The General Equilibrium Long Term Effects of the Canadian Education Policies

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Abstract

This paper is the result of a study done for the Human Resources and Skill Development of Canada (HRSDC), and aim at providing answers to several questions of importance for policy makers, on the relationship between the Student Loan Program in Canada and its effects on labor productivity. The paper provides a general equilibrium model of educational choices and skill development, under different conditions that mimic the current and alternative policies available in Canada. The simulations based on the calibrated model, clearly show that all the policies have a limited long-run impact on productivity and GDP, compared to their cost. The limited effect is due primarily to the fact that in the long run the general equilibrium effects on the wage premium dominate and create a disincentive to invest in higher education for marginal students. The short run effects are instead more significant. Interestingly though, the last two policies, which target high ability students, are more effective in terms of productivity, however they also increase inequality.

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1 Introduction

The objective of the work presented here is to provide a quantitative analysis of the relationship between education and productivity in Canada and the effects that different educational policies have on the overall Canadian GDP. In pursuing this objective the paper answers several questions of particular interest to policy makers that are mainly related to the existing educational programs:

- What would be the impact of providing grants instead of loans? And what would be the appropriate mix between grants and loans?
- What are the short and long run effect of a change in policy?
- Is the current Canada Student Loan Program (CSLP) a cost-effective program?

Although there exists an extensive literature that analyzes the relationship between education policies and outcomes in terms of wages, educational attainment and other relevant effects[1] little has been written about the long run effect at the aggregate level of these policies. One notable exception is the seminal paper by Heckman, Lochner and Taber (1998), which studies the effect of different tax policies on aggregate human capital, the relationship between different educational levels and aggregate human capital and how aggregate human capital affects the overall productivity. Heckman et al. (1998) use a dynamic general equilibrium approach to model the economy, making it ideal to answer macroeconomic questions related to the functioning of the labor market with particular focus on education decisions. However, Heckman et al. (1998) rely on US data for the identification of the model's parameters and reproduces the evidence related to the US economy making it only suggestive for policy makers interested ion the Canadian labor market and economy. Moreover, the paper does not explicitly consider policies designed to directly affect educational attainment such as the CSLP. In this work I follow the basic ideas laid down by Heckman et al. (1998) in order to answer the set of questions above. I build a dynamic general equilibrium model of school choice based on the double selection mechanism with respect to ability and credit availability (or constraints). The basic idea is that individuals are different with respect to the amount of assets that are available to them at the moment they invest in education, and also with respect to their ability. Both factors can affect their educational decisions. Having more assets may be important when credit constraints are present. It is widely recognized by the literature on economics of education that the educational investment is a particular one where it is not possible to collateralize the future gains. In other words, a student that would like to borrow money to finance her study period at a post secondary education cannot give her own future earnings to the lender as a collateral for the loan received. This represents a limit that can lead to a constraint in the ability of the potential student to borrow, who might need to pay an extra interest to compensate the lender for the higher risk implied by the absence of a collateral. Therefore, a student with more assets available could borrow with a lower interest and be less credit constrained than a student with less assets. Ability is also an important factor that determines the educational investment because it affects its gains. Individuals with

[1] Heckman and Krueger (2003) for a good introduction to this literature.

higher levels of ability are likely to have higher returns from the investments, although they also face higher opportunity costs given by the fact the market value of their work is higher also if they remain uneducated.

Following Heckman et al. (1998) in this study I provide an overlapping generation model in which individuals make decisions about their education at the first period taking into account their rational expectation about their earnings in the whole working life thereafter. However, departing from Heckman and other I model the heterogeneity in credit access by assuming that different individuals face different interest rates based on amount of funds they need to borrow in order to finance their education. In this sense the model I propose is also similar to Cameron and Taber (2004). The model also takes in to account the effects of a wide set of policies already implemented or available to the government that directly or indirectly can affect the educational choices and therefore the overall GDP of the Canadian economy. The model takes also into account the costs of these policies and their general equilibrium effects through the taxes needed in order for the government to provide for these policies. Finally, the parameters' values of the model are largely assigned through calibration in order for the model to give a correct representation of the quantitative predictions of alternative scenarios.

2 The Model

I start with a simple model that has the main features useful to analyze the impact of policies such as the loan program or grants on total labor productivity and inequality in the economy at large. One of the main features introduced in the model is the presence of borrowing constraints that potential students face when they choose to finance their schooling with loans. Following Cameron and Taber (2004) I model the heterogeneity in credit access implied by the constraints by a person specific markup rate of interest ρ faced by agents while in school. That is, agents pay an interest that is equal to $r + \rho$ where r is the market rate. I also assume that agents are heterogeneous in another dimension: ability.

The model economy is populated by fifteen cohorts of heterogeneous agents that differ in terms of credit access, ability and age. Agents start to make decisions at the age of 17, which is their first period in the model economy. In each period, corresponding to four years, agents decide how to allocate the one unit of time they have in leisure, job training and work. By working agents can generate earnings that are proportional to the wage rate paid to the corresponding skill chosen in the first period, and the human capital acquired by the individual. Human capital is perfectly substitutable within the skill, but imperfectly between skills, and is acquired by training. Human capital also depends on initial ability of the individual. Each period a new cohort of seventeen year old agents enters in the economy and an old cohort of 77^{th} years old dies. Population growth is assumed exogenous.

Credit access and ability, denoted by ρ and e respectively, are assigned randomly to individuals following some joint distribution. Although it is useful to keep the analysis in terms of credit access, as it will be more clear in the following, credit access will be modeled as a function of the wealth the individual holds at her initial stage of life which can be used for financing education. For example a Registered Education Savings Plan (RESP), or simply what can be imputed on parent's wealth as the portion should be used to support children. In this sense individuals will be endowed with an initial amount of wealth a, and their access to credit will be a function of this wealth.

