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Abstract

This paper uses a quantitative general equilibrium model to analyze the impacts of selective immigration policy targeting skilled immigrants on the college attainment rate, earnings inequality and welfare of natives. 1981-2008 period is analyzed in Canada, which is a country with a unique immigration policy explicitly targeting highly educated individuals. The results from the quantitative analysis reveal that the increase in the share of highly skilled immigrants generates a 7 percentage points lower college attainment rate among natives. The size and compositional changes in the immigrant population together lead to a 2.15 percentage points higher growth rate of college premium during this period. This increase is mainly driven by the rise in the relative size of the foreign-born labor force. An analysis of the long-run compensating differentials reveals that immigration generates a loss that corresponds to 3.59 to 4.45 percent permanent reduction in the consumption of natives. The increase in the relative share of immigrants is the main reason for this welfare loss. On the other hand, the compositional change towards college graduates benefits natives at the bottom and middle of the ability distribution.

Keywords: International Migration, Aggregate Factor Income Distribution, Human Capital, Wage Differentials by Skill.
JEL code: F22, E25, J24, J31

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1 INTRODUCTION

Immigration is a highly debated issue among policy makers, researchers, and the public. The immigrants' impact on the native population of a country has been evaluated from many aspects including wage and overall welfare changes as well as the burden or relief they create for the fiscal system.[1] The objective of this paper is to quantify the effects of selective immigration policy targeting skilled immigrants on natives' college education choices, earnings and welfare in a general equilibrium framework.

To accomplish this goal, I focus on the case of Canada since it is a host country that explicitly targets skilled immigrants. The immigrant population in this country has two remarkable features. The first one is that immigrants constitute an important proportion of the total population and their share among the total population has been increasing. According to 2006 Canadian Census data, the foreign born are almost 20 percent of the total population and their share exhibited a 5 percentage points increase since the beginning of the 1980s.[2] The second distinguishing feature of the immigrant population in Canada is the significant proportion of college-educated individuals, which is an outcome of the selective immigration policy enacted in 1967. The 1967 Immigration Act introduced the points system as a tool to select immigrants into the country. In this system, immigrants are admitted to the country based on the points they collect according to their education, age, language and other qualifications.[3] Soon after the implementation of the new policy, there was an increase in the share of the highly educated individuals among the immigrant population in Canada. The share of professional and managerial workers and clerical, commercial and financial laborers which

[1] Card (1990, 2001), Altonji and Card (1991) use spatial approach to estimate the impacts of immigrants on the wage and employment of natives in the U.S. Borjas (1995, 2003), Borjas et al. (1997), Aydemir and Borjas (2007) are nationwide analyses of the labor market impacts of immigration. Storesletten (2003) evaluates the fiscal impacts of immigrants.

[2] See Chui et al. (2007).

[3] See Green and Green (1999).

are the occupation groups requiring highest level of education was around 43 percent in 1966. This ratio increased to 52 percent in 1977.[4]

A rigorous evaluation of the post 1967 immigration experience of Canada in terms of how it affects the income, college education choices and welfare of natives is important since there are other immigrant receiving countries that adopt a similar policy. The most recent example of such countries is France.[5] In 2007, a new immigration law which gives the government new powers to encourage high skilled immigration took effect in the country. Among the main objectives of the new policy are recruiting skilled workers, facilitating foreign students' stay and tightening the rules on family reunification.[6]

In this paper I develop a heterogeneous-agent overlapping generations (OLG) model to analyze the impacts of selective immigration policy targeting skilled immigrants. Population is composed of natives and immigrants in the economy and all agents maximize present discounted value of life-time utility from consumption in a perfect-foresight market setting.[7] Native individuals are heterogenous with respect to their ability levels, and in addition to their standard consumption-savings decision, they make a discrete college decision at the beginning of their lives. The ability level of a native individual determines her (his) schooling decision and the efficiency units of labor she (he) provides either as a skilled or an unskilled worker. The cost of college education to an individual is the tuition payments she (he) makes during their college years, and unskilled wage earnings foregone during college years and the benefit is the wage premium she (he) gets during their working years. The model features no uncertainty

[4] Source: Statistics Canada: Historical Statistics of Canada, Population and Migration Statistics, Table A351-368: Immigration to Canada by intended occupations and dependents, 1953 to 1976

[5] Chojnicki (2013), Chojnicki and Ragot (2014) document benefits of skilled immigration for France using a generational accounting and a dynamic general equilibrium model, respectively.

