On the Concept and Dimensions of Human Capital in a Knowledge-Based Economy Context

MIREILLE LAROCHE AND MARCEL MÉRETTE
Department of Finance
G.C. RUGGERI
University of New Brunswick

Les changements technologiques de même que la globalisation des marchés transforment les pays industriels en économies axées sur la connaissance, faisant ainsi du capital humain un thème principal des politiques publiques. Cependant, les mesures existantes de l'investissement ne permettent pas de comprendre toutes les implications du capital humain sur la performance économique et les progrès technologiques. Cet article discute les éléments d'une définition complète du capital humain et identifie les différences fondamentales entre capital physique et humain. Il montre que ces différences de même que les caractéristiques principales du capital humain ont des implications pour la comptabilité nationale, la classification des dépenses gouvernementales et la littérature sur la croissance endogène.

Technological changes, along with the globalization of markets, are transforming industrial countries into knowledge-driven economies. This shift has made human capital one of the leading public policy themes. However, existing measures of investment do not allow policymakers to comprehend fully the implications of human capital on economic performance and technological advancement. This paper discusses the elements of a comprehensive definition of human capital and identifies the fundamental differences between human and physical capital. It shows that the main features of human capital and its differences with physical capital have implications for national income accounting, the classification of government expenditures, and the endogenous growth literature.

INTRODUCTION

The importance of human capital as a source of progress and economic growth has long been recognized in the economic literature. Adam Smith (1776) was the first classical economist to include human capital in his definition of capital. He included in the capital stock of a nation the inhabitants' acquired and useful talents, because human skills increase wealth for society as well as for the individual. The concept of human capital was largely forgotten by economists until its re-birth in the early 1960s with the writings of Becker (1962, 1964); Schultz (1961, 1962); and Mincer (1958, 1962, 1974). These economists rekindled this old concept by reaffirming its links with economic growth and by emphasizing its importance in explaining earnings differentials.[1] During the same period, the

development of neoclassical (Solow-Swan) growth theory failed to provide a framework for incorporating human capital as an engine of growth. Such a framework became available later with the seminal work of Romer (1986) and Lucas (1988) and the emergence of a new endogenous growth literature, which stimulated the interest of economists in the role of human capital as a determinant of economic growth.[2] In some of these models, human capital induces growth by stimulating technological advancement or by enhancing labour productivity. Recent empirical studies of economic growth also suggest that the skills and knowledge of a nation's population are important in determining its economic performance. For instance, a higher stock of human capital can allow a less developed country to converge more rapidly to the income levels of a developed country through increased absorption of international technologies or capacity of imitation.

The emergence of the endogenous growth literature came about at a time when technological changes are continuously modifying production operations. These changes, along with the globalization of markets, are transforming industrial countries into knowledge-driven economies. This shift away from resource-based toward knowledge-based economies has made human capital one of the leading public policy themes. However, existing measures of investment do not allow policymakers to comprehend fully the implications of human capital on economic performance and technological advancement. Within this context, this paper argues that it is essential that the definition of human capital, its measurement, and specification in economic models capture most of its inherent features. This paper first incorporates various elements of definitions found in the literature into a comprehensive definition of human capital. This definition then allows us to identify the fundamental differences between human and physical capital and discuss the implications of these differences for the public and national accounts, the measurement of human capital, and the specification of both forms of capital in endogenous growth models.

This analysis highlights the close interactions of policy, human capital and growth in a knowledge-based economy. We show that the main features of human capital and its differences from physical capital have important implications for national accounts, the classification of government expenditures, and the evaluation of government policy. We also show how the specification of physical and human capital in endogenous growth models influences the estimated impact of policy on growth and other macroeconomic variables. We thus argue that in order to be able to recommend effective policy programs in a period of transition to a knowledge-based economy, a number of preliminary steps are necessary. First, it is essential to develop a measure of the stock of human capital to calibrate accurately computable growth and macroeconomic models, and to perform growth accounting studies. Second, the procedures of national and public accounting need to be revised to correctly measure savings and investment, and the effectiveness of government expenditure programs. Third, it is necessary to better integrate human capital theory into endogenous growth models. This would lead to a specific treatment of human capital, rather than a treatment similar to physical capital as is now commonly found in these models.

The arguments that support these recommendations are organized as follows: The next section discusses the major elements of human capital and highlights five special aspects. Section three identifies the fundamental differences between human and physical capital with respect to property rights and marketability, accumulation, financing, returns, and taxation. The following section reports on measurement problems associated with human capital, while the next section evaluates the treatment of human capital in endogenous growth models. We end with some concluding remarks.

Definition of Human Capital

Capital is typically defined as produced commodities, which are used in the production of other goods

and services (Smithson 1982). In the neoclassical theory of the firm, capital is one of the factors of production and represents the stock of previous investments made in the economy, which, in turn, requires the substitution of current consumption for future consumption. Agents add to the stock of capital by reducing current consumption in the expectations of increased consumption in the future.