2.1 The Individual Problem

Individuals maximize their lifetime utility given their time preference (i.e. - they might prefer consumption earlier rather than later). Utility is derived from consumption. It is also assumed that the intertemporal trade off between bundles of consumption and leisure in different periods, represented by the intertemporal elasticity of substitution, is constant and equal to 1.

In order to maximize their lifetime utility individual will need to make choices that will affect their earnings as well. The level of skills will be chosen in the first period of life while levels of borrowing or savings will be chosen in each period of life.
Let $s \in \{0, 1\}$ represent the skill value, the problem of the individual is to solve the following

$$V(\rho, e) = \max_{s,d} \left\{ \sum_{g=1}^{15} \beta^g \log(c_{g,t+g-1}) \right\} \tag{1}$$

s.t.

$$c_{1,t} = s\ell(a) + d_{1,t} + (1-s)w_{0,t}h_{0,1,t} + s(a - F + B(e) \tag{2}$$
$$c_{2,t+1} + (R_{t+1} + \rho)d_{1,t} = w_{s,t+1}h_{s,2,t+1} + d_{2,t+1} - s\gamma(e)\ell(a) \tag{3}$$
$$c_{g,t+g-1} + R_{t+g-1}d_{g-1,t+g-2} = w_{s,t+g-1}h_{s,g,t+g-1} + d_{g,t+g-1} \quad if \;\; g > 2 \tag{4}$$
$$d_{15,t+14} = 0 \tag{5}$$

where the subscript g indicates the period of life of an individual, t the timing of the economy, and s the skill level of an individual. The functions ℓ and γ are the policy instruments. depending on the choice of the functional forms and the parameters they can represent a pure loan policy, a pure grant policy or a mix of the two. For example, if ℓ is constant with respect to ability and $\gamma(e) = 1$ then we only have a pure loan policy. The government provides an amount of loan ℓ in the first period while the student is in school that must be repaid starting from the second period. The loan is interest free for as long as the student is in school while starts to cost an interest from the second period. This can be seen by the fact that the agent that has to repay ℓ starting the second period must borrow from future earnings (d) at market rate. Since the loan is interest free and since starting from the second period the interest rate on the loan is at the market level, the loan policy has the wanted effect to relax the borrowing constraint represented by ρ for the amount ℓ given. Moreover, the amount of the government loan might also depends on the initial wealth. In particular, I assume that the government fixes a cap ℓ_{max}, and reduces the loan available by an amount equal to the available wealth to the student, that is, $\ell(a) = \ell_{max} - a$.

A grant policy can be integrated in the model by choosing the amount $B(e)$ increasingly high in the ability level e. In this sense more able individuals will receive higher support from the government. A mixture of policies is also possible. For example we can set γ increasing with ability so that part of the loan is forgiven for poorer students, in which case the loan

policy includes a need-based grants policy and at the same time give also an ability-base grant B.
Skill specific human capital is accumulated by learning by doing following the rule

$$h_{s,g+1,t+1} = \Gamma_s(e) h^{\gamma}_{s,g,t} \tag{6}$$
$$\tag{7}$$

where $\Gamma_s(e)$ is a multiplying factor that depends on initial ability and skill.

Agents start their first period of life as unskilled with a level of human capital $\Gamma_0(e)$ proportional to their ability. If in their first period they choose to become workers then they can work and earn a wage proportional to their human capital. If, instead, they choose to invest in skill acquisition, and therefore they go to college, they do not work, but they become skilled workers in the next period. Skilled workers start their working life at the start of the second period of their life with a level of human capital given by $\Gamma_1(e)$.

2.2 The Aggregate Economy

The production function in this economy represents the technology available to transform resources, aggregate human and physical capital, into aggregate income. This is specified as follows

$$Y_t = A_t H^{\alpha}_t K^{1-\alpha}_t \tag{8}$$

where H_t is the aggregate human capital measured in efficiency units. H_t is itself a composite of the two aggregates human capital per skill $H_{0,t}$ for the unskilled and $H_{1,t}$ for the skilled. The aggregation follows a constant elasticity of substitution functional form given by

$$H_t = [\zeta_1 H^{\eta}_{0,t} + \zeta_2 H^{\eta}_{1,t}]^{\frac{1}{\eta}}. \tag{9}$$

Given the policy function for education $s(\rho, e)$ which is equal to 1 for college and 0 otherwise, the aggregate human capital values per cohort are given by

$$H_{0,g,t} = \int\int (1 - s(a, e)) h_{0,g,t}(\rho, e) f_a(\rho, e) d\rho de \tag{10}$$
$$H_{1,g,t} = \int\int s(a, e)(\rho, e) h_{1,g,t}(\rho, e) f_a(a, e) d\rho de \tag{11}$$

That is, in $H_{0,g,t}$ the integral is over all the workers that chose to remain unskilled, for whom $1 - s(\rho, e) = 1$. For those workers their labor supply is multiplied by the chosen level of unskilled human capital they possess, and they are finally weighted according to the distribution function of (ρ, e) that characterize the worker entirely within her generation.
The economy wide aggregates are

$$H_{0,t} = \sum_{g=2}^{15} H_{0,g,t} \tag{12}$$

$$H_{1,t} = \sum_{g=2}^{15} H_{1,g,t} \tag{13}$$

We finally assume that our economy is a small open economy in which capital is free to flow in and out of the country. In this case the interest rate is determined by the world market for capital and is imported in our economy. In our model is therefore exogenously determined.

