estimated share of physical capital that is not substantially different from that derived from national income accounts. In the authors' view this demonstrated consistency between the neoclassical growth model and the international evidence, while incidentally pointing to the importance of the role of human capital.

Cross-country analyses focusing on convergence are subject to a number of general critiques (see Durlauf and Quah, 1998, for a detailed survey on the following issues). First, such studies assume away any unobservable country-specific heterogeneity. This has motivated Benhabib and Spiegel (1994), Barro (1996), and still others, to use panel-data methods in their econometric work, allowing for country-specific "fixed effects". Their results broadly suggest that the rates of convergence are more varied than the 2% per year implied by many of the early cross-country studies. Second, since convergence studies do not capture the whole dynamics of the cross-country distribution, a number of recent papers (e.g., Durlauf and Johnson, 1995, and Quah, 1997) have studied other features besides absolute convergence. The presence or absence of a secular tendency towards relative convergence, i.e., a narrowing of the proportional dispersion of per capita incomes among countries, is referred to as "σ-convergence", and it was to the strength of this phenomenon among the industrially advanced economies that attention was first drawn in the now widely cited paper by Abramovitz (1986) on "Catching Up, Forging Ahead, and Falling Behind" (see also Abramovitz and David, 1997).

Other phenomena have also been studied empirically, including the possibility that the countries do not converge to a single steady state path, but belong to sub-groups (also called clusters) of countries that share a common growth equation. Recent studies of this kind have revealed more complex patterns of convergence and non-convergence co-existing in the international cross-country data. In particular, they find evidence that countries can be divided into groups (determined by initial conditions, such as income and literacy), which also differ among themselves concerning the aggregate production functions that describe the member-countries' dynamic behaviours. Convergence occurs within such groups, but it may be to a different level of income per capita than other groups attain in the long run. This casts doubt on the explanatory power of the conclusions of Mankiw, Romer, and Weil (1992) regarding the neoclassical model. But, as Romer (1994, p. 11) emphasises, "the convergence controversy captures only part of what endogenous growth has been all about. It may encompass a large fraction of the

recently published papers, but it nevertheless represents a digression from the main story behind endogenous growth theory".

A recent paper by Wolff (2000), however, appears to throw doubt upon both the neoclassical theorists who argue for the existence of convergence in an "augmented growth model" (including human capital among the inputs), and the emphasis given to education and knowledge investments by the proponents of endogenous growth theory. Examining the entire set of OECD member countries, Wolff confirms that over the period stretching from 1950 to 1990 there has been evident convergence in levels of real GDP per worker and in various indicators of human capital intensity. A variety of indicators of educational investment (both enrolment and attainment rates, derived from different sources) point to two important trends that these economies experienced in common. First, starting from ubiquitously high levels of primary schooling at the beginning of the post-World War II period, the decades following 1950 saw a significant increase in average schooling levels at the secondary and tertiary levels throughout the OECD economies. Second, the relative dispersion in educational attainment and average schooling levels declined substantially over the postwar period, particularly at the secondary level. In other words, there has been "σ-convergence" in average educational levels as well as in the labour productivity levels among these economies.

Closer examination of this body of data reaffirms the cautionary injunction that a variety of detailed international patterns is indicated when different methods and definitions of the education variables are adopted, the broad consonance in their movements notwithstanding. It is worth remarking in this connection that the coefficient of variation (a measure of relative of dispersion) of the average years of schooling of the *total population* aged 25 and over exhibits a persistent downward drift over the whole interval from 1960 to 1985, with a long period of stability between 1965 and 1980; by contrast, the same dispersion measure for the average years of schooling in the *labour force* decreased substantially between 1965 and 1980, before rising slightly in the early 1980's.

Wolff's (2000) study uses the pooled time-series and cross-section observations for the 24 OECD countries to test three regression models of the relationship between labor productivity growth and human capital. To test what he refers to as "the catch-up model" he includes the *level of schooling*, considering that in the framework suggested by Abramovitz (1986), a key dimension of the social capability of the population can be viewed as the educational attainment of the workforce; more specifically, Wolff suggests that there may be an educational "threshold effect" permitting the successful borrowing of advanced technology. Secondly, since human capital theories posit a positive relation between the rate of productivity growth and the rate of change of schooling levels, Wolff specifies a model of the growth of labour productivity in which the *change in schooling level* (rather than the level of schooling) appears as an explanatory variable. A third model includes a variable for the level of schooling *and an interaction term* of schooling with R&D intensity, in order to test the hypothesis that human capital affects growth through its interactions with technical change. In all three model specifications, however, Wolff also includes among the regressors the level of labour productivity at the beginning of the period, the ratio of investment to GDP, and the average ratio of R&D to GNP.

The econometric results reported by Wolff are striking, in that none of the three specifications show any substantial, statistically significant "effect" of formal education on productivity growth. In all three regressions the most powerful explanatory variable in accounting for differences in labour productivity among OECD countries turns out to be the relative level of labour productivity at the beginning of the period: "By itself, the catch-up variable explains 74 percent of the variation in RGDPW growth over the 1950-1988

period" (Wolff, 2000, p. 458). While, as has been noticed, other international regression studies – that of Mankiw, Romer, and Weil (1992) aside – also fail to find substantial human capital growth effects, Wolff manages a clean sweep in rejecting hypotheses involving level effects as well. These results from an important contributor to the literature on human capital, skill demands and productivity growth are so surprising that they deserve closer examination.

Wolff (2000) himself feels obliged to offer a number of reasons for the divergence between his negative conclusions regarding the role of human capital and the general tenor of the literature based upon comparative macroeconomic growth data. Concentrating upon the discrepancy with the growth accounting literature's positive stance regarding the contribution made by increases in the average level of schooling of the workforce, he points out that although growth accounting studies implement the human capital model, they (i) do not allow for a "catch-up" effect, (ii) typically assume that the effect of increases in average educational attainment levels can be gauged from associated relative earnings differentials, rather than testing the hypothesis, and (iii) do not restrict the effect of educational input changes to be uniform across countries, as is the case in his regression model.

While each of the foregoing points are valid, only the first of them also addresses the failure of Wolff's analysis to turn up any "level effects", as well as finding no quantitatively significant "change effects". This draws attention to the dubious role of the so-called "catch-up" term in these regression exercises. Inasmuch as the dependent variable is the proportionate change in labour productivity, and its changes from the initial level appears as a regressor, errors in the regressor will be correlated with those in the dependent variable. This contributes to the apparent explanatory power of the "catch-up" term. Wolff's own discussion of convergence in educational levels within the OECD makes it evident that at the start of each sub-period the dispersion in labour productivity levels was correlated with the dispersion in the average schooling level of the labour force; that although the dispersion was reduced within each period, the rank ordering of the countries by those relative educational standings was not markedly altered. Hence, it is not apparent why one should include the initial productivity level at all. Indeed, were the country's ability to absorb the technology of the leader country governed by the country's level of human capital, as Wolff hypothesises, then one might take the initial average schooling levels (or some other knowledge infrastructure index) as a "catch-up" variable in the sense suggested by Abramovitz (1986).

(iii) The limitations of the international cross-section evidence

Beyond conceptual questions of the sort just raised, it is important to call attention to some basic limitations of the statistical methodologies that have been employed in undertaking cross-country studies aimed at evaluating the impact of human capital upon economic growth. To suggest the nature of the problems, and the need for careful scrutiny before accepting announced "results" at face value, it is useful to make a close examination of several very recent studies that have cast doubt upon the role of human capital and educational investment.

One may start by noting that Wolff's approach, while making use of panel data, treats every country-period observation as independent, rather than allowing for heterogeneity among the countries (both in the measurement of variables, and in their relationships) by specifying a regression model with "fixed", country-specific effects. Furthermore, although there are potential problems of simultaneity in the regression equations estimated by Wolff, these have not been addressed by the use of instrumental variables or other

methods. To be specific on this point, rapid growth in productivity (which is taken to be the dependent variable) also tends to be accompanied by high retained earnings rates, and the latter, in turn, tend to induce both higher conventional investment rates, and higher ratios of (internally financed) R&D to GNP. As a result, one would expect the estimated elasticities of labour productivity with respect to the human capital variables to be downward biased even in the absence of the dubious "catch-up term".

Thus, one may conclude that numerous econometric problems vitiate the force of the negative findings reported by Wolff (2000). Yet, those problems are not shared by another very recent international panel-data based study, by Boskin and Lau (2000), which also concludes that human capital inputs have contributed comparatively little to economic growth among the industrially advanced countries. This NBER working paper is focused exclusively upon the G-7 economies, using a specially constructed annual data set, and employs econometrically sophisticated (instrumental variables) analysis in estimating a large number of the parameters of a transcendental logarithmic production function model for purchasing power parity adjusted constant dollar GDP. The author's model has three inputs – the utilised gross stock of non-residential capital, the employed number of person hours, and human capital measured as the number of years of schooling of the working age population (obtained by the perpetual inventory method). The "translog" function provides a very flexible specification, allowing for generalised input-augmenting technological changes at exponential rates that are constant throughout the period 1958-97 but specific to each input in each country; country-specific variations in initial input efficiency levels, and in the degree of economies of scale, also are accommodated by the regression model.

Boskin and Lau (2000) find that among all the proximate sources of real output growth in the G-7 economies, save for Canada, the contribution of human capital accumulation during the 1958-97 era accounts for between 4 and 6 percent, the latter being the figure in the US; the highest proportionate contribution is found for Canada, at 8 percent. In the period since 1973, their estimates put human capital's contribution at only 5 percent. These authors also report a rapid rate of human capital augmenting efficiency change (technological progress, in their interpretation); indeed, the rate matches their estimated rate of physical capital-augmenting technological change.

The results just described disagree sharply with the picture formed on the basis of the US growth accounting study by Abramovitz and David (2000, Tables 1:IA, 1:IVA), which estimated that the proportional contribution to the growth of real Gross Private Domestic Product (GPDP) from compositional changes raising the average "quality" of labour inputs were twice as large, i.e., just under 11 percent in each of the sub-periods 1948-66 and 1966-89, and 12 percent over the whole period 1929-89. Moreover, Abramovitz and David (1973, 1996, 1999) have shown that the US macroeconomic data, as well as much micro-level evidence points to a conclusion diametrically opposite to Boskin and Lau's inferences regarding the bias of technological and organisational innovation. The intangible capital-augmenting changes of the sort envisaged by Boskin and Lau's reading of their econometric results would have the effect of lowering the marginal capital-output ratios for tangible and intangible capital alike. Instead, the Abramovitz-David thesis argues that during the twentieth century, and particularly from the 1920s onwards, innovation-driven efficiency change has been biased towards intangible capital *deepening*, given unchanging relative rates of input remuneration. In other words, by tending to *raise* the marginal intangible capital-output ratio, this bias in technological change has worked in conjunction with a continuing unskilled labour-augmenting bias (vis-à-vis the rate of physical capital augmentation) to encourage a shift of the overall domestic asset portfolio away from physical capital and toward intangible capital.

Why is it that the sophisticated methodology employed by Boskin and Lau (2000) yields a diametrically opposite picture? An explanation is to be found not in the econometric techniques, but in the data to which it has been applied; the disparity in conclusions stems mainly from the difference between the measures of the human capital input that have been used in these two studies. Boskin and Lau's work relies upon a surrogate human capital index, provided by the number of schooling years per person in the workforce, whereas the figures cited from Abramovitz and David are based on their calculations using an average labour input quality index derived by weighting the service inputs of workers in different educational attainment (as well as age and gender) categories by their relative wage rates. The latter measure is hardly ideal, but the point here is that the shift of the labour force composition towards higher, and more highly remunerated educational levels, makes the average labour quality index rise more rapidly than the simple measure of average schooling years.

The implications this carried for Boskin and Lau's regression estimates will be considered shortly, but it is worthwhile digressing briefly to point out the generality and seriousness of this particular data problem. It should be understood that whereas the outward institutional features of educational systems around the world are highly mimetic, the reality of the educational services provided is highly variegated. The "school year" is not an internationally standardised unit -- neither of time, nor of real resource inputs, nor of educational outcomes; average schooling quality varies widely at both the secondary and tertiary school levels (see Behrman and Rosenzweig, 1994). Furthermore, the distribution of educational attainments in the working age population and in the employed workforce is not identical, or everywhere related in the same way. Yet, for want of better, most of the large international cross section studies that introduce human capital stock measures are obliged to ignore those differences when using the perpetual inventory approach to estimate the average number of years of education completed by members of the working age population. (See Barro and Lee, 1993, Kim and Lau, 1993; although Barro and Lee, 1996, attempt adjustments for the variability of schooling quality.)

As Temple (1999) has pointed out, the presence of even a comparatively small number of "outlier" countries in the international cross-sections may bias the overall regression results, particularly when the statistically anomalous observations reflect an underlying inhomogeneity in the relationship between the proxy measure and the true variable. A specific problem, illustrative of this source of bias, can be observed in the Barro and Lee (1993) perpetual inventory estimates of average educational attainment for a small number of countries in the Penn World Table dataset whose populations are predominantly Moslem: the proxy variable for human capital reflects previous rates of school enrolment among a large (female) section of the population that has very low adult participation rates in market work. As a result, when the proxy measure of average (years) of education per worker is constructed as the ratio of the total stock of human capital to the number of gainfully employed persons the estimates for the countries concerned turn out to be aberrantly high. In a less dramatic fashion, Boskin and Lau's (2000) reliance on the same kind of average schooling years measure of human capital intensities in the G-7 exposes their work to estimation biases, as will be seen.

A more striking disparity in the measured growth of human capital services than the contrast already mentioned between the Boskin-Lau and Abramovitz-David findings could be seen by referring to a still larger estimate of the contribution from the accumulation of intangible human capital that has been presented by the latter pair of authors. This emerges when Abramovitz and David (2000, Tables 2:III, 2IV) adopt an accounting framework based upon an "augmented Solow model" of growth. In that framework the contribution to output growth is calculated from the rate of increase of the real stock of

intangible human capital per person hour worked, weighted by the share of earnings that represent the gross return on intangible human assets. Because the increase in real investment costs per schooling year were rising dramatically, as continuation rates from secondary to tertiary educational levels climbed and the foregone earnings component of college and university attendance grew with the rise in real wage rates, it is hardly surprising that this methodology yields a substantially larger assessment of the impact of human capital formation – surpassing even that obtained with the more conventional average labour quality index. The proportional contribution to the average growth of (augmented) GPDP approaches 19 percent for the period 1966-89, almost four times the magnitude indicated by the Boskin and Lau (2000) proxy index-based estimates for the US.

A variety of evidence suggests that in the post-WWII era all the G-7 countries shared similar experiences in regard to the rising investment devoted to higher education. Consequently, Boskin and Lau's panel regression estimates must compensate for the understated growth rates of their proxy measure of average human capital inputs for these countries, and this results in strongly over-stated estimates of the rate at which the human capital efficiency index in their production function must have grown. But that is not the whole of the story: another part of the explanation for the low impact attributed to educational investment by Boskin and Lau's study also is related to the inadequacies of their proxy measures for human capital intensity increases, because these errors in the indices do not take a simple, proportionate form across all the G-7 countries.

Furthermore, in some countries the participation rate of women in the workforce was rising more rapidly than in others. On that account alone, Boskin and Lau's measures of average schooling years attained per person of working age behave differently (from country to country) than the corresponding figures on a per person hour worked basis. Both defects in that proxy variable, and particularly the last mentioned one (which recapitulates the problem previously noted in regard to the Barro-Lee methodology for obtaining indicators of human capital intensity growth), give rise to an errors–in-variables bias in the regression coefficients estimated by Boskin and Lau (2000). The coefficients of interest here are those for the elasticity of real output with respect to the human capital inputs, and the direction of the econometric bias is downwards, thus contributing further to the surprisingly weak role that their study reports for human capital among the sources of output growth.

The foregoing observations on the distorting influence of inadequacies in simple measures of intangible human capital formation that are most widely available for use in cross-country statistical analyses can be further reinforced, by comparing the findings of Boskin and Lau (2000) with those of the recent growth accounting exercise carried out by Bassanini, Scarpetta and Visco (2000) for the G-7 countries during the 1980s and 1990s. The latter OECD study builds upon the same information for the average number of years of education in the working age population, based on data about the highest level of education attained and assumptions about the number of years of schooling implied (for the various countries) by different levels of educational achievement. But the authors then segment the working population into six categories, based upon gender and three different educational attainment levels, and apply a standard set of relative wage weights to obtain an average labour quality index (which they label the human capital input). As would be expected, their findings for the G-7 countries ascribe a rather larger contributory role in real output growth to human capital than that found by Boskin and Lau (2000): the US fraction implied by the estimate in Bassanini et al (2000, p. 14) approximates 7 percent, rather than 5 percent. But, as their index of compositional changes is a very crude one, these results for the US are still weak in comparison with the role that human

capital formation is seen to occupy in the growth accounts prepared by Abramovitz and David (1999, 2000).

Cross-section studies of the sort just reviewed are thus seen to be subject to criticisms on a variety of rather esoteric, technical grounds. In many cases they are subject to econometric or other methodological failings that undermine their credibility, either because of the defects in the data that go in, or due to biases in the results that come out, or both. In a heterogeneous collection of societies, many of which do not collect reliable statistics for all of the variables of interest to the economist, there are obvious risks in employing indirect measures and proxy variables that are satisfactory for many, but not all of the countries. Thus, in regard to the issues of present concern, there is ample cause to worry that errors of measurement in explanatory variables such as the level, or rate of growth of educational capital per worker, may result in regression estimates that systematically understate the magnitude of the elasticity of output with respect to human capital inputs.

A more fundamental criticism, however, concerns the interpretation of the cross-section results: the positive correlation between education and growth does not entail a direction of causality. The issue of causality reveals the fundamental problem faced by this type of econometric study, which may be able to demonstrate that there is a process of convergence and an empirical relation between education and growth, but cannot identify the *underlying mechanisms* that link education to growth. This limitation is crucial because a simplistic reading of the evidence can lead to errors in policy, whereby an increase in the supply of skilled workers is thought to lead automatically to growth, without regard to the industrial structure or the characteristics of the labour and credit markets.