[6] See Murphy (2006) for details of this law.

[7] There is no endogenous labor choice in the model.

hence agents know the precise return from college education at the time of their decision making. Immigration is exogenous and grows at a constant rate and immigrants enter the economy past their college education age.

On the production side, production technology features complementarity between skilled labor and physical capital as in Krusell et al. (2000). The main motivation for choosing this type of technology is to capture the impacts of skill-biased technological change in the quantitative analysis. Another agent in the model is the government that spends a certain fraction of output and provides social security payments for retirees. It uses distortionary taxes to pay for these expenditures and keeps the government budget in a balance.

Selective immigration policy affects the native population through its direct and indirect impacts on prices and the tax rates in the economy. An increase in the proportion of college graduates among the immigrant population, as in Canada, is a positive supply shock to college-educated labor, which decreases the wage level for this group. On the other hand, unskilled labor and physical capital become relatively more scarce, therefore the return on these factors increases. Immigration also alters the factor returns indirectly through two channels. The first is the human capital channel. The inflow of skilled immigrants discourages some natives from enrolling in college and leaves only the higher ability ones with a college education. In other words, both the number and the average ability level of skilled and unskilled labor change in response to an increase in the proportion of college-graduate immigrants. Another indirect channel through which immigration affects prices is the physical capital channel. Immigrants arrive in the country with some asset holdings, so their inflow changes the physical capital stock which affects the interest rate, hence the saving decision of natives.[8]

[8] The median amount of savings by all immigrants in 2001 is reported as $15,000 in Longitudinal Survey of Immigrants to Canada: A Portrait of Early Settlement Experiences (2005).

In my quantitative analysis, I run counterfactual experiments to quantify a *composition effect* from a change in the relative share of college graduates among the foreign-born and a *size effect* due to the increase in the share of immigrants in the labor force. These experiments show that both the rise in the relative size of foreign born population and the shift in the composition of this population towards more skilled individuals result in a decline in the college attainment rate among natives. Almost 7 in every 100 natives opt out of college education due to the smaller net return to college education that is generated by the increase in the relative share of college-graduate immigrants. The model also predicts that the size and compositional changes in the immigrant population together lead to a 2.15 percentage points higher growth rate of college premium among natives between 1981 and 2008 in Canada. Decomposing the impacts of the size and compositional change shows that the increase in the relative size of immigrants alone yields a 2.64 percent higher growth rate in this premium paid to skilled natives.

The impact of immigration on the native population is also evaluated by quantifying its welfare effects. The welfare analysis in the paper compares the 2008 economy with a counterfactual one in which the immigrant population keeps its 1981 share and composition. The results reveal that immigration creates a welfare loss for natives. This result is different from the results of the static model with undifferentiated labor in Borjas (1995) that predicts a small 'immigration surplus' accruing to natives. Based on the results of counterfactual experiments, I conclude that the main driver of the welfare loss is the increase in the size of the immigrant population. On the other hand, the shift in the composition of immigrants towards college graduates creates a small net welfare gain to natives at the lower end and the middle of the ability distribution. This gain amounts to 1.19 percent permanent increase in their consumption.

This paper's focus on immigration and between group inequality among natives relates it to two strands of the literature. The first one consists of studies that examine the wage differential between highly- educated individuals and those with lower education levels. In this literature there are are empirical papers that analyze wage premium to high education in the U.S. and Canada (see, for example, Katz and Murphy (1992), Autor et al. (2008), Krusell et al. (2000), Bar-Or et al. (1995), Burbidge et al. (2002), Murphy et al. (1998), Kryvtsov and Ueberfeldt (2009)). Besides these, there are also general equilibrium models that explain the rise in skill premium in the U.S. (see, for example, Guvenen and Kuruscu (2009), He (2012), He and Liu (2008)). These general equilibrium studies do not include immigrants in their model environment and hence they do not study how immigrants changed the wage inequality between education groups.

The second strand of the literature that the current paper is related to, examines the impacts of migratory flows on the native population of host countries. A majority of the studies in this literature are empirical studies that analyze the wage impacts of immigration on natives. These studies present conflicting evidence regarding the impacts of immigrants on the earnings of natives (see, for example, Altonji and Card (1991), Card (1990, 2001), Borjas et al. (1997), Borjas (2003), Aydemir and Borjas (2007) and LLull (2013)).