Human capital is represented by the aggregation of investments in activities, such as education, health, on-the-job training, and migration that enhance an individual's productivity in the labour market (see e.g., Kiker 1966; Becker 1964; Schultz 1961, 1962). More recently, this concept has been extended to include non-market activities (see e.g., OECD 1996; Jorgenson and Fraumeni 1989; Schultz 1994). For the purpose of this paper, we define human capital as the aggregation of the innate abilities and the knowledge and skills that individuals acquire and develop throughout their lifetime. This definition is broader than what is typically found in the literature as it includes innate abilities. Innate abilities represent an individual's intrinsic potential to acquire skills. They can be defined as all physical, intellectual, and psychological capacities that individuals possess at their time of birth. They are received as gifts by individuals without any action or choice of their own, and they differ greatly across individuals because of heredity, parental decisions, and purely random factors. Acquired skills represent the actualization of this potential mostly through individual efforts involving a cost. These skills are acquired over one's lifetime through intergenerational transfers of knowledge, personal contacts, work experience, on-the-job-training, education and socialization. Since the number of skills individuals acquire through their lifetime depends partly on their initial abilities, this potential is an important aspect of the human capital concept.[3] Both components enhance the productivity of individuals in the production of goods, services and ideas within market as well as non-market environments. The concept of human capital is a complex and multifaceted one. We suggest that five specific aspects of the broad definition of human capital outlined above warrant special consideration.

First, human capital is a non-tradable good. Whether innate or acquired, skills and knowledge are embodied in human beings. As long as human beings remain non-tradable goods (no slavery), there exists no market that would permit the exchange of human capital assets.

Second, individuals do not always control the channels and pace by which they acquire human capital. When young, they cannot make rational decisions about their needs for human capital, nor can they assess the potential of their innate abilities. Consequently, during the first years of life, human capital decisions are not made by its owners, but by their parents, teachers, governments, and by society as a whole through its educational and social institutions. As individuals become able to make independent decisions, they will internalize the decision process on human capital investments. However, since the owners' ability to invest further in human capital depends on past investments and on the social environment, the influence of their peers and the institutional context in which they live continually shapes their acquisition of human capital, both in type and amount. For instance, Schweinhart, Barnes and Weikart's (1993) study on disadvantaged, subnormal children suggests that early childhood interventions may have lasting effects by improving later market earnings and by reducing the probability of future pathological behaviour.

Third, human capital has qualitative as well as quantitative aspects. Although one can easily quantify an individual's total years of schooling or daily caloric intake, it cannot be assumed that human capital investments are qualitatively homogeneous. For example, individuals who obtain a university degree from an Ivy League university may acquire a better formation than those who graduate from less renowned universities.

Fourth, human capital can be either general or specific. Knowledge and abilities are said to be

general if it is possible to use them in a variety of activities and if they are easily transferable from one employer to another without any significant loss of value. Conversely, human capital is specific if it can only be used in a limited number of activities and if the dissolution of employment relationships between workers and firms represents considerable loss of value which can only be regained through costly investments.

Finally, the definition of human capital also contains the notion of external effects. These spillovers take into account the influence that individuals have on the productivity of others and of physical capital, as well as the fact that individuals will be more productive, for any given level of skills, in an environment containing a high level of human capital. This facet of human capital highlights the determinant role that highly concentrated human capital centres, such as universities, cities, research centres, and agglomerations of high technology firms (e.g., Silicon Valley) have in the development and advancement of knowledge, technology, and growth (Jacobs 1984). Human capital also generates what can be referred to as social externalities. These externalities, which include, among other things, increased utility from living in a society with democratic institutions, freedom of thought and speech, and more varied literary expressions and means of communication, enable individuals to live effectively in a society whose members share common goals. The pursuit of common goals, in turn, enhances mutual trust among individuals and strengthens social institutions. The collection of all these externalities has recently been termed *social capital*. There is theoretical and empirical evidence that societies with high levels of social capital can operate economic and social institutions at lower transaction costs than those with lower levels of social capital (e.g., Helliwell 1996; and Platteau 1994).

Comparison between Human and Physical Capital

Human capital is frequently treated in economics in a manner similar to physical capital. This section highlights the differences between human and physical capital that are relevant to public policy in knowledge-based economies. Human and physical capital differ with respect to property rights and marketability, accumulation, returns, financing, and taxation.

Property Rights and Marketability

Physical capital is tangible; something that can be easily seen or touched. It includes machinery, factories, plants, patented processes, raw materials, inventories held by producers or traders, and means of transportation and communication. Furthermore, physical capital can be easily sold and transferred from one owner to another. As noted earlier, human capital is inseparable from the human being and its ownership is restricted to the individual in whom it is embodied. Unlike physical capital, the stock of human capital is not marketable: only the services that emanate from this stock are market goods.

Accumulation

The accumulation of capital in a given period, regardless of its forms, can be defined as the difference between the production of new capital and the depreciation of its existing stock. However, the processes by which human and physical capital are accumulated differ with respect to decision making, depreciation rates, and technology used to produce the two forms of capital.