$$R_t = \bar{R} \tag{14}$$

2.3 The Government

Finally the government in this economy sets the education policies and collect taxes to finance these policies. I will initially assume that taxes are collected only on labor income and are proportional to earnings. On the expenditure side, the government has several expenses. First, it finances universities directly so that the tuition fees entering in the total cost T is lower for the students than what the actual cost is. Second, it pays the interest on the amount of loan given to students for the first period. Third, it pays for grants, and finally bear the costs associated to defaults in paying back the loan plus other administrative expenses. Therefore, given the proportional tax rate τ on labor income, the budget constraint for the government is,

$$\begin{aligned} \tau\alpha Y_t = \; & \frac{R-1}{R}\int\int \ell(e,a)f(e,a)dade + \int\int(1-\gamma(e))\ell(e,a)f(e,a)dade + \\ & \lambda\int\int\gamma(e)\ell(e,a)f(e,a)dade + T_u \end{aligned} \tag{15}$$

where λ is the default rate, and T_u direct transfers to universities. Simplifying,

$$\tau(1-\alpha)Y = \int\left(\frac{R-1}{R} + 1 + (\lambda-1)\gamma(e)\right)L(e)f_e(e)de + T_u \tag{16}$$

where $L(e) = \int \ell(e,a)f_a(a)da$, is the total amount of loans and grants issued.

2.4 Solving the Problem

First we specify the functional form that describes the relationship between access to credit and personal wealth. We assume that at zero level of personal wealth the person has her maximum difficulty evidenced by the highest possible ρ, this difficulty decreases proportionally with wealth to a point at which the person can actually borrow at market rates for her educational expenses. We assume that this happens when the wealth is equal to the total cost of education T. Therefore we have

$$\rho = \begin{cases} \frac{\rho_{max}}{TF}(TF-a) & \text{if} \quad TF \geq a \\ 0 & \text{if} \quad T < a \end{cases}$$

where TF represents the minimum necessary expenditure a student incurs when decides to enrol in a PSE program. This includes fees, books and so on, but also basic consumption such as food, rent etc...

Given the initial state of an agent and the set of present and future prices from period 1 to 16, the agent solves the problem in equation 1 by finding policy functions for $s(a, e)$ and $d(a, e)$ in terms of the state variables. Given these policy functions we can calculate all the other individual variables. The policy functions can be characterized analytically by solving first the first order conditions then by backward induction using the last period borrowing condition.

After some math eventually we have that, if $\ell_{max} \geq a$, then $s(a, e) = 1$ if,

$$(1-\tau)(W_1-W_0) \geq (R+\rho_{max})F+R(1-\tau)w_{0,1}h_{0,1}-(R+\rho_{max}-\gamma(e))\ell_{max}(e)-\left[\frac{\rho_{max}}{TF}(F-\ell_{max})+\gamma(e)\right]a \tag{17}$$

and similarly, if $\ell_{max}(e) < a \leq TF$,

$$s(a,e)=\begin{cases} 1 & \text{if} \quad W_1 - W_0 \geq \frac{1}{(1-\tau)}\left\{(R+\frac{\rho_{max}}{TF}(TF-a))(F-a)+Rw_{0,1}h_{0,1}\right\} \\ 0 & \text{otherwise} \end{cases}$$

and finally if $a > TF$,

$$s(a,e)=\begin{cases} 1 & \text{if} \quad W_1 - W_0 \geq \frac{1}{(1-\tau)}\left\{R(F-a+w_{0,1}h_{0,1})\right\} \\ 0 & \text{otherwise} \end{cases}$$

Clearly indicating that there is a positive effect of taxes on the cost of attending college.

2.5 Partial Equilibrium Analysis

Keeping wages constant and taxes equal to zero for different scenarios, Figure 1 shows the problem of an agent that has to choose between going to college or not going when $\ell(e) = 0$, that is in absence of government loans. On the $x-axis$ is measured the ability of the individual and on the $y - axis$ are measured the lifetime benefit of going to school $W_1 - W_0$ and the cost faced by the individual. As we can see, the cost is both a function of ability and of ρ the idiosyncratic rate of interest paid by the agent. Benefits instead only depend on the ability since, except for the school years, all agents can borrow or lend at market rate.
The figure clearly shows that higher constrained individuals need a higher ability to choose college over high school attendance. Figure 2 shows what happens when a loan policy is introduced. The total cost of education in this example is set at $T = 20$, in Figure 2 there are four different costs, two are like before for two different agents with different interest rates $\rho = .03$ and $\rho = .13$ in case there is no loan policy $\ell(e) = 0$. Other two for the cases in which these constraint agents have access to loans for a total of $\gamma(e) = 10$. The figure shows that for both agents the level of ability at which attending college is convenient declines, however it declines more for the more constrained individual. In fact the levels are from 2.44 to 2.39 for the less constrained and from 2.51 to 2.43.

Figure 3 Reproduces the schooling decision as a function of idiosyncratic rate of interest ρ and ability e. The black area shows when a individual chooses to attend college.

