The Impact of Government Capital Expenditures on Economic Growth: The Case of Canada

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I. Introduction

One of the compelling issues in the contemporary macroeconomic literature involves identifying the mechanism of economic growth and the key determinants of growth. This strand of economic research gained additional momentum in light of the expanding gap between nations in terms of economic development and prosperity. The major outcome of this wave of research is that capital accumulation and productivity growth are the basic elements of economic growth.

The new concept of economic growth powered by productivity and investment activity has attracted further investigation by many economic theorists. The search for answers launched along the way a parallel investigation on the government involvement in economic activity and therefore on the effect of government role on the economic growth. The empirical research on this issue was based on the government control of fiscal and monetary policies, in addition to its administrative and regulatory functions. In the neoclassical analytical framework, government policies are likely to have a permanent effect on the level of output, especially in the long-run as implied by Solow (1956) where the growth rate is motivated by exogenous variables. In other models such as that of Romer (1986), Lucas (1988) and Barro (1990), government policies can have a positive impact on the growth rate of output rather than on the level of output[1].

However, this issue is handled differently in the Keynesian and Post-Keynesian literature where the focus is directly on government policies spending and its temporary positive effect on the economy during cyclical shocks. During the Great Depression years, Keynes pointed out that government spending could play a significant role in activating the economy. When the government increases its spending, aggregate demand increases if the economy is in an underemployment stage. Hence, when output is below its full-employment level, public spending should be raised; while it should be decreased when the output level is above full-

[1] See Aschauer (1998)

employment[2]. The Monetarists, on the other hand suggest that government expenditures should be set at a level that is determined by the requirements of economic efficiency rather than by macroeconomic stability. The marginal utility of government spending should equal the marginal utility of private spending.

Recent studies conclude that distinguishing between "productive and unproductive" government spending is crucial when studying the effect of government spending on the economy, as productive spending has proved to be of positive effect on private sector production[3]. Productive spending refers to government capital spending or investment that includes spending on infrastructure (streets, highways, dams, bridges, water and sewerage systems, education and research and development). It consists basically of spending on items the productive impact of which could extend to generations.

Economic growth and productivity trends in Canada have, as in other countries, received considerable attention due to its marked slowdown since the 1970s, and due to concerns about its implications on the competitiveness of Canadian industries, especially since the signing of the Free Trade Agreement (NAFTA). Throughout the period 1961-1998, the Canadian economy was able to achieve a positive overall growth rate that averaged 3.7 percent a year, based on the GDP estimates at 1992 prices. The best annual rates of growth are achieved during the 1960s, with averages at 5.3 percent, while growth was rather moderate during the 1980s and 1990s when it reached an annual rate of 2.34 and 2.91 percent respectively (see Table 1). The highest growth rate achieved by the Canadian economy in the last three decades was that of 1973 over 1972 when it jumped to 7.2 percent. Government investment grew more slowly over the same period, at an annual rate of 2.9 percent. The highest growth rate in capital accumulation by government was during the 1980s, when it averaged around 5.6 percent a year going up from 4.8 percent in the 1960s. But these rates were notably very low in the 1970s: they did not exceed 0.5 percent a year.

[2] Parkin and Bade (1985)
[3] Aschauer (1993).

Private investment on the other hand witnessed a fluctuating trend during the said period, but with overall growth rate that averaged around 5.45 percent per year between 1961 and 1971. Private investment increased at an averaged rate of 6.27 percent a year during the 1960s, while it grew at about 7.86 percent a year in the 1970s. For the rest of the period, investment activity of the private sector was also growing at an average of 2.1 and 3.95 percent per year in the 1980s and the 1990s respectively, although it declined by 9.93 percent in 1990.

Through the 1960s, 1970s, and 1980s, output per capita in Canada increased more rapidly than productivity. But over the past 10 years, it has fallen behind the growth in productivity. The Canadian economy has bounced back strongly from the effects of the Asian financial crisis and the turmoil in the world financial markets in 1998. The sharp pickup in output growth over the year to the third quarter of 1999 has reflected a rebound in commodity prices, continued robust US growth, and strengthening domestic demand. Output growth slowed significantly in late 1997 and in the first 3 quarters of 1998 owing to the fallout from the Asian crisis and a few major work stoppages. Growth accelerated in the final quarter of 1998, with the recovery from the effects of domestic labor strikes, and has risen to an annual rate of 4 percent.

Multi Productivity Factor (MPF) growth in Canada averaged 2.25 percent annual growth during the 1960s, but following the first oil price shock in 1973, the average annual growth rate dropped to about 0.50 percent through 1988 (see Table 2). Subsequently, MPF growth has picked up modestly at 0.75 percent per year through 1997. However, over this period, Canada's position, compared to the United States for example, has improved slightly, as Canada's MPF growth has outpaced that in the United States[4]. It is worth noting that MPF growth in Canada has declined sharply since 1973, and was negative between 1989 and 1995, a fact that that was also observed in four other advanced economies during this period, where a marked improvement in the quality of labor and capital was experienced like in Canada[5].

The present trend of research on the impact of government relies on several different approaches, including the production function approach, cost function approach, cross-

[4]IMF Staff Country Report No.00/34, March 2000.

[5] These countries are United Kingdom, Germany, Italy, and France

sectional studies using country-level data and calibrated structural models. To capture dynamic interaction between output, public capital, and private capital, some authors such as Otto and Voss (1996), Batina (1998), and Sturm, Jacobs and Groote (1999) employed a vector autoregressive (VAR) model. Within this context, every endogenous variable is modeled as a function of its own lagged value and lagged values of other endogenous variables, consequently allowing for a better identification of the feedback from private sector variables to the public capital stock (ligthert, 2000). Cost functions and production functions are the most common and widely used approaches in much of the empirical works in the last two decades. In these models, private and public capital formation are assigned a central role, and therefore government policies pertaining to spending including capital spending are likely to have a permanent effect on the long-run rate of growth (Aschauer, 1998). Several studies have suggested such a quantitatively important relationship between public-sector capital accumulation and private sector productivity, with the most compelling evidence derived from analyses of state-level data.

The production function approach incorporates public capital as an input into the production function; that is public capital is treated as another determinant (variable) of the growth of output. In this case, the production function is estimated either directly by introducing the input levels into the function as independent variables, or an estimation is made in terms of marginal product equations where input prices resemble the dependent variables[6]. The cost function approach is based on the effects of external factors such as public capital, that might be represented explicitly as a fixed input in the cost function. This representation allows the capture cost-minimizing behavior, direct and indirect external scale effects of this input on the costs of production.

Most time series studies employ a Cobb-Douglas production function to estimate the output effects of public capital. On average, these studies estimate a production elasticity of public capital (β) of 0.25 for various Organization for Economic Cooperation and Development (OECD) countries when the production function is estimated in levels. These estimates vary

[6] Morrison and Schwartz (1992)

considerably across countries but fall in the range 0.2-0.3 at a 95 percent level of confidence. If the model is estimated in first difference, estimates of (β) are on average higher and confidence intervals are wider. Panel studies; based on regional data for a single country, find in general much lower estimated coefficients, which could be ascribed to "leakage" reflecting the fact that, at the regional level, not all beneficial spillover effects of public investment can be internalized (see Munell, 1992).

In view of the wide divergence in theoretical stands, a good amount of empirical research has been carried out to evaluate the impact of public capital spending on economic growth. Despite the differences in specific inferences, many empirical studies appear to support the hypothesis of significant impact of public capital on economic growth. This paper therefore examines the effect of public capital on economic growth in Canada by applying the production function approach that has been adopted in many empirical studies in the last two decades. For that matter, the paper is divided into six sections, where section II provides a theoretical framework through a review of theories of economic growth, while Section III reviews the literature on empirical studies and the various approaches applied. Section IV on the other hand taps on the econometric specification of the model that has been adopted in this paper as well as relevant statistical tests. Sections V and VI analyze the results obtained and put forward the conclusions that have been reached.