To gain an understanding of the underlying mechanisms of growth involving human capital formation, it is necessary to look at detailed historical studies. The latter permit one to connect the rising educational attainment of a population with other processes of change, particularly those affecting technology, but also the organisation of production, and the labour market. From there the effects can be traced forwards, to the subsequent change in the characteristics of the country's effective labour supply, and the impacts on industrial productivity. Some of the historical evidence about these underlying processes in the growth experiences of the developed countries is examined in the following section, where it will be seen that the advance and diffusion of technology is the prime mediator in the relationship between human capital and growth. The survey concentrates on material from the US experience, as well as that of other industrialised countries in Western Europe, and Japan.

Evidence from the Historical Experience of Developed Economies

Most of the theoretical literature on economic growth focuses for quite understandable reasons on the role that investment in formal education plays in modern economies, and, in a broad sense has been informed largely by empirical generalisations about aggregate economic growth performance that derive from comparatively recent historical experience. Nevertheless, there are some insights to be gained by considering human capital's changing role over the longer time span that is afforded to us by the historical growth records of some among the presently developed economies.

(i) Human capital and economic growth policy in broad historical context

Indeed, it is useful to begin by taking even the briefest notice of economic historians' recent researches into the era before the Industrial Revolution, as this serves to direct

attention to the importance in proto-industrial development of state policies affecting aspects of human capital other than formal educational attainments and literacy. Cosimo Perrotta (1999), for example, compares the viewpoints and policies regarding poverty and employment in 17th century England with those of contemporary Spain, identifying the former as the "first policy of human capital". The presence of vagrant "sturdy" beggars (i.e., the able but unemployed poor) not only was seen in England as a social problem requiring governmental action, but contemporary thinking there explicitly acknowledged the existence of connections between the conditions of economic development, employment and poverty. As a consequence, the policy approach adopted in England (including the administrative apparatus established by the "poor laws") was geared to promoting "industriousness" and the acquisition of work-experience among the able-bodied poor, and so tended to foster economic growth. In Spain, according to Perrotta, a "medieval mentality" prevailed and influential commentators did not link the problems of vagrancy and begging with questions of employment creation and the economic prosperity of the realm; no comparable reorganisation of poor-relief was undertaken in Spain throughout the 17th and 18th centuries, the era of that nation's economic decline.

Humphries (2000), has examined the extensive use in 17th- and 18th century England and Wales of apprenticeship contracts that rested upon the institutional base created by the labour-market policies of the Tudor State during the preceding century. This, she suggests, had created an unusually skilled artisanal workforce, which contributed significantly to the precocious growth of manufacturing industries in Britain, setting the state for mechanisation and the applications of inanimate power sources in the Industrial Revolution. For the workforce in this era, therefore, the formation of intangible human capital was not a matter of formal schooling; in British society the dominant causal connection between expenditures on education and real income ran from the latter to the former, and this was reflected by predominance of private (church and charity) educational institutions.

Indeed, as regards the role of governmental funding and provision of primary (and *a fortiori* secondary level) schooling, and in respect to the prevailing rate of literacy in the adult population, England and Wales was shockingly laggard. Until the closing decade of the 19th century the "first industrial nation" and "workshop of the world" continued to lag far behind other comparatively un-industrialised countries – such as Prussia, the United States and New Zealand. (See Lindert, 2000, for comparative historical evidence on the political economy of mass education before 1910.) Britain's remarkably delayed adoption of mass public education, even at the primary level, combined with the weaknesses of its apprenticeship and technical education system (especially in comparison with that of contemporary Germany) after 1870, may well have considerable responsibility for the much-discussed inflexibilities and "bad attitudes" attributed to its industrial workforce. Economic historians continue to hotly debate whether such was the case, and whether it contributed to the country's well-known difficulties during the 1880-1913 era in making a structural transition from the old staple lines of manufactures into the "new industries".

Even though the specifics of the foregoing abbreviated discussion appear far removed from modern concerns, it should serve to underscore the value of maintaining a broader perspective than that commonly allowed even in the currently fashionable endogenous economic models. By considering a longer time span and the interactions with cultural, institutional and technological development, one can better appreciate the complexities and issues of timing that may prove critical in the evolving nexus between human capital formation and economic growth.

(ii) Lessons from the long-run growth experience in the US economy

Recent contributions by Abramovitz and David (1996, 1999) bring out the part played by educational capital formation in the contrasting characteristics of the US economy's growth path over the course of the 19th and 20th centuries. The quantitative base for their analysis is an augmented "growth-theoretic accounting" framework, which is employed to separate the "sources of growth" of output between the proportional rates of change in the quantity of tangible (or physical) capital, in man-hours of labour, measures of average labour input "quality", and the growth of total factor productivity (TFP). This last is the "residual" component, which is equivalent to the weighted sum of the rates of growth of average labour input productivity and average capital productivity. Conventionally it is attributed to the effect of technological and organisational innovations, but, of course, it also includes the net effect of any inputs left out of the accounting altogether, and errors in either the input growth rate estimates and the weights.

Abramovitz and David (1999, Part I) find that during the nineteenth century increasing labour productivity was attributable to a high and rising *capital intensity* (measured by the tangible capital per man-hour worked). They also show that over the long period 1835-90 the economy-wide trend towards "capital-deepening" (i.e., the rising capital-output ratio) must have been reinforced by a tangible capital-using bias in technological progress. The latter worked against the rising labour productivity, resulting in a very low growth rate of TFP. The authors' conclusion that the accumulation of tangible capital was more important than total factor productivity in the American economic growth experience of the 19th century is consistent with Broadberry's (2000) findings in a comparative study about productivity in the US, the UK, and Germany.

One implication derived by Abramovitz and David (1973, 1996, 2000) from these growth accounting calculations is that intangible human capital formation contributed little if anything to labour productivity growth in the 19th century: the crude residual is very small, and hence improvements in average "labour quality" due to education, etc., could not have been substantial. This macro-level inference is supported by micro-level evidence from this era, showing the absence of significant labour earnings effects of differential educational attainments among the factory workforce.

There is a striking contrast between that situation and the 20th century US economy's rising dependence upon improvements in "average labour quality" as a proximate source of the growth of labour productivity. Following the methodology pioneered by Denison (1974) and subsequently elaborated by Jorgenson, Fraumeni, and Gollop (1987), measures of the contribution to real output growth from this source may be obtained by classifying the employed labour force according to age (or experience), educational attainment and gender, and applying weights based upon relative average wage rates in each category – as proxies for the relative marginal value productivities – in order to quantify the impact of compositional shifts within the aggregate labour input. An estimate of the "contribution" that the latter makes to the growth rate of real output (and real output per manhour) is found by multiplying the growth rate of the average quality index by the fraction of real output imputed to earnings on intangible human capital.

Growth accounting and the rising contribution of human capital inputs:

According to the estimates presented by Abramovitz and David (1999, 2000), in the US the 20th century has witnessed a five-fold expansion in the relative contribution that increases in "average labour quality" (due to compositional changes) have been making to the growth rate of real output (GPDP) per manhour. Starting from a negligible 5.2 percent level in the period 1890-1905, the proportionate contribution to the labour productivity

growth rate increased to 9.3 percent in 1905-29, 16.7 percent in 1929-66, and reached 25.2 percent in 1966-89. Alternative estimates, based upon 1998 data released by the US Bureau of Labour Statistics (USDL Release 98-187), similarly put the average level of the proportionate contribution over the entire period 1972-96 at 25.1 percent; but they differ somewhat, in suggesting that the level was a more modest 16 percent in 1972-88, and then rose markedly during the early 1990's.

The significance of the contrast between 19th and 20th century American experience in regard to the significance of intangible human capital accumulation among the sources of growth deserves further notice on at least two counts. First, the findings, especially those pertaining to the first half of the 19th century, accord well with the impressions that historians of Britain's Industrial Revolution have reached (albeit on less solid quantitative grounds) about the relationship between educational expenditures and rising income levels during those early phases of modern economic growth. Secondly, the correlation between high levels of human capital per worker and labor productivity growth that can be observed in cross-section and panel-data pertaining to the second half of the 20th century evidently is not a "law" valid for all times and places. It is, instead, a phenomenon particular to the present historical era.

One may press the latter point further, by observing that a strategy for development that relies heavily on accelerated human capital formation, without reference to the specific, prevailing economic, social and technological context, scarcely can be justified universally on purely *economic* instrumental grounds. To be sure, a policy of "investing in people" may be deemed generally desirable for humanitarian or other ethical reasons, but that rationale should be clearly distinguished from the considerably more restricted contention that human capital formation in some circumstances yields attractive social returns through its effects in accelerating economic growth.

In contrast with the sources of growth in the 19th century, the main source of US labour productivity and real output per capita growth in the 20th century was rising total factor productivity (TFP). This reflected complicated underlying patterns of change. A crucial aspect of this underlying process was the changing bias of technological and organisational innovation away from marked capital-deepening and (plain) labour-savings, and towards intangible (human) capital-deepening. These developments were responsible for upward pressure on the marginal efficiency of investment schedules pertaining to the accumulation of capital in the forms of education, training, and the knowledge gained through organised R&D activities. They thus worked to maintain the real rate of return on intangible capital investments in the face of a massive rise in the ratio of intangible capital to real output, and a correspondingly dramatic "portfolio shift" that saw intangible human capital substituted for tangible non-human wealth.

According to the estimates available for the 20th century, the ratio of the real intangible capital stock to real GDP (appropriately augmented for foregone earnings) was essentially constant from 1900 to 1929, and then rose from 2.4 to 3.46 in 1948, and to 5.1 by 1990. Most of this reflected the accelerated accumulation of post-high school education and training, a trend that became especially pronounced in the US after WWII. In relation to the real stock of conventional tangible capital, however, the rise of the real intangible capital stock was a much more continuous process throughout the 20th century: the ratio climbed from 0.31 c.1905, to .54 by 1929, to .71 in 1948, and had reached 1.15 by 1990. At the same time, the share of (augmented) real output imputed to the stock of intangible human capital was rising – from 0.09 in 1890-1905, to 0.18 in 1905-27, 0.24 in 1929-66, and 0.25 in 1966-89; whereas the corresponding share of conventional tangible capital

drifted steadily downwards, falling from 0.44 in 1890-1905 to 0.27 in 1966-89. (See Abramovitz and David, 1999, Part 2, Tables 2-I, 2-II.)

The combined effect of these developments was a marked 20th century rise in both the absolute and relative "contribution" that the increasing level of intangible human capital per manhour was making to boost the growth rate of (augmented) real GDP per manhour. During the 1890-1905 period this source had been responsible for adding a mere 0.2 percentage points per annum, or about 19 percent of the realised labour productivity growth rate; whereas during the 1929-66 interval the corresponding figures were 1.1 percentage points, or a 41 percent contribution. The absolute contribution of rising intangible capital intensity fell back to 0.7 percentage points per annum in the aftermath of the golden era of post-WWII growth, 1966-1989; but, as the pace of labour productivity growth itself had slowed, the magnitude of the relative contribution grew even larger, to 59 percent. (See Abramovitz and David, 1999, Part 2, Tables 2-IV.) It will be noticed that the effects on the productivity growth rate just reported are considerable larger than those which were indicated by the previously cited calculations of the impact of compositional changes in raising average labour input quality. This is the case because the Abramovitz and David's (2000) "augmented growth accounting" calculations using the real stock of intangible human capital, in effect, take into consideration the capital formation that goes towards improving productivity capabilities *within* each of the categories of the workforce, rather than considering only the effects of shifting the distribution of the workforce among the various categories of educational attainment.

Skill bias in technological and organisational innovation and the demand for human capital:

The thesis that the 20th century US economy has been shaped in significant ways by the emergence of an *intangible* human capital-deepening bias in the trajectory of technological and organisational innovations, suggests that the general phenomenon of skill-bias in technological change is not a particularly novel phenomenon. What has directed economists' attention to this subject lately has been the suspicion that the introduction of information technologies is largely responsible for the observed widening of average education-associated wage differentials, as well as of the residual wage dispersion among the ranks of the university educated workforce.

The more general conclusion that technological change in manufacturing industries during the post-WWII era has been skill-biased finds strong support from econometric studies using less aggregated US data (Mincer, 1993a, b; Kahn and Lim, 1998), as well as data from other developed countries. According to Berman, Bound, and Machin (1998, p. 1246), "skill-biased technological change was pervasive in the OECD over the past two decades, occurring simultaneously in most, if not all, developed countries". This conclusion is advanced on the grounds that it provides an explanation consistent with the simultaneous rising wage premiums for skilled workers, and the observed within-industry substitution towards skilled workers. Similar inferences support the conclusion that this phenomenon had emerged considerably earlier in the century. This may be seen from the historical research of Goldin and Katz (1999), who find that skill-biases appeared most notably in the technologically novel industries and where factory electrification was under way.

The Abramovitz-David hypothesis that the changing morphology of long-run US growth was driven primarily by "biased" technological progress implies that the relative rise of intangible capital, especially that embodied in people during the 20th century, was not the result of largely exogenous institutional developments and political forces that managed to

mobilise state subsidies for mass education. Instead, the latter facilitating, infrastructural transformations can be seen as being directly and indirectly *induced* by changes on the demand side of the labour market.

One important source of support for that view is that the succession of new "general purpose technologies" (GPTs) that were introduced in the US (and elsewhere) from the late 19th century onwards required incremental technical improvements (so-called secondary innovations); in turn, each set in motion a process of further technical elaboration and gradual diffusion that resulted in a broad range of specific product innovations and applications in old and new industries alike. The electric dynamo, the internal combustion engine, the synthesis of organic chemical compounds, and still others, are identified prominently among the GPTs that figured in the transformation of the early 20th century American economy. The new technologies give rise to economies of scale and scope at both plant and firm levels, lending impetus to strategies of mass production and mass marketing.

The hypothesis that the introduction and elaboration of new GPTs was important in the acceleration of productivity growth during the 20th century is taken up by David and Wright (1999a, b), who examine the evidence for two alternative conceptualisations of the process of productivity growth. In the first of these, advanced by Harberger (1998), aggregate TFP growth typically reflects highly *localised* cost-saving developments (within a small number of industries in any narrow time-frame); it stems from *independent* technological and organisational innovations that do not generate important knowledge spill-overs. Alternatively, the growth process has been seen as the consequence of the diffusion of a new "techno-economic regime" affecting many industries and sectors; that is, a *generic* form of technological progress that creates dynamic spill-overs and results in economy-wide surges of productivity growth. The latter vision is the one more readily assimilated into the aggregate dynamic models found in the recent literature on endogenous growth.

David and Wright argue against the first of these views on the basis of diverse theoretical and historical considerations. They point out that the quantitative support Harberger (1998) presents is drawn from a period of unusually slow growth in US industrial productivity; whereas proximate responsibility for the marked post-World War I acceleration of TFP growth in the US manufacturing sector was shared by many different branches of production, rather than concentrated in only a few industries. Further, they link that productivity surge with the final stage of factory electrification that was under way during the 1920s: the diffusion of the "unit drive" system of the dynamo technology alone is conservatively estimated to have accounted for roughly half of the 5 percentage point rise in the manufacturing sector's average annual TFP growth rate. Analogous effects may be found in previous as well as subsequent historical episodes involving "general purpose technologies:" David (1991, 2000b) has argued that this is likely to hold true in the case of the microelectronics-based digital computer, which continues to open a broad stream of complementary innovations that are penetrating different products and processes across a range of both old and new industries.

Yet, GPT's require the introduction of complementary *organisational changes* at the level of the plant office and store, in order effectively to exploit the new possibilities of production and marketing. This is where the connection with human capital formation becomes critical. For complementary organisational changes to be implemented on a wide scale necessitates learning by architects and engineers of the new designs for industrial facilities, and by managers of new techniques of controlling and directing organisations that are more complex. The specifics of such knowledge generally are

acquired through learning-by-doing; even though mastery of general principles acquired through formal professional education may be involved, the process of such technologies' diffusion, therefore, can be gradual and quite protracted. Innovations in *industrial practice* facilitated by the introduction of a GPT are thus to be seen among the (non-neutral) processes that have altered the relative demands for tangible and intangible productive assets, including labour qualities and skills. The technologically driven shift towards mass production organisations taking place in the US during the first half of the 20th century was thoroughly implicated in both the transformation of high school and college education, and the quickened pace of productivity advance.

A rising demand for higher and higher levels of schooling, evident in the recurring educational movements – first to mass secondary schooling, and later to mass college education – taking place in the US over the course of the first three-quarters of the 20th century, undoubtedly drew strong impetus from developments in the country's labour markets. Recruiting practices and pay-scales gave indications that the firms embracing new technological trajectories particularly valued worker qualities (such as general intelligence, alertness, diligence, flexibility in the sense of versatility as well as receptivity to change) that tended to be correlated with higher educational attainments. The *signalling* motive for seeking education implies that the social marginal productivity of schooling in terms of raising "labour quality" need not be very large for "education" to be used by firms in selecting and sorting workers. Where considerable uncertainty surrounds the degree to which individuals possess those desirable attributes, general education attainments will be sought by potential workers as a means to secure better paying jobs in firms that "screen" on that basis, as well as the ticket of admission to professions that require further, more vocationally specific training.

The trajectory of technological evolution from the late 19th century onwards also has stimulated "an increasing demand for scientists and engineers and supporting personnel, who could carry on the necessary knowledge-generating and knowledge-applications activities". That provided new incentives for upwardly mobile families and individuals to seek and invest in further university training, but it also impelled US university administrators to seek to fulfil new needs arising in the various business communities from which they sought financial backing – whether directly or through legislative action in the case of the state universities. According to Abramovitz and David (1999, p. 38): "The prospective demand from industrial employers also stimulated efforts on the part of colleges and universities to adapt existing curricula, or establish entirely new areas of instruction that would be better attuned to those needs".

This claim contrasts sharply with the pioneering models of endogenous growth (Romer, 1986 and 1990) in which technological change is assumed to be "neutral", and where it is the increased *supply* of skilled workers (through education, e.g., in Lucas 1988) that automatically promotes greater productivity and growth. A second point of contrast is the emphasis placed upon the reciprocal links between technological change and human capital formation through formal education. In addition to the previously cited microeconomic studies of wage behaviour that point to the existence of strong skill-technology complementarity, a considerable body of empirical evidence below the macroeconomic level can be adduced to support the proposition that in the latter half of the 20th century, if not before, the overall bias of technological innovation has been in the direction of human capital-deepening; that is to say, it has tended to raise the marginal rates of return on investments in formal education and training.