Decision Process. The decision process in the production and accumulation of human and physical capital involves decisions under uncertainty by individuals and firms. While the decision about physical capital is typically made by investors or managers, the production of human capital involves decisions by different agents over an individual's lifetime, including parents, educators, and peers. This interdependence in the human capital decision results from the fact that every investment in human capital builds upon the existing stock. If an individual's abilities were not developed at a young age, then he/she would confront limited opportunities for human capital accumulation during adulthood.

Accumulation of Capital. The accumulation of human and physical capital exhibits important similarities: for both it requires time and involves foregoing current consumption for an increase in expected future production and consumption. The accumulation of human capital, however, possesses a social aspect that is much less present in the production of physical capital. Indeed, human capital is developed and accumulated through the interactions of individuals and ideas, thereby making it a social activity (Lucas 1988). This inherent feature of human capital implies that the process by which it is produced and accumulated is more labour-intensive than that for physical capital. Furthermore, since human capital is formed by the interactions of human beings, it is subject to spillovers and externalities, which have the potential to alter drastically the learning and accumulation processes. This social dimension of human capital has important implications for public policy related to institutions such as families and other social organizations.

Human and physical capital also differ in terms of *mobility*. Since the stock of human capital is nontradable, its mobility depends on the owner's capacity to move and adapt to change, as well as on regulations over domestic and international labour movements. For physical capital, its marketable nature as well as increased globalization and industry restructuring have increased its mobility. These differences have led to some specialization of inputs within the economy. Physical capital tends to be concentrated in goods and services that are more tradable, such as manufacturing goods. Human capital is used more in industries, such as the public sector and the service industries, which trade less on world markets. Thus, the process by which society acquires human and physical capital differs with respect to their factor intensity, their mobility, and their specialization.

Depreciation. Time depreciates human as well as physical capital. The latter also depreciates when it is either consumed or used up. Knowledge, abilities, and technology embedded in both types of capital become obsolete when new and improved ideas and technology become available. Human capital also deteriorates when it is idle, since inactivity impairs the skills that individuals have acquired throughout their lives. This process can be partly reversed, however, when human capital is again put to use, a feature, that highlights the endogenous aspect of human-capital depreciation. While a component of human-capital depreciation is directly related to external shocks, ageing, and involuntary unemployment, another component results from an individual's conscious decision about the use of his/her knowledge and skills in a productive process. Physical capital depreciation may also have an endogenous component determined by the owner's conscious decision about the utilization of a particular machine, but its relative importance is negligible given the existence of markets for used equipment.

From the investors' perspective, human capital depreciates precipitously at the time of retirement and is reduced to zero at the time of death. However, from society's perspective, the death of individuals who had invested in human capital does not imply a total loss of that capital, as part of their knowledge would have been transmitted to other generations through personal contacts and the production of goods, services, and ideas prior to their death. This feature does not apply to physical capital since it is always possible to sell and transfer physical capital assets from one person to another. A sum invested in human capital ceases to yield a return after the investor's death, at the latest.

Financing

Lenders are more willing to lend for physical than for human capital accumulation because the former is marketable and constitutes a better type of collateral. Physical capital can easily be seized, sold, jointly owned, and transferred by sale or by inheritance, while human capital is intangible and cannot be disassociated from its owner. This makes private financing for the acquisition of human capital harder to obtain. Market failures in the private financing

of human capital combined with liquidity constraints resulting from income inequalities and a lower propensity to finance human capital investments would yield a suboptimal level of human capital. To alleviate these liquidity constraints and the potential inefficiencies resulting from market failures, governments have established programs which partly subsidize the financing of investments in human capital. For example, governments finance investments in education through lower tuition fees, loans, and scholarships.

Returns

The returns to human and physical capital tend to behave differently. When individuals invest in physical capital, they are return-takers, that is, the owners accept the returns dictated by the market and cannot influence them. On the contrary, human capital has a lifecycle perspective that guarantees higher returns to young investors because they have a longer horizon over which they reap the benefits of their investments and also because early learning facilitates later learning. Given this lifecycle characteristic and the absence of markets for the stock of human capital, investors in human capital are more return-makers as the timing, the amount, the quality, and the maintenance of their human capital investment will dictate what the market will be willing to offer for their services. As a consequence, returns to investments in human capital are more variable across investors than are returns to investments in physical capital.

Taxation

The tax treatment of human and physical capital varies considerably across jurisdictions. We concentrate our attention on the current tax treatment of human and physical capital by the Canadian federal-provincial tax systems.

Since physical capital is produced as part of a business activity, all expenses incurred in its joint production-accumulation stages are deductible in calculating taxable income, thus reducing the tax otherwise payable. Moreover, physical capital is generally free of sales taxation and even the inputs used in the production of physical capital are largely exempt from sales taxes. Investments in physical capital may benefit from public subsidies, loans, and loan guarantees. When physical capital is used for production, all expenses related to its operation and maintenance are deductible. Firms can also deduct an amount based on the depreciation of the asset. However, the returns to physical capital may, in some cases, attract taxes at both the corporate and personal level.