There are also studies that assess the impacts of immigration in a general equilibrium framework. These papers mostly have an endogenous physical capital choice however human capital is either absent or exogenous. Among the general equilibrium analyses of immigration, Ben-Gad (2004, 2008) find the wage and welfare impacts of immigration to be lower than the static models. Storesletten (2003) analyzes the fiscal impacts of different education levels of immigrants and concludes that high skilled immigration can be used to ease the fiscal burden of an ageing population. Akın (2012) also examines the effects of exogenous changes in immigration policy on individual welfare using German data. There are a few general equilibrium studies that endogenize human capital however these preclude an endogenous physical capital choice in their setting (see, for example, Heckman et al. (1998) and Eberhard (2012)).

This paper fits into the second group where the immigration is analyzed taking into account its impact on all prices and quantities in the economy. Different from the existing general equilibrium analyses of immigration, I endogenize the human capital choice by incorporating a discrete college education decision for natives. In addition, the production technology has the feature of complementarity between capital and skilled labor in the model economy coupled with a falling relative price of capital. Therefore, the model examines how labor market outcomes, the college education decision of natives are affected by immigration in an environment where there is skill-biased technological change. It also provides an environment to evaluate the immigration's effect on all prices in the economy through changes in both physical and human capital stock. The remainder of the paper is organized as follows. Section 2 discusses the data and Section 3 describes the model. In Section 4, results of the quantitative analysis are discussed and Section 5 offers a conclusion.

2 DATA

In this section, I present the relevant Canadian data for the 1981-2008 period.[9] As mentioned previously, there are two important observations about the immigrant population in Canada during this period. The first one is the increase in the relative share of immigrants among the total population. The second one is the shift in the composition of immigrant population towards college graduates. Table (1) reports the relative share of the immigrants in the sample as well as the proportion of college graduates among the immigrants.[10]

Between 1981 and 2008, the relative share of immigrants among the sample increased from 20 to 30 percent. The increase in the share of immigrants occurred mostly after the 1990's. On the other hand, the increase in the relative share of college graduates among immigrants was observed throughout the whole period. College-graduate immigrants constitute 12 percent of immigrants in the 1981 sample. The same ratio is 30 percent for the 2008 sample of immigrants. Comparing these numbers with the U.S. data shows that in Canada, immigrants are a greater proportion of the total population and the relative share of college graduates increased at a faster rate between 1981 and 2008. Table (2) presents the relative share of college graduates among the immigrants that inflow to the economy in the designated periods. 14 percent of the immigrants that came to Canada between 1961 and 1971 were college graduates. This ratio increased to 44 percent among those who entered the country between 2000 and 2008. This fact il-

[9] I make use of two different micro data sets for my analysis. The first one is the Survey of Consumer Finances (SCF), which contains information on individuals aged 15 years and over for the 1981-1997 period. The second one is the Survey of Labor and Income Dynamics (SLID), which covers the 1993-2008 period. The sample consists of employed wage and salary workers between ages 18 and 65, and retired individuals above 65. I am interested in immigrants who have acquired all their education before arriving in Canada therefore, I exclude immigrants below age 22 from my sample.

[10] Section A.1 on data sources and construction gives more detailed information about how the two education groups -college graduates and less than college graduates- are constructed both for SCF and SLID data.

lustrates a shift in the educational profile of immigrants towards more college graduates in the country.

Along with these changes there was also a rapid decline in the relative price of machinery and equipment during the same period. As illustrated in Figure (1), the price of machinery and equipment relative to consumer nondurables in Canada fell by almost 50 percent. In a production environment where machinery and equipment are complementary to more educated or skilled labor, the lower relative price of machinery and equipment implies higher productivity for these workers. In a simple supply and demand framework, the stylized facts presented in Tables (1), (2) and Figure (1) suggest that the skilled labor market in Canada experienced a positive supply shock due to increasing inflows of college-educated immigrants and a positive demand shock stemming from declining relative price of machinery and equipment between 1981 and 2008.[11]

One objective of this paper is to assess the impacts of observed changes in the immigrant population on the wage earnings of natives. In particular, I am interested in how the shift in the composition of the immigrant labor force affected the relative earnings of college-graduate natives in the country. Table (3) reports the relative share of college graduates among the native population and the college premium. The college premium in the country increased by nearly 8 percent between 1981 and 2008. Meanwhile the share of college graduates among the native population also increased from 8.6 to 24.4 percent. A relevant question to ask here is how did immigration contribute to the change in relative earnings of college graduates and their share among the native population in Canada.[12] These questions are addressed in the quantitative analysis part.