Thus, using industry-level data for 61 branches of US manufacturing over the 1960-80 period, Bartel and Lichtenberg (1987) found that the relative demand for educated

workers was greater in sectors where newer vintages of capital equipment had been installed. Such findings are not confined to the manufacturing sector: in a study of the returns to education in US farming based upon 1959 data, Welch (1970) concluded that a portion of the returns to further schooling resulted from the greater ability of more educated farmers to adapt to new production technologies. Using data from the US Population Survey in the period 1959-69, Gill (1969) calculated rates of return to education and found that among the highly educated workers these were differentially greater in industries where technological change was faster. In the same vein, Wolff (1996) found that in US industries in the period 1970-85 the growth of cognitive skill levels (defined by the Dictionary of Occupational Titles) among employees was positively correlated with indicators of recent technological change, including computer intensity, low average ages of equipment, and R&D intensity.

Although recognised in the historical and applied empirical literature for some while, the important implications of the dynamic interplay between induced skill-biased innovation and induced biases in human capital formation at the macroeconomic level have only recently attracted the attention of theorists. Examples of this may be found in the formal analyses of skill-biased innovation (Eicher, 1996, and Galor and Moav, 1998), and the macro- model of Acemoglu (1998) that has already been considered at some length (see the closing sub-section in section II.2, above).

(iii) Comparative historical experience

Regional comparisons across European countries have been particularly useful in determining the importance of geographical proximity in convergence. They also suffer less from the bias of "outliers" in broad samples and allow for a more careful measurement of output and other variables than is possible with a broad sample of countries. Van Ark (1997) compares the productivity performance of economies in Europe's eastern and south-western periphery with the richer, "core" countries of Northwest Europe. He finds evidence of *divergence* of the first two groups of countries with respect to the "core" European economies in terms of manufacturing productivity performance, particularly so in the case of the Eastern European countries.

On close examination of the post-World War II evidence, Van Ark (1997, p. 302) concludes that the major factors behind this divergence are: (1) "differences in emphasis on 'extensive' versus 'intensive' growth strategies; (2) the variation in investment in human capital; and (3) the openness to trade and foreign investment". Using the same regional approach, Koman and Marin (1997), compare the growth record of Austria and Germany from 1960-92. They also find divergence in the time-series evidence that cannot be explained wholly by differences in physical and human capital accumulation; instead, they explain divergence from differing rates of technical accumulation in the two countries.

The comparative growth experience of the US vis-à-vis other OECD countries since the mid-19th century has been examined by Abramovitz and David (1996; 1999, Part 3) to gain further understanding of the elements influencing catch-up and "forging ahead" (i.e., the overtaking of a productivity leader by a former laggard). In their reading of the evidence, the simple catch-up hypothesis – whereby the relative growth potential of a country reflects the size of the productivity differential that separates it from the leader – is mediated by two classes of constraints: "technological congruence" and "social capability".

Limitations in the laggard's "technological congruence" stem from differences from the resource availabilities, factor supplies, technical capabilities, market scales, and consumer demands in the leader's economy. The more fuzzily defined concept of "social capability"

is meant to capture a myriad of factors, including the level of general education and technical competence, institutions that affect the financing and operation of industry, and political and social characteristics that influence risks and incentives. During the extended period between 1880 and 1929, according to Abramovitz and David (1996), the gap between the situation of the western European economies and the US in regard to both technological congruence and social capabilities militated against the former's ability to catch up, and the relative size of the trans-Atlantic productivity gap continued to widen.

Broadberry (2000) compares the US growth experience in the 20th century to that of Britain and Germany. He shows that while the productivity records of these countries are quite different, the human capital record that emerges from school enrolment is very similar for the three countries. In order to understand why Germany has overtaken Britain since World War II, and the US "forged ahead" in productivity, Broadberry finds it necessary to consider the educational path followed by each country.

On disaggregating productivity performance to consider vocational training in addition to formal education, it becomes apparent that: (i) the US specialised in higher level skills (particularly for managerial and research tasks) from formal education that were used in capital-scale intensive, hierarchical organisation of mass production, in combination with unskilled labour; (ii) Germany followed the opposite path, specialising in intermediate skills learnt through vocational training, which were used in a handicraft, "flexible system" of production; (iii) Britain tried to accumulate both types of human capital, falling behind the US in high-level skills and Germany in intermediate ones.

If one accepts the author's suggestion that vocational training is a substitute of tangible capital, but general education (through its provision of "social capabilities") is complementary to tangible capital, then the divergent paths in human capital accumulation can explain the evolution of the countries' growth rates. This article therefore reinforces the general message that a simplistic view of human capital accumulation cannot yield an adequate account of the historical patterns of growth: the industrial path followed – mass production or flexible production, oriented to industry or services – determines the need for different kinds of human capital, and this in turn depends on the resources and conditions of the country.

Another important lesson underscored by a comparative analysis of historical experiences is the value of drawing a clear distinction between the growth and level effects of education. This distinction can be perceived clearly in the work by Godo and Hayami (1999) comparing the US and Japanese growth performance in the 20th century. The authors show how the average schooling in Japan increased rapidly from the moment when schooling was made compulsory at the turn of the 20th century, approaching the US average schooling by World War II, without a corresponding increase in per capita growth. The celebrated Japanese growth experience occurred in the post-WWII era, and was accompanied from the start by a rising capital-labour ratio. The most likely explanation for this experience is that a crucial threshold level of education was required in order successfully to import foreign (American) technology.

A generalised formulation of this particular hypothesis would hold physical and human capital to be complements, as has been discussed above. Consequently, the increased schooling could not contribute to growth without a simultaneous increase in physical capital. Reflecting back on the similar suggestion advanced by Wolff (2000), were the latter to be the case, it would be important to properly measure the growth of the physical stock of capital when conducting econometric time series tests of this particular formulation of the role of educational capital in growth. It is unfortunate, therefore, that like

so many other studies based upon international data, Wolff's econometric investigations rely upon measures of the national (gross) domestic investment rate in lieu of the growth rate of the real tangible capital stock.

We might then conclude by observing that the eminently plausible idea that investments in human capital have an important payoff in economic development through their role in facilitating the successful transfer of technologies that are embodied in physical plant and equipment, has yet to be adequately tested by econometric methods applied at the macroeconomic level. Nevertheless, the hypothesis can be supported by a wealth of historical case study evidence from the "late industrialising" economies, much of it having been ably drawn together and synthesised in the recent work of Alice Amsden (2001). The historical record testify to barriers impeding technology transfer and adaptation, in even the most advanced of those countries prior to WWII, as a consequence of poor human capital endowments.

There is positive evidence as well, in the heavy educational investments that subsequently became characteristic of the successful Asian industrialising societies. Moreover, as Amsden (2001, pp. 238-45, 277-81) emphasises, subsidies to learning and education by the highly successful late entrants to the global market for sophisticated manufacturing products were targeted, rather than across the board. In Korea, Taiwan and China, the path pioneered by Japan was followed in first concentrating their tertiary educational investments upon building engineering skills. From that base they moved on to repatriate cadres of foreign-trained scientific and technical workers among their overseas nationals, and to create new, complementary financial and research institutions that would sustain the transition from "intelligent buying" to "strategic making" of new technologies.

Part III: Public Policy Implications for New Zealand: Enhancing Economic Well-being through Human Capital Formation

This Part provides some guidance for policy formulation in regard to human capital, based upon the analytical conclusions and empirical findings discussed in the preceding Parts. It begins by considering what might be described as "generic" implications for policy, and then takes up the question of whether, and in what respects, the major conclusions that can be drawn from the economics literature are applicable to guide policy-making for an economy whose particular structural characteristics resemble those of New Zealand. In order to address these issues, a preliminary examination of relevant policy objectives is required, including a number of more focused policy directions that appear to be especially germane in the NZ context, and thus deserving of special attention. Although the systematic development of a comprehensive programme containing concrete policy recommendations lies beyond the scope of this undertaking, some novel proposals for fiscal reforms and supporting institutional experiments are put forward for further consideration.

The organisation of the discussion thus proceeds, straightforwardly, from generic concerns towards increasingly specific policy issues:

- Section III.1 considers what might be termed the "meta-implications", that is to say, the implications that the general approach adopted in this Report would seem to carry for the task of framing "human capital policies".
- Section III.2 summarises and comments upon the principal *generic* policy implications that emerged from the large body of theoretical and empirical material surveyed in Part II.
- Section III.3 begins by indicating several distinctive structural aspects of the economic situation of New Zealand as a small, open economy, and their specific implications for policies aimed at altering the country's human capital endowment. The nature of the additional empirical information needed to identify certain policy objectives and feasible instruments is briefly indicated in connection with the presentation of specific policy suggestions. The latter include:

a fiscal (tax and subsidy) reform measures to improve the allocation of domestic investment between tangible capital and intangible human capital formation;

b fiscal and other tools for implementing a policy of selective encouragement of immigration by people who have received education and practical training overseas;

c several proposed complementary innovations in institutional infrastructure, directed to improving access to scientific and technological knowledge and channelling private and public investment towards economically productive, job-specific training programmes;

d coordinated programmes of public action targeted to counter-act the low levels of investment in human capital formation that are associated with persisting socio-economic disparities and disadvantages that particularly affect Maori members of New Zealand's society.

III.1 Meta-Implications: Orienting the Formulation of Human Capital Policies

What are "Human Capital Policies"?

To orient thinking about government policies that seek to target human capital formation as a means of promoting sustainable economic growth in New Zealand, or indeed, in any modern market economy, it is best not to begin with a narrow set of preconceptions about which interventions are to be considered under the heading "human capital policies", and which are not. This proposition, as unsettling as it might be, is probably the most robust as well as the most general implication to be drawn from the foregoing review.

Indeed, this advice follows more or less directly from the breadth of the concept of human capital investments, and the general equilibrium character of the analytical framework adopted in this report. Human capital formation decisions at the microeconomic level are influenced by a wide variety of interdependent economic factors, as well as non-economic, conditioning circumstances, as has been emphasised in Part I, and Part II.1. Most of those micro-level decision-factors are potentially subject to being directly altered by the application of some state policy instrument or a number of the latter taken in combination. Thus, taxes and subsidies, and direct procurement programmes can affect the behaviours of households and firms affecting human capital formation and its deployment, by altering the constellation of wages, prices and costs; whereas fiscal, monetary and exchange-rate policies will have impacts on current incomes and employment prospects. Furthermore, policies that impinge in the first instance upon tangible, physical capital formation, and upon the rate and direction of technological changes – whether through invention or the diffusion of innovations – have potentially important feedback effects upon human capital investment decisions.

Thus, whatever the purposes for which their application is intended, the whole panoply of economic policy tools also can produce significant indirect dynamic effects on the growth of the country's human capital resources. Even if the point is an obvious one for economists, it is useful to bear in mind that where the initial effects (whether positive or negative) of policy initiatives first impact the accumulation and utilisation of classes of assets other than human capital, the indirect repercussions are likely to be positively correlated where those seemingly unrelated investment targets had a *complementary* relationship to human capital inputs in production activities. Analogously, negative impacts on particular types of human capital formation would follow from policy measures that stimulated the supply of assets that were *substitutes* in production activities. Putting this in other words, adverse effects upon investment in some particular form of (human) intangible capital would be expected to flow from the relative growth of demand in markets for goods and services that were related as "gross substitutes" (either in consumption or in production) to the human capital investment activities in question.

To be concrete: consider the economic factors affecting the choice that students entering tertiary education might make among different courses (fields of concentration), some of which can be expected to extract more rather than less study-time than is the norm among college and university attendees. For example, laboratory course requirements for students in fields such as chemistry and physics, and mechanical engineering, are generally held to be especially time-consuming. Decisions favouring the latter areas of study therefore would have to overcome the additional discouraging economic effect that was created by a macroeconomic policy which had resulted in high job-vacancy rates and high wage offers to young part-time workers. Does the latter policy then qualify for

description as a human capital policy biased towards university training in the humanities, rather than the sciences?

Extrapolating from the foregoing illustrative case, would it be justifiable to regard any and all government economic policy measures that have perceptible effects upon human capital formation as belonging to the set of "human capital policies"? Practical reason suggests otherwise: just as it is good advice to avoid the extremes of taxonomic "splitters", so it is equally sensible to resist the efforts of "lumpers" who aim to eliminate all the bases upon which distinctions can be erected. With regard to the taxonomic question at hand, perhaps the simplest middle way is just to avoid the entangling market connections that are articulated in general equilibrium analysis; to entirely abandon efforts to discriminate between "human capital policies" and other policies on the basis of their *effects*. A much more workable basis for selectively applying that label can be found by referring, instead, to the policies' *proximate intentions*.

One may then answer the question posed at the beginning of this sub-section straightforwardly, by identifying generic "human capital policies" as those which are introduced with the explicit intention of affecting the levels, diversity and relative availability of human capabilities. Further distinctions might be made when such intentions are combined with an additional goal: for example, to affect human capabilities not only in a welfare-enhancing way, but one that achieves and sustains some specified pace of economic growth. The latter is more or less the classification principle that has been embraced for the purpose of this discussion.

The digression taken before arriving at this point will have been useful if it underscored the message that clarity of intentions does not relieve policy designers from the responsibility of thinking hard about questions of efficacy and ultimate effects. If any good practical use is to be made of the implications for policy recommendations that emerge in this report, much additional effort will have to be devoted to examining possibilities of *unintended outcomes*. The latter of course may include quite perverse effects arising from the complex interactions among the myriad of government regulations, programmes and policy initiatives that are found in virtually every modern economy.

Human Capital and Economic Growth Policies in a Human Welfare Context

The introductory attention devoted (in section I.1) to the quantitative definition of "economic growth", and to the relationship between the latter and alternative ways of gauging improvements in economic welfare and human well-being, may have seemed unnecessary, and perhaps even tedious on first reading. Yet, those preliminaries are well justified by the policy development concerns that motivate this report. They carry the quite clear implication that a general *caveat* should precede any specific efforts to suggest directions for human capital policies that derive only from considerations of the human capital-economic growth nexus. There are three main points of caution, or at least of qualification, to be noticed in this connection.

First, a society's endowments of human capital, and the actions on the part of public and private agents that alter them, are likely to impinge in quite different ways upon the growth of real GDP per capita and each of the available, alternative indicators of economic welfare, or of human well-being. To make this observation more concrete, suppose that identical levels of public resource expenditures are entailed in setting up either a technical apprenticeship programme targeted at secondary school leavers, or a programme of automatic post-natal home visitation by paediatric nurses. It is improbable that the pair of

items on this menu of public investment projects would exert identical proportionate leverage on a welfare index that accorded heaviest weight to the near-term goal of raising average incomes among the poor. Were a different (less Rawlsian) indicator of the society's "growth in welfare" – say, an index that assigned very heavy weight to reductions in infant mortality and morbidity rates – to be consulted, the relative efficacy standings of the two public policy options would be different again, and actually might be reversed. If human welfare is to be made the "objective function" for purposes of analysis and policy selection, the details of the way in which a notion of welfare is reified and associated with measurable magnitudes really do matter greatly.

The existence of classic index number biases of the sort just illustrated is a matter that is easy enough to gloss over when discussing "economic growth" and "human capital" as abstract, aggregate variables. It should be borne in mind that such biases nonetheless are very much present. Indeed, it is all too likely that they will resurface with a vengeance as soon as any concrete policy options are put on the table. Thus, it is seen that inasmuch as the selection of a particular criterion function for evaluating alternative policies will matter, the set of issues surrounding that (constitutional) choice ought to be made the subject of explicit discussion.

A second equally basic point, corollary to the one just noted, is that normative issues obviously are raised by the focus of this study upon the relationship between "human capital" and the conventional "economic growth" measure – in preference to one or another of the alternative indicators of economic welfare improvements. The background motivation here is one that regards human capital as an instrumentality, and proposes to evaluate various possible courses of government policy affecting human capital formation by considering their likely impacts upon the selected criterion, "economic growth".

Of course, it might be objected one need not be overly concerned on that score, because the subjective and ethical issues raised by emphasising "economic growth effects" in the criterion function for designing human capital policies really are not so stark. The reason that could be offered for such a view is simply that the historical records for the world's developed economies show that growth in real GDP per capita has been positively correlated over the long run with that of most of the conceivable alternative "welfare indicators" – average nutritional status, terminal adult height, the human body-mass index, health status, life expectancy, the variety and quality of goods and services available for consumption, and so forth. That is a good argument for the long run.

But, the third point to be noticed is that even within the moderately brief time-spans that separate one human generation from the next, the movements among the various welfare indicators may be seen from the same historical records to be capable of diverging widely from one another. Political decision-makers need to be alert to that fact, and therefore to what is implied by accepting the promotion of "economic growth" as *the* objective in framing governmental policy affecting human capital formation. To take one elementary example: other things being equal, a programme that would encourage a higher rate of continuation from secondary to university and post-graduate levels of education would entail a *short-run sacrifice of "economic growth*" as measured by real GDP per capita. That particular (statistical) outcome, however, simply turns upon the convention that the foregone production incomes of those who remained longer in school should not be counted as "investment" and so included in the gross product reported by the official GDP accounts.

By contrast, in an alternative augmented system of (MEW) accounting, the foregone earnings of students engaged in education and training beyond the compulsory level of

schooling would form part of (augmented) gross private domestic investment. Now, there is no doubt that a proposal to increase the (intangible) human capital investment rate involves an actual trade-off – between short-run and long-run *consumption*. Whether or not it is perceived also to be a trade-off between "economic growth now" and "faster economic growth in the future", is a question whose answer will depend upon the particular product accounting standards, and the time frame. Too often these remain implicit when reference is made to the goal of promoting faster "economic growth". Seasoned political practitioners in representative democracies, however, ought to have an appreciation for both the statistical and rhetorical niceties in all of this, if only because they appear so instinctively to take to heart the message of John Maynard Keynes' famous aphorism: "in the long run we are all dead".