The situation is different for human capital. Since human capital is necessarily embodied in human beings, its accumulation requires the steady addition of new children by each successive generation. Although procreation decisions by parents are not usually made for the purpose of increasing the supply of potential human capital, the fiscal system does provide benefits to the generations of new carriers of human capital. In Canada, health-care expenses associated with gestation and birth are provided free of charge (but are financed through general taxation) and some financial support is offered during a specified period prior to and following childbirth. During infancy, additional benefits for low- and middle-income families are offered through the child tax credit and through the tax deduction for child-care expenses. The child and adolescence stages receive fiscal benefits through the provision of almost free compulsory education for those attending public schools. However, no tax deductions are available for any living expenses or any expenses ancillary to primary and secondary education. The only tax benefit is the non-taxation of basic groceries under federal and provincial sale taxes and the non-taxation of clothing, footwear, and educational materials in some provinces.

The voluntary acquisition of human capital (e.g., postsecondary education) by an agent receives some tax-related benefits. The foregone salary, which is a large portion of the total cost of a voluntary investment in postsecondary education, is not taxed in Canada, as in most countries. Second, students in

postsecondary institutions and other approved institutions of learning can claim a credit against the amount of tuition paid. This credit equals on average 25 percent of the tuition paid (combined federal-provincial benefits). Moreover, since this credit is non-refundable and can be transferred to a supporting parent, it provides a benefit only to the extent that there is some tax liability to offset. Third, students can claim a non-refundable credit of $100 per month of full-time enrolment. All other costs of acquiring human capital — such as food, clothing, shelter, books, and other supplies — are not deductible in computing income taxes. Finally, students can be eligible for publicly-funded scholarships and loans.

Measurement Problems of Human Capital

As human capital is increasingly recognized by economists and policymakers as a key asset in modern knowledge-based economies, it is crucial to measure accurately its stock and contribution to economic growth. However, the measurement of the contribution of human capital to economic growth is impeded by the inability of the national and public accounts to measure correctly investments and savings, and classify government expenditures within the context of a knowledge-based economy. Jorgenson and Fraumeni (1989) show that, between 1948 and 1984 in the United States, investment in human capital was at least four times the magnitude of investment in physical capital and that during the same period, the value of human capital exceeded the value of physical capital by more than 11 times. Thus, the exclusion of human capital in national and public accounts greatly underestimates the true levels of investment and wealth in an economy. Moreover, recent empirical studies of growth have attempted to assess the role of human capital as a determinant of long-term economic performance using measures of human capital based on, among other things, school enrolment rates (Barro 1991), literacy rates (Romer 1989), and educational attainment (Koman and Marin 1997). These measures are subject to considerable data limitations and only capture certain aspects of human capital.

Shortcomings of National and Public Accounts

National Accounts, Savings and Investment. National accounts were developed for the purpose of recording the value of production, income and expenditures during a particular period of time. While these accounts have evolved through time into important yardsticks to gauge the effectiveness of economic policy, their usefulness for the analysis of savings and investment is undermined by their neglect of human capital. In the national accounts, investment includes business expenditures on long-lived assets — buildings, machinery, and equipment — personal expenditures on housing, and government spending on durable investments. Expenditures on human capital are often treated as consumption. For example, the construction by a firm of a clubhouse on a golf course is classified as investment, while its spending on training is not. In countries devoting increasing quantities of resources to education and training to face the knowledge-based environment, the national accounts would record a decline in the investment-GDP ratio, thus providing misleading information about the country's investment effort. In a recent study, Kirova and Lipsey (1998) estimate a more comprehensive measure of capital formation for the United States, which incorporates, along with physical capital, expenditure on education, research and development, consumer durables, as well as military spending. The authors find that, while the conventional measure of capital formation for the United States is below that of OECD countries, the more comprehensive measure shows a higher capital formation to GDP ratio for the United States than for the other OECD countries.[4] Furthermore, the new measure correlates with the superior rate of economic growth observed in the United States over the past decade.

Similarly, national savings is defined as the difference between the income received by the

business, personal, and government sectors minus the amount classified as consumption. Since consumption includes expenditures, such as those for education and training, which, as components of human capital, should be classified as investment, the national accounts underestimate the savings rate as well as the rate of investment. For example, income used to purchase foreign equities is treated as personal savings, while the same amount spent on acquiring additional skills is classified as consumption. The former adds nothing to the domestic stock of capital, while the latter increases it.

Estimates of a more general savings rate for the United States over the period from 1929 to 1993, including the components associated with human capital, were prepared by Nordhaus (1996). He shows that the "genuine" savings rate is a least three times the "conventional" rate.[5] Moreover, during the past 20 years, the conventional savings rate fell sharply, while the genuine rate remained stable. According to Nordhaus (1996, p. 48), "Our tools for measuring savings are stone-age definitions in the information age."

To provide a comprehensive perspective on the role of capital formation in Canada within a knowledge-based economy context, the national accounts ought to consider expenditures on human capital as investments. This can be achieved through the inclusion of savings (investment) in human capital in the national accounts. This inclusion is becoming more pressing with the rapidly advancing process of population ageing in Canada. It is expected that Canada will no longer be able to rely on rapid labour force growth to contribute to economic growth. Therefore, the contribution of labour to growth must come from either an improvement in the quality of labour or an extension of the work life. A commitment to the improvement of the quality of the labour force will require investments in human capital formation. National accounts, as they stand, are not capable of capturing the potential increase in human capital or measuring its benefits in terms of output and welfare. Moreover, in order to increase human capital formation, resources may need to be diverted from current consumption and other types of investment. This would involve trade-offs and welfare implications that would be better assessed with a national accounting system that included human capital investments.