II. Theoretical Framework:

The Theory of Economic Growth

The issue of economic growth is one of the serious challenges facing macroeconomic theorists nowadays as well as commentators and policy makers for its compelling nature. Within the context of the economic growth, pivotal questions that are often asked by economists are: how does the economy grow? or, under what conditions could economic growth be achieved? These questions which have been phrased in different ways are initially raised by economists in the light of the prolonged attempts to explain the expanding gap between nations in terms of the level of modernization and economic prosperity which were always linked to the ability of the economy to grow. That is, economic growth implies sustainable increases in production that translate into higher national and per capita incomes. An interesting way of presenting the soundness of the idea of economic growth was fashioned by Robert Lucas, in his Marshall Lectures at University of Cambridge (Debraj, 1998):

> Rates of growth of real per-capita income are...diverse, even over sustained periods...Indian incomes will double every 50 years; Korean every 10. An Indian will, on average, be twice as well off as his grandfather; a Korean 32 times...
>
> I don't see how one can look at figures like these without seeing them as representing possibilities. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what, exactly? If not, what is it about the "nature of India" that makes it so? The consequences for human welfare involved in questions like these are simply staggering : once one starts to think about them, it is hard to think about anything else.

Reviewing the historical evolution of the economic growth theories and models in the contemporary economic literature indicates that the concept of economic growth used to overlap another important economic topic, that is the economic development, especially during the first half of the 20th century. Therefore, the distinction between the two concepts was a matter of debate for quite long time and there are reasons to believe that this debate is far from over.

The notion that economic growth, as the title of Kuznets' [1966] pioneering book on the subject suggests, is a relatively "modern" phenomenon and could simply be described as the result of abstention from current consumption (Debraj, 1998). However, one indisputable difference between growth and development is that economic growth is associated with the increase in national physical output between two periods. This increase reflects on the Gross Domestic Product (GDP) and consequently on the per-capita income. Economic development on the other hand is being thought of by most of development economists and specialized international agencies as a concept that is associated with the overall well being of the society and individuals. Accordingly, this concept widens to become a continuous process of changes that incorporates a growing per capita income accompanied by changes in the social, health and educational domains of the society.

It is also worth mentioning that the prevailing theoretical framework of economic development and the concept associated to it is no longer confined to the economic prosperity and the social, cultural and health advancements. That is, by mid 1980s, most of the international developmental agencies adopted a new concept of development that addresses the level of political participation or democracy enjoyed by individuals in society.

As a measurement issue, some economists argue that economic growth embedded by the physical increase in output and per-capita income should lead to the actualization of economic development. This insinuates that when the economy grows, and the individuals' standard of living ascends, the society would witness a chain of tangible changes in most of the social and cultural aspects including the existing structure of the social relations. It also implies that economic growth contributes to positive changes in the prevalent educational and health conditions encountered by the individuals, which culminates in meeting the economic development requirements as defined in the present concepts of economic development. This is also possibly the reason why some economists tend to overlook and jump over the distinction between economic growth and development for its irrelevance.

Furthermore, the relationship between growth and development according to Rostow are inseparable if not equivalent, whereas others find it more convenient to focus on economic growth rather than economic development (Oman and Wignaraja, 1991). Yet, this quick preview of the two concepts as such is intended to appeal to the review of the evolution of economic growth theories and models in this chapter. Thus this study will stick basically to the concept of growth that is related to the increase in the physical output and its equivalency to the notion of economic development.

Providing an answer to the economic growth question was, as indicated in some references, the focal point of many studies and researches initiated as early as the end of the eighteenth century. Other references pointed out that investigating the causes of, and barriers to, economic growth and development by analysts and policy makers could be dated back to the end of the Second World War (Oman and Wignaraja, 1991). One rapid review of the historical evolution of the theory of economic growth shows that the works and efforts exerted by many macroeconomists have contributed to a remarkable progress towards better understanding of the process of economic growth. The intelligent works of many classical economists such as Adam Smith (1776), David Ricardo (1817), and Thomas Malthus (1798), and much later, Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944), and Joseph Schumpeter (1934) provided much of the basic ingredients of economic growth theories including the modern models (Barro and Sala-I-Martin 1995).

During the period of the postwar II, the thinking on economic growth and development went through several shifts in explaining and solving the problem of economic growth and development, especially with the presence of economic crises in various parts of the world. During that period, the overall attention was given to economic growth as the workhorse of economic development and was shaped and theorized in orthodox thinking as such. Several economic theorists have contributed to the evolution and enrichment of economic growth thought during that period, leading to the presence and prevalence of two main approaches.

The first of these approaches that emerged during the 1950s and 1960s was related to more emphasis on capital accumulation and industrialization. This was part of the so-called orthodox thinking that prevailed during the immediate postwar period up to the early 1970s. Based on this kind of thinking, many viewed the developed countries as rich countries because they were industrialized, and thought that the poverty in the Less Developed Countries (LDCs.) could be attributed significantly to their dependence on subsistence agriculture (Oman and Wignaraja, 1991).

The most widely discussed studies of economic development to highlight the key role of industrialization was that of W.W. Rostow, elaborated in the 1950s and published in 1960. It is frequently referred to as the "Take Off Theory". The very important feature of his study is the relationships between economic growth and development, and between capital investment and growth. Rostow portrayed development as an essentially linear historical process consisting of five consecutive stages. Moreover, the growth-development relationship, according to Rostow was inseparable, if not equivalent. As part of the thinking that prevailed back then, Rostow subscribed to the notion that revolutionary increases in the country's production capacity are a fundamental requirement of more comprehensive development (Oman and Wignaraja, 1991). The achievement of this increase in production capacity must take place by the "leading sector". Oman and Wignaraja (1991) also pointed out that this notion was first appealed to in the writings of Simon Kuznets, Albert Hirschman and others. It states that at different moments or periods of industrial growth, different sectors within the industry grow considerably faster than the economy as a whole and give dynamism to the rest of the economy. This notion was later reinforced by Gerschenkron's works on the economic growth in Europe during the 19th century.

As for the relationship between economic growth and investment, Rostow's approach might very well represent the great influence of the post-Keynesian growth models on the contents of the development literature of the 1950s and 1960s. His perspective of the relationship between investment and growth was the center of the "take off" period in which the country arrives to a high level of productive investment which rises from 5% or less to over 10% of national income (or net national product) heading towards a further industrialized economy. The role of savings and investment in the process of economic growth as illustrated in these models, was basically influenced and shaped as mentioned earlier by the most important post-Keynesian growth model of Harrod-Domar developed in the 1930s and 1940s. This model, which was adopted by many developing countries have targeted the delicate balance between income, savings, investment and output required to maintain stable growth and full employment (Oman and Wignaraja, 1991).

Harrod (1939 and Domar (1946) attempted to integrate Keynesian analysis with elements of economic growth. They used production functions with little substitutability among the inputs to argue that the capitalist system in inherently unstable. Since they wrote during or immediately after the Great Depression, these arguments were received sympathetically by many economists (Barro and Sala-I-Martin 1995).

In the famous macroeconomic balance equation $\mathbf{S_t = I_t}$, where **S** is total savings, and **I** is total investment, they introduce the concept of the saving rate which is simply savings divided by income and denote it by $\mathbf{s = S_t / Y_t}$, There is also the concept of the capital–output ratio, denoted it by θ which is expressed as $\theta = \mathbf{K_t / Y_t}$. Combining the macroeconomic balance equation and the above two expressions, we get: $\mathbf{s/\theta = g}$, where **g** is the overall rate of growth. This is the Harrod-Domar equation named after Roy Harrod and Evsey Domar and introduced in 1939 and 1946, which was believed to be very powerful in the sense that it reflects the link between two fundamental variables: the ability of the economy to save and the capital-output ratio (Debraj, 1998).

The application of the Harrod-Domar model in many developing countries and the slow growth encountered by many developing countries led to the development of the "Two-Gap" model. This model was essentially based on the hypothesis that shortage in national savings may hamper capital formation in the early stages of industrialization. But once industrialization gets under way, the availability of foreign exchange needed for importing capital and intermediate goods may become the main barrier towards further industrial growth. The "Two Gap" model thus claims that the foreign exchange gap may supersede the insufficient national saving gap as the main constraint of development. It was also believed that the "Two-Gap" model that imposed a significant and better understanding on the initial saving-investment – growth relationship in the development process coincided with Rostow's ideas. In particular regarding the role of foreign aid in bridging the gap between national saving and the country's investment requirements (Oman and Wignaraja, 1991).

In addition to these two major models of the 1950s and 1960s, other theorists such as Walter Galenson and Harvey Leibenstein (1955) raised the issue of income distribution in relation to the level of savings and investment required for economic growth and development. They argued that a high unequal distribution of income might be necessary to achieve the sufficient level of savings that is needed for investment and hence growth. This argument was based on the view that rich individuals have a higher propensity to save than poor ones. The inequality of income distribution can be eliminated later on by market mechanisms. A similar description of the early stages of industrialization and its requirements in terms of the relationship between per capita income and the distribution of income was also presented by Simon Kuznets in 1955 (Oman and Wignaraja, 1991).