III.2 Generic Economic Policy Pointers from Theoretical and Empirical Studies

Policy Implications from the Microeconomics of Human Capital Formation

Microeconomic studies conclude that numerous structural conditions – especially those peculiar to economic transactions involving knowledge, and the services of free persons -- are likely to drive persisting wedges between the private and social rates of return to investing in human capital. These "wedges" signal the existence of mal-allocation. As was pointed out in Part I.3, they are likely to appear in either of two broad sets of circumstances: (1) the existence of non-pecuniary "externalities", and the interdependence of individuals' preferences over outcomes, results in some significant portions of the benefits and/or the costs of particular investments failing to accrue to the agents responsible for undertaking those projects; (2) there are persisting "market imperfections" (including incomplete and missing markets) that prevent relative prices from properly signalling relative private marginal costs and private marginal productivities – excepting those cases where the imperfections arise from complete market power that accompanies the "internalisation" of all relevant costs and benefits.

The general implication of this is that the volume and composition of investments made in people tend to diverge from levels that would be socially optimal. A widely shared expectation that in the aggregate private investments undertaken solely for business profit, and to increase present or future private consumption satisfaction, will neglect the positive externalities, and therefore fall short of the social optimum, offers a broad rationale for the consensus favouring public policy measures that would encourage human capital formation activities.

Where and how should government intervene?

Strictly speaking, however, an economic justification for governmental (or charitable institution) interventions directed to raising human capital investment in particular categories is more demanding than that. The classic, theoretical criteria can be formulated this way: subsidies are called for only where it is found that the respective marginal social rates of return on such investments – whether directed to human capital investment among particular population groups, or for specific categories of training – exceed (i) the corresponding private marginal rates and (ii) the marginal social opportunity cost of the public tax revenues that would be absorbed by the indicated subsidy programmes.

The application of this test, as a practical matter, is not so easy. A comparatively straightforward and widely accepted methodology has been developed to obtain estimates of the *private* marginal rates of return on investments in formal education, on-the-job training of various kinds, and even in health care. Such calculations typically make use of synthetic cohort estimates of age-earnings profiles derived from census and survey data for individuals classified by educational attainment, or health status; they indicate either the present values of the differential earnings streams (discounted at some opportunity cost interest rate on financial assets), or the internal rate of return on the stream of differential earnings. The latter measures are equivalent to the former only where reinvestment of the net earnings stream at an invariant rate of return is feasible, and this is not necessarily true in the case of educational investments, due to the effects of ageing upon an individual's access to institutionalised educational opportunities.

Comparisons among private net-present-value estimates for population groups that are distinguished by ethnic or racial markers, by geographic location, by type of educational institution and/or by training program, can be very useful, even when the corresponding social returns figures are not available. Differences in the private return to human capital may be illuminating in accounting for observable differences in socio-economic patterns of behaviour with respect to education and training. Furthermore, to the extent that there are pronounced inter-group differences among the private marginal rates, the latter signal the existence of market imperfections of one sort or another. The latter can operate as occupational entry barriers that are maintaining higher rates of return in some skilled occupations, or borrowing constraints that limit the access of low income groups to human capital investment opportunities. Cross-sectional comparisons of the private rates of return also may reveal the effects of discriminatory labour market treatment, whether in the form of differential wage rates, occupational segregation, or preferential hiring standards that ration jobs characterised by regularity of employment (rather than seasonality and exposure to frequent layoffs). The presence of differential subsidy programmes also may be discerned, if they encourage private human capital investments among some non-competing groups of workers, and so tend to drive down their internal rates of return.

The foregoing discussion has concentrated on what there is to be learned from analysing information on the private rates of return. Although such calculations undoubtedly can be of use to inform the direction of government actions regarding human capital formation, their value is primarily diagnostic; without the counterpart information on the pattern of differences between private and social marginal rates of return, these indications cannot be regarded as "scientific" economic welfare criteria justifying the allocation of specific amounts of public resources for human capital formation purposes.

Unfortunately, correspondingly detailed social rate of return estimates are hard to come by, except in some special circumstances where specialised occupational skills are required for an industry to be pursued, or for a specific technology to be adopted. It may then be feasible to estimate the incremental producer and consumer surpluses that would be generated in the society by providing the training necessary to meet those "critical human resource requirements". Many historical instances might be cited, but a very recent one may suffice here: special interest has been shown by the US National Science Board supporting university curriculum innovations that would provide computer programming training to graduate students specialising in genetics; the signal for that initiative has been the surprising persistence of vacancies in positions for biology Ph.D.'s with experience in programming for the computational techniques employed in gene sequencing, notwithstanding the spectacular pay being offered to qualified recent graduates (Stephan and Black 1999, Romer 2000).

As to the question of how government ought to seek to alter the allocation of investment in human capital, the literature on the economics of public finance points almost exclusively to subsidies and taxes as the instruments of choice for effecting such corrections. A review of the generic implications of applying optimal tax and subsidy principles to the treatment of investments in intangible forms of human capital – specifically, education and training – therefore will occupy us in sub-section 2 (i), below. But, before turning to that task, a number of preliminary qualifying remarks are in order, to set the conclusions of that discussion against the background of pragmatic policy considerations.

Theoretical prescriptions for taxes and subsidies typically stop far short of suggesting specifics for their implementation through tax codes and administrative procedures governing government subsidy programmes. Therefore, until such generic prescriptions are given a particular form that will be defined in terms of the categories and ranges of income subject to specified tax rates, and the legal conditions determining the eligibility of activities to receive stipulated levels of government subsidies, one can talk only in the loosest terms about the expected efficacy of such measures in any particular economic context.

Just where, and on which particular capability-building activities such measures should be focused, however, are questions that only can be answered properly on the basis of more detailed analyses, in which the institutional setting also is fully specified. Thus, it would be reckless to start from a general *a priori* position regarding the directions or the severity of the various kinds of "market failures" that are thought to emerge in regard to human capital formation activities.

True, there is a broad presupposition among economists of an overall systemic tendency toward under-investment in human capital, due to the incomplete private appropriation of their contribution to the (external) benefits of having a labour force (and a polity) that is more highly educated and possesses a greater degree and variety of skill. Yet this does not preclude the possibility that in some situations the behaviours of agents left to themselves in the private sector results in a level of educational investment that is sub-optimal, not only when viewed from the social perspective but quite possibility also from the standpoint of the individuals themselves. Such is too frequently the situation of young labour market entrants, whose work habits and educational preparation reflect the limitations of previous interests and judgements on their parents' part.

At the same time, a condition of overall under-investment is quite compatible with there being socially excessive expenditures of private and public resources for formal schooling, i.e., levels of investment that drive the social marginal rate of return below the marginal private rate. Such a situation sometimes is alleged to be the case in regard to university-level educational credentials that are sought (whether by students or their parents) primarily as "signals of quality" for prospective employers. The source of the putative inefficiency lies in the society's lack of some alternative institutional mechanism that would perform the socially productive, signal-supplying function of educational credentials – with equal credibility but at lower unit cost.

Corrective interventions by government therefore must be formulated on a case-specific basis, once the nature and seriousness of the existing misallocation has been established. Yet most corrective policy actions – whether they take the form of subsidies and taxes, or legal and administrative regulations, or the creation and management of special institutions by the public or private sector – will impose some costs of their own. That too must be taken into account in judging whether they should be recommended as "second

best" solutions, or only as the "n-th best" means of addressing the identified sources of "market failure".

A systems analysis of the sequence of educational choices points to the importance of targeting policy measures to address tendencies to under-investment during the earlier stages of the life-cycle. Schooling provides intangible capital that is a foundation of the capabilities for successfully undertaking later investments in education and training, including various kinds of on-the-job training. Market failures, or public institutional failures, that result in under-provision of "educational capital" at the primary level, therefore will raise the costs or reduce the effectiveness of subsequent investments in secondary schooling, tertiary vocational and university education, and in on-the-job training.

Frustratingly, there are significant limitations to the degree of remedial leverage that government programmes can exert to effectively alter the family settings and neighbourhood environments of young children by targeting micro-level interventions – however critical those conditions appear to be for the subsequent development of their capabilities. Such problems are likely to have differential incidence within the population, and so may be responsible for permanent and increasing educational and socio-economic stratification among the members of the society. This implication is particularly relevant in diagnosing and addressing the sources of persisting segmentation of the population along racial and ethnic lines, a policy challenge which is considered more explicitly below, in section III.3.

Adjusting the supply of various human capabilities found among the domestic workforce generally will be a comparatively slow and inevitably inexact process. Policies directed towards achieving specific goals of that kind when it must be achieved through subsidies for education, training and retraining, must take account of the long lags and uncertainties about future states of demands in the economy. Accordingly, they should be designed wherever feasible to allow for maximum flexibility and mid-course corrections. Yet, the latter implications derive much of their force from the "closed system" approach to human capital formation that dominates the macroeconomic analysis of the latter's role in economic growth. A full-fledged open economy analysis, on the other hand, by taking into consideration that factors of production as well as their products can move across regional and national borders, is likely to steer the discussion of human capital subsidies and taxes towards rather different conclusions.

The discussion of these matters is structured here in the following way. Sub-section 2(i) starts by reviewing the rationale for subsidies, and considers the case for direct subsidies even in the absence of externalities. It then examines in some detail both the actual and the desirable tax treatment of private investments in human capital. For purposes of exposition, the complications arising from international labour mobility are suppressed until sub-section 2(ii), where the effects of a variety of tax and subsidy measures affecting immigration and emigration are considered. The discussion of this section concludes, in 2(iii), with a short note on the neglected subject of human capital investments that ought to be directed towards enhancing individuals' capabilities and economic welfare in the retirement phase of the life-cycle.

(i) Taxes, subsidies and investment in human capital

Logically, the first set of questions to be considered under the heading of tax and subsidy policies for human capital formation concern the *status quo*: What is the level of national resources that currently are being devoted to human capital formation? Are those

resources being allocated in the most effective way, given the goals of economic growth and human welfare enhancement that the government seeks to attain? Focusing on intangible human capital formation, one should ask whether the existing mix of the various fiscal devices that the government has deployed for this purpose is yielding the best results attainable with the amount of public resources that are being invested. Such an assessment should be comprehensive, and therefore consider the resource costs entailed by the whole spectrum of measures – directly subsidised programs (whether implemented through the private or the public sectors), tax credits, and tax deductions allowed for training or educational expenditures. Having addressed those issues, one can then go on to pose a second set of questions: how much further it would be desirable to raise (or, for completeness, to lower) the overall rate of investment in intangible human capital? Is a "balanced" or equi-proportional increase of human capital investments indicated, or should the incremental mix be altered?

In order to proceed with either of those inquiries it is of course necessary to have some idea about the way in which private investments in human capital formation are presently affected by the structure of educational subsidies, and also by the prevailing tax codes. The latter are likely to impinge in a direct way upon the inter-temporal resource allocation behaviour of individuals with regard to accumulating human capital through formal education beyond the mandatory school-leaving age, and through decisions to engage in on-the-job training (OJT) activities. Fiscal codes also may indirectly affect the supply of educational services; as, for example, through the tax deductions afforded to those making charitable bequests to educational institutions, and the treatment of the expenses employers incur for worker training.

The following discussion is intended only to indicate the broad class of issues that need to be addressed, and to suggest the sort of empirical information that ought to have a bearing upon the design of specific government proposals in this area. We begin with a review of the basic logic of providing public subsidies for private investment in education and training, as it is presented in the modern economics literature. Following some brief comments on the rationale for direct, rather than preferential, tax treatment of those forms of investment expenditure, we turn to examine in some detail the analysis of the effects of the taxation of personal income.

There remains, of course, the pragmatic issue of how government should allocate the subsidies it provides for human capital formation. Here fewer generic insights are to be found in the public finance literature, largely because practical choices among alternative forms of subsidisation cannot be made without reference to the specific structures of tax codes and the existing public and private agencies in the society concerned; nor without reference to inter-industry differences in the importance of different forms of investment in human capital, such as formal training outside the firm or OJT. On the latter question, however, notice already has been taken (in Part II.1) of a further practical difficulty – viz., that econometricians repeatedly have been frustrated by a lack of the kind of data that is needed to provide an empirical basis for deciding, in any given industrial setting, whether the emphasis should be placed upon job-specific training, rather than general human capital formation.

A case for differential subsidisation of investments in human capital:

A preliminary point needs to be made explicit. To the extent that investments in human capital yield positive externalities and so yield marginal social rates of return that exceed the corresponding marginal private rates of return, there is a case for public subsidisation. Much of the discussion in the preceding sections of this report (especially Part II)

addresses this question, implicitly and explicitly in the context of the social returns generated through processes of economic growth in which human capital plays a variety of roles. Whether a case can be made for *differential* tax treatment of investment in human vis-à-vis non-human capital, therefore is a question upon which the optimal tax literature *per se* is not helpful: the answers depend upon the direction and magnitude of possible externalities deriving from each kind of investment.

Thus, the accelerated depreciation schedules and investment tax credits for outlays on producers' durable equipment that are allowed by some countries (e.g., the US), are sometimes justified on the grounds that the rate of embodied technological progress is especially high for this category of physical capital, and the latest vintages of equipment have strong complementarities with specific investments by employers in worker training and organisational change, all of which contribute to total factor productivity growth. So long as the buyers of such equipment are competitors in the final product market, the spill-overs through TFP increases will end up in the form of greater consumer surpluses.

Similarly, and perhaps with stronger empirical justification, the most straightforward case for subsidisation of R&D investment rests upon a preponderance of evidence that public grants and contracts for research are net complements rather than net substitutes for private R&D (see David and Hall 2000; David, Hall, and Toole, 2000, for a review of the econometric evidence). This could justify either the granting of R&D tax credits, accelerated depreciation or, more usually, total deductibility ("full expensing") of costs, where the policy intention was to raise private demand for this type of capital formation. Alternatively, as Romer (2000) recently has pointed out, the instrument selected for encouraging a larger volume of R&D investment might be the subsidisation of the training activities to create an enlarged supply of research personnel – a strategy that would have the merit of encouraging more private R&D investment by reducing its marginal costs.

For present purposes, however, we may put aside consideration of externalities arising from interdependencies of the sort just recognised, and, further, ignore the existence of spill-overs from individuals' respective investments in human capital. In the absence of all such "externalities", expenditures on education and training can be treated as yielding purely private payoffs by raising individuals' productivities and earnings; the issues involved in determining the proper tax-subsidy treatment of human capital investments are reduced to just those concerned with the degree to which private investment incentives may be distorted (to the detriment of individual well-being) in ways that can be remedied by direct subsidies, or corrected by alterations in the tax regime.

Most of the discussion that occupies the economics literature devoted to this topic addresses the distortions that are perceived to arise from the workings of income tax systems. But before examining the nature and implications of that body of analysis, it is worth noting a distinctive rationale for direct subsidisation of educational investment, based upon the distortions caused by uninsurable private risk and its interaction with imperfections in the market for personal finance.

The dominant stream of economic analysis concerning fiscal policies affecting education and training investments proceeds under the simplifying assumption that agents are risk neutral and all calculations affecting behaviour can be carried out in terms of expected values ("certainty-equivalents"). Some refinements in the analysis, however, do acknowledge the presence of *differential uncertainty* affecting the private returns to human capital investments. Eaton and Rosen (1980) were the first to argue that because individuals undertaking such expenditures had to assume idiosyncratic and uninsurable

risks of a sort not present in tangible capital investments, special subsidies were warranted to encourage private investment in education.

Of course, in the face of moral hazard, subsidisation in the form of publicly funded grants to defray training costs are not unproblematic. This objection applies *a fortiori* to subsidies in the form of loss offsets symmetrical to the taxes that would be levied on the incremental returns from the human capital investment in question. But the Eaton-Rosen (1980) proposition would suggest, at the very least, that the extent and form of educational subsidies should take into account empirical data indicating the severity of uninsured individual risks, particularly those that for all intents and purposes can be viewed as uninsurable. As Judd (1998) points out, this rationale carries less force where private agents (say, firms and employees) possess more information about the idiosyncratic risks (of, for example, their joint investment in OJT) than does an outside party, such as a government agency.

The same may be said where workers are able to write flexible contracts with risk-neutral employers. Such contracts in effect would induce the choice of a level of human capital investment that equated its marginal product with the return available on a risk-less asset, thereby implying no risk premium. Private contracting arrangements of that sort seem plausible in circumstances such as those of high-tech "incubator" organisations. The latter are modelled by Goddard (2000) as bundles of contracts designed to induce prospective start-up entrepreneurs to undertake the kinds and amounts of human capital investments that would maximise the expected rates of return on the backers' equity.

Yet the circumstances just cited are rather exceptional. It would seem to be a serious policy mistake to overlook the substantial transaction costs of arriving at transparent, flexible contracts that simultaneously address the problems of uncertainty, asymmetric information, tacit knowledge and moral hazard. Eaton and Rosen's (1980) argument for "education subsidies" thus is hard to dismiss out of hand in the more general situation, where employers recruit and offer job-specific training to large numbers of workers under conditions of incomplete information, and where the idiosyncratic characteristics affecting the post-training productivities of a cohort of trainees, at best, will be revealed only after irreversible training investments have been sunk. Moreover, for individuals at the low end of the income and wealth distribution, the combination of high contracting costs, asset constraints (due to capital market imperfections), and uninsurable private risk is likely to pose such a strong deterrent to significant individual educational investment that direct subsidies remain the only practical and effective corrective.

Taxation and intangible capital formation:

Systems of taxation under which workers are treated (like machinery) as agents of production – the income tax being the prime exemplar, distort the allocation of resources in a direction that militates against human capital formation. The most general formulations of optimal tax theory, such as the classic papers of Diamond and Mirrlees (1971), argue that there should be no taxes levied on intermediate goods. Plainly, investments fall under the heading of intermediate goods, as they are an instrumentality for shifting resources from the present to the future. Human capital formation today is regarded as yielding enhanced capabilities from which derive an incremental stream of human productive services (and corresponding earnings) in the future. But the process of forming human capabilities through education and other kinds of training also may yield consumption satisfactions for the recipients.

The practical implications for policy design that can be derived from an application of optimal taxation principles, however, remains less than immediately clear. This is so because in practice human capital may be a mixture of labour supply, capital investment and a final good, and because it may be necessary to consider general equilibrium effects, as well as the first-order impacts upon the behaviour of individual agents (see, e.g., Boskin 1977, Davies and Whalley 1991, Trostel 1993, Dupor et al., 1996, Heckman, Lochner and Taber 1998, Judd 1998).