Figure 1: Cost-Benefit Analysis of the School Choice, $\ell(e) = 0$

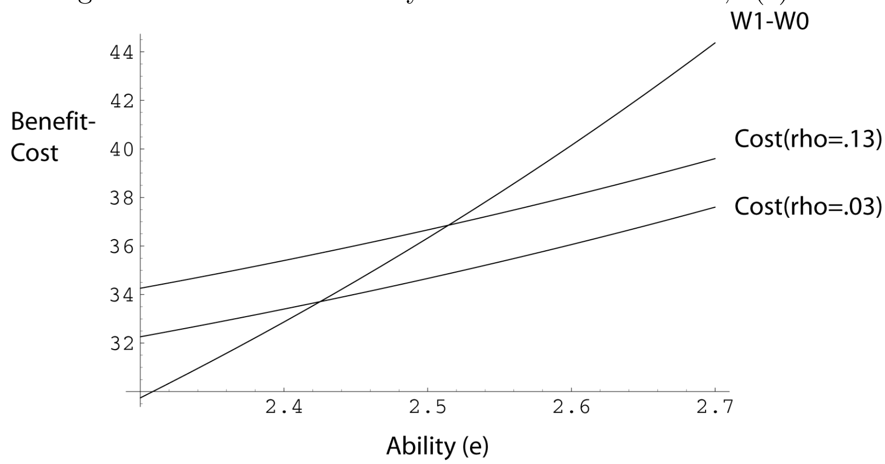
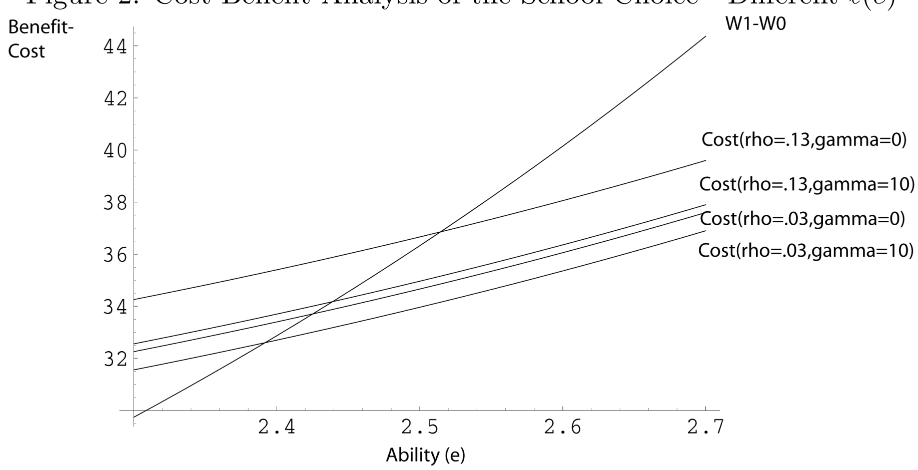


Figure 2: Cost-Benefit Analysis of the School Choice - Different $\ell(e)$



To calculate the share of agents college educated is therefore sufficient to calculate the density of the black area given the distribution of interest rates and ability. That is,

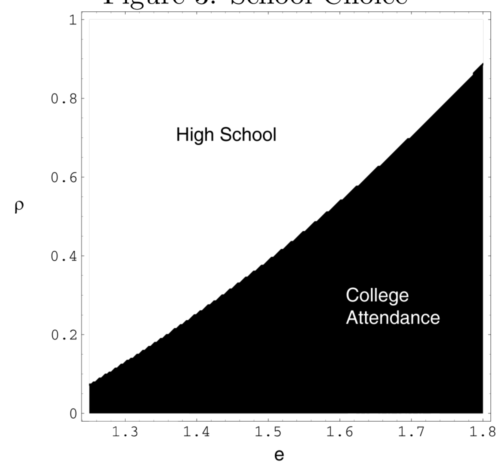
$$C = \int\int s(\rho, e) f(\rho, e) d\rho de \tag{18}$$

where C is the fraction of the population with college education. To solve the double integral we find, conditional on ability, the value of ρ that makes the individual indifferent between attending college or remaining with high school, that is,

$$\rho(e) \quad s.t. \quad W_1 - W_0 = (R + \rho)T + Rw_{0,1} - (R + \rho - \gamma(e))\ell(e) \tag{19}$$

then first conditional on ability we find the share of population with an interest rate equal to or lower than $\rho(e)$,

Figure 3: School Choice



$$C_\rho(e) = \int_0^{\rho(e)} f_\rho(i)di = F_\rho(\rho(e)) \tag{20}$$

where f_ρ is the marginal *pdf* of the idiosyncratic rate of interest distribution and F_ρ its CDF. Finally we integrate out the result with respect to ability,

$$C = \int_{lb}^{+\infty} F_\rho(\rho(e)) f_e(e)de \tag{21}$$

where f_e is the marginal *pdf* of the ability distribution, and lb is a lower bound obtained by solving $\rho(e) = 0$.

3 Calibration

The model is calibrated taking as reference year the last year for which we have available data, which is 2002. Since the period length in our model is four years, all the figures relative to 2002 are taken as percentage of GDP. Since it is assume that the model is in a steady state in 2002 it is also assumed that those percentages do not change over time, therefore these ratios are applied to the four year period as well. The model begins with generation 1 which is 17 years old and ends with generation 12, which is 65 years old and retiring. It is important to notice that all individuals except for those attending school in their first period of their life are workers, i.e. the entire population is in working age, and there is no unemployment. Population is normalized to one unit for each generation, so that the total population is of 12 units. GDP per capita is therefore total GDP divided by 12. First, to calibrate the model I set GDP per capita equal to 10, this implies that the TFP parameter A, is scaled such that the total GDP is equal to 120. I also assume that the Canadian economy is a SOE economy with perfect capital mobility with the rest of the world and therefore that the interest rate plus the depreciation rate are fixed by the global markets and do not change in time and as reaction of different policies in Canada. Therefore, I set,

$$Y = AH^{\alpha}K^{1-\alpha} = 120 \tag{22}$$

Now, in perfect competitive markets it must be,

$$r + \delta = \frac{\partial Y}{\partial K} = A(1-\alpha)H^{\alpha}K^{-\alpha} = A(1-\alpha)k^{-\alpha}, \tag{23}$$

where $k = \frac{K}{H}$ is the total capital per unit of human capital in the economy. Therefore,

$$k = \left(\frac{A(1-\alpha)}{r+\delta}\right)^{\frac{1}{\alpha}}. \tag{24}$$

Moreover,

$$\frac{Y}{H} = AH^{\alpha-1}K^{1-\alpha} = Ak^{1-\alpha} = \left(\frac{A(1-\alpha)}{r+\delta}\right)^{\frac{1-\alpha}{\alpha}}. \tag{25}$$