Public Accounts and Government Expenditures. The shortcomings in the measurement of savings and investment are also considerable in the case of various types of public accounts. These accounts were developed primarily for the purpose of recording government income and outlays, and although some attempts have been made to provide classifications incorporating economic interpretations, they offer no information on the human capital aspects of government policies. With respect to investment, the definition of the national accounts is used and it is limited to the purchase of fixed assets — such as buildings, waterworks, sewage, machinery, and equipment — except when purchased by the armed forces. Yet, the largest share of government purchases is for programs that build up human capital (education) and support its maintenance (health care). By treating the purchase of machines as investment and the acquisition of knowledge and skills as consumption, the existing accounts' structure does not allow policymakers to assess accurately the impact of human capital on growth. For example, the construction of a publicly-owned parking lot is recorded as a capital expenditure, while additional spending on teaching is treated as current consumption. Yet, the former adds little to potential economic growth, while the latter is likely to increase it by improving the production of human capital.

The misclassification of government expenditures with respect to human capital — especially those for education and manpower purposes — is equally important, though not so obvious, in the case of transfer payments. At a general level one may note, for example, that in the Canadian national accounts, scholarships and grants to universities are treated as government transfers to persons and placed on equal footing with Guaranteed Income Supplement

(GIS) benefits. The latter supports consumption by the elderly while the former adds to the nation's stock of knowledge and its rate of economic growth. Moreover, some of the transfer payments, which are classified as government-aided consumption, may be in part investments in human capital. For example, financial assistance to social institutions, which help individuals in need, may facilitate the accumulation of human capital. When viewed as consumption, these expenditures are considered to be unproductive and behaviourally distortive.

Shortcomings and misclassifications of the system of public accounts do not readily allow policymakers to view public expenditures as investments in human capital rather than simply public consumption. Investments in the public accounts should include (at least partially) expenditures on education, health, research and development, and the nation's physical infrastructure. A better accounting procedure could enhance the analysis of a large number of policy issues. For instance, a substantial part of the accumulation of human capital is in the hands of governments, through mandatory enrolment for primary and secondary school levels. Thus, it is important for the government to be able to assess its educational policies. For example, should governments raise expenditures for teachers and schools or increase enrolment. Moreover, the financial scheme chosen to raise spending on today's young students has obvious distributional consequences.

At the postsecondary educational level, policy options are more intricate. Indeed, the primary input into the production of postsecondary education is students' time and effort. This factor, and not the spending on education, is the primary determinant of educational performance. As time and effort are alterable, small changes in the incentives of students to invest in education can potentially have an important impact on educational outcomes. For example, existing tax structures in industrialized countries may discourage the investment in human capital since marginal tax rates are relatively low when most human capital investments occur (since earnings are relatively low) and relatively high when the investments mature (since earnings are relatively high).[6] Similarly, unemployment could be a strong deterrent to investment in human capital if losses in employment income are greater than the income "premium" associated with higher education. Moreover, if a country's human capital is much larger than its physical capital, then the deterrent effects of taxation and unemployment on human capital may also be more important than the effects on physical capital, the other area that traditionally receives policy experts' attention.

There are also important issues associated with the trade-off between investing in physical infrastructures and human capital. The trade-off is complicated further by the existence of the complementary relationship of human and physical capital. The efficiency of an investment in physical capital may be further enhanced if the quality of workers is adequate. Within the human capital sector, a similar problem arises because of the complementarity between school education and job training. The lower the quality of their school education, the more difficult it is to train workers. Although learning on the job is, to some extent, substitutable for learning at school, a solid educational background is helpful for efficient training.

Measuring Human Capital

In recent years, several researchers have developed measures of the stock of human capital to facilitate empirical studies on the role of human capital for cross-country growth comparisons (see e.g., Barro and Lee 1993, 1996; Barro 1991; Psacharopoulos and Arriagada 1986, 1992). These measures of human capital are compiled to cover broad samples of countries/states, thereby emphasizing quantity over quality. Focusing on the broadest sample possible has led to the development of measures of human capital that are unable to capture some of the key dimensions of education, yet alone of human capital.[7] In addition, these measures are subject to considerable data limitations. While censuses are the

best source of educational data, they are generally performed every five or ten years and, in some countries, are not performed regularly. Researchers typically use enrolment or educational attainment data in a perpetual inventory framework to fill intercensal years, which may not be fully satisfactory.

In Canada, few attempts have been made to estimate the stock of human capital. Macklem (1997) estimated human wealth as the present value of aggregate labour income net of government expenditures, while Beach, Boadway and Bruce (1988) produced a human capital wealth series from 1964 to 1981 by estimating the discounted present value of real after-tax per capita earnings over individuals' lifetime. While these measures are useful tools to assess human and physical wealth, estimates of Canada's *accumulated human capital* stock are needed to specify accurately growth models and perform growth accounting studies. Estimates of human capital savings (investments) are needed to revise national and public accounts and hence, to perform more accurate policy analyses.