To make any headway towards policy recommendations, therefore, it is best to begin by trying to reduce the tension that exists between the principle that human capital (being "an intermediate good") should not be taxed, and the practical difficulty of attempting to tax income from labour services in a way that would not distort human capital investments. Judd (1998) suggests that this may be done by taxing workers' incomes but immediately expensing all human capital expenditures: the proposal is to extend the (automatic) deductibility of foregone earnings costs to all direct education and training outlays. Furthermore, for the sake of consistency, it would seem to be appropriate for the central government to allow individuals to deduct from taxable income any mandatory community tax payments that were devoted to local public education and training activities. The latter detail that would preserve neutrality in the tax treatment of privately vs. publicly provided educational services.

To be sure, were a significant portion of educational (and/or training) expenditures to represent "consumption" goods (or bads) it would be appropriate to tax these. But, the obvious practical difficulties in strictly implementing such a tax policy suggest that, instead, reasonably generous caps might be imposed on the deductibility of direct education and training related expenditures. Furthermore, a rigorous interpretation of the optimal tax proscription to leave capital of any form untaxed, would confine the taxation of investments in education and training capital to just that portion of direct expenditures that generated "educational consumption" satisfactions. The inter-temporal effects on individual economic welfare of educational investments made early in the life cycle – in raising marginal satisfactions derived subsequently from complementary consumption activities – is perfectly analogous to the effect of investing in financial or durable physical assets that yield a positive rate of return.

Consideration of existing tax codes quickly reveals that, contrary to common opinion, some portion of human capital investments actually may be taxed more heavily than financial investment and tangible physical investments made by households (see, e.g., Judd 1998: Steuerle 1996). As a result of efforts since the 1980's to increase the conventional personal savings rate in the US, UK and some other advanced economies, special tax provisions presently allow the sheltering of income in pension funds, individual retirement accounts, and other vehicles for savings. The use of these instruments for shifting income from the present into the future has thus been favoured, in comparison with others, including human capital formation, that may accomplish the same purpose. In addition, investments in corporate debt also avoid the corporate income tax, whereas equity investment is subject to taxation at the corporate as well as the household level; the interest expenses of financing owner occupied houses is deductible from taxable household income, whereas the service flow of the residential structure itself is not treated as part of taxable income.

Consequently, the elimination of taxation of all investment in human capital has been recommended in some guise or another by economists and tax analysts, e.g., Boskin 1977, Kaplow 1996. This is a partial tax reform proposal, and falls rather short of a "second-best" policy, for it would not be likely to result in a tax regime that was "neutral"

with respect to the formation of different types of capital. Physical capital goods purchased by businesses cannot be fully "expensed", i.e., set off against earnings by firms that pay corporate income taxes; instead, most national and local tax codes allow depreciation charges on these durables to be deducted from gross earnings. One might view the persistence of differential tax treatment of different types of capital as a potential source of allocative inefficiency, and therefore favour far more sweeping reforms, such as the adoption of taxes on *consumption* expenditures alone.

It should be understood that nothing in the economic arguments favouring a consumption tax regime (over regimes that implicitly tax investments) constitutes grounds for establishing fiscal neutrality with respect to capital formation. Under a consumption tax regime it would be entirely feasible to introduce differential subsidies for private investments, say, in order to counteract the effects of externalities and incomplete markets that otherwise would result in a socially sub-optimal national asset portfolio. Consumption tax rates could then be set so as to recover the revenues required to pay those subsidies, and the tax schedules (and exclusions from "consumption") could be implemented with whatever degree of progressive-ness in the rates that was deemed desirable on welfare redistribution grounds.

The consumption tax proposal to which public finance economists widely subscribe compounds two distinct departures from most existing tax regimes' treatment of human capital. First, it removes the tax disadvantage of human capital investments due to the difference between the non-deductibility of the direct cost component of human capital investment, in contrast with the deductions allowed for depreciation of tangible non-human capital. Second, by eliminating the taxation of labour income, it does away with the effects of progressive marginal taxation on the amount of human capital invested privately by individuals (both foregone earnings and direct educational and training costs). Both features of the proposed reform are mimicked by the less sweeping proposal to shift to a "flat tax" on wage income, with full deductibility of human capital costs. To be sure, the abandonment of progressive taxation is from some viewpoints the really radical aspect of the "flat tax" scheme; that aspect of the reformers' proposal is not a logical requirement of shifting to consumption expenditures as the basis for taxation, instead of continuing to tax labour incomes.

It may be pointed out, further, that eliminating the inefficiencies in resource allocation created by differential "tax wedges" (gaps between pre-tax and after-tax rates of return that vary according to the type of asset) is not an obviously compelling goal for tax policies to pursue. There often will be a trade-off between improving *static* economic welfare efficiency and "dynamic efficiency". Putting this in less abstract terms, a consistent growth-promoting logic may be read in the tax treatment of investment so as to favour both shorter-lived tangible assets (and intangible non-human assets such as patents and software), and comparatively long-lived, intangible human capital on the other hand. In the first case the tax bias tends to promote rapid turnover of the tangible capital stock, and so tends to enlarge the market for producer goods that embody technological innovations; in the second case the tax bias works to compensate for the greater systematic obsolescence risks to which owners of human capital are exposed by policies that promote more rapid rates of advance of fundamental knowledge and technological progress.

Conventional income taxation is based upon current earnings, rather than accrual accounting which typically applies to physical capital. Under the latter system, the returns from the investment are included in current income; the costs of the asset are capitalised (not immediately expensed) and depreciated at a rate reflecting its "economic service life",

i.e., the temporal change in the present value of the remaining stream of returns; current depreciation charges are set against current income. Were accrual income taxes to be applied to human capital, the effect would be less favourable to investment in education and training than the conventional income tax regime, as Kaplow's (1996) analysis shows. The reason simply is that such investments tilt the time-profile of earnings upwards, and conventional income taxes do not impose additional taxes on the implicit interest component of higher later returns – whereas an accrual income system would do so.

One therefore can see that, under the conventional income taxation, human capital investments are a favoured vehicle for young households to transfer income (and consumption) into the future. Those that opt instead to begin saving immediately to meet for their future needs, would choose earnings profiles that were higher at the outset but flatter; but they therefore must do their savings out of current after-tax income, and also pay taxes on the interest income from their financial assets. The foregoing tax regime comparisons, however, focus only upon the effects of differences in the method of income accounting, and their implications for human capital are quite separable from those that derive from the structure of marginal tax rates. It will be seen that the latter exert a counter-acting force upon educational investments as a vehicle for income shifting.

Putting to one side for the moment the (redistributive) equity grounds for progressive regimes of taxation, it is a defect of rising marginal income tax rates that they militate against investment in human capital. This effect is due entirely to the temporal positioning of this particular mode of saving within the household's life-cycle. The expensing of foregone earnings costs, as well as any deductions that are allowed for direct education and training costs, comes during the early phase of workers' lives, when incomes and marginal tax rates are low in any case. But, these investments, especially when supplemented by taking advantage of OJT options, generate a rising stream of labour earnings that are exposed to higher marginal rates under progressive tax regimes. The option of sheltering pension contributions (with equal pre-taxes rates of return), by comparison, provides a more attractive vehicle for personal savings. This is so because the tax implications of deferring income are exactly the opposite of those which apply in the case of education and training investments: pension proceeds typically are realised during retirement when earned income levels and marginal rates of income taxation are expected to be lower.

Is the impact upon human capital investment really a serious drawback of the progressive taxation of labour incomes? The answer surely will be sensitive to how steeply marginal tax rates rise over the upward-sloping portion of typical earnings profiles. Nevertheless, differences in economists casual responses to this question appear to turn on their intuitions as to whether individuals' behaviours in this regard more closely resembles the degree of inelasticity typical of household labour supply (in response to variations in marginal tax rates on wage income); or whether individuals' educational choices exhibit the higher degree of sensitivity that financial investors typically display in response to changes in the spread between pre-tax and post-tax yields.

Good "natural" experimental data might permit the foregoing question to be resolved empirically, but, in its absence, recent studies have turned to simulation models. The latter combine theoretical specifications and parameters estimated from microeconomic data, in order to create quantitative models of household behaviour that can be used to evaluate effects of hypothetical alternations in the regime of taxation. Following Heckman (1976), the paradigmatic approach to the problem postulates that individuals make educational investment decisions within the framework of a model of inter-temporal expected utility maximisation, subject to the constraints of a human capital production function and private

borrowing in perfect (financial) capital markets. Dupor et al. (1996), for example, econometrically estimate the parameters of a life-cycle human capital investment model of US white males (based upon synthetic cohort data for various educational attainment groups in the 1970 Census), and use these to simulate the effects of various tax regimes.

According to the results obtained by Dupor et al. (1996), shifting from the mildly progressive US 1970 tax regime to a flat tax rate would raise the foregone wages that were invested in human capital by 7.2 percent among high school dropouts, 5.2 percent among high school graduates and 2.8 percent among college graduates. But, these findings are sensitive to the choice of a baseline tax regime (modelled on the 1970 tax code) that was not particularly progressive: the proportionate rise in the marginal tax rate over the life-cycle of the typical worker was approximately 4 percentage points. Under a different tax rate schedule in which there are sharp discontinuities – such as is the case under the US 1990 tax code's rate increase from the 15 percent to the 28 percent level – the effect upon workers who would be pushed across a "kink" in the rate schedule is found to be much more marked. Human capital investment (foregone earnings) is reduced by as much as 22 percent. Overall, the simulation results that Dupor et al. obtain by substituting a flat tax schedule for progressive rates suggest that a 10 percent rise of the marginal tax rate over the increasing portion of the individual earnings profile has the effect of reducing investment in human capital by 15 percent. In other words, the (arc-) elasticity of education and training investment with respect to the marginal tax rate is roughly – 1.5.

Partial vs. general equilibrium and the policy relevance of microeconomics:

Up to this point, the discussion of generic fiscal policy implications has been preoccupied with conclusions derived from partial equilibrium studies. It has not considered what effects would ensue from altering the tax treatment of earnings derived from human capital investments in the context of general equilibrium models of capital accumulation. Quite obviously it is important to take account of the general equilibrium repercussions of tax policy changes. Over the long run it is possible that the immediate positive impact upon the level of human capital investments of setting lower tax rates on labour income – vis-à-vis taxes levied on the returns to physical capital – may well be substantially mitigated, if not completely nullified by the induced change in the economy's asset portfolio. (This proposition is brought out in the work of Auerbach and Kotlikoff 1987, Davies and Whaley 1991, Heckman, Lochner and Taber 1998, and Trostel 1993.)

It is not difficult to see why that would be so. In the absence of countervailing skill-deepening biases in technological change, the induced increase of the pace of accumulation of human capital (in relationship to the supply of raw labour-power through population growth) should operate to depress the marginal productivity of additional educational training. This is a point that was noted in considering the historical experiences of the developed economies (see Part II.3, above). Furthermore, to the extent that the contemplated tax reforms induce agents to substitute human capital for physical capital investments, the long-run effect on the level of physical capital per worker in the economy would depress the marginal productivity of labour and drag down before-tax rates of return to human capital. The after-tax interest rate in the economy's steady-state equilibrium, therefore, may not be affected by removing taxes on human capital investment (Trostel 1993).

Dynamic general equilibrium considerations of this kind are particularly relevant when analysing fiscal policies in a closed economy setting. But, the case of large economies, in which the supply of savings and the age- and educational attainment distribution of the population are determined largely by endogenous forces in the domestic economy, must

be contrasted with the situation of a small open economy. There the conclusions of the foregoing partial equilibrium analyses are more applicable, because when international financial flows and labour migration are unobstructed they can operate in the long-run to peg the before-tax rates of return on human capital and physical capital investments.

The implications of these "small, open economy" conditions for the use of taxes and subsidies as means of promoting human capital formation are not entirely straightforward, however. Whereas unrestricted international factor movements tend to give these fiscal instruments stronger long-run leverage over national capital formation, the very same conditions make it necessary to allow for the possibilities that national investments in human capital will not be tantamount to changes in available stocks of human resources and productivity growth in the *domestic* economy. This significant complication is one that must now be addressed (immediately below, in sub-section III.2.ii) by examining the direct and indirect impact that migration policies, including the tax treatment accorded to immigrants and emigrants, can have in shaping an open economy's human capital endowment.

(ii) Migration policies and their relationship to human capital formation

An extensive economic literature is devoted to the subject of international migration and its effects upon income in the sending countries (see, e.g., Bhagwati and Wilson 1989, World Bank 1995). The portions of it that are generally thought to be most immediately germane to policies affecting a region's human capital endowments usually are focused upon the effects of so-called "brain drains": the emigration of the more able, and more highly educated and skilled members of the population provides a form of windfall capital transfer to immigration regions. The latter can enjoy the benefits deriving from the newcomers' knowledge and skills without having borne the associated costs of their education and training. Even had the latter investments not been subsidised in any way by their native country, so that the migrants and their families might be supposed to have borne the full educational investment costs and recouped the private returns, whatever positive externalities their presence in the labour force and the polity created would redound in the first instance to the advantage of the receiving nation.

A country that already devotes considerable resources to domestic investment in human capital therefore must live under the spectre of a "brain drain" that will carry off cadres of highly educated personnel to other regions, where they are offered more attractive environments in which their talents and training can be employed. This was first identified as a worrisome economic issue in post-WWII Britain, where well qualified scientists, engineers and doctors were seen to be leaving home in search of more promising professional situations in America. More recently, renewed concerns about "brain drains" have focused upon the supposed damage that the phenomenon may do in developing countries, where already existing deficits in the human capital endowment are thought to be a major contributory factor in low productivity levels and poverty (see Bhagwati and Wilson 1989). Thus, the *World Development Report* (World Bank, 1995, p. 64) asks: "Can something be done to stop the exodus of trained workers from poorer countries?"

Countermeasures against "brain drains"?:

Such concerns are quite reasonable in some economic development contexts, especially those where there are critical scarcities of educated personnel required to maintain the minimal functions of a modern government, and to facilitate economic and political interactions with other, more economically advanced societies.

But, where there is substantial supply-side capability for expanding the numbers who can be trained, and the problem is one of insufficient private demand for investment in human capital, efforts to curtail out-migration of the highly trained may have counter-productive consequences. The effect may be to further weaken private incentives to invest in education. Conversely, there are conditions under which investment in human capital might be raised by allowing those whose expected earnings potentials would thereby be increased to chose to work abroad in order to realise such gains. This effect could affect the investment behaviour of a much larger portion of the population than would actually emigrate, and consequently could augment the impact of public subsidies for the types of education and training that would provide the skill qualifications required for overseas employment (see Stark and Wang 2000).

The selectivity of emigration decisions, which often has been held to draw off the more innately able and enterprising members of the society in economically less developed regions, tends to be amplified by selective immigration policies in the higher income regions: such restrictions typically favour the admission of applicants who have obtained higher educational credentials, and thereby are likely also to select individuals from the upper tail of the (academic) ability distribution in the origin population. The negative externalities (which may be cultural and political in character as well as economic) that are entailed by their removal from their native land, may well be more palpable than the positive externalities they bring to their new society.

One basis for this conjecture is that immigration societies typically are already more heterogeneous, than the individual societies from which they draw new members, and the selectivity of migration simply amplifies that difference by further homogenising the population who remain at home. Indeed, the greater diversity of peoples, and the wider variance in the array of economic opportunities created by the variegated array of human skills and tastes, is one feature of regions of in-migration (such as large metropolitan agglomerations) that renders them more attractive destination markets for newcomers who can invest further in job search when they arrive. The job-searcher is concerned with the value of the best among the employment opportunities that he or she will encounter, and, in any given sample of job openings, the expected *extreme* value tends to be larger where the relative dispersion of the underlying distribution of job offers is greater. (For models of migration *cum* local job search, see David 1974.)

Selective immigration policies for raising the human capital endowment:

Policy measures that are directed towards affecting the international movement of people potentially offer a far more controllable and faster mode of response to labour market demands that remain unmet by the gradually evolving domestic supply of suitably qualified personnel. There is a wide range of instruments that can be applied selectively in this connection:

- discretionary controls over visas and the issuance of employment permits, subsidies for passage and settlement costs,
- tax concessions for immigrants who are burdened by the repayment of educational loans,
- subsidised provision of schooling and social services to accommodate special needs of families of new immigrants,
- licensing requirements for professionals having obtained qualifications and certification in foreign countries,

- requirements for “naturalisation” of the foreign born and for indefinite leave to remain in the country, and so forth.

Obtaining reliable indicators of the likely effects of introducing differential treatments of this kind, both in terms of their influence on the characteristics of the arriving immigrants and the anticipated duration of their attachment to the country's workforce, generally will not be a simple matter – especially not without some experimentation. But, the costs of designing experimental immigration schemes, and of administering a system that features a multitude of different rules and entitlements, may be very substantial.

Moreover, there are numerous vexing distributional issues raised by selective immigration policies. The arrival of a substantial number of skilled immigrants relative to the pre-existing domestic supply would be most likely to prove beneficial in the short run for those who own complementary human and non-human assets. On the other hand, their competition in labour markets tends to lower the rates of remuneration received by the owners of assets for which they represent replacements, or very close substitutes. The immediate impacts on relative wage and salary rates are likely to be felt most strongly by domestic workers situated at the opposite extremes of the skill-spectrum.

There is an offsetting income effect that also should be considered. Encouraging a substantial inflow of immigrants who have special, high-skill qualifications – such as those needed in computer programming for financial, banking and insurance industries, or for computational chemistry, and biogenetics research – would tend to lower the costs and raise the profitability of the domestic organisations that made intensive use of workers of that kind. If this attracted investment to expand capacity, the impact of expanding employment demand could be sufficient to counteract the downward relative price effect on the remuneration of new, domestically trained workers. There would be, in addition, a potential benefit for the industry’s customers, as well as for the vendors and owners of complementary physical capital equipment. Consequently, the impact of an inflow of trained workers from abroad upon the incipiently rising wage premia for workers with programmers’ skills will not necessarily result in a weakening of the long-run incentives for the domestic population to invest in such training.

