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Public policy and growth in Canada: An applied endogenous growth model with human and knowledge capital accumulation☆

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ABSTRACT

Evidence suggests that the Canadian economy is over-shadowed with lagging productivity growth and that its innovation strategy lacks a market-oriented focus; and is unbalanced and biased. We study this problem with the aid of a dynamic general equilibrium model driven by analytics of endogenous growth and investigate the viable policy options and assess the interactions between knowledge driven growth, acquisition of human capital, and the role of strategic public policy for the Canadian economy. We study alternative public policies aimed at fostering the development of human capital (investment in education) and those at enhancing investments in innovation. Based on the re-allocation effects triggered by public subsidization policies on higher education versus industry/business R&D, our results corroborate that Canadian economy is falling short of its potential in (business) technological innovation. Our analyses further imply that the most welfare enhancing policy is to have a complementary mix of education and R&D subsidization designed to avoid the trade-offs that emerge in the short run.

1. Introduction

In the face of accumulating evidence that Canada is lagging behind in productivity growth, there is a growing concern that its innovation strategy lacks market-oriented focus. It is argued that its aggregate national output remains lower than its potential, and that Canada is over-investing in education and under-investing in R&D, business R&D in particular. This asymmetry is highlighted in Cook (2008:1) who claimed, for instance, that "*Canada's innovation strategy is unbalanced and biased; focused on technology-push, overlooking… market-led innovation*". McFetridge (2008:2) in turn argues that "*Canada's disappointing record is due, in part, to a lack of innovation in the business sector of the economy*", and criticizes that this had been "*a recurring theme… for more than forty years*".

Statistics Canada (2007) further reports that Canada's rate of growth of labor productivity has been lower than that of the United States over the last quarter of the last century, and that the gap seems to be widening. Sharpe (2007:21) has made an even stronger case arguing that "*over 2000 to 2006, Canada's labor productivity growth in its manufacturing was only one-tenth of that witnessed in the US*".

Conventional analysis suggests that the reason of this gap can be two-fold:

(1) diminishing returns to investments in physical capital, which is a well-known factor embedded in the traditional neoclassical paradigm; (2) slow rate of growth in technological innovation.

However, the Canadian reality signifies yet another mix: impediments to innovation; or rather, the widening gap between advances in pure sciences and commercialization of the fruits of this research within a balanced innovation system that is inclusive of a market-led, pull-innovation framework. Cook (2008:5) concludes for instance, that "*Canada's innovation system has been disproportionately focused on fundamental research for nearly a century*", and that, "*recent innovation strategies have resulted in substantial increases in push-innovation funding; however, commercialization results have been disappointing and Canada is not considered an innovation leader*". A natural issue of concern in bridging the aforementioned gap between the *push* and *pull* attributes of innovation is education and training of the research personnel, that is, the pace of human capital formation. This was highlighted in Expert

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Panel on Commercialization (2006) where, among many sets of recommendations, the Panel explicitly called for "*new or expanded fellowship programs to employ undergraduate, graduate and postdoctoral students and recent graduates in the business sector*"; and"*a commercialization superfund to support research and training in university and nonproprietary laboratories in areas of research in which Canada could become a market leader*."

Given these discussions, in this paper we ask what can be done to boost and manage Canada's productivity growth. Recent advances in the "new growth theory" identify and emphasize the roles of R&D activities and accumulation of human capital as the key determinants in explaining disparity across countries in income per capita, productivity, and the rate of growth. Investment in education directly stimulates the productivity of the labor force, and thus provides significant externalities for growth. Similarly, R&D activities conducted by both private and public sector raise the available knowledge stock and elicit capital accumulation. Thus, economic growth is fed from two sources which nourish each other: investments in education and R&D capital accumulation.

The crucial roles attributed to R&D activities and accumulation of human capital in explaining economic growth have led to construction of economic models which allow for sustained, boundless growth of per capita income, where long run performance depends on structural parameters and domestic and foreign fiscal policies. In this literature, a branch studied capital accumulation, which became a broader concept with the inclusion of human capital, as the engine of growth (Jones and Manuelli, 1990; King and Rebelo;, 1993; Rebelo, 1991). Another approach attributed a leading role to externalities in growth process. Each firm's physical (Arrow, 1962) and human (Lucas, 1988) capital investment unintendedly contributes to the productivity of other firms' capitals. Pioneered by Romer (1990), Grossman and Helpman (1991,1994), Aghion and Howitt (1997), a third approach focused on economic growth triggered by technological development and adoption of new technologies.