Therefore,

$$Y = \left(\frac{A(1-\alpha)}{r+\delta}\right)^{\frac{1-\alpha}{\alpha}} H = 120. \tag{26}$$

In 2002 the total GDP in Canada was 1,152,905 million Canadian dollars. The working population in 2002 was composed of 15,310,400 individuals, so that each worker produced on average 75,302.08 Canadian dollars. Also in 2002 about 51% of the young population of Canadian attended some PSE education.[2] The model assumes that there are 12 generations of equal size normalized to 1. Individuals of the first generation either work or study, while individuals of generations from 2 to 12 all work. Matching the share of share of PSE attendance to the actual figure in 2002, we have that the total working population predicted by the model is

$$.49 + \sum_{g=2}^{12} = 11.49. \tag{27}$$

Since I have set the total GDP in the model equal to 120, the model GDP per worker must be equal to 120/11.49=10.4439. Dividing the actual GDP per worker by the GDP per worker predicted by the model we obtain the dollar value of the model unit, which is 7,210.17 dollars. Also, each population unit in the model can be converted to the actual Canadian working population by multiplying by 1.3325 millions.

The calibration also assumes that the Canadian economy in 2002 was in a steady state. Therefore, I choose the values of the model's parameters so that the predictions from the steady state computation of the model relative to some relevant moments match the moments

[2] OECD statistics, percentage of population aged between 25 to 34, attended Type-A and B tertiary education.

observed from the data. First of all, from OECD data we know that in Canada the total expenditure for PSE is about 1.51% of total GDP. That is,

$$\frac{T_u C}{Y} = 0.0151. \tag{28}$$

Therefore, considering that $C = .51$ and $Y = 120$

$$T_u = \frac{0.0151 \cdot 120}{.51} = 3.5533. \tag{29}$$

Moreover, the total amount of fees paid by students in 2002 was about 0.39%. Again, this implies that each model student pays,

$$Fees = \frac{0.0039 \cdot 120}{.51} = 0.9157. \tag{30}$$

adding other direct costs to education such as books, computers for the amount of about 1,600 dollars per year, we have the direct costs incurred by each student equal to,

$$F = 0.9157 + .223 = 1.1401. \tag{31}$$

The parameter TF represents the minimum amount of income a student needs during a study year to sustain the direct costs of education and her basic level of consumption. This is calculated to be around 17,229 dollars. In model units this becomes therefore 2.3896.

I also assume that the interest rate is 4% per year, and since one model period correspond to 4 years, I set $R = 1.17$. The depreciation rate of physical capital is set equal to 5.1% per year, which in four years becomes 22.01%. All other parameters are computed to match relevant moments or normalized to appropriate levels to guarantee feasibility to the problem solution. The following Table 1 resumes all the parameters and their values.

4 Policy Scenarios and Evaluation

Once the values are assigned to the parameters is possible to calculate the benchmark values of the variables of interest. By changing the values of the policy parameters is finally possible to evaluate alternative policies looking at the alternative scenarios. In what follows I present five scenarios that correspond to five alternative policy implementations. The first two policy alternatives are the increment of the maximum allowed loan and a reduction of the education fees. The aim of both policies is to increase the level of education in the population, and therefore to increase the overall productivity as measure by total GDP. A rough measure of inequality, given by the ratio between the skilled and unskilled wage level can also be calculated in order to take into account the possible trade off between inequality and productivity. Other two scenarios refer to the "γ" policies. That is, the coefficient related to the amount of the loan that needs to be repaid is changed to reflect a set of grant related policies correlated or

Table 1: A: Parameters of the Model - Behavior/Technology

Description	Parameter	Value
Intertemporal Utility Discount Factor	β	0.8515
Elasticity of Human capital technology	η	0.7000
Production Share of Physical Capital	$1-\alpha$	0.3000
Depreciation Rate of Physical Capital	δ_k	0.2201
World Interest Rate	R	1.0400
Mean of Ability Distribution	μ_e	-1.4500
Standard Deviation of Ability Distribution	σ_e	0.0600
Mean of Asset Distribution	μ_a	-0.5000
Standard Deviation of Asset Distribution	σ_a	0.3500
Upper bound of idiosyncratic interest rate premium	ρ_{max}	0.2000

B: Parameters - Calibrated

Description	Parameter	Value
Total Factor Productivity	A	496.9230
Returns to Experience	γ_1	0.0467
Returns to Experience Squared	γ_2	-0.0009
Relative Weight of Unskilled Human Capital	ζ_0	0.4680
Relative Weight of Skilled Human Capital	ζ_1	0.5320
Average Direct cost of Education	F	1.1401
Total Cost of PSE per Student	T_u	3.5533
Total Minimum Expenditure Incurred by Students for PSE	TF	2.3896
Maximum Available Loan	ℓ_{max}	1.9417

C: Policy Parameters - Benchmark Model

Description	Parameter	Value
Loan Repayment Discount Factor	$load$	0.0000
Ability Based Grants	B	0.0000

not with ability. The first of these two cases assumes that part of the loan that a student receives needs not to be repaid if the students performs well in school. In this sense the policy mimics a merit based grant policy which also takes into account financial needs since it is proportionally higher for poorer students. The second assumes that the "discount" is given to al students regardless their ability. In this case the grant is only need-based. Finally, I also take into account a third scenario in which the discount is decreasing with ability. This last case mimics the opportunities that low income families have to reduce the repayment of their loan once graduated. Finally, I take into account a policy that gives directly to higher than average ability students a grant regardless of their financial need.