The second approach to economic growth thinking that evolved and prevailed during the mid-1940s up until 1970s centered on the inter-industry relationships. This approach has emerged as early as 1943 by Paul Rosenstein-Roden, who is generally identified as the pioneer of inter-industry relationships and their implications on economic growth and the author of the "Big Push Theory". Rosenstein-Roden was the first to come out in favor of the "big push" development strategy. He argued that investment decisions are interdependent and investment projects are often too risky for the investors to undertake as a result of the market characteristics, especially in the underdeveloped economies. He also called for government involvement in planning and providing the necessary incentives that would motivate simultaneous investments in certain complementary industries, a matter that led to substantial increases in national output and the size of the domestic market. Furthermore, Rosenstein-Roden argued for major public investments in social overhead capital, and concluded that due to their indivisibilities and significant externalities in creating profitable investment opportunities, such investments in social overhead capital or infrastructure would have to precede directly productive investments by the private (or the public) sector (Oman and Wignaraja, 1991).

Building on Rosenstein-Roden's perspective of the "vicious circle of poverty", Ragnar Nurske developed in 1952 a different theme of this phenomenon known as the theory of Balanced Growth. Nurske's version of the " vicious circle" was directed to underline that low incomes result in limited market size, which in turn represents low productivity levels that indicate to insufficient levels of national capital formation. Accordingly, the demand for capital or investment is determined and affected by the limited market size. From the supply side, low incomes lead to low national savings imposing a lack of capital and so low productivity and incomes. In order to break this circle and overcome the barriers arising from the limited size of markets, Nurske's proposed the balanced growth strategy in which a synchronized and simultaneous capital expansion may take place in all economic sectors (Oman and Wignaraja, 1991).

Another influential contribution to the issue of economic growth and the saving-investment-growth relationship was presented by Albert Hirschman in 1958. It is best known as the theory of " Unbalanced Growth". Aside from his agreement on the limited nature of capital and investment capacity as the principal constraint to growth, Hirschman argued that an intended creation of disequilibria might be the best solution to economic growth. That is investment should be directed and intensified in the industries with a higher number of backward and forward linkages. This argument was to motivate the growth of sectors or industries that use the output of other industries as inputs and in the meantime produce intermediate and input goods needed by other sectors for production (Oman and Wignaraja, 1991).

Moreover, Hirschman's unbalanced growth theme stressed the scarcity of entrepreneurial and managerial decision making as an important obstacle to growth, arguing that this obstacle could be eliminated through the unbalanced growth mechanism that entails the creation of high profitable investment opportunities. This could be achieved by establishing external economies and linkages effects that would benefit other industries and thus inducing investment decisions (Oman and Wignaraja, 1991).

Although economists have realized the importance of economic growth long ago, this vital aspect of economics crumbled for nearly two decades after the late 1960s. During the sixties, the neo-classical model represented the backbone of the growth theory as developed by Ramsey (1928), Solow (1956), Swan (1956), Cass (1965) and Koopman (1965), strengthening the belief that the workhorse of growth theories was the basic model of Solow (1956) and Swan (1956) (Barro and Sala-I-Martin 1995).

Solow's and Swan's contribution to this area of economic studies was always appreciated to the extent that their work is increasingly being tested and exposed to more empirical evidence. The key point of the Solow-Swan model is the neo-classical formulation of the production process; the production function that assumes a constant returns to scale, diminishing returns to production factors, and an elastic substitution of inputs. According to this model, the combination of this production function with a constant saving rate rule generates an extremely simple general-equilibrium model of the economy. The Solow-Swan model was a twist of the Harrod-Domar story with respect to the law of diminishing returns to individual factors of production. Further, capital and labor work together to produce output, so if there is plenty of labor relative to capital, a little bit of capital will go along way, while if there is a shortage of labor, capital-intensive methods are used at the margin and the incremental capital-output ratio rises. According to Solow, the capital-output ratio is endogenous and it may depend on the economy wide relative endowments of capital and labor. Concerning the conditional convergence which has been investigated empirically only in recent years, the lower the initial level of real per capita GDP in relation to the steady state level, the faster is the growth rate. The convergence is conditional because the steady-state levels of capital and output per worker depend on the saving rate, population growth, and the type of production function (Barro and Sala-I-Martin 1995).

The technological progress feature of the Solow-Swan model on the other hand implied by the assumption of diminishing returns to capital dictates that in the absence of continuing improvements in technology, per capita growth can not be sustained indefinitely. For this to happen, capital must grow faster than population, but in this case putting the diminishing return to capital in action implies that the marginal contribution of capital to output must decline leading to subsequent decline in the growth of output and eventually of capital. This strong claim of technological progress could easily be questioned in the light of the observation that positive growth rates can persist for periods as long as a century, even longer. However, the neoclassical theorists of late 1950s and 1960s used to treat this shortcoming by assuming that technological progress takes place in an exogenous fashion in a way that can reconcile the theory with a positive per capita growth rate in the long-run. That is in addition to retaining the prediction of conditional convergence (Barro, R.J, 1997). This treatment placed the theory into a more vulnerable position, that is the long-run growth rate depends now on the technological progress and population growth which both are determined outside the model.

In contrast to the conclusion drawn from the Harrod-Domar model that the rate of saving affect the growth rate, the Solow-Swan model insures the absence of such an effect at least in the long - run. This basic disagreement between the two pillars of the growth theory could only be explained by the fact that the Solow-Swan model brings in the property of diminishing return to capital in its model. While Harrod and Domar built the structure of their model on the property of a constant capital-output ratio (Debraj, 1998). In the former, this notion implies that economies with less capital per worker (relative to their long – run capital per worker) tend to have higher rates of return and higher growth rates (Barro, R.J, 1997).

Arrow (1962) and Sheshiniski (1967) provided models of economic growth implying that knowledge is a by-product of production or investment generated by a rule described as learning-by-doing where new knowledge spillovers to the whole economy instantaneously. The standard competitive assumption within this framework could be retained.[7]

Other additions to growth theories took this area of research ahead towards excessive technical destinations, leading it to an imperative disengagement from empirical applications. This is possibly the reason why growth theory has been abandoned as an active field of research by the early 1970s in favor of more emphasis on short-term fluctuations. There was also the birth

[7] Romer showed later that equilibrium rate of technological progress may be determined by the competitive framework, but the resultant growth rate is not Pareto optimal.

of rational expectation approach and its incorporation into the business-cycle models, as well as the application of general-equilibrium methods to real business-cycle theory (Barro and Sala-I-Martin 1995).

The present vigorous revival of growth theory was based on the researches of the mid-1980s which incorporated models of the determination of long-run growth or the so-called endogenous growth theory because of the new understanding of the importance of long-run growth rather short-run fluctuations. Some other recent research was based on extending the neoclassical growth model for the purpose of bringing out further empirical implications of the theory. Indeed, the clearest difference between growth theory of the 1960s and that of the 1980s and 1990s is that recent research gives more weigh to empirical implications and to the relation between theory and data (Barro, R.J, 1997).

Economic growth research experienced a new boom since the mid 1980s that was ignited by the work of Romer(1986), Lucas(1988) and a little later Rebelo(1991). The apparent reason behind this evolution was the increasing importance of the long-run economic growth and its determinants. These issues became crucial and far more important than the study of business cycles or the countercyclical effects of monetary and fiscal policies. This wave of new research which was built on the work of Arrow(1962), Sheshinisky(1967), and Uzawa(1965), did not come up with a theory of technological change. Rather it gave rise to economic growth that may last indefinitely. This reasoning rests on returns to investment in a large list of capital goods, including human capital that do not necessarily diminish as the economy develops (Barro, R.J, 1997).

The idea that economic growth can remain positive in the long-run became applicable with the incorporation of R&D theories and imperfect competition into the growth mechanism that was first developed by Romer (1987, 1990), with significant contributions by Aghion and Howitt (1992), and Grossman and Helpman(1991). Under these models, the technology advances as a result of R&D activity, leading to some form of ex-post monopoly power. As a result, the economy will grow as long as it does not run out of new ideas. In this setting, the long-run depends on governmental policies with respect to taxation, regulations, the provision of infrastructure..,etc, giving the government a substantial role in the determination of the long-run growth rate (Barro, R.J, 1997).