Clearly, the measure of human capital must extend beyond formal education. But as education remains at the core of human capital formation, the measure of human capital should start with a measure of educational savings (investments). The most common approach is the cost-based methodology which consists of summing direct expenditures on schools and universities to which is added the opportunity costs of students attending school. This gives a measure of the flow of resources invested in the educational sector, which can be very useful for cost-benefit analyses. However, the cost-based approach for measuring human capital ignores the lengthy gestation period between the application of educational inputs and the emergence of human capital embodied in the graduates of educational institutions.

With an income-based approach, educational investment is defined as an increment in the value of human assets (or the present value of lifetime income) resulting from an increment in education. This approach captures the benefits of human-capital investment as reflected in transactions in the labour market. An income-based approach is preferable to a cost-based approach since it makes the methodology of calculating human and physical capital investments fully comparable within the revision of national and public accounts.

The next step consists of developing measures for the stock and savings of human capital for Canada and its provinces. While human capital encompasses more than education, education data are the most readily available. Relevant data such as educational attainment are routinely collected as part of the population census. These data can be complemented by, among other things, participation in schooling, as recorded in enrolment statistics, using a perpetual inventory method. These measures will then set the foundations for the development and the restructuring of the national and public accounts.

Modelling Human Capital

Human and physical capital are often treated similarly in endogenous growth models. In many cases, the accumulation processes, the production functions, the factors of production, the input shares and elasticities of substitution, as well as the depreciation rates of human and physical capital are specified similarly. Even the taxation of the factors used in the production of both types of capital is often assumed to be identical (see e.g., Mulligan and Sala-i-Martin 1993; Rebelo 1991; King and Rebelo 1990). We have argued earlier that human capital differs from physical capital in many dimensions. We show in this section how the specification of physical and human capital in endogenous growth models influences the estimated impact of policy on growth and other macroeconomic variables. To do so, we give three examples where a specific rather than a similar treatment of physical and human capital leads to different conclusions in endogenous growth models.

Technology and Framework

An important approach in the endogenous growth literature assumes that growth is generated by capital accumulation activities. For instance, there exists a literature on the effect of taxation on growth using a two-sector endogenous growth model (see e.g., Devereux and Love 1994; Rebelo 1991; King and Rebelo 1990) where growth is generated by the accumulation of physical capital (final goods sector) and human capital (education sector). It has been shown (Stokey and Rebelo 1995) that the technology specifications used for the production functions of physical and human capital in these models have an impact on the magnitude of the growth effects of changes in the tax rates applied to factor incomes. The role played by technology specifications is related to the extent to which human capital differs from physical capital. In a two-sector model, a new tax policy will generate intersectoral and intertemporal reallocations. The greater the intertemporal (current versus future consumption) reallocation is relative to the intersectoral (final goods versus education sector) reallocation, the higher will be the growth effect. When human and physical capital technologies are specified symmetrically, that is, with the same inputs and elasticity of substitution, the intertemporal effect dominates and a change in the income tax rate has qualitatively similar effects on both accumulating activities (see Rebelo 1991; King and Rebelo 1990). It modifies the rate of return on investment activities and leads to a permanent and significant change in the rate of growth. On the other hand, when human and physical production functions differ, the intersectoral reallocation and sector-specific intertemporal substitution effects become more important. The new tax policy generates more intersectoral than intertemporal reallocation, which weakens the impact on growth.[8] Moreover, Mérette (1997) shows that the growth effects of income taxation are often very different in an overlapping generations framework from those obtained in a Ramsey framework. The main reason for this is that the overlapping generations framework captures the lifecycle aspects of investment decisions. These lifecycle aspects are crucial for human capital, given its non-tradable nature.

Externalities

Human capital accumulation is a social activity. It is accumulated through the interactions of ideas and individuals in a way that has no counterpart in the accumulation of physical capital. Only a few endogenous growth models have investigated the effect of externalities from human capital accumulation on growth. In Lucas' (1988) first model, technological externalities arising from human capital production generate output-level effects, but do not change the long-run equilibrium growth rate. Eicher (1996), however, builds upon Grossman and Helpman's (1991) work and proposes a model in which the production of human capital not only forms skilled workers, but also generates technological change, and hence growth. Acemoglu (1996) proposes a microfoundation for social increasing returns in human capital accumulation. His underlying mechanism is a pecuniary externality due to the interaction of *ex ante* investments and costly bilateral search in the labour market. In his framework, returns to human capital increase in the average human capital of the workforce, even in the absence of technological externalities. Assuming externalities in the human-capital accumulation activity may thus have strong implications for policy experiments within endogenous growth models.