Table 2 shows the steady state equilibrium in the benchmark and in the first scenario where the maximum possible loan is raised from about $14,000 to $15,896. The effect of such a change is not very large in steady state. The share of PSE graduates raises only 0.26 percentage points and the GDP overall increases only $317,230, by about 0.025%. The cost of this policy

Table 2: Alternative Policies: Steady States - Loans

		Benchmark	Scenario 1
Policy Parameters			
Average Direct cost of Education	F	6157.29	6157.29
Maximum Available Loan	ℓ_{max}	13997.15	15895.51
Total Educational Cost	T_u	17613.07	17613.07
Loan Repayment Discount Factor	$load$	0.00	0.00
Ability Based Grants	B	0.00	0.00
Results			
Share of PSE Graduates		50.90	51.16
Yearly Wage Rate	HS Grad.	31029.90	31061.75
Yearly Wage Rate	PS Grad.	34876.05	34845.47
Inequality Measure		112.39	112.18
Yearly Earnings	HS Grad.	53057.81	53057.81
Yearly Earnings	PS Grad.	59381.05	59381.05
Total GDP		1286463.71	1286693.59
Tax Rate (%)		0.87	0.91
Total Expenditure for PSE		7814.16	8232.85
Total Expenditure for Loans		1982.82	2371.95

is significant compared to the initial budget. The total cost of education raised by $418.69 per person, or by about 5.36% due primarily to the increase in loans which amounts to $389.13. The loan budget increases by 19.63%. Overall, the analysis suggests that a relatively large modification in the loan policy has a very limited effect on the aggregate variables.

A look at the dynamics in Table 3 gives some more information about the reasons of the relatively low impact. The very first period of the change the share of PSE graduates raises to 53.67%, at the same time the wage gap between skilled and unskilled workers is at its maximum after the policy implementation. Once the new graduates enter in the labor market the skilled human capital becomes relatively more abundant and the wage gap decreases. This implies that later cohorts of students find relatively less attractive to enroll in PSE and the share of PSE graduates declines until the new steady stat is reached. Given that each model period is worth 4 years, the steady state is reached in about 12 years. The low effect of loans on the aggregate variables is also due to the government balance budget. An increase of government spending on PSE implies an increase in taxes which lowers the gain from the PSE investment.

Tables 4 and **??** repeat the previous analysis assuming a change the fee policy rather than the loan policy. Here the fees are reduced from the initial $6,157.29 to $5,248.93 by about 14.75%. Again, as before a relatively large change in the education policy does not imply a large change in our aggregate variables. The overall cost of education in this case is a little higher than in the previous one, and so is the change in the share of PSE graduates. GDP also

Table 3: Alternative Policies: Dynamics - Loans

Steady State 1							
Average Direct cost of Education						F	6157.29
Maximum Available Loan						ℓ_{max}	13997.15
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Steady State 2							
Average Direct cost of Education						F	6157.29
Maximum Available Loan						ℓ_{max}	15895.51
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Transition Path							
	Yearly Wages		GDP	Coll. Share	Tax Rate	Tot. Exp.	Tot. Loans
	HS	PSE					
t16	31029.90	34876.05	1286463.71	0.5090	0.8677	7814.16	1982.82
t17	31042.73	34863.71	1284947.16	0.5367	0.9614	8647.84	2499.09
t18	31058.89	34848.21	1286452.03	0.5147	0.9198	8283.33	2387.39
t19	31061.75	34845.47	1286693.59	0.5116	0.9141	8232.85	2371.95

changes a little more, by \$447,980, or 0.035%.

The look at the dynamic tells the same story as before. In the first period the changes are significantly larger, but thereafter because of the adjustment in the relative prices of skills, the aggregate variables return to values that are closer to the starting ones.

Tables 6 to 9 report the two scenarios in which the repayment of the loan is discounted. In Tables 6 and 7 the discount is proportional to the ability, so that it is a form of ability and need based grants. Tables 8 to 9 report the case in which the discount is given uniformly to all the students. Since students with higher financial needs can borrow more from the government, they are also more benefited by this policy. In both cases we can see that the policy has very little impact on aggregate figures, although is also little expensive. One interesting feature of the first of these policies is that in the long run tends to decrease the share of PSE graduates in spite to the fact the productivity remains higher. This is due to the fact that incentivates more higher ability students to attend PSE. In other words, this policy amplifies the self selection of higher ability students into education and increases the human capital of skilled workers while their number decreases.

The uniform policy does not have this feature, and in fact the share of PSE graduates increases. In all other dimensions this policy is similar to the previous ones.

Tables 10 and 11 reproduce a pure ability-based grants policy. This policy once again shows that to large changes in policy the aggregate effect resulting are limited. By giving a grant of \$3,645 to all above average students the government would increase the PSE expenditure

Table 4: Alternative Policies: Steady States - Fees

		Benchmark	Scenario 1
Policy Parameters			
Average Direct cost of Education	F	6089.71	5191.32
Maximum Available Loan	ℓ_{max}	13999.99	13999.99
Total Educational Cost	T_u	25619.90	25619.90
Loan Repayment Discount Factor	$load$	0.00	0.00
Ability Based Grants	B	0.00	0.00
Results			
Share of PSE Graduates		18.43	51.51
Yearly Wage Rate	HS Grad.	36993.36	37334.70
Yearly Wage Rate	PS Grad.	47065.34	46698.61
Inequality Measure		127.23	125.08
Yearly Earnings	HS Grad.	46963.18	47399.90
Yearly Earnings	PS Grad.	53863.65	53440.96
Total GDP		883134.10	865859.67
Tax Rate (%)		0.70	1.99
Total Expenditure for PSE		4309.39	12083.01
Total Expenditure for Loans		950.38	2696.76

by about \$1,181.26 per person, or by about 15.12%. In the long run this would lead to a gain of only \$123,710 in total GDP, or by 0.0096%. Interestingly, here too the self selection is amplified, and the GDP gain is present even though the share of PSE graduates shrank by a significant 1.74%. In this case, the limited effects on aggregate variables are mainly due to the government budget constraint. In fact, even in the short run the effects are limited.