Within the same framework, Kuznets (1973, 1981) listed out other characteristics of modern growth, where he raised the issue of the rapid rate of structural transformation, including the shifts from agriculture to industry and to services. He also argued that modern growth involves an increasing role for foreign commerce and that technological progress implies less dependence on the use of natural resources. He also underlined the growing importance of government in terms of its organizational role that affects the performance of the economy and as a referee and provider of infrastructures (Barro and Sala-I-Martin 1995). A number of recent theories of modern growth go beyond the simple postulate of labor as a single input of production, dealing with labor that by technical advancement, being concerned with the ability of the country to build human capital. Households savings are no longer held as physical capital, but they can also be invested in education, raising the value of labor supplied by household sector (Debraj, 1998).

Finally, in the economic growth models of the post-Keynes of the Kalecki-Steindl type, endogenous capacity utilization and the level of employment are a key determinant factor of capital accumulation. That is, the Kalecki-Steindl growth and distribution models incorporate a positive long-period relationship between the real wage and government expenditures on one hand, and rates of growth on the other hand (Lavoie, 1995).

III. Empirical Literature Review

1) Empirical Approach

The government involvement in the economy during much of the 20th century was justified based on its traditional functions, including the administrative and regulatory functions in addition to the government's possession of the fiscal and monetary instruments that enable it to affect the performance of the economic sectors. However, this role has strengthened and gained support in the last fifty years as a result of several historical developments that have been witnessed in the world during this century. The first of these influential developments was the birth of Communism in Europe and the rapid spread of Marxism, giving rise to the adoption of socialism in a substantial number of countries in Europe, Asia and Africa. The Great Depression that shocked the capitalist countries for a number of years and the economic difficulties associated to market failures in this period also contributed to a larger government involvement in economic activity. These failures have also prepared the political economics literature for embracing the Keynesian perspective vis-à-vis the indispensable role of government and its policies as a remedy for business-cycle instabilities.

Most research in this area during that period, particularly between 1940s up until 1980s, tended to trace the effects of government various fiscal policies, including public spending, on economic growth without tapping on capital spending in particular. The basic question that these studies attempted to answer was whether government spending had an impact on economic growth or not, and if yes, how much impact and in what way it took place? . Unsurprisingly, the pile of empirical research undertaken to analyze the impact of public sector behavior on the economy in the last three decades came up with different findings and produced inconsistent and contrasted results.

As more research was induced because of the discrepancies in literature, some authors attempted to distinguish crucially between productive and unproductive public spending (Aschauer, 1998), while others went further in analyzing the composition of government spending in studying the effect of government role on growth. The argument behind this distinction is that productive public spending is believed to have positive economic implications, especially on the private sector productivity. It is argued that such spending would positively affect the productivity of the private sector through external economies and the cost saving it generates for the firms. Public spending on infrastructure and R&D, for instance, would benefit the various sectors of the economy and its productive uses could extend to generations to come. This new insight emerged in response to the traditional measures of productivity growth, that typically neglect forces external to firms. In fact, the assumption of constant returns to scale in measured inputs and instantaneous adjustments implies that both external and internal scale effects in the long run and short run are being ignored (Morrison & Schwartz, 1992).

The present research on the impact of government on the economy is based on several different approaches, including the production function approach and the cost function approach that are the most common and widely used approaches. In this respect, the endogenous growth models in particular those developed by Romer (1986), Lucas (1988) and Barro(1990), constitute the backbone of a good part of the research that has already been undertaken. In these models, private and public capital formation are assigned a central role, and therefore government policies pertaining to spending including capital spending are likely to have a permanent effect on the long-run rate of growth (Aschauer, 1998).

2) Production Function Approach

The production function approach was adopted in many empirical studies, among which the influential work of Aschauer (1989,1990) who is described as one of the first authors to attempt to quantify the statistical relationship between public infrastructure investment and private sector productivity. Aschauer used a Cobb-Douglas production function to explain the productivity slowdown in the United States during the 1970s. The main conclusion of this work was that public capital should be considered one of the important determinants of production along with labor and private capital as 1% increase in public spending increases the private capital productivity by 0.3 (Aschauer, 1993). His work brought attention to the potential importance of public capital in private production, with estimates of output elasticity of public capital in the range of 0.35 to 0.40 in the US over the post-World War II period. Similar conclusions were also obtained in other studies by Aschauer (1989) and Munnel (1990) where it was suggested that the reduction in the pace of public capital accumulation is capable of explaining a very substantial portion of productivity slowdown. Munnel (1990), Aschauer (1989), and Ford and Poret (1991) also found that the level of public capital spending might even explain across-country productivity differences (Aschauer 1993). Munnel (1990), Garcia-Mila and McGuire (1992) and Eberts (1986, 1990) came up with qualitatively similar but smaller findings.

Despite a series of studies that have obtained similar findings regarding the positive impact of public capital on output growth, some writers remain skeptical regarding the magnitude of the impact. The most controversial point in these studies is related to the estimate of the elasticity of output with respect to public infrastructure capital. The elasticity coefficients estimated in these studies deviate significantly such that the elasticities estimated based on national time series data were found to be larger than those based on state-level data. These different elasticities might be attributed to the fact that measuring productivity effects using data on small geographic area may prevent the inclusion of the external benefits emanating from public infrastructure capital (Erenberg, 1993). Hutlen and Schwab (1993) used the production function approach to explain the unbalanced growth of the U.S regional manufacturing industries in the decades after World War II. They have found little evidence that public capital externalities were significantly capable of explaining the relative success of industries in the South and West (Hutlen & Schwab, 1993).

Holtz-Eakin and Schwartz (1994) studied the infrastructure in a structural model of economic growth using the production function approach and panel data for the years 1971- 1986. They found that an increase in infrastructure investment would have a negligible impact on annual productivity growth and there is little support for the hypothesis that infrastructure has an important quantitative role in explaining the growth patterns of states. Lynde (1992) investigated the contribution of public capital services to the rate of profit derived from the production function with labor, public and private capital inputs. She pointed out that the data of the U.S. non-financial corporate sector during 1958-88 resembled a declining trend in the profit rate. It was also found that there is a significant positive share of profits attributable to public capital, especially the state and local component. Constant returns to scale in production, and a falling marginal productivity of public capital in the last decade suggest that increasing public investment may help to restore the profit rate and to raise output. Ligthart (2000) used the production function approach to study the long run and short run effects of public capital on growth in Portugal using time series data for the period 1965-1995. He found that public capital is a significant long run determinant of output growth, that is the elasticity of production suggested that a 1 percent increase in the public spending would result in an increased output of about 0.20-0.35. Thus, the marginal productivity of public capital would conservatively be estimated around 40 percent in 1995.

Other authors have employed this approach, but some pointed to its lack of attention to feedback effects because it assumes that the causality runs from public capital to output. In order to capture the dynamic interactions between output, public capital and private capital, some writers (e.g., Otto and Voss, 1996; Batina, 1998; and Stem, Jacobs, and Groote, 1999) have recently employed a vector autoregressive (VAR). In this model, every endogenous variable is modeled as a function of its own lagged value and the lagged values of the other endogenous variables and therefore, the whole model is assessed as to whether there is any feedback from private sector variables to the public capital stock (Ligthart 2000)[8].

The cost function approach has also been the base of many other empirical studies including Lynde and Richmond (1993), who employed this approach to examine the public capital contribution to productivity growth in the long–run using a model of U.K. manufacturing production that incorporates public and private capital inputs. Using data for the period 1966-1990, they found that, before 1980, the public and private capital contributions were of comparable magnitude. After 1980, the contribution of public capital declined significantly. Lynde and Richmond (1992) also examined the impact of the stock of public capital on costs of production in the private sector using annual data over the period 1958-89. They estimated a translog cost function and found that public capital is a significant input. The estimates indicate

[8] See for example: Gasper and Pereira (1995)

that public capital has a positive marginal product and that private and public capital are complements in production, rather than substitutes.