Financing

The endogenous growth literature typically specifies two costs associated with individuals' human-capital investment. These costs are foregone wages by students during the time spent in school (see e.g., Lucas 1988; Grossman and Helpman 1991, ch. 5.2) and foregone consumption (tuition) (see Nerlove *et al*. 1993). It can be shown that the way human-capital investment is financed within a model can directly influence the estimated impact of public policy on growth. For instance, Laroche, Mérette and Ruggeri (1997) use a finite lifetime framework, where human capital is embodied and no deductions are allowed for interest and human-capital

depreciation. In such a framework, the imposition of an income tax introduces a distortion against human-capital accumulation when human capital is financed through foregone consumption, and a distortion in favour of human capital when it is financed through foregone wages.

Conclusion

The pivotal role played by human capital in the process of economic growth in knowledge-based economies is increasingly recognized by academics and policymakers. Yet, neither economic accounts nor endogenous growth models capture fully the specific elements of human capital. The former tend to treat spending on human capital as consumption, while the latter tend to model human capital as if it were physical capital. The result is misleading information on the relevance of human capital and possibly inappropriate policy advice.

This paper suggests that in knowledge-based economies, a major shift in the way we look at human capital is necessary. For example, national income accounts and public sector accounts developed in the early postwar period, and used worldwide ever since, are not designed to capture fully the size and contribution of human capital. As has already been advocated by Jorgenson and Fraumeni (1989) and Nordhaus (1996), among others, a better understanding of the role of human capital in modern economies is predicated on the development of adequate measurement instruments. An obvious starting point would be to develop accurate measures of human capital stocks. A similar restructuring is needed for government spending accounts, starting with a more accurate distinction between expenditures on the acquisition and maintenance of human capital. This distinction should be applied to both government purchases, such as spending on health care and education, and transfer payments where some of the funds transferred may assist in the nurturing of potential human capital. Finally, endogenous growth models must be specified in ways that address the fundamental conceptual differences between human and physical capital.

Notes

This paper was written while G.C. Ruggeri was working at the Department of Finance. We would like to thank Charles Beach, Jim Davies, Claude Felteau, Neil Guppy, André Plourde, Arndt Vermaeten, Jing Xu, three anonymous referees, and the participants at the Société canadienne de science économique and Canadian Economic Association meetings for their useful comments. The views expressed in this paper are solely those of the authors. No responsibility for them should be attributed to the Department of Finance.

[1]For an historical survey on the concept of human capital, see Blaug (1976) and Kiker (1966).

[2]For theoretical models of endogenous growth, see Grossman and Helpman (1991), Rebelo (1991), King and Rebelo (1990), and Romer (1990).

[3]The inclusion of innate abilities in our definition of human capital also reflects the fact that not all factors affecting investment in human capital are under the agent's control or can be influenced by policy. While ideally it would be preferable to separate innate from acquired abilities, there are no data, at least in Canada, that allow the separation of the returns from abilities from that of acquired skills.

[4]Twelve countries were examined: Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, and the United Kingdom.

[5]To compute his "genuine" savings rate, Nordhaus recalculated the expenditure side of the national accounts for government purchases and consumer spending and regrouped them under the following two headings: current purchases and gross capital formation. Capital formation includes "… all expenditures that do not contribute to current consumer satisfactions" (Nordhaus 1996, p. 46). These include, among other things, consumer spending on cars, household durables, and most health expenditures as well as government expenditures on research, education, and most government expenditures on health.

[6]However, subsidies to education may compensate for this type of income tax structure.

[7]For a survey of measures of human capital and their limitations, see Laroche and Mérette (1997).

[8]See Laroche, Mérette and Ruggeri (1997) for a more technical development.

References

Acemoglu, D. (1996), "A Microfoundation for Social Increasing Returns in Human Capital Accumulation," *The Quarterly Journal of Economics* 111(3): 779-804.

Barro, R.J. (1991), "Economic Growth in a Cross-Section of Countries," *The Quarterly Journal of Economics* 106(2): 407-42.

Barro, R.J. and J.W. Lee (1993), "International Comparisons of Educational Attainment," *Journal of Monetary Economics* 32(3): 363-94.

____ (1996), "International Measures of Schooling Years and Schooling Quality," *American Economic Review* 86(2): 218-23.

Beach, C.M., R.W. Boadway and N. Bruce (1988), "Taxation and Savings in Canada," Economic Council of Canada Technical Paper (Ottawa: Economic Council of Canada).

Becker, G.S. (1962), "Investment in Human Capital: A Theoretical Analysis," *Journal of Political Economy* 70(5, Part 2, Supplement): 9-49.

____ (1964), *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education* (New York: National Bureau of Economic Research).

Blaug, M. (1976), "The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey," *Journal of Economic Literature* 14(3): 827-55.

Devereux, M.B. and D.R.F. Love (1994), "The Effects of Factor Taxation in a Two-Sector Model of Endogenous Growth," *Canadian Journal of Economics* 27(3): 509-36.

Eicher, T.S. (1996), "Interaction Between Endogenous Human Capital and Technological Change," *Review of Economic Studies* 63(1): 127-44.

Grossman, G.M. and E. Helpman (1991), *Innovation and Growth in the Global Economy* (Cambridge MA: MIT Press).

Helliwell, J.F. (1996), "Economic Growth and Social Capital in Asia," NBER Working Paper No. 5470 (Cambridge, MA: National Bureau of Economic Research).