The considerations leading to that conclusion are likely to have greater force where there are threshold-effects, or minimum scale and critical density effects in the industries that make intensive use of workers with specific human capital qualifications. Inducing the immigration of qualified foreign workers in numbers sufficient to attain those critical levels, constitutes one path to initiating a cumulative process of growth in such industries. Were it to be made clear -- by explicitly stated “sunset” provisions – that the programmes and subsidies being offered to induce an inflow of suitable workers from abroad would not continue indefinitely, then the longer-term prospects of domestically trained workers to find future employment in the expanding industry would be more likely to elicit a subsequent accommodating expansion in the supply of domestically trained workers.

What should be clear from the foregoing is that programs promoting selective immigration and tax policies promoting human capital formation in the domestic population should not be regarded automatically as substitutes, especially not when their effects are considered over a suitably extended time horizon. Nevertheless, where-ever the government of the day cannot credibly make policy commitments that are effectively binding upon future administrations (such as sunset provisions), the short-run substitution effects can be expected to be dominant. The two classes of policy measures consequently will be perceived correctly to be in conflict, and the instrumental value of both would be diminished, if not wholly vitiated. This point simply echoes the emphasis which the

preceding discussion of reforms in the taxation of human capital investments laid upon the government's need to establish the credibility of its policy commitments in this area.

(iii) Human capital policies and retirement

It is appropriate to close this section with a comment on a neglected topic: the role of human capital in *retirement*. In large part because straightforward methods of measuring the private (let alone the social) economic returns on human capital investments that yield payoffs when the individuals in question has ceased to engage in market employment, the economics literature has had little to say on the subject, as was stressed in section II.1. Nonetheless, peoples' intangible capital needs do alter when they enter retirement. Voluntary retirement is occurring at earlier ages in the advanced, higher income economies, and the circumstances of formal retirement there entail both enlarged opportunities for non-market productive activities, and an increasing number of personal transactions with public and private bureaucracies, and greater sophistication concerning aspects of healthcare and medical technology.

In view of the demographic trends towards the ageing of the population, and the growing importance of the time and resources that individuals devote to recreational pursuits and leisure-related consumption, the economics of "education for retirement" is a subject that would seem to merit more serious attention from the public sector. Although it is obvious that the social returns from such investments could not be expected in the form of increasing direct measured productivity on the part of the recipients, there may be significant economic "payoffs" that will be reflected in the improved cost-effectiveness of many of the private and public service organisations whose performance is affected by the characteristics of the elderly clientele with which they must interact. Enhancing the "capabilities" of those people is likely to yield significant gains in their well-being as well as reductions in the economic burden they place upon the working population. The geriatric literature is replete with testimony to the beneficial effects for the health and mental acuity of the elderly of continuing to utilise previously acquired skills, and of acquiring new ones.

The Coordination Challenge: Aligning Human Capital and other Investments

A general point on which modern growth theory and empirical observations quite clearly agree is that it is a tricky, delicate matter to establish a smoothly virtuous dynamic of positive feed-backs that will drive steady growth at the macroeconomic level. Looking below the long-term trends one finds periods of slowed and accelerated productivity advance, as well as episodes of under-utilisation of productive potentials and others that are marked by recurring inflationary pressure.

Putting to one side questions of short-run demand management, the reason given by most recent contributors to growth theory to explain why maintaining a high growth rate path is such a challenge for a market economy is that the sources of social increasing returns to investment derive from "spill-over effects" of one kind or another. In an economy of any complexity, especially in one where there is decentralised decision-making and competition in many sectors, crucial positive spill-over effects created by technical complementarities and coordination of exchange transactions take place at the microeconomic level. Consequently, they must be underpinned largely by the development of mutually aligned expectations regarding the positive pecuniary externalities that will result from investments in a variety of durable productive assets. This will be the case especially where the "investment projects" that are required to achieve

complementarity between the characteristics of newly developing technologies and matching worker capabilities usually involve rather long periods of gestation.

This leads, on one hand, to what some economic thinkers regard as the uncomfortably pessimistic conclusion that we should not expect a perfect, free market economy to arrive spontaneously at a sustainable set of such expectations. On the other hand, the "good news" – or, perhaps one should say, the less discouraging news – is that the important initiating and guiding function that exists to be filled in such situations is one that lies well within the scope of national government agencies that are already established in most countries, save for the poorest and smallest. Working in partnership with the private sector, public agencies may promote growth by facilitating better dynamic co-ordination. This involves increasing the flow of reliable information to shape mutually reinforcing expectations that, in turn will affect private investment decisions. Of course, financing for the necessary human capital components cannot effectively be left to either the households or the business sectors, for all of the reasons that already have been reviewed here.

What will be required to shape expectations in this context is the publicising of the state's credible commitments to undertake long-term programmes that offer subsidies for basic education and training investments, and provide assistance with the financing of continuing education and re-training. Furthermore, from the narrow resource allocation viewpoint it is obviously important that subsidies in this area should have a two-part structure: in addition to promoting general education in the population, they should aim to elicit further human capital formation which are aligned specifically with indicated broad trajectories of technological development, business reorganisation, and structural reorientation related to international trade specialisation. The latter, of course, ought to be identified on the grounds of being those holding the greatest promise for the economy's future.

Policies to Promote Catch-Up and Convergence through Human Capital Formation?

NZ's relative standing in the international ranking of countries by GDP per capita has slipped considerably over the course of the last quarter of the 20th century. Without entering into the question of whether that is a serious problem in itself, or is symptomatic of conditions in the NZ economy that need to be addressed, one may ask what the findings of the macroeconomic growth literature offer by way of a general answer to this question: Is there a role for public policy to take, in generally encouraging a higher human capital formation rate as the means of enabling NZ's economy to catch up with the productivity leaders?

The first point to be made in this regard is that the empirical evidence from international comparisons suggests that it is the level, rather than the rate of growth of the average human capital endowments in a country that affects its productivity growth rate. Raising that level would therefore tend to accelerate the growth rate, and it appear that (other things being the same) such effects are stronger when the initial human capital-intensity is low than when it is already high. For an economy that starts from the latter, favourable position, the prospects of a big relative growth payoff from reaching a still higher general level of human capital-intensity do not appear particularly promising.

Furthermore, at least in the near term the potentials for a country to catch up with the reigning international productivity leader(s) are not unqualified. Instead they are bounded by conditions that limit economic integration through trade and capital movements, as well

as cultural and institutional dissimilarities – including differences in political and legal institutions. Such heterogeneities appear to impede the easy and effective international transfer of technological and commercial capabilities. Rather than permitting those processes to occur in the manner of an *undirected diffusion,* those conditions, and others work to channel effective knowledge transfers much as they direct flows of labour and capital, guiding these along particular paths that have been formed through the past history of specific bilateral and multi-lateral international contacts. Cross-country economic convergence, in the form of the reduced relative dispersion of productivity and per capita real income levels, has thus been found to occur within "clusters" of countries both historically and in more recent times.

The policy implications for a country that is already a member of a "convergence club" situated at the upper end of the international distribution of productivity and per capita real income level, would seem be to that it should eschew pursuing an across-the-board approach to reaching higher average educational attainment levels. Instead, government-initiatives in the area of human capital formation should focus upon the opportunities and needs for selectively augmenting the capabilities of the work-age population. Enhancing capabilities for knowledge transfers and closer commercial integration with other "club members" whose endowments are complementary, and whose geographical locations are conductive to regular commodity trade and the circulation of expert personnel, is a strategy that would reinforce the already existing mechanisms that enable comparative laggard's within the club to gain ground on its leading members.

If subsidising higher and higher general education attainments in the population at large does not appear to be the indicated policy for an already comparatively well off, and highly educated population to accelerate the domestic economy's productivity growth and catch up with the leaders, it may nonetheless be a strategy worth continuing as a means of protection against the possibility of falling farther behind. The broad rank ordering of economies according to their standing in the international distribution of labour productivity (and per capita output) levels exhibits considerable inertia over the span of several decades. A country's maintenance of a high average level of educational attainment that is widely shared throughout its population appears to serve as a potent *stabilising* force against serious and prolonged decline in its relative per capita GDP standing. Nevertheless, nothing is guaranteed: the persistence of seemingly small differences in productivity growth rates can take a toll, and over the longer-term such differentials have resulted in some marked historical realignments in the rank ordering of nations by average levels of economic welfare.

III.3 Human Capital Policy Implications for the New Zealand Economy

The situation of the New Zealand economy is one that presents something of an anomaly in the context of modern generalisations about economic development and growth. The country has enjoyed moderately high levels of productivity and GDP per capita, in both absolute and comparative international terms. In many respects the economy's historical development paralleled the early 19th century experience of the US, Canada and Australia – the other predominantly English-speaking regions of European overseas settlement in that epoch. Like those regions, too, its early comparative prosperity, and ability to sustain a high standard of living in the face of rapid population growth, rested for a long time on the exploitation of the country's primary resource base.

Settler society in 19th century New Zealand was characterised by what for the times was an uncommonly high material standard of living, but also by an egalitarian income distribution, and democratic internal political traditions. Those unusual circumstances seem to have had much to do with the fact that the European part of the population and their descendants attained and sustained remarkably high rates of school enrolments and literacy from a very early point in the country's history. By 1870 the NZ primary school enrolment rate, relative to the number of children ages 5-14, approached 70 percent – a level very close to that of the US, Switzerland and Prussia, the then world leaders. By 1910 the country's primary school enrolment rate had edged above the corresponding US rate and stood near the 90 percent mark (see Lindert 2000).

Yet, New Zealand's long-term growth path during the 20th century has seen its level of labour productivity overtaken and surpassed by that of many of the high average income member states of the OECD; today the country stands around 24-25 places down in the international rank ordering based levels of per capita GDP. Having lost the favoured agricultural export niche that Britain's market formerly provided, prior to its entering the EU and submitting to the Common Agricultural Policy, New Zealand is undergoing a slow process of transformation from a predominantly primary producer into an economy with an expanding service sector – without having passed through a stage of significant industrialisation.

The country's population still features a high average level of educational attainments by international standards, but the distribution of those attainments is rather skewed: at the low end there is an ethnic minority population (the Maori and Pacific Island peoples) among whom there are many without any educational qualifications at all, whereas among the educated elite there are many who have attained advanced postgraduate degrees. Although its economy remains dominated by primary production and related processing industries, these are highly sophisticated in their use of modern technologies for dairying and animal husbandry, etc., but the lack of a significant manufacturing base has left the country with a cadre of highly qualified scientific and technical workers that is quite small in absolute number (in the range of 3000–4000), comparatively more heavily stocked with agronomists and specialists in veterinary medicine than with engineers.

New Zealand's Situation: What Correspondence with Economic Growth Literature?

It must be said straightaway that little of the macroeconomic growth theory literature (upon which the discussion in section II.2 is based) has an immediate bearing upon the circumstances of an economy such as the one just described. Virtually all the models of endogenous growth have been developed for economies that are closed to trade and therefore, presumably, have a sufficiently extensive and varied resource endowment to provide for their own consumption requirements. By implication it could be said that those growth models therefore apply more directly to the situation of large economies, there being two distinct senses of "large" that are worth remarking upon briefly in this context.

The first of these concerns the relative importance of *domestic* sources of the growth of productive inputs – savings, population growth and human capital formation – in comparison with the magnitude of the supplies of those factors that are available to be drawn into the economy within a short time-span. A comparatively small region, such as New Zealand, typically faces highly elastic international factor supply conditions; and so long as regulations blocking the movements of labour and capital have not been imposed, international flows of those mobile resources can rapidly alter the country's factor endowments, thereby permitting it to quickly change growth paths.

The policy implications for the NZ economy are immediately transparent, and this has already been recognised in section III.2, where a number of issues were examined for their bearing on the possibilities of affecting immigration rates selectively, and thereby adjusting a (small) country's human capital portfolio. It may be added here that some further significance attaches to the international mobility of certain occupational groups within the NZ population. Extensive experience in travelling and living abroad (for study and professional purposes) is typical among the more highly educated stratum of NZ society, and it is ubiquitous among the country's professional, business management and scientific and technical personnel. In regard to this aspect of "personal contacts and maintained foreign connections" which continued to be so important a complement to overseas telecommunications access, the NZ economy is very much open to global flows of both codified and tacit knowledge.

There is, however, something of a linguistic and cultural "bias" in those connections: they are particularly strong in regard to exchanges with the US, Great Britain and the English-speaking Commonwealth. That is largely a heritage from the past, when New Zealand was an "immigration economy". Subsequent restrictive immigration policies, however, have left it less ethnically heterogeneous than other, larger commonwealth countries such as neighbouring Australia and remote Canada – the presence of the sizeable indigenous Maori population notwithstanding. But the other aspect of that historical legacy is that New Zealand's citizens and residents offer a comparatively thin base of personal and kinship connections ("social capital") to support the development of extensive commercial and financial transactions with the populous business communities of South-east and North-east Asia, including the overseas Chinese. Whether this constitutes a disadvantage, in view of the effort to develop new bases of comparative advantage, and how the situation could best be redressed were it deemed to be an impediment to accessing Asian markets, are matters that may warrant further discussion.

The second sense of an economy's "smallness or largeness" has to do with the assumptions made by most of the endogenous growth literature concerning the nature and sources of technological change, and the access that agents in one country may have to scientific and technological knowledge that is generated elsewhere. What the growth models depict in this regard is the technological situation of a "global" economy, one that is closed in regard to knowledge flows and so must invest in R&D activities in order to generate a basis for continuing innovation. Such is not the situation in which New Zealand finds itself, although, as will be seen, this does not imply that the human capital policies of a small, open economy can simply ignore the need to invest in infrastructure and direct generation of new knowledge.

Designing Taxes and Subsidies for Intangible Human Capital in a Small Open Economy

A significant *ex ante* limitation has been placed upon the scope of the fiscal policy initiatives to be discussed here, inasmuch as they deal exclusively with *intangible* human formation through education and training investments. Consequently, nothing will be said regarding possible complementary and competing government actions immediately affecting investment in health care, occupational and consumer safety, or in economically motivated geographical mobility within NZ. Care should be taken that the effects of the design of programmes, and the tax treatment of those related human capital investments is not such as would tend to vitiate the force of the policies suggested here.

(i) Full deductibility of education and training costs: a new reform proposal

Several modifications of the income-tax system could augment New Zealand's human capital resources, without requiring the potentially more disruptive and administratively more costly replacement of income taxation with a consumption tax regime. Our discussion of optimal and second-best tax policies, in the preceding section, II.2 (i), carries two major implications. One is that the principal goal of a partial fiscal reform should be the elimination of the differential tax treatment of human capital investments *vis-à-vis* other forms of investment by households. A secondary, reinforcing objective is to mitigate the disincentive effects of progressive taxation of the interest component of the wage-income streams deriving from private investments in intangible human capital.

The first of these objectives would be met by making all certified *direct* costs of education and training deductible from taxable wage income; whereas, the second objective can be reached (without altering the progressivity of existing tax schedules), by the device of shifting to a later point in the life-cycle the date at which such deductions from taxable income can be exercised by private individuals on whose behalf the direct educational expenditures were made. Under quite plausible assumptions about the time distribution of education-associated earnings differentials, it is feasible for the state – by acting as a financial intermediary in the market for human capital investments – eventually to recoup enough in extra tax revenues to do more than make up for allowing the individual to claim the deduction on their direct costs of education.

To fix ideas here we may consider the simplest case, in which direct costs of educational investment are being met out of individual households' current income flows, as would be true either when the young adult undergoing training had independent means, or received *inter-vivos* income transfers for the purpose from family members. Under the proposed scheme, neither the recipient nor the household that had borne these current direct costs would be allowed immediately to enjoy such tax savings as would be generated by claiming them as deductions from taxable income. Instead, the nominal value of the tax savings would be recorded in the current year's tax return filed by the student, and would be credited to a new, non-transferrable government guaranteed account established in the name of that individual (identified by a taxpayer number). The novel asset thus created is an untaxed, interest-bearing educational (expense) deduction account – the UIBEDA (or, phonetically, "we-bedda").

Comprehensiveness is desirable in defining "direct costs" for these purposes. Thus, this category should be taken to include expenditures for tuition and educational fees, for textbooks, equipment and supplies purchased in connection with enrolment in formal training programmes and additional expenses for living away from one's place of residence whilst engaged in education and training. If local tax authorities subsidise educational and vocational training programmes and use local excise and property taxes for that purpose, and all such taxes are not already treated as deductible under the national tax code, the fraction of local tax rates attributable to the subsidies can be announced by local authorities, and used by households to calculate an allowable deduction.

The maximum life of these UIBEDAs would be set uniformly, with consideration given to the possibility that post-university professional education, and post-graduate training that would generate subsequent direct cost should similarly be "credited" in the account. The actual life of an account, however, would be a matter of the account-holder's discretion, in that after some initial fixed waiting period from the date at which it was established, the account either could be liquidated, or that action could be further deferred.

Ideally, UIBEDAs should resemble a tax-free long-term bond in at least one respect: they grow at a fixed rate of interest (set at, say, the Treasury's long-term borrowing rate in the year that the credit was established) through automatic reinvestment of yields, up to a maximum attainable surrender value. But, unlike bonds, they would not be transferable, they would not throw off any "coupon" yields prior to being "cashed in", and they would have a variable surrender value even if held as long as was possible.

The aggregate nominal value of an UIBEDA, that is, of the portfolio consisting of a bundle variously dated "certified deposits" (direct cost expenditures) each of which would be growing exponentially at their respective government bond rates, could be "cashed in" for the sole purpose of claiming deductions from the account-holder's domestic NZ wage earnings. Once the UIBEDA had been thus broached, the stream of annual tax deductions would then resemble a term annuity, in having to be taken – whether in equal amounts (or according to some other pre-specified formula – over a fixed number of consecutive years. But unlike annuities, their monetary value would be the resulting tax-savings, and therefore would depend upon the account holder's current earnings, given the stipulated tax rate schedule(s) that would apply to the UIBEDA account.

The purpose of the foregoing provisions should be transparent enough. The benefits they offer in terms of tax-savings are intended to induce the account holder to make use of such capabilities as they gain through human capital investment, by working in NZ at the higher-income occupations that their education qualifies them to enter. The restrictions that have been imposed upon the way in which these benefits can be realised are meant to prevent tax-payers in high income brackets from benefiting by claiming a deduction for education-related expenditures in the name of other individuals, especially those who do not intend, or are unlikely ever to utilise that "investment" by working in New Zealand at subsequent dates.