Morrison and Schwartz (1992) used the cost function method to study public infrastructure and productivity performance based on a complete production theory model of firms' production and input decisions. This framework was then applied to state-level data on the output production and input (capital, non-production and production labor and energy) use of manufacturing firms to evaluate the effects of government infrastructure on the costs and productivity growth of firms. The study reported that public spending on infrastructure provides no significant direct benefit to manufacturing firms. Finn (1993) examined the total U.S. government capital and found that only certain components, namely, government-owned but privately operated capital, government enterprise capital, and government highway capital directly contribute to the production of U.S. private sector output. During 1950-1969, positive highway capital growth raised the average growth rate of private output from 1.7 percent to 2.2 percent. In contrast, in the productivity slowdown period, 1970-1989, negative highway capital growth reduced the average growth rate of private output from 1.4 percent to 1.3 percent. Dalenberg and Eberts [1992], and Nadiri and Mamuneas [1991] investigated the relationship between public capital and costs of private production and found a statistically significant reduction in private costs.

Tatom (1991) argued that the effects of fluctuations in energy prices on productivity and the slow trend rate of technological change in the production function reduces the estimated effect of public capital on private sector output by more than 50%. He also pointed out that such findings are examples of "spurious regression bias," where variables appear to be statistically significantly related but they are actually not. Tatom also emphasized that this applies on tests of the public capital hypothesis and concluded that the public capital stock has no statistically significant effect on business sector output. Evans and Karras (1994) used panel data for seven countries in each year between 1963 and 1988 to investigated the extent to which government capital contributes to production. They reported that no statistically significant evidence is found that government capital is productive. In another work that was based on panel data for the forty-eight contiguous U.S. states in each year between 1970 and 1986, Evans and Karras

(1994) investigated again the government capital and current government services contribution to private production. They found fairly strong evidence that current government educational services are productive but no evidence that the other government activities considered are productive.

To support the endogenous growth models approach, Kocherlakota and Yi (1996) presented evidence that emphasize public structural capital by applying a simple test of endogenous vs. exogenous growth models. In exogenous growth economies temporary innovations to policy variables lead only to temporary changes in GNP levels, while in endogenous growth economies the innovations can lead to permanent changes in GNP levels. They also indicated that only non-military equipment capital and non-military structural capital have a statistically and economically significant effect on long-run GNP levels from the seven policy variables they examined. Further estimation suggests that the non-military equipment capital result is not robust and that several disaggregate components of structural capital contribute significantly.

Another method to examine the productivity of public capital is adopted by Karras (1997), who estimated the productivity of government capital for a panel of fifteen European countries in the period 1960-1992 and tested whether government investment is optimally provided. The main findings of this work were that when time effects are included in the regression, the estimated marginal product of government capital is not statistically significantly different from zero. In addition, the hypothesis that the marginal products of private and government capital are equal cannot be rejected, which coincides to the Panglossian view that government investment is neither under-provided nor over-provided in the fifteen countries sampled. Karras (1997) also investigated the role of public services in the production process by estimating the optimal government size for the representative European country. The empirical findings of this work supported the conclusion that government services are significantly productive but the marginal productivity of government services may be negatively related to government size. Karras (1993) also found that the effects of government spending on employment and output might depend on government size and the persistence of spending suggesting that permanent (or persistent) changes in government consumption have a greater impact on output and employment than temporary (or cyclical) changes. This implies a negative wealth effect and reduces the stabilization potency of government spending. The findings also support the hypothesis that the output elasticity of government consumption is positive but declines with increases in government size. Using the estimated equations, the author calculates the optimal government size for the representative country at around 20 percent of GDP.

Other strand of studies appealed to the effect of public capital spending or government investment activity on private investment. The idea that infrastructure capital has an impact on private investment activity and economic growth is discussed in the literature by Buiter [1977] who asserted that a complementary relationship between public and private investment was obvious, citing public investment in projects such as dam construction. Munnell [1992] also argued that: "Everyone agrees that public capital investment can expand the productive capacity of an area, both by increasing resources and by enhancing the productivity of existing resources" (Erenburg, 1993). Amongst those who addressed this issue, Erenburg (1993) investigated the relationships between private sector investment spending and government provision of public capital utilizing major private investment models. Her empirical results indicated that private sector equipment investment is inversely related to government investment spending and directly related to the existing public capital stock. Also, private equipment investment is much more sensitive to public provision of capital than either structure investment or measures of total investment. Short-run empirical estimates indicate that each additional one percentage point increase in public infrastructure and government investment spending is associated with an approximate three-fifths of a percentage point increase in private sector equipment investment per year. These estimates indicate an increase of an approximate two-fifths of a percentage point increase in private equipment investment per year. Projections reveal that if the rate of growth of public capital stock had continued from 1966 through 1987 at the 1947-1965 average growth rate (instead of decreasing), the growth rate of private sector equipment investment would have been between 4 to 6 percentage points above the actual rate of growth.

Ligthart (2000) compiled an overview of the studies in which the production function approach was adopted. This overview shows that the coefficient (β) associated with public spending in the production function when estimated in levels was in average 0.25 for various OECD countries.

IV. Model Specification and Data Description

1) Model Specification

In order to answer the particular question pertinent to the effect of public capital spending on economic growth, the study follows the footsteps of several empirical studies based on the production function approach. This approach was extensively employed by many researchers in this area in spite of its shortcomings. This study appeals in particular to Aschauer (1989, 1990), who applied this approach in his research on the USA, Ligthart (2000), Munnell (1990), Ratner (1983) and others.

The model assumes a neoclassical Cobb-Douglas production function that incorporates the public capital stock (G) and takes the following form:

$$Y = AK^{\alpha} L^{\beta} G^{\gamma} \qquad \alpha, \beta, \gamma > 0 \qquad (1)$$

Where,

Y: economic output,

A: An index of multi-factor productivity

K: private capital stock,

L: labor input,

G: public capital stock.

The inclusion of the public capital stock in the production function is intended to capture the effect of the public capital on economic productivity growth that is believed to be generated by this kind of capital. According to this setting, an increase in public capital will have positive direct and indirect effects on the level of output. That is an increase in public capital would directly raise the level of output captured by the partial derivative of Y with respect to G:

$$Y_G = \gamma(Y/G) > 0$$

Where G in the subscript represents the partial derivative. This direct effect is necessitated by the fact that public capital spending is one of the aggregate output components. The indirect effect of this increase would be an increase in the marginal productivity of private capital and labor (i.e.,$Y_{KG} > 0$) and (i.e., $Y_{LG} > 0$) (Ligthart, 2000). This setup also implies that the coefficients associated with the three determinants in the production function; α, β, γ resemble the output elasticity coefficients of the correspondent inputs.

2) Ordinary Least Square (OLS)

To use the conventional Ordinary Least Square method (OLS) in the estimation of the model equation, the Cobb-Douglas production function is transformed to this end to a linear form by taking the natural log of both sides of equation (1) as follows:

$$\text{Log } Y = \log A + \alpha \log (K) + \beta \log (L) + \gamma \log (G) \qquad (2)$$

Denoting the natural log of variables in lowercase, equation (2) could be re-written as:

$$y = a + \alpha k + \beta g + \gamma l, \qquad \alpha > 0, \beta > 0, \gamma > 0 \qquad (3)$$

The issue of the inclusion of public capital in the production function usually gives rise to the restrictions of returns to scale. The assumption of constant returns to scale across all production factors **(i.e. $\alpha+\beta+\gamma = 1$)** is the most applied restriction in the empirical work, where the private capital and labor are characterized by decreasing returns **(i.e. $\alpha+\gamma < 1$)**. Imposing this restriction on equation (3) gives the following expression:

$$y - k = a + \beta(g - k) + \gamma (l - k) \qquad \alpha+\gamma < 1 \qquad (4)$$

Alternatively, the assumption of constant returns to scale only in the private capital and labor allows all inputs to run on increasing returns to scale[9]. This assumption was applied in several theoretical models of endogenous growth[10].

As in some of the empirical studies that take account of the possible effect of business cycle on the level of inputs used up in production, the capital utilization rate (U) was also included in the estimation of the coefficients of the model for that matter. This study assumes a significant effect to the technology variable (a) represented by Multi-Factor Productivity (MFP). Some empirical studies applied this specification with the inclusion of a constant and time trend to capture Hicks-neutral technological improvements (Ligthart, 2000).

To provide a more detailed picture for the public capital effect on output, some studies applied this specification to each component of public capital that includes mainly the stock of equipment and of infrastructure. In these studies, each of these two components is incorporated in the production function to capture its individual effect on output and the effect generated through the interaction with the other two inputs in the function (see Ligthart, 2000).