5 Conclusions

In this paper I propose a general equilibrium model to evaluate alternative policies of financial aid for post-secondary education. I propose a merit based grant policy which takes into account financial needs, that is proportionally higher for students in need. The second policy I propose assumes that a "discount" in repaying a loan is given to all students regardless of their ability. That is as giving a grant need-based only. In a third scenario the discount is decreasing with ability, in this case I mimic the opportunity that low income families have to reduce the repayment of their loan once graduated. Finally, I take into account a policy that gives directly to higher than average ability students a grant regardless of their financial need. The simulations based on the calibrated model, clearly show that all the policy have a limited long-run impact on productivity and GDP, compared to their cost. The limited effect is due primarily to the fact that in the long run the general equilibrium effects on the wage premium

Table 5: Alternative Policies: Dynamics - Fees

Steady State 1							
Average Direct cost of Education						F	6089.71
Maximum Available Loan						ℓ_{max}	13999.99
Total Educational Cost						T_u	25619.90
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Steady State 2							
Average Direct cost of Education						F	5191.32
Maximum Available Loan						ℓ_{max}	13999.99
Total Educational Cost						T_u	25619.90
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Transition Path							
	Yearly Wages		GDP	Coll. Share	Tax Rate	Tot. Exp.	Tot. Loans
	HS	PSE					
t12	37233.02	46805.70	865421.65	0.5108	1.9086	11562.38	2674.15
t13	37147.89	46896.73	871045.24	0.4064	1.5623	9525.62	2120.11
t14	37463.47	46565.53	837873.82	1.0000	4.0092	23514.73	5293.19
t15	37570.53	46456.99	890319.16	0.1264	0.4736	2951.48	648.02
t16	36993.36	47065.34	883134.10	0.1843	0.6971	4309.39	950.38
t17	37334.70	46698.61	865859.67	0.5151	1.9936	12083.01	2696.76

dominate and create a disincentive to invest in higher education for marginal students. The short run effects are instead more significant. Interestingly though, the last two policies, which target high ability students, are more effective in terms of productivity, however they also increase inequality. The model presented here, however, may be incomplete for a good general equilibrium evaluation as it does not include several variables that may affect the overall results. For example, migration is not taken into account while it is for Canada an important source of labor and skills.[3] Another variable that is not considering is TFP growth, and in particular if the growth is skilled biased. Moreover, Caponi and Plesca (2009) also show that a large part of post secondary education in Canada is absorbed by vocational education and they also show that this education has significantly lower returns than university, this could even lower the effect of financial aid if a significant portion would finally help students on this type of education.

[3] CAPONI (2010) shows that migration can significantly change the distribution of skills when selection is considered.

Table 6: Alternative Policies: Steady States - Loan Discount by Ability: Increasing

		Benchmark	Scenario 1
Policy Parameters			
Average Direct cost of Education	F	6157.29	5248.93
Maximum Available Loan	ℓ_{max}	13997.15	13997.15
Total Educational Cost	T_u	17613.07	17613.07
Loan Repayment Discount Factor	*load*	0.00	0.10
Ability Based Grants	B	0.00	0.00
Results			
Share of PSE Graduates		50.90	50.83
Yearly Wage Rate	HS Grad.	31029.90	31044.12
Yearly Wage Rate	PS Grad.	34876.05	34862.37
Inequality Measure		112.39	112.30
Yearly Earnings	HS Grad.	52767.52	52767.52
Yearly Earnings	PS Grad.	59691.85	59691.85
Total GDP		1286463.71	1286566.94
Tax Rate (%)		0.87	0.88
Total Expenditure for PSE		7814.16	7897.85
Total Expenditure for Loans		1982.82	2074.63

References

Acemoglu, Daron, “Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality,” *Quarterly Journal of Economics*, November 1998 1998, *113* (4), 1055–1089.

——, “Changes in Unemployment and Wage Inequality: An Alternative Theory and Some Evidence,” *American Economic Review*, December 1999 1999, *89* (5), 1259–1278.

Becker, Gary S., “Investment in Human Capital: A Theoretical Analysis,” *The Journal of Political Economy*, Oct. 1962, *70* (5, Part 2: Investment in Human Beings), 9–49.

Ben-Porath, Yoram, “The Production of Human Capital and the Life Cycle of Earnings,” *The Journal of Political Economy*, Aug. 1967, *75* (4, Part 1), 352–365.

Cameron, StephenV. and Christopher Taber, “Estimation of Educational Borrowing Constraints Using Returns to Schooling,” *Journal of Political Economy*, 2004, *112* (1), 132–182.

CAPONI, Vincenzo, “Heterogeneous Human Capital and Migration: Who Migrates from Mexico to the us?,” *Annales d’Economie et de Statistique*, 2010, (97-98), 207–234.

Table 7: Alternative Policies: Dynamics - Loan Discount by Ability: Increasing

Steady State 1							
Average Direct cost of Education						F	6157.29
Maximum Available Loan						ℓ_{max}	13997.15
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Steady State 2							
Average Direct cost of Education						F	5248.93
Maximum Available Loan						ℓ_{max}	13997.15
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.10
Ability Based Grants						B	0.00
Transition Path							
	Yearly Wages HS	Yearly Wages PSE	GDP	Coll. Share	Tax Rate	Tot. Exp.	Tot. Loans
t16	31029.90	34876.05	1286463.71	0.5090	0.8677	7814.16	1982.82
t17	31035.55	34870.60	1285794.66	0.5194	0.8971	8074.45	2124.59
t18	31042.73	34863.70	1286452.87	0.5098	0.8796	7920.92	2081.15
t19	31044.12	34862.37	1286566.94	0.5083	0.8770	7897.85	2074.63

Caponi, Vincenzo and Miana Plesca, "Post-secondary education in Canada: can ability bias explain the earnings gap between college and university graduates?," *Canadian Journal of Economics*, August 2009, *42* (3), 1100–1131.