A further problematic issue they address is that an individual account holder might be myopically opportunistic, and so seek to "cash in" the deduction immediately upon completing her studies, after which she would permanently exit the NZ labour force. The minimum waiting period should serve to diminish the attractiveness of the scheme to such individuals.

In addition, it would be desirable to provide the Treasury with greater predictability in the reduction of taxable incomes due to the liquidation of UIBEDAs and their conversion into an annuity-like stream of deductions in consecutive tax-years.

The effective after-tax yield on UIBEDAs would thus be determined by three sets of conditions: the Treasury's long-term borrowing rate, the degree of progressiveness in the income tax schedule, and the steepness of the individual's earnings profile during the period following their education and training investments. The first two of these being under the government's control, it is important that the rates in effect at the time the particular individual's account was established remain fixed throughout its life, whether or not they actually changed. Keeping track of the implicit fiscal obligations of the Treasury in respect to the credits in these accounts will not pose any real burden for modern financial information systems.

For such a programme to be effective it would be essential that statutory provisions be made to prevent subsequent changes from altering the government's obligations to the account holders, whether by executive or legislative action. The terms of individual UIBEDA accounts, apart from the necessarily variable current government nominal borrowing rate that establishes the yield on deduction credits, should thus remain fixed

throughout the life of the UIBEDA account. Of course, establishing a reasonable measure of "credible commitment" would not require binding future governments from altering tax rates, or changing the expenditure eligibility provisions which were applied in the cases of individuals newly entering the system. Conceptually, what is appropriate is to render these assets as secure from the risk of default as government guaranteed bonds.

Domestic inflation is a form of "constructive default" on the part of the state, but, in view of the fact that the great bulk of the UIBEDAs will represent future deduction claims by tax-paying residents, it would be sufficient to fix the real yield on deductions credited to these accounts and index the accounts' value to the domestic consumer price index. There would be no need to provide separate protection against the risk of depreciation in the country's currency *vis-à-vis* other currencies.

For administrative simplicity, and to give the programme greatest initial impact, it would be desirable for "sunset provisions" to be specified at the inception of the UIBEDA scheme, and for the major features of the programme to remain fixed for a stipulated period, say 10 years. By thus creating a fixed temporal window during which individuals would be assured of being able to enter this programme, families would be encouraged to take advantage of it in their long-term planning. The intention underlying this feature is to create a future "opportunity" that would affect decisions not only about investment in the further education of secondary school-leavers and university graduates, but one whose existence also would exert an influence on families' attitudes towards preparatory schooling at the secondary level.

From the foregoing it should be apparent that the novel instruments (UIBEDAs) created under such a reform would work to offset the taxation of the interest component in the returns on investment in human capital, But, in addition, because their value is increased by utilising that asset in employment at higher earnings rates within the NZ economy, they add to agents' incentives to use their skills at home. UIBEDAs therefore have the expected effect of raising future tax revenues derived from whatever public subsidies had been given to the individuals during their education in New Zealand.

Moreover, it also may be seen that once the administrative apparatus for such a scheme is in place, the way would be prepared to replace heavy government subsidisation of the direct (tuition) costs of university instruction by a programme of government guaranteed student loans. In general the incidence of direct government subsidies for education provided by public institutions is regressive in its effects upon the taxpaying population, for higher income households tend to be in a better position than are the poor when it comes to taking advantage of the benefits it conveys. Loan financing creates the opportunity to remove this regressive feature of the provision of higher education through publicly supported educational institutions, and replace it by a policy that was redistributive in favour of the economically disadvantages.

By extending the scheme contemplated here, it would be entirely feasible, as well as desirable on social and economic grounds, to make zero- or low-interest loans available to finance the direct human capital investment costs of low-income individuals. This could be readily done, by allowing a mixture of deferred deductions and deferred tax credits for the amortisation of those loans. Following "financial needs-blind" university admissions, as in the case of other educational borrowing options, the subsidies provided to individuals should be made available on a means-tested basis. They ought to be large enough to finance the larger, indirect costs of the investment, namely, the foregone earnings of individuals from low-income households whose need for the labour market earnings of

their young members would otherwise discourage the latter from pursuing post-high school, or post-university training.

In order to make clear what would be entailed in altering the tax regime in this way, and, particularly, the nature of the empirical and institutional details that would have to be considered in designing a scheme of reforms that was implementable in practice, it would be necessary, in effect, to set out in considerably greater detail the features of a "reform" programme of the sort that is contemplated. A recently prepared memorandum by David (2001) does that, but to pursue those details would go beyond the bounds of this report, and further expand an already lengthy discussion of this proposal.

(ii) Fiscal measures affecting selective immigration flows

The foregoing proposals to encourage private investment in further education and training by permitting full deductibility of eligible direct and indirect expenditures lend themselves readily to implementation in an open economy context. Arguments already have been advanced, above in section III.2(ii), against the imposition of restrictions on the freedom of recipients of educational subsidies to emigrate and take up employments abroad. It should be noticed that the structure of the UIBEDA scheme not only accommodates that policy position, but would allow such individuals to establish accounts whose future value constitutes an inducement for them to return to work in New Zealand after gaining further training and work experience abroad.

Thus, the UIBEDA may be seen as a means of encouraging the voluntary repatriation of New Zealanders who have acquired knowledge, skills and overseas connections that are likely to be of considerable value in domestic employment. The structure of the benefits provided in the form of income deductions, further, makes this option particularly attractive to individuals in the age range between 35 and 45, for whom relocation costs otherwise might prove a disincentive that New Zealand firms would have to overcome in order to recruit them. Although it is likely that such individuals would have made further, indirect investments in human capital whilst working outside the country, there are no compelling reasons to make such expenditures eligible for further deduction credits in their UIBEDA accounts. Closing that option not only has the virtue of eliminating a source of considerable administrative costs, but creates a marginal incentive to take up employment at home after graduation from university, and thereby benefit from the additional deductibility of investments in further education and on-the-job training.

The provisions of the UIBEDA scheme also lend themselves quite naturally to use as an instrument for encouraging selective immigration of people who received education and training investments in other parts of the world. The mechanism of selection available to the government in this case is the determination of the list of eligible institutions, and the date of receipt of specified degrees and competence certifications will be accepted as qualifying them to set up a UIBEDA account when they first enter employment in New Zealand. Evidence would also have to be submitted to establish the direct expenditures incurred overseas in connection with obtaining those credentials. For administrative simplicity, however, no deduction credits would be allowed for indirect investments in the form of foregone earnings.

Some foreign governments, or business sponsors of university education and other specialised vocational instruction impose debt obligations upon the recipients, and their family members, and require that they repay those before they are at liberty to take employment abroad; in other cases debts are incurred for overseas training, and these must be repaid in a lump sum if the individual does not return to take up employment in

his or her country of origin. Where foreign nations have made provision for the extinguishing of such educational debts as a condition for permission to emigrate, or remain abroad in employment, it would be appropriate for New Zealand to supplement the UIBEDA scheme by allowing the debtors to obtain deduction credits for the formal re-financing of their educational debt obligations.

In effect, immigrants with "approved" educational credentials could be made eligible (upon entering NZ employment) to receive educational loans in the amount of their pre-existing indebtedness on the same terms as are available to residents, provided those monies are used to extinguish their previously incurred debts. Upon doing so, the full amount of such outlays could be made the basis on which UIBEDA credits would be accumulated. A more cautious approach also might be adopted, to increase the probability that the re-financing loans would be repaid: UIBEDA credits would be granted only upon production of evidence of actual loan repayments. In principle it would be possible to implement such a scheme using private lenders for the re-financing activity, with some government guarantees to keep interest rates at the same level as those being offered to NZ students. Depending upon the scale of the programme, the costs of administering the re-finance arrangements for emigrants might be reduced were the state itself to take the financial intermediation role, and establish UIBEDA credits automatically as a step in the repayment process.

The intention of the foregoing proposals is to place another (fiscal) tool in the hands of the government which can be utilised to encourage a rapid inflow of migrants that can not only raise the average human capital endowment of the working age population, but do so in a controlled and selectively targeted manner. Immigration, as has been pointed out previously, offers the most direct and flexible means of transforming labour market conditions to facilitate particular lines of economic expansion and alter perceptions among the domestic population of future career opportunities that would warrant their investing in human capital formation. Although a wide array of other instruments has been identified (in section II.2(ii)) as permitting selectivity in this regard, many of them entail granting differential access or subsidies to social services and therefore are more likely to elicit resentments from members of the citizenry to whom such benefits are not available.

Moreover, coordinating the administration of such programs might require establishing a special, integrated agency dealing with housing, language instruction and family services to be handled with the special needs of various categories of immigrants. Therefore, it appears to be far more efficient and transparent an arrangement to confine the selective instruments to the fiscal sphere, as has been proposed here, and provide social services that meet the needs of immigrants on the same criteria that apply to the rest of the population.

(iii) Tax credits and subsidies for cooperative business investments in job-specific training

In order to guide a country's public policies affecting the extent and forms of investment in human capital beyond general, formal educational training, it would be desirable first to have ascertained empirically whether or not job-specific capital accumulation – through learning-by-doing and formal on-the-job training programmes (OJT) – was important in the occupations and industrial sectors that are of particular interest. The existence of experience-based "learning" that might not be entirely appropriated by the employing firm has a bearing also on several issues of "industrial" policy.

Granting subsidies for the adoption of new technologies whose use entails special workforce skills, for example, can be rationalised on the argument that firms that are early adopters may be providing benefits for subsequent competitors, who would draw upon an already-formed pool of skilled workers. Such a line of reasoning could apply not only where training in the use of truly novel technologies was involved, but, equally to policies of granting "import patents" (a form of monopoly franchise) to establish a known industrial production process, or research technique, in a new location.

The classic "infant industries" argument for tariff protection thus can be recast in a form that makes the existence of on-the-job learning externalities critical for its justification. Where learning spill-overs do not require the multiplication of production facilities as training sites, direct subsidies generally would dominate infant industry protection by means of tariffs levied on imports (see, e.g., David 1970). Similarly, the promotion of import substitution through awards of patent monopolies is a second-best policy that is more readily justified where learning by "pioneer" or "pilot" firms in the market gives rise to strong and widespread knowledge spill-overs (see David and Olsen 1992).

Unfortunately, as was previously noted in Part II, sect.1(3), the unambiguous empirical identification of micro-level learning effects in data collected for other purposes has proved difficult, except in some rather special circumstances that leave doubts as to the validity of generalising from those findings. Consequently, systematic sample survey data from interviews conducted at the business establishment level are likely to remain the most practical, widely applicable solution to the challenge of informing the design of public policies concerning OJT investment. From such sources it may be possible, at least, to learn more for particular industries and sectors about the extent of the gaps that exist between average practice and what might be viewed as "best practice" training policies. The latter can be gauged by inter-firm comparisons as to the scale, per worker costs, and the nature and modes of training; and before-and-after comparisons the distributions of workers' performance, and rates of job among the trainees.

It is indeed a pity that greater empirical attention has not been given to examining intra-industry variability of businesses' training practices and their comparative merits and costs, because it seems clear that in contrast with the longer-term effects of lifting the general quality of the workforce through schooling investments directed to the young, public subsidisation of OJT human capital formation undertaken jointly by employers and workers offers the prospect of much quicker payoffs. The latter may well bring positive externalities, by affecting not only the trainee's productivity performance within their firm, but by easing skilled labour supply constraints upon the diffusion of new production methods, and inducing greater investment in the physical plant and equipment that embodies new technologies.

At the same time, it must be recognised that OJT investments are in general less amenable to standardised modes of training, far more heterogeneous in the content of what is to be learned, and less amenable to external monitoring, than are physical capital formation projects. Of course, it is in the interest of employers, as a rule, to make such investments in the most effective form possible if they internalise the benefits – whether they are spending their own money or funds provided by public agencies. Thus, a good case can be made for avoiding government micro-managing, or even certification of the forms of training that will be subsidised.

On the other side of the argument, survey data as well as casual observation indicate the existence of wide and unjustified inter-firm and inter-establishment variations in training practices, and thereby provide empirical ground for inferring that there is significant under-

investment in information about best practice training methods, and that private incentives to share knowledge about the details of successful training methods remain inadequate. Hence, proactive provisions for information exchanges, at very least, ought to receive support from public funds or be made a condition of receipt of public subsidies offered under the terms of other public programmes directed to small and medium size businesses.

One way in which this latter objective would be achieved is by allowing employers to form cooperative training associations, whose activities would receive matching public funding according to a pre-determined formula for this form of fixed investment in building information infrastructures. In effect, such organisations would be "clubs" engaged in the voluntary production of a public goods of two kinds: knowledge about effective methods of training and retraining employees, and the actual augmented supply of workers suitably trained to take up employment in firms other than those where they were trained.

Direct subsidisation of private investments through tax credits for *incremental* training expenditures, would not be inappropriate here, inasmuch as the efforts of these associations yielded public goods whose benefits could be shared by "non-club" firms (and their workers). The analytical argument for this is completely analogous to that which has been developed in the case of tax credits for private R&D outlays. The pertinent empirical question, therefore, is whether the marginal social rate of return on such subsidies matches that yielded by other public uses of tax revenue. More concretely, it would be relevant to ask whether the impact of such tax credits in inducing additional training investments by firms would turn out to match the level of effectiveness that recent econometric studies at the microeconomic level have found for the case of R&D (see Hall and van Reenen, 2000).

The rules of the proposed cooperative training associations would establish a two-part structure for the contributions of member firms: the fixed part being uniform, and the variable portion rising with *the absolute growth in the total employment roster* of the firm. The effect of the latter, beyond assessing costs in a manner related to the benefits (which would tend to enable successful enterprises to expand production and employment), would be to create an added incentive – beyond that of the tax credits – for each firm to upgrade the skill level of its existing employed workforce.

Firms' contributions to these organisations' outlays should be treated as fully expensed, in keeping with general principles of taxing consumption rather than investments. Furthermore, the work of the training association could be reinforced by automatically allowing full deductibility of the foregone earnings costs incurred by the trainees enrolled in these "approved" training institutions. That, of course, would be more immediately feasible were the scheme to be implemented in conjunction with a tax incentive programme aiming to encourage prospective workers to undertake further investment in acquiring specific skills, along the lines of the UIBEDA programme that has been proposed in the preceding sub-section.

Romer (1993), in calling for the formation of "self-organised industry investment boards" that would sponsor both R&D and specialised training programmes, has put forward a proposal that is similar to this one in spirit, if not in its details. A problematic feature that is common to both proposals, however, is the need for the internal decision structure of such organisations, as well as their actual patterns of investments, to be closely monitored by the authorities responsible for the enforcement of competition policy. Lacking that precautionary measure, it would be quite possible for these organisations to become vehicles for employers' cartels, restraining the participants' abilities and readiness to

compete through the introduction of new technologies and products requiring specialised worker training, as well as through the recruitment of workers with better qualifications.

Another, closely related worry is that the larger firms within these "boards" and "associations", by virtue of the greater initial dependence of the club's activities upon their financial contributions and managerial expertise, would in all likelihood exert greater political leverage upon their internal political proceedings. There thus is a definite risk of the "capture" of these associations by their dominant members, and the direction of the organisations' collective activities towards projects whose direct or indirect effects reinforced the industry position of these incumbents against the challenges posed by rapidly growing entrants. This particular risk would need to be contained by some combination of supervised internal rules and external monitoring. There are precedents for the effectiveness of the latter instruments: in the organisational regulations adopted upon voluntary standards development bodies by the American National Institute of Standards (ANSI); and in the recourse that individual firms have under U.S. anti-trust law to private damage suits when standards-writing bodies are found to have acted in an anti-competitive manner (see, e.g., David and Shurmer 1996, and references therein).

Knowledge Infrastructure Policies for a Small Open Economy

In a large economy, the government enjoys greater scope to focus national science and technology policy inwards, placing greater emphasis on the indigenous creation of new knowledge and capturing the rents on such investments through the protection of intellectual property rights. Correspondingly, rather less attention may be devoted to identifying and absorbing such knowledge from abroad. Of course, an efficient system providing access to relevant scientific and technological data, and reducing the costs associated with their domestic distribution remain important. Not only do such facilities as on-line access to databases – of patent filings, scientific working papers and archival publications, and the like – help firms to monitor developments that could enable overseas and domestic competitors to attack their market positions. In a growing number of industrial sectors, ready access to such information also is essential in translating new discoveries and inventions into new commercial opportunities. As David and Foray (1995, p. 91) recently argued in an OECD report, "knowledge *distribution* is the crucial issue in the relationship between the stock of knowledge and the flow of innovation" [emphasis added].

What this view implies for a small, open economy is that economic growth policies affecting the national institutional knowledge infrastructure should be directed *primarily* towards the goal of providing potential innovators with greater access to the relevant global knowledge bases. The proximate goal is to increase the rate of assimilation of the large additions to reliable knowledge that are accumulating in the world at large, and which are likely to prove relevant to enhancing the capabilities of the country's population. Among the obvious material benefits from this, one would expect some of this information to be applicable in generating technological innovations at home, and adapting for local implementation innovations that were being commercialised elsewhere. But no less important, from either the perspectives of individual human well-being or global economic welfare, are the positive consequences of educationally preparing members of society to pursue the realisation of their talents and aspirations in endeavours that might well carry them into the wider world.

Thus, in countries such as Denmark, the Netherlands and New Zealand, domestic science and engineering capacity cannot be expected to push the frontier of knowledge sufficiently fast to keep up with the much greater research efforts and opportunities for field

experimentation in the world's larger countries. The aim of innovation infrastructure policy in such circumstances, therefore, should be to effectively "plug in" as much of the economy as is possible to the rest of the world, especially in the domains of information and technological know-how. There is an important exception to this prescription: substantial domestic investments in the generation of knowledge may be called for to support those local industries that have no major foreign counterparts, or where prior experience has established that little in the way of relevant scientific and engineering advances will be forthcoming from external R&D efforts.