To enable the comparison of findings with the literature, this empirical work involves first estimating the log-transformed unrestricted production function represented by equation (3) in levels and then in first difference. The production function will then be estimated in levels and in differences after imposing the restriction of constant returns to scale as in equation (4).

3) Data Description

The empirical analysis of this study is conducted by employing annual data for Canada that cover the period (1961-1995). The model uses data on GDP annual estimates that are known to be the most common measure of economic growth and are widely used in many economic studies. The model and the related analysis is also built on annual series of private capital stock

[9] The resultant expression would be: $y-k = a + \beta g + \gamma (l-k) \ldots \alpha+\gamma = 1$
[10] See Barro, 1990

(K), number of hours worked (L) and public capital stock (G) for the said period. Data series on public capital stock was compiled for the Federal government, Local, municipal / regional, provincial and territorial administrations. Several authors attempted different approaches by employing public capital investment (I), the new additions to the capital stock that was accumulated during the accounting period to represent (K) in the model instead of capital stock[11]. However, this approach could be envisioned inappropriate on the ground that it ignores the fact that the present level of output (Y) in the production function was produced by the economy as a result of the employment of all capital assets at the economic sectors' disposal. This eventually includes whatever capital stock accumulated in the past, therefore relating the present level of output to the new additions of capital (I) would involve some misleading outcomes.

Estimates of private and public capital stocks used in this model are net of depreciation that is estimated by the geometrical perpetual method[12]. According to this approach, capital stock values are computed as the sum of all past investments appropriately adjusted for the rate of depreciation. All previously accumulated capital as well as the capital added during the accounting period is depreciated, and the obtained depreciation estimate is then deducted from the total value of capital investments up until the end of the accounting period. To get rid of inflation effects, all variables are valued at 1992 constant prices[13].

4) Cointegration and Non-Stationary Tests

Taking into account that this empirical work uses annual data series, all variables are to be tested for unit root in levels as well as in differences using the Augmented Dickey-Fuller (1981) (ADF) test so as to address the stationary issue in data series. The data series is non-stationary if it has a unit root, therefore the usual test statistics have nonstandard distribution implying that using standard inference tests may give misleading inferences. The analysis also

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[11] Ferreira (1994), Dalamagas (1995), Ramirez (1998) applied Production Function in which they used time series data on public capital investment in the US, Greece and Mexico respectively.
[12] These series are also made available in CANSIM
[13] Data series for these measures were obtained from the Canadian Social Information Management System (CANSIM).

examines the data series for cointegration, to deal with the non-stationary variables and to explore the long-run equilibrium relationship between various series. The idea of cointegration is that, if a group of non-stationary time series is cointegrated, there is a linear combination of them that is stationary. Then their combination does not have a stochastic trend, therefore the equation can be estimated in levels. The cointegration test would be conducted based on Johansen's (1987) test[14], assuming that the data has a linear deterministic trend for which the Johansen test procedure computes the likelihood ratio statistic for each added cointegrating equation.

5) Granger-Causality Test

To explore the interaction between the various series in terms of the mutual effect among the variables, the model is also examined for causality using Granger Causality tests. This test deals with hypotheses involving restrictions on the coefficients of the explanatory series and if these restrictions were valid there should be little difference in the fits obtained for the unrestricted and restricted regressions. The essence of this test is to provide some answers as to whether the public capital stock (G) causes output (Y), and how much of the current (Y) can be explained by past values of (Y), and then to see whether adding lagged values of G can improve the explanation. (Y) is Granger-caused by (G) if (G) helps in the prediction of (Y), or equivalently if the coefficients on the lagged (Gs) are statistically significant.

It is worth noting that the statement "G Granger causes Y" does not imply that (Y) is the effect or the result of (G) since Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term. The null hypotheses being tested are that (G) does not Granger-cause (Y) and that (Y) does not Granger-cause (G) and the statistics used in this case are the relevant F-statistics for these two hypotheses. The results of these tests are derived by running bivariate regressions of the relevant pair of variables where each equation contains lagged values of the left-hand side variable plus lagged

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[14] Another procedure that has been widely applied is the Engle-Granger test (1987) that tests unit roots on the residual of the estimated equation

values of other variables under consideration. It is essentially equivalent to running a two-variable VAR and testing whether the lags determined are significantly different from zero[15]. The application of this test could provide a significant explanation of a number of empirical issues that have been raised by the studies undertaken in this field. Particularly, it can be used to study the short and medium-run linkages between public capital and other macroeconomic variables[16]. Some researchers concentrated on the linkage between public capital and private investment[17].

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[15] See Ligthart (2000).

[16] Aschauer (1990), and Munnell (1992) pointed that the direction of causation may run from high levels of output to larger public investment rather than the other way around.

[17] Sharon (1993) and Aschauer (1985) studied the relationship between public and private investment.

V. Empirical Results for Canada

Estimating equation (3) in levels, the unrestricted production function with the use of OLS yielded the findings presented in table (4). The results show that all the coefficients have their expected signs. The production elasticity with respect to public capital is statistically significant (different from zero) and mounted to 0.41, very much less than 0.52 estimated by Wylie(1996) in levels, but a little more than 0.37 obtained by Munnell (1990) in levels. But it was clearly way higher than the average output elasticity of 0.25 that is estimated for the OECD countries. The elasticity measure implies that a 1 percent increase in public capital leads to an increase in the GDP by 0.41 percent.

As to the elasticity measure of output with respect to private inputs, private capital stock and labor, the estimated coefficients were around 0.23 and 0.60 respectively. The elasticity measure with respect to private capital is far below those presumed in the industrialized countries, but as far as labor input is concerned, it is closely in line with the industrialized countries' measure. The sum of the three input coefficients gives a total of 1.24 that is a little more than unity. The Wald test statistics show that the production function failed to fulfill the constant returns to scale characteristic. The null hypothesis of this assumption could be rejected given the value of both F and Chi-square statistics (see Table (4)).

The estimation of unrestricted production function on first differences yielded slightly different results as shown in Table (4), where the elasticity coefficient of output with respect to public capital was estimated at 0.43 that is nearly 0.02 less than what is obtained by the estimation in levels. However, this estimate is significantly less than 0.63 obtained by Ford and Poret (1991) for Canada in the case of difference of logs. It is also worth noting that this estimate is reasonably close to that estimated at 0.39 for the OECD countries. Private input elasticity coefficient however did not deviate significantly from those estimated in levels, as they were estimated at 0.17 for the elasticity with respect to private capital stock and 0.636 with respect to labor input. The Wald test on the coefficients associated with the three variables shows again that the production can not be characterized by constant returns to scale based on F and Chi-square values computed under this test (see table (4))

Testing various series for stationarity using the ADF test provided evidence that all series are non-stationary in levels, where Y, K and L possessed a first-order unit root (I (*1*)), while G has second-order unit root (I(*2*)) (see Table (5))[18]. The non-stationary of series in levels may invalidate standard test statistics that have nonstandard distribution, consequently the use of standard inference based on estimates obtained in the model might be inaccurate and misleading. Cointegration tests are performed using Johansen cointegration approach. The test was performed first with one lag interval and then with two lags interval.

One advantage of this test is that it is built on a dynamic multiple equation system known as a VAR approach to capture any existent feedback between the variables in use. The results of the cointegration test with one lag interval are presented in Table (6). They show that the group of series in the model is cointegrated, and the rank of cointegration is one (r = 1), giving one cointegration equation. The elasticity coefficients of output with respect to various inputs were close to those obtained by the OLS method as far as the public capital and labor inputs are concerned, as they mounted to 0.40 and 0.65 respectively. But it was notably less than that estimated in levels for the private capital based on OLS. These results eventually support the claim that the public capital stock does have a positive effect on output expressed by GDP estimates.

The two-lag interval cointegration test confirmed that the group of series in the model is in fact cointegrated of rank 2 (r = 2), that is there are two cointegration equations that can be identified. Output elasticity with respect of public capital resulted from the test mounted to 0.40 that is close to previous estimates obtained through one-lag interval cointegration test. The elasticity coefficients with respect to private capital and labor were estimated at 0.065 and 0.65 respectively, where the later is apparently much lower than that estimated with the application of the OLS both in levels and in differences.