The new growth literature that followed the paths of the above mentioned literature, developed models that attempt to reconcile Romerian/Krugmanesque R&D-driven growth along with Lucasian human capital formation in which private industrial development, capital variety production, and technical skill dispersion lead to growth, given the importance of representation of knowledge-led economic conditions (Arnold, 1998; Dalgaard and Kreiner, 2001; Riberio-Thompson, 2000). Based on these hypotheses, models with joint consideration of human capital accumulation and endogenous technology contested the standard models of the literature where (steady-state) growth rate is only dependent on human capital variable(s) and their structural parameters, and showed that (steady-state) growth paths would also be affected by the level of innovative activities (Sequeira, 2008, 2011; Zeng, 2003).

Such contributions bring the issues of innovation, R&D production, human capital formation and optimal design of public policies that take into account the simultaneous interaction among the mechanisms that contribute to the generation of economic growth to the forefront of analysis. Zeng (2003), utilizing a model with innovations, physical, and human capital, studies the impact of government policies on long-run growth and shows that long-run growth rate is responsive to the choice of government taxes and subsidies. Similarly, Hagedorn et al. (2003), in a model of endogenous growth with a combination of physical and human capital, and R&D based technology accumulation calibrated to the US economy, investigate Ramsey-optimal taxation regimes and indicate that a government policy designed to lower the cost of financing for R&D firms would help induce a higher level of private R&D and a higher path of growth. Grossman (2007) in a two-period OLG model in which the young agent decides to devote time to increase (specialized) skill level or to remain unskilled, compares the growth implications of R&D subsidy to firms with a publicly provided education targeted to the development of (specialized) science and engineering skills. In a different setting, Agénor (2012) sets up an overlapping generations endogenous growth model with interactions between public capital, human capital and innovation, and emphasizes the trade-offs involved in the allocation of public spending to R&D subsidies. Gomez and Sequeira (2014), in a recent paper present a model of R&D, human capital, and physical capital with creative destruction. The model is calibrated to US economy and intertemporally budget-neutral policies are compared. The authors show that subsidies to R&D are most welfare increasing when the main target is to keep the intertemporal budget balance.

Following these theoretical and empirical contributions, the main purpose of this study is to analytically investigate and assess the interactions between knowledge driven growth, acquisition of human capital, and the role of strategic public policy for the Canadian economy within the context of a general equilibrium, endogenous growth model. To this end, we investigate alternative public policies aimed at fostering the development of human capital (such as investments in education and learning) and those at enhancing total factor productivity through investments in innovation (such as subsidies to R&D); and study the impact of various public policies on patterns of growth, along with their likely consequences from the points of view of per capita income growth, social welfare, burden to government budget and economic efficiency.

We calibrate the model to the real macroeconomic data of the "Canadian economy" and solve both for the transition and the steady-state path of the economic variables under an inter-temporal general equilibrium setting. With the aid of our analytical structure, we focus on the innovation/R&D- and human capital-driven patterns of growth from a macroeconomic perspective. To this end, and briefly within the specifics of our model, we organize this study around the most conducive questions concerning public subsidization policy for enhancing growth and social welfare: promotion of human capital formation through subsidies to education expenditures *or* promotion of industry/business R&D through (direct) subsidies to R&D investment and the role of re-allocation effects on human capital triggered by such policies.

We also explicitly model the government accounts to be able to have a well-defined platform to compare the effects of alternative scenarios on the key variables of the macro economy. Calibrated to the Canadian macro data, the model associates and extends the frameworks of R&D based endogenous growth models (Ghosh, 2007; Russo, 2004) and education based endogenous growth models (Annabi et al., 2011) in analyzing alternative policies to promote growth within the Canadian context.[1]

Remaining pages of this paper are designed in five sections. In the second section, we present R&D and human capital data, and provide a synopsis on the characteristics of the innovation-driven growth prospects for the Canadian economy. Analytical and algebraic set up of the model is presented in the third section, while policy analyses are conducted in section four. In the fifth section we summarize the main findings of the study and conclude. The data set and calibration strategy of the algebraic model are narrated in detail in a separate Appendix A.

2. Growth with respect to R&D and human capital accumulation in the Canadian economy: facts and figures

Concerns over promotion of R&D and innovation-led growth are currently at the center stage of public policy debates in Canada. Based on the comparative OECD data, reports by Science, Technology and Innovation Council[2] emphasize, for instance, that the Canadian economy has been in a "low ranking" position in terms of performance in R&D in general; but especially reveals "low ranking" status in areas such as industry/business expenditure on R&D, percentage of total R&D

[1] Applied work analyzing alternative growth promoting policies either through R&D or education based endogenous growth models within advanced country settings also include Diao et al (1999), Bye et al (2009) and Mattalia (2012).

[2] *State of the Nation* (2008, 2010, 2012).