To promote the general goal of improving the distribution and utilisation of knowledge requires specific policies that seek to overcome the obstacles arising from a variety of conditions. Thus:

- government subsidies may be required to finance the *access costs* to building up "information structures";
- in order to tap into the large body of uncodified and possibly *tacit knowledge*, it may be necessary to send people for training overseas;
- otherwise, as has been suggested already, immigration by foreign workers who have the appropriate skills must be encouraged;
- *intellectual property rights* (e.g. copyright, patent, and trade-secrecy laws) must be seen as "a vehicle of cooperation and investment coordination to expand productive capacities", rather than as a stream of monopolistic profits that restrict knowledge distribution;
- special "bridging" institutions – such as multi-disciplinary technology development centres, business incubators, and "science parks" that promote university-industry, or public institute-industry research collaborations may be required to surmount other, *institutional impediments* to knowledge access.

The extensive recent literature that has been devoted to each of the foregoing topics notwithstanding, it remains far from clear that there exists an optimal set of public schemes ("best practice policies") to induce and assist agents to access external knowledge resources as a strategy for enhancing productivity. The frequency with which mixed or negative results emerge in case studies of widely different technology transfer programmes, points to the existence of numerous pitfalls in designing such policies. Even though it is tedious (as well as disheartening) to catalogue and seek to generalise about the multitude of "things that don't work", such experiences can provide useful cautions for policy-makers, and therefore ought not to be ignored.

A pair of recent case studies, selected more or less at random, can serve to illustrate this point, and to inject a note of caution regarding the current enthusiasm in many policy circles for engaging the resources scientists and engineers engaged in the public sector (whether in universities or government institutes and laboratories) in "transferring" technological knowledge to commercial firms. Harmon, et al. (1997) examine the experiences of efforts to transfer technologies developed at the University of Minnesota to firms. They present evidence for approaching technology transfer as a collaborative activity that is less effectively carried on outside an established network of formal and informal relationships; success entails "network building and relationship marketing efforts".

This view contrasts with the approach to technology transfers as "arms length", buy-sell transactions between university research units and firms. The latter conceptualisation has encouraged concentration on the provision of "on-line" information about technology

offerings, with the goal of enabling potential developers and users to conduct more technically informative searches at lower cost. The latter undoubtedly is important, but it is observed that as a rule university-industry collaborative research entities are ill-situated to engage in effective "relationship marketing" activities of the sort that emerge between successful vendors of new technologies and their clients.

One source of this disability is the conflicts with other missions of the university that circumscribe the ability of universities to make legal commitments to industrial "partners" which, as a practical matter could be fulfilled only if administrators possessed the power to direct faculty researchers to develop the close and continuing connections with their industrial counterparts. Yet, from studies such as the one just cited, it appears that such connections are likely to be required with each of the organisations to which technological capabilities are to be "transferred", especially in fields where the technical knowledge is complex and undergoing rapid modification (see, e.g., David 1997: esp., pp. 22-24). Were university administrators not dissuaded from entering them by the inherent conflicts of institutional interests, it also is the case that passive provision of information about "technology offerings" constitutes an activity that absorbs far less administrative resources in monitoring and reporting the operations of "technology management/transfer" offices.

In another recent study, Bessant (1999) evaluates a UK programme called "Supernet", which aimed at improving the access of SMEs to research centres. His findings emphasise the need for better understanding of the nature and distribution of SME demands for technological support. This was particularly important because the programme's performance evaluation judged it to be a failure when requests for technological information failed to match the designers' expectations as to the *number* of SMEs that would be helped by the project, as well as the *type* of information they required. This sort of information is essential in designing effective schemes, because (in the absence of pre-selection) the population of potential clients is extremely heterogeneous. Some SMEs have no need for technology support at all, whereas others will "already know what they need and why", so that some subsidisation of costs and sign-posting may be sufficient. Yet, there also are likely to be firms in need of sustained, interactive consultancy relationships in order for them to understand and articulate a technological strategy that has reasonable chances of success.

A general point that emerges in this case study is that the transfer-promoting organisation must be designed so that it has strong incentives to invest resources in improving its own knowledge – about the distribution of "customer" needs. Unfortunately, this is not an orientation that automatically characterises agents and agencies that see themselves as, and work to promote the perception in others that they are repositories and disseminators of knowledge. What might follow from that observation is an organisational design policy that structured the budgets of "technology transfer programmes" in terms of an array of differentiated services that it provided, with correspondingly differentiated costs and activity levels for each category. This would create incentives for undertaking initial "market research", and for periodically updating survey information on the population of potential clients as a basis for subsequent budget adjustments.

Detailed characterisation of the relevant technological knowledge bases for existing and prospective lines of production would be needed to structure more specific policy implications regarding the form of "knowledge infrastructure" investments that would be most appropriate in the case of any particular economy. Thus, given the resource endowments and industrial structure of New Zealand's economy, concentrating on close, participatory monitoring of global advances in certain branches of the life sciences, including biotechnology, plant and animal genome sequencing, cloning techniques,

clinical areas of veterinary medicine, and related disciplines, would appear more economically relevant (at least at first consideration) than would, say, comparable attention being given to developments in robotic engineering, high temperature superconductivity, and quantum computing. The implication is clear that such considerations ought to enter into the *targeting* of domestic knowledge infrastructure support, and cooperative agreements with other countries for the use of advanced training facilities, exchanges of graduate and post-graduate students and research personnel.

Equally clearly, in fields where the objective is to create a capability for discovery and innovation, passive acquisition of information from external sources is not a pragmatic option. The consensus of the theoretical and empirical economics literature is that only exceptionally can the absorption of knowledge that is useful for such applied purposes be accomplished solely on the basis of codified material available in published sources (see Cowan, David and Foray 2000). For a variety of reasons, much relevant complementary knowledge pertaining to recent research advances remains uncodified, and therefore costly to transfer; often it must be acquired through personal exchanges among individuals and teams qualified as participants in highly specialised international research communities. These are not costs that can be readily avoided.

In place of the traditional view of non-rival, public knowledge diffusing automatically and instantaneously, it is now recognised that significant portions of industrially relevant data are characterised by a considerable degree of “stickiness”. As a result, informational spill-overs remain localised within large multi-establishment corporations, consortia and other inter-organisational research networks, and geographically “clustered” agglomerations of small and medium size enterprises (see, e.g., David, Foray and Steinmueller 1999). Although it may be feasible for New Zealand to make itself the site of one or two such nodal “clusters” for research-oriented firms in the Southeast Asian region, the country’s physical remoteness suggests emphasising an alternative strategy. This would combine the provision of greatly enhanced digital communications capacity through high-speed electronic network connections, and public support for extensive overseas exchanges of research personnel. In a sense, then, the indicated direction of knowledge infrastructure investments represents a continuation, modernisation and elaboration of the educational policies of subsidising overseas studies and scholarly exchange, in which New Zealand historically has engaged.

Human Capital Policy and the Economically Disadvantaged Minorities

New Zealand’s long history of near universal mass education starting at the primary level, and then moving rapidly on to secondary schooling in the first quarter of the 20th century, as did the US, formed a base for the subsequent high average level of educational attainment in the majority of the population. But, this history was not shared with the indigenous population of Maori.

Recent data on the educational, health and employment characteristics of the different ethnic groups in New Zealand document the well-recognised pattern of economic disadvantage that exists among Maori and Pacific peoples, vis-à-vis the majority of the population. The patterns of educational difference among the ethnic groups are striking and are worth describing in some detail.

According to data published by the NZ Ministry of Research, Science and Technology (1998) among the population of European descent, 21.5 percent have a tertiary education, whereas the same is true for only 8.3 percent of Maori and 5.5 percent of Pacific peoples. The third non-European ethnic minority is the Asian people, who comprise only a small

proportion of the total population and are atypical in having the highest fraction of their number educated at the tertiary level. This same pattern is repeated in the respective ethnic population proportions reported as having *no* educational qualifications at all: 24.7 percent among the European group, whereas among Maori and Pacific peoples the proportions are twice as high – at 50.3 and 52.6 percent, respectively.

One may infer that the pattern exhibited by the ethnic differentials in the population's educational attainments at the university level is not likely to alter appreciably, at least not if current schooling rates remain unaltered. The tertiary school entry rate among Maori high school graduates is down to the 22 percent level, less than one-half of the corresponding figure among non-Maori, but a still more marked relative differential appears between the two populations in regard to the type of tertiary education institutions they attend: only 8 percent of Maoris enter a university rather than attending a polytechnic, whereas about 25 percent of non-Maori do so. As a proportion of the numbers entering tertiary education directly from secondary school, university entrants account for well more than one-half (0.55) of non-Maori students coming directly out of secondary schools; whereas the corresponding proportion among Maori students is only 0.36. (See, Ministry of Maori Development 2000, for this and the following statistical material.)

The same government statistical source reveals that these ethnic disparities are already evident at the very beginning of the educational process: even in early childhood, the pre-school enrolment rate (for 3- to 4-year-olds) is 98.4 percent among non-Maori, and only 65.2 percent among Maori – a difference of over 30 percent points. The gap becomes smaller at the next, primary education stage, but the secondary school retention rates still show Maori being 20 percentage points below the 89 percent average retention rate that prevails among the rest of the population; a gap of the same proportions (23 percentage points) persists between the rates at which the two groups enter formal tertiary education directly from secondary school.

Parallel differences appear among the groups in regard to their tangible human capital situations, as may be seen from the various health indicators in a recent document published by the NZ Ministry of Maori Development (2000): Maori life expectancies are lower, while average infant mortality rates are higher, as are coronary heart disease and lung cancer death rates compared with those among non-Maori. Not surprisingly, opportunities for on-the-job training which would lead to higher earnings, are correspondingly different among the two sub-populations. Maori have consistently lower age-specific labour force participation rates than the rest of the population, lower median hourly earnings from wages and salaries in most occupations, and they are concentrated at the low end of the distribution of personal and household weekly incomes' distributions (see Ministry of Maori Development, 2000).

Efforts clearly have been under way to address this situation. The gap between Maori and non-Maori in the shares of the working age population that lack any schooling qualifications has narrowed more or less continuously from c. 27 percentage points in 1986 to the 20 percentage point level in 1998 (Chapple 2000: p. 12). At present the proportion of Maori who participate in the Training Opportunities Programme is almost four times larger than the corresponding proportion of non-Maori. A hopeful prospect may be formed from such indicators, and when the situation is viewed from a truly historical perspective there are grounds for optimism about the eventual outcome of the transformations that have been underway in NZ society to eradicate persisting socio-economic disparities between Maori and non-Maori.

Indeed, the trends in a variety of demographic and socio-economic indicators since the 1920s point not only to secular gains in average absolute levels of material wellbeing among Maori, but to gains relative to the levels characterising the non-Maori majority. The process of rapid urbanisation following WWII brought improvements associated with access to better schooling, better housing, better health service, and better jobs than had been available to Maori in rural areas. As Chapple (2000: p. 2) points out: "[t]he post-1970s Maori population is in absolute terms larger, per capita materially wealthier, and has a higher life expectancy than at any other time in New Zealand's history".

Yet, significant disparities remain, as has been noted, and a more detailed examination of the recent data reveals that the slowing down of New Zealand's economic growth, and the rising unemployment rates during the latter 1980s significantly arrested the country's progress towards socio-economic convergence. There undoubtedly was some recovery in this regard during the 1990s, but throughout the second half of that decade the disparity between the non-Maori and Maori average employment rates remained in the region of 11 percentage points, well above the levels seen in the years preceding the late 1980s. Data on median incomes, also presented by Chapple (2000: pp. 11-12), reveals the proportionate income gap between non-Maori and Maori females to have remained essentially unchanged since the mid-1960s, while the corresponding gap in the case of males still is substantially bigger than it had been in the pre-1986 era.

Thus, the expected narrowing of the relative gap in employment rates as the overall macroeconomic picture continues to improve, seems likely at best to restore the relative inter-group income gap for males to its historical range between 10 and 20 percentage points, but not to initiate a new era of relative income convergence.

The thrust of the thesis that Chapple (2000) advances is that Maori members of NZ society today are not disadvantaged due to any lack of inherent abilities, nor because they form a distinct ethnic minority that has suffered active social and economic discrimination at the hands of the majority. Rather, as a group Maori are comparatively poor, and it is suggested that they suffer the self-perpetuating disabilities associated with poverty. If that view is accepted, the economic literature on "poverty traps" (which in its general logic resembles discussion of the "low-level equilibrium trap" phenomena studied by development economists) suggests that this condition will not cure itself spontaneously.

Dynamic models containing multiple equilibria in human capital formation rates (e.g., Redding 1996 and Acemoglu 1996) suggest how an easily identified ethnic or racial segment of the population could become chronically disadvantaged. Suppose that there is a group of people that has high educational qualifications and hence has access to jobs with high wages and productivity, while another group is initially disadvantaged with low levels of education, and therefore remains in low wage and productivity jobs, with little prospect of advancement. Then society as a whole, and employers in particular, will infer that the group (say an ethnic minority, but one can easily think of a division by gender or race) is a "low productivity" group and will tend to discriminate against them on a statistical, rather than a personal basis.

Clearly, it is the initial human capital of each group combined with a "segmented" labour market that causes the productivity differences, but the signal extracted by firms will result in differential treatment. This sort of stereotyping can result in the initially disadvantaged group remaining in less advantageous occupations, which also reduce its members' incentives to acquire higher educational qualifications.

The appropriateness of such a diagnostic approach, however, might well be challenged by those who also agree with Simon Chapple's (2000: p. 10) contention that "[p]opular rhetoric to the contrary, Maori do not share a common experience of socio-economic disadvantage. The Maori ethnic group is not a group whose boundaries are well defined by socio-economic failure. Socio-economic differences *amongst* Maori as a group overwhelm socio-economic differences between Maori and other groups". The force of this proposition would seem to be directed against targeting interventions to assist Maori qua Maori, rather than Maori qua "Poor".

Yet, the major piece of quantitative support adduced by Chapple (2000: pp. 8-10) is the observation that the 1997-98 distributions of real hourly earning for Maori and non-Maori workers are not at all disjointed; indeed their domains overlap completely, even though the Maori distribution exhibits greater weight in the lower tail. Although this evidence would seem sufficient to establish the absence of any significant degree of wage discrimination, it does not demonstrate that occupational segmentation is not a factor disadvantaging those identified with the Maori minority.

The income distributions for Maori and non-Maori show substantially greater separation than the hourly earnings distributions, implying that employment rates vary between the groups in the same direction as do the wage rates. Thus, to equalize the two distributions of earnings requires moving only 13.4 percent of Maori to higher real wage rates, whereas equalisation of the two income distributions would require moving 28 percent of Maori to higher income levels. It remains a matter for further research to determine whether the high-wage rate end of the Maori hourly earnings distribution corresponds to seasonal and erratic employments, and dangerous occupations wherein Maori workers are disproportionately represented.

If the structural, "culture of poverty" diagnosis of the relative socio-economic status of Maori in New Zealand is accepted, this would suggest that successful remedial measures would entail making substantial transfers of resources through integrated public programmes. Such an approach would permit the provision of community health care services to raise levels of tangible human capital and reduce the losses of employment experience and income due to sickness and medical disabilities. Further, in order to enable students to remain enrolled in school, thereby raising the primary and secondary completion rates, it might be appropriate to provide family income support conditional on continuing educational enrolment.

Establishing programmes leading to successive degrees of vocational certification at the secondary school level, and immediately beyond, would create positive incentives, complementing conditional grants of family income support that also aimed at reducing the wastage of high drop-out rates. To complement that strategy, it would be appropriate, in turn, to expand opportunities for entering tertiary educational institutions and programmes after a period of labour market experience. Corresponding direct subsidies, to replace foregone earnings, would most likely be required for such measures to become effective. Such investments could boost the productivity of disadvantaged minority workers in the types of jobs they currently hold, and also improve access to job- and occupational-ladders leading to steeper earnings profiles.

Via that route one might hope to eradicate remaining ingrained perceptions on the part of employers that the inferior qualifications of the general run of Maori workers justifies their under-representation among steady, higher paying and low risk occupations. Some further policy pointers may be extracted from the discussion in the macroeconomic growth literature of the role played by expectations in coordinating other investment activities that

would be complementary with those involving human capital. Small business loan programmes, eligibility for which is tied to the acquisition of specific business skills and vocational qualifications, fits neatly enough into that larger strategy. But public dissemination of information about the range of investments that are being undertaken in this fashion is also a way in which the expectations and actions of economic agents in the predominantly Maori urban communities can become better co-ordinated with, and reinforced by, activities taking place elsewhere in the economy.

An integrated programme of support designed to substantially raise average levels of human capital (the tangible as well as the intangible components) throughout these relatively disadvantaged minority groups can be envisaged. But its resource costs and coordination requirements imply that such an approach would represent a major political, as well as an economic commitment. Expanding the coverage of such an approach, so that it addressed the needs of economically and educationally disadvantaged families and youths throughout the NZ population, might raise its political attractiveness on grounds of equity alone. Nevertheless, the added administrative complexities of determining eligibilities for such targeted subsidies, and the potential drawbacks of establishing general programmes of entitlements to resource transfers, should not be underestimated.

The new macroeconomic theories of endogenous growth, and the econometric investigations which they have inspired, agree in finding that an important force making for international convergence to *common* levels of human capital and income is the cross-border flow of technical information and business knowledge. By contrast, the opposite result is to be expected in the case of economies that are closed in terms of knowledge transfers, and information-bearing transactions more generally. These comparatively isolated systems will converge to *different* long-run levels of productivity and per capita real income that are determined by their respective initial endowments of physical and human capital.

An analysis of this kind, on its face, does not seem immediately applicable to the situation within New Zealand; Maori and non-Maori are not segregated population groups, functioning in different economic spaces. On the other hand, just how densely, or sparsely connected the two sub-populations are by social communication networks is a different question. The answer to it may turn out to be important in gauging the likelihood that information diffusion would promote a tendency towards socio-economic convergence.

Thus, analysis of the role of human capital in open economy models of endogenous growth may yet hold some useful insights about ways of mitigating the forces that promote economic stratification along ethnic community lines within the economy of New Zealand.

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For Parts II and III, the selected references are only those that are specifically cited by the text of the various sections that make up each Part. In order to enable readers to move conveniently between the text citations and the full publication details, a self-contained listing has been provided of the references for each of the sections. Consequently, there are instances in which a particular publication appears more than once in the following listing.

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