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[18] Similar findings were obtained by Ligthart (2000)

The elasticity measure with respect to labor input however is around its OLS estimation. The causality tests were carried out as well using the Granger causality approach and the results are given in Table (7). The evidence suggests that the hypothesis that the public capital stock does not Granger cause output should be rejected in favor of the existence of such a causal relationship. However, the hypothesis that output does not Granger cause public capital can be accepted considering the F statistics value. These findings are consistent with the hypothesis that public capital variations contribute to economic fluctuations. Both output and the private capital stock do significantly Granger-cause each other taking into account the large values of the computed F statistics.

One more important outcome of this test is that public capital Granger causes private capital at a high level of significance represented by the large value of F statistics. This indicates that public capital induces positive "Crowding-in" in private investments. Yet, the test shows that private capital does not Granger-cause public capital. As for the employment of labor, the test showed that public capital Granger-causes labor, but labor does not Granger-cause public capital. From all of the above, one can notice that public capital Granger causes all other variables, but none of these variables Granger-causes public capital.

Imposing the restriction of constant returns to scale, following Aschauer's (1989) specification as a benchmark, on the production function gives the expression in equation (4) that has been estimated by the OLS[19]. The production function therefore is assumed to possess the characteristic of constant return to scale across all inputs. From the result presented in Table (8), output elasticity coefficient with respect to public capital stock, γ was estimated at 0.42 that is obviously close to the unrestricted elasticity measure.

It is worth noting that this measure is slightly higher than 0.39 obtained by Aschauer (1989,1990), but very much similar to the estimate calculated by Aaron (1990) who estimated it at 0.41 and Sturan and de Haan (1995) who obtained an estimate of 0.41. Elasticity measures

[19] The rate of utilization is not including in this estimation

with respect to private capital and labor were estimated at 0.31 and 0.265 respectively, where they clearly deviate from these obtained from the unrestricted estimation of the production function.

VI. Conclusion

The main objective of this study was to analyze the public capital spending and identify its impact on economic growth using annual data on the Canadian economy for the period (1961-1995). The empirical analysis was carried out with the use of the familiar Cobb-Douglas production function approach presented in the core of neoclassical literature. According to this framework, the public capital stock has been incorporated as an additional determinant of production a long with the two traditional factors, namely private capital stock and labor. Subsequently, the augmented production function was estimated by applying the Ordinary Least Square method (OLS) on the log-transformed function both in levels and on differences. For further in-depth analysis, the production function was also estimated in light of the assumption of constant return to scale for all production inputs so as to identify its characteristics versus the constant return to scale assumption. Furthermore, data series have been tested for stationarity through the application of test for unit root using Dickey-Fuller (1981) test and Johansen (1987) cointegration test. Causality features of this specification were also addressed by examining the data for Granger-causality relevant tests.

The results obtained from the estimation of production functions by the OLS method both in levels and on differences showed that public capital is a significant long-run determinant of output growth. This was concluded based on output elasticity with respect to public capital denoted by (β) that mounted to 0.41 when estimated in levels and to 0.43 when estimated in first difference. This implies that a 1 percent increase in public capital leads to an increase in output by 0.41 percent. The estimation of the production function with the restriction of constant return to scales yielded similar results concerning the significance of the effect of public capital on output.

In terms of causation, public capital was found to Granger-cause output implying that public capital spending does have a positive contribution to output growth. Moreover, there was no evidence that any of the variables (output, private capital and labor) Granger-causes public capital, which suggests that the level of public capital spending is determined by other factors, presently the political will of government.

Appendix

Table (1): GDP, Public & Private Capital Average Growth Rates
For the Period (1961-1995)

	GDP	Public Capital Stock	Private Capital Stock
1962-71	5.33	4.46	4.69
1972-82	4.06	3.21	3.78
1983-91	2.34	2.3	1.87
1992-95	3.26	2.07	0.51

Source: CANSIM historical data series

Table (2): Productivity Average Growth Rates for the Period (1966-1997) 1/

	1966-73	1973-79	1979-88	1988-97
Business Sector	2.1	0.6	0.5	0.7
Goods	2.3	0.4	0.8	0.9
Service	1.9	0.8	0.3	0.3

1/ IMF Staff Report No. 00/34, March 2000

Table (3): Overview of Empirical Studies Based on the Production Function Approach

Author	Year	Country	β	Specification	Data
Ratner	1983	U.S	0.06	CD,LL	TS,1949-73
Aschauer	1989	U.S	0.39	CD,LL	TS,1949-85
Ram & Ramsey	1989	U.S	0.24	CD,LL	TS,1948-85
Munnell	1990	U.S	0.31	CD,LL	TS,1949-87
			0.37 1/		
Aaron	1990	U.S	0.41	CD,LL	TS,1952-85
			0.27	CD,DL	
Tatom	1991	U.S	0.13	CD,LL	TS,1948-89
			0.04 2/	CD,DL	
Ford & Poret	1991	U.S	0.30	CD,LL	TS,1949-87
			0.25	CD,DL	
		Germany	0.53	CD,DL	TS,1961-87
		Canada	0.63	CD,DL	TS,1963-88
		Belgium	0.52	CD,DL	TS,1967-88
		Finland	0.54	CD,DL	TS,1967-88
		Australia	0.34	CD,DL	TS,1967-87
Hutlen & Scwab	1991	U.S	0.21	CD,LL	TS,1949-85
			0.03 2/	CD,DL	
Berndt & Hansen	1991	Sweden	n.a 4/	CD,LL	TS,1960-88
Finn	1993	U.S	0.16	CD,LL	TS,1950-89
Bajo-Rubio & Sosvilla-Rivero	1993	Spain	0.19 5/	CD,LL	TS, 1964-88
Eisner	1994	U.S	0.27	CD,LL	TS,1961-91
Ferreira	1994	U.S	0.08 6/	CD,LL	TS,Q,1975-1986
Sturm & de Haan	1995	Netherlands	0.41	CD,LL	TS,1949-85
			0.26	CD,LL	
Dalamagas	1995	Greece	0.53 7/ 6/	TL	TS,1950-92
Ai & Cassou	1995	U.S	0.15	CD,DL	TS,1947-89.
Otto & Voss	1996	Australia	0.17	CD,LL	TS,Q,1959III-92II
Wylie		Canada	0.11-0.52	CD,LL	TS,1946-91
Crowder & Himarios	1997	U.S	0.17-0.38	CD,LL	TS,1947-89
Flores de Frutos et al.	1998	Spain	0.21 5/	CD,LL	TS,1964-92
Ramirez	1998	Mexico	0.12 6/	CD,DL	TS,1950-90
Mamatzakis	1999	Greece	0.25	CD,LL	TS,1959-93
Costa et al.	1987	U.S	0.19-0.26	TL	CS,48 states,1972
Merriman	1990	U.S	0.20	TL	CS,48 states,1972
		Japan	0.43-0.58	TL	P,9 region,54-63
Munnel & Cook	1990	U.S	0.15	CD,LL	P,48 states,70-86
Aschauer	1990	U.S	0.11	CD,LL	P,50 states,65-83
Eisner	1991	U.S	0.17 2/	CD,LL	P,48 states,70-86
Garcia-Mila & McGuire	1992	U.S	0.04-0.05	CD+TL,LL	P,48 states,69-83

Table (3): Overview of Empirical Studies Based on the Production Function Approach (cont..)*

Author	Year	Country	β	Specification	Data
Munnel	1993	U.S	0.14-0.17	CD,LL	P,48 states,70-86
Evans & Karras	1994	U.S	n.a 2/	CD,TL,LL,DL	P,48 states,70-86
Holtz-Eakin	1992	U.S	n.a 2/	CD,LL	P,48 states,69-86
Pinnoi	1994	U.S	0.08	TL	P,48 states,70-86
Baltagi & Pinnoi	1995	U.S	n.a 2/	CD,LL	P,48 states,70-86
Mas et al	1996	Spain	0.08	CD,LL	P,17,regions,80-89
Garcia-Mila et al.	1996	U.S	n.a 2/	CD,LL	P,48 states,70-86

CD= Cobb-Douglas

LL= Estimated in log levels

DL= Estimated in first difference of logs

TL= Estimated in translog levels

TS= time series

CS = Cross-sectional

Q= Quarterly data

1/ No constraints on the production Function imposed

2/ Coefficient is insignificant at 5% level

3/ Study of 11 OECD countries. Only the coefficients of the listed countries were significant

4/ Finds implausible values of the coefficients

5/ Cointegration relationship identified

6/ Public investment rather the public capital stock

7/ Only when fiscal deficit is included in the equation, otherwise the coefficient is insignificant.