Jacobs, J. (1984), *Cities and Wealth of Nations* (New York: Random House).

Jones, L. E, R. E. Manuelli and P. E. Rossi (1993), "Optimal Taxation in Models of Endogenous Growth," *Journal of Political Economy* 101(3): 485-517.

Jorgenson, D.W. and B.M. Fraumeni (1989), "The Accumulation of Human and Nonhuman Capital, 1948-1984," in *The Measurement of Saving, Investment, and Wealth*, ed. R.E. Lipsey and H.S. Tice (Chicago: University of Chicago Press).

Kiker, B.F. (1966), "The Historical Roots of the Concept of Human Capital," *Journal of Political Economy* 74(5): 481-99.

King, R.G. and S. Rebelo (1990), "Public Policy and Economic Growth: Developing Neoclassical Implications," *Journal of Political Economy* 98(5, Part 2, Supplement): 126-49.

Kirova, M.S. and R.E. Lipsey (1998), "Measuring Real Investment: Trends in the United States and International Comparisons," NBER Working Paper No. 6404 (Cambridge, MA: National Bureau of Economic Research).

Koman, R. and D. Marin (1997), "Human Capital and Macroeconomic Growth: Austria and Germany, 1962-1992," CEPR Discussion Paper No. 1551 (London: Centre for Economic Research).

Laroche, M. and M. Mérette (1997), "Measuring Human Capital in Canada," Mimeo (Ottawa: Department of Finance).

Laroche, M., M. Mérette and G.C. Ruggeri (1997), "On the Concept, Dimensions and Specifications of Human Capital," Mimeo (Ottawa: Department of Finance).

Lucas, R.E., Jr. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22(1): 3-42.

Macklem, R.T. (1997), "Aggregate Wealth in Canada," *Canadian Journal of Economics* 30(1): 152-67.

Mérette, M. (1997), "Income Taxes, Life-Cycles and Growth," Working Paper No. 97-06 (Ottawa: Department of Finance).

Mincer, J. (1958), "Investment in Human Capital and Personal Income Distribution," *Journal of Political Economy* 66(4): 281-302.

____ (1962), "On-the-Job Training: Costs, Returns, and Some Implications," *Journal of Political Economy* 70(5, Part 2, Supplement): 50-79.

____ (1974), *Schooling, Experience, and Earnings* (New York: National Bureau of Economic Research).

Mulligan, C.B. and X. Sala-i-Martin (1993), "Transitional Dynamics in Two-Sector Models of Endogenous Growth," *The Quarterly Journal of Economics* 108(3): 739-73.

Nerlove, M., A. Razin, E. Sadka and R.K. von Weizsächer (1993), "Comprehensive Income Taxation, Investment in Human and Physical Capital, and Productivity," *Journal of Public Economics* 50(3): 397-406.

Nordhaus, W.D. (1996), "Budget Deficits and National Savings," *Challenge* 39(2): 45-49.

Organization for Economic Cooperation and Development (OECD) (1996), *Measuring What People Know: Human Capital Accounting for the Knowledge Economy* (Paris: OECD).

Platteau, J.-P. (1994), "Behind the Market Stage Where Real Societies Exist: Part I, The Role of Public and Private Order Institutions," *Journal of Development Studies* 30(3): 533-77.

Psacharopoulos, G. and A.M. Arriagada (1986), "The Educational Composition of the Labour Force: An International Comparison," *International Labour Review* 125(5): 561-74.

____ (1992), "The Educational Composition of the Labour Force: An International Update," *Journal of Educational Planning and Administration* 6(2): 141-59.

Rebelo, S. (1991), "Long-Run Policy Analysis and Long-Run Growth," *Journal of Political Economy* 99(3): 500-21.

Romer, Paul M. (1986), "Increasing Returns and Long-Run Growth," *Journal of Political Economy* 94(5): 1002-37.

____ (1989), "Human Capital and Growth: Theory and Evidence," NBER Working Paper No. 3173 (Cambridge, MA: National Bureau of Economic Research).

____ (1990), "Endogenous Technological Change," *Journal of Political Economy* 95(5, Part 2, Supplement): 71-102.

Schultz, T.P. (1994), "Human Capital, Family Planning, and their Effects on Population Growth," *The American Economic Review* 84(2): 255-60.

Schultz, T.W. (1961), "Investment in Human Capital," *The American Economic Review* 51(1): 1-17.

____ (1962), "Reflexions on Investment in Man," *Journal of Political Economy* 70(5, Part 2, Supplement): 1-8.

Schweihart, L., H. Barnes and D. Weikart (1993), *Significant Benefits: The High/Scope Perry Pre-School Study through Age 27* (Ypsilanti, MI: High-Scope Press).

Smith, A. (1776), *The Wealth of Nations*, Book 2 (London: G. Routledge).

Smithson, C.W. (1982), "Capital," in *Dictionary of Economics*, ed. D. Greenwald (New York: McGraw-Hill Book Company).

Stokey, N. L. and S. Rebelo (1995), "Growth Effects of Flat-Rate Taxes," *Journal of Political Economy* 103(3): 519-50.