Card, David, *Earnings, Schooling, and Ability Revisited* Research in labor economics. Volume 14, Greenwich, Conn. and London: JAI Press,

Fougère, Maxime, Simon Harvey, Jean Mercenier, and Marcel Mérette, "Population Ageing, Time Allocation and Human Capital: a General Equilibrium Analysis for Canada," 2005. Mimeo.

Heckman, James and Pedro Carneiro, "Human Capital Policy," 2003. SO: National Bureau of Economic Research, Inc, NBER Working Papers: 9495, 2003.

Heckman, James J. and Alan B. Krueger, *Inequality in America: What role for human capital policies?*, Cambridge and London: MIT Press, 2003.

—, **Lance Lochner, and Christopher Taber**, "Tax Policy and Human-Capital Formation," *American Economic Review*, May 1998 1998, *88* (2), 293–297.

Lucas, Robert E. Jr., "On the Mechanics of Economic Development," *Journal of Monetary Economics*, July 1988 1988, *22* (1), 3–42.

Table 8: Alternative Policies: Steady States - Loan Discount: Universal

		Benchmark	Scenario 1
Policy Parameters			
Average Direct cost of Education	F	6157.29	5248.93
Maximum Available Loan	ℓ_{max}	13997.15	13997.15
Total Educational Cost	T_u	17613.07	17613.07
Loan Repayment Discount Factor	$load$	0.00	0.10
Ability Based Grants	B	0.00	0.00
Results			
Share of PSE Graduates		50.90	51.38
Yearly Wage Rate	HS Grad.	31029.90	31087.63
Yearly Wage Rate	PS Grad.	34876.05	34820.76
Inequality Measure		112.39	112.01
Yearly Earnings	HS Grad.	53199.24	53199.24
Yearly Earnings	PS Grad.	59236.06	59236.06
Total GDP		1286463.71	1286876.98
Tax Rate (%)		0.87	0.92
Total Expenditure for PSE		7814.16	8274.43
Total Expenditure for Loans		1982.82	2388.62

Table 9: Alternative Policies: Dynamics - Loan Discount: Universal

			Steady State 1				
	Average Direct cost of Education					F	6157.29
	Maximum Available Loan					ℓ_{max}	13997.15
	Total Educational Cost					T_u	17613.07
	Loan Repayment Discount Factor					$load$	0.00
	Ability Based Grants					B	0.00
			Steady State 2				
	Average Direct cost of Education					F	5248.93
	Maximum Available Loan					ℓ_{max}	13997.15
	Total Educational Cost					T_u	17613.07
	Loan Repayment Discount Factor					$load$	0.10
	Ability Based Grants					B	0.00
			Transition Path				
	Yearly Wages		GDP	Coll. Share	Tax Rate	Tot. Exp.	Tot. Loans
	HS	PSE					
t16	31029.90	34876.05	1286463.71	0.5090	0.8677	7814.16	1982.82
t17	31054.53	34852.39	1283556.82	0.5621	1.0104	9078.18	2638.46
t18	31084.52	34823.73	1286559.40	0.5177	0.9260	8339.27	2408.70
t19	31087.63	34820.76	1286876.98	0.5138	0.9185	8274.43	2388.62

Table 10: Alternative Policies: Steady States - Ability-Based Grants

		Benchmark	Scenario 1
Policy Parameters			
Average Direct cost of Education	F	6157.29	5248.93
Maximum Available Loan	ℓ_{max}	13997.15	13997.15
Total Educational Cost	T_u	17613.07	17613.07
Loan Repayment Discount Factor	$load$	0.00	0.00
Ability Based Grants	B	0.00	3645.09
Results			
Share of PSE Graduates		50.90	49.16
Yearly Wage Rate	HS Grad.	31029.90	31046.96
Yearly Wage Rate	PS Grad.	34876.05	34784.41
Inequality Measure		112.39	112.04
Yearly Earnings	HS Grad.	51019.17	51019.17
Yearly Earnings	PS Grad.	61604.66	61604.66
Total GDP		1286463.71	1286587.42
Tax Rate (%)		0.87	1.00
Total Expenditure for PSE		7814.16	8995.42
Total Expenditure for Loans		1982.82	1993.82

Table 11: Alternative Policies: Dynamics - Ability-Based Grants

Steady State 1							
Average Direct cost of Education						F	6157.29
Maximum Available Loan						ℓ_{max}	13997.15
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	0.00
Steady State 2							
Average Direct cost of Education						F	5248.93
Maximum Available Loan						ℓ_{max}	13997.15
Total Educational Cost						T_u	17613.07
Loan Repayment Discount Factor						$load$	0.00
Ability Based Grants						B	3645.09
Transition Path							
	Yearly Wages		GDP	Coll. Share	Tax Rate	Tot. Exp.	Tot. Loans
	HS	PSE					
t16	31029.90	34876.05	1286463.71	0.5090	0.8677	7814.16	1982.82
t17	31037.45	34868.78	1285570.12	0.5071	1.0261	9233.90	2054.35
t18	31046.14	34860.43	1286555.14	0.4917	0.9991	8998.01	1994.48
t19	31046.96	34784.41	1286587.42	0.4916	0.9988	8995.42	1993.82