* Source: Ligthar(2000)

Table (4): Results of Estimation of Unrestricted Production Function 1/

Unrestricted Production Function in Levels

$$\ln(Y) = -7.65 + 0.54 \ln(A) + 0.229 \ln(K) + 0.603 \ln(L) + 0.413 \ln(G) + 0.049 \ln(U)$$

(-13.55)** (8.69)** (4.24)** (7.69)** (6.02)** (0.75)**

$R^2 = 0.99$, D-W = 0.477

Wald Test of constant returns scale: $\alpha + \beta + \gamma = 1$

F statistics = 101.899	Probability = 0.000
Chi-square = 101.899	Probability = 0.000

Unrestricted Production Function on First- Differences

$$\Delta\ln(Y) = 0.56\ \Delta\ln(A) + 0.17\ \Delta\ln(K) + 0.63\ \Delta\ln(L) + 0.43\ \Delta\ln(G) + 0.045\ \Delta\ln(U)$$

(7.1)** (2.02)** (10.65)** (4.02)** (1.08)

$R^2 = 0.96$, D-W = 1.815

Wald Test of constant returns scale: $\alpha + \beta + \gamma = 1$

F statistics = 29.609	Probability = 0.0000007
Chi-square = 29.609	Probability = 0.001710

1/ t-statistics in parentheses
** Significant at 1 percent level of confidence
*Significant at 10 percent level of confidence

Table (5): Results of Augmented Dickey–Fuller for the Data Series 1/

Series	ADF	1%	Difference	Intercept	R^2
D(Y)	-3.93**	-3.64	1	X	0.38
D(K)	-3.88**	-3.64	1	X	0.39
D(G)	-4.82**	-4.28	2	X	0.58
D(L)	-3.76**	-3.65	1	X	0.35

1/ The test' hypothesizes there is a unit root

** Significant at 1 percent; the hypothesis is rejected

Table (6): Results of Johansen Cointegration Test 1/

Rank of Cointegration	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	
A. One Lag Interval					
Eigenvalue	0.717	0.493	0.352	0.235	
Liklihood Ratio (λ)	87.57**	45.86	23.46	9.12	
Critical Value (5%)	68.52	47.21	29.68	15.41	
Critical Value (1%)	76.0	54.46	35.65	20.04	
Cointegration Estimates 1/	Y	A	α	β	γ
	1.00	-0.832	-0.065	-0.40	-0.65
B. Two Lags Interval					
Eigenvalue	0.73	0.571	0.387	0.276	
Liklihood Ratio (λ)	96.35**	53.45*	26.32	10.65	
Critical Value (5%)	68.52	47.21	29.68	15.41	
Critical Value (1%)	76.07	54.46	35.65	20.04	
Cointegration Estimates 1/	Y	A	α	β	γ
	1.00	-0.866	0.000	-0.422	-0.626

1/ The coefficients should be multiplied by (-1) to obtain the original values

(**) The null hypothesis accepted at 1% significance level

(*) The null hypothesis accepted at 5% significance level

Table (7): Results of Pairwise Granger Causality Tests

	Y		K		L		G	
Direction of Causality	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
Y →	-----	-----	7.33**	0.0028	4.106**	0.0273	0.33	0.72
K →	8.36**	0.0014	-----	-----	6.71**	0.0042	0.27	0.77
L →	3.19**	0.056	4.783**	0.016	-----	-----	0.23	0.797
G →	5.33**	0.0109	9.438**	0.0007	4.477**	0.0205	-----	-----

(**) Significant at 1% level of confidence

Table (8): The Result of Estimation of Restricted Production Function 1/

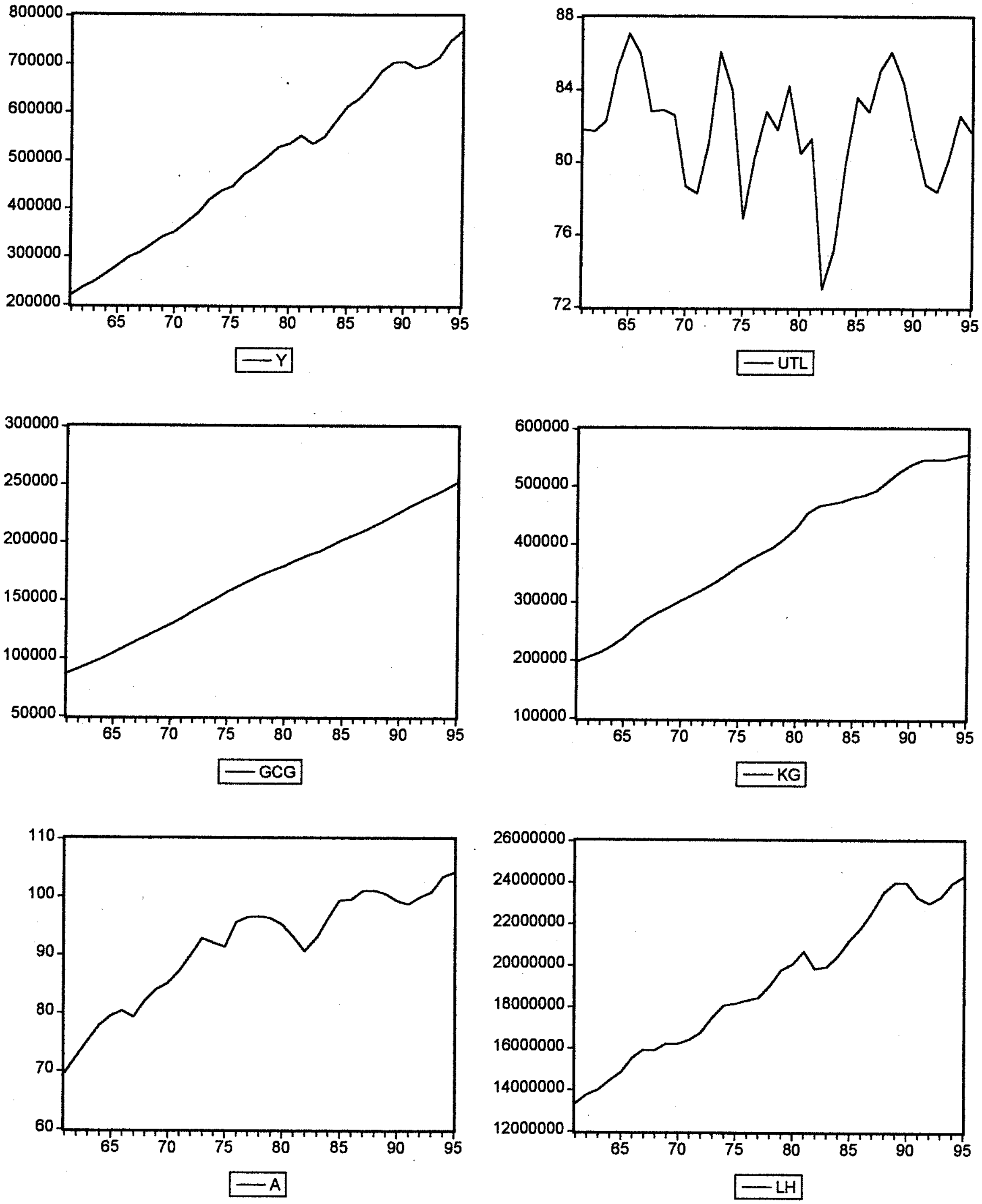
$$\underset{(-5.69)^{**}}{\ln(Y) = -4.178} + \underset{(9.47)^{**}}{0.82 \ln(A)} + \underset{(2.80)^{**}}{0.312 \ln(K)} + \underset{(3.837)^{**}}{0.26 \ln(L)} + \underset{(6.16)^{**}}{0.423 \ln(G)}$$

$R^2 = 0.998$, D-W = 0.315

1/ t-statistics in parentheses

(**) Significant at 1% level of confidence

Multiple Graphical Presentation of the Data Series Employed in the Model



On-Line Sources of Data

CANSIM Historical Series

Series	Label No.
1) Public Capital Stock	
i) Federal Government / public administration capital stock	D834756
ii) Local, municipal and regional administration	D834820
iii) Provincial & Territorial administration	D834788
2) Private Capital Stock	D993325
3) Industrial Capacity Utilization rates	D883644
4) Number of hours worked	D1601501
5) GDP estimates at 1992 prices (Quarterly estimates)	D15721

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