[11] Lewis (2011) shows that a production technology with capital-skill complementarity changes the impact of immigration on the relative earnings of natives from different skill groups.

[12] The college premium among natives is calculated using full-time full-year wage and salary workers between ages 18 and 65. I follow Autor et al. (2008) definition of 40+ weeks in a year, for full year workers. 30+ hours of work per week is the criterion for a full time worker based on Statistics Canada's def-

Before that, the model is discussed in detail in the following section.

3 MODEL

The model is a 68 period OLG model that incorporates a discrete college education decision for natives, exogenous flows of immigrants and skill-biased technological improvement.

3.1 Individual's Problem

3.1.1 Preferences

Natives

Native individuals are heterogeneous with respect to innate ability a. The ability level of an individual affects his college decision and the human capital he will provide in the labor market. Individuals make their college choice in period 1 of their lives, which corresponds to age 18. They retire at the age of 65 and die when they are 85. An individual with ability a, born at time t chooses consumption and savings $\{c^{n,e}_{j,s}, k^{n,e}_{j+1,s+1}\}$ to maximize the discounted value of life time utility given by

$$\max_{\{c^{n,e}_{j,s}, k^{n,e}_{j+1,s+1}\}} \sum_{j=1}^{J} \beta^{j-1} u(c^{n,e}_{j,s}) \tag{1}$$

subject to his budget constraints. Here $j = 1, 2, ..J$ is the age index, $e \in$ {c=college graduate, h=high school graduate} indicates the education level of the individual, n

inition (http://www.statcan.gc.ca/pub/71-222-x/2008001/glossary-glossaire-eng.htm) Workers with an hourly wage of less than \$1 are also dropped from the sample. To compute the college premium, I regress log hourly wages on age, age-squared, a sex dummy and a dummy variable indicating whether the individual is a college graduate or not. The college premium is measured as the coefficient of the college graduate dummy in this regression.

denotes that the individual is a native and $s = t + j - 1$ is the time index.[13]

Each individual chooses whether or not to go to college at the beginning of his life. If he chooses to remain as a high school graduate i.e. $e = h$, he starts working immediately until the retirement age j^*. If he chooses to go to college, he spends the first four years at school, then starts working as a skilled worker. Accordingly, for $e = c$ the budget constraints of the individual born at time t are

$$c^{n,c}_{j,s} + k^{n,c}_{j+1,s+1} + T \leq ((1 - \tau_k)(r_s - \delta) + 1))k^{n,c}_{j,s} \quad \text{for } j = 1, ..4 \tag{2a}$$

$$c^{n,c}_{j,s} + k^{n,c}_{j+1,s+1} \leq ((1 - \tau_k)(r_s - \delta) + 1))k^{n,c}_{j,s} + (1 - \tau_l)w^c_s a\varepsilon^{n,c}_j \quad \text{for } j = 5, ..j^* \tag{2b}$$

$$c^{n,c}_{j,s} + k^{n,c}_{j+1,s+1} \leq ((1 - \tau_k)(r_s - \delta) + 1))k^{n,c}_{j,s} + b^{n,c}_{j,s} \quad \text{for } j = j^*{+}1,..\text{J} \tag{2c}$$

for $e = h$ the budget constraints are

$$c^{n,h}_{j,s} + k^{n,h}_{j+1,s+1} \leq ((1 - \tau_k)(r_s - \delta) + 1))k^{n,h}_{j,s} + (1 - \tau_l)w^h_s a\varepsilon^{n,h}_j \quad \text{for } j = 1, ..j^* \tag{3a}$$

$$c^{n,h}_{j,s} + k^{n,h}_{j+1,s+1} \leq ((1 - \tau_k)(r_s - \delta) + 1))k^{n,h}_{j,s} + b^{n,h}_{j,s} \quad \text{for } j = j^* + 1, ..J \tag{3b}$$

I define $b^{n,e}_j$ as the social security benefits and $\varepsilon^{n,e}_j$ as the age-specific efficiencies for the two education groups.[14] r, w^c, w^h are returns on capital, and two types of labor, τ_k and τ_l are tax rates on capital and labor income. T is the tuition cost that an individual needs to pay for college education.

[13] I abstract from labor supply decision in the model similar to numerous other related papers (see Ben-Gad (2004), Ben-Gad (2008), Eberhard (2012), Guvenen and Kuruscu (2009), He (2012), He and Liu (2008), and Heckman et al. (1998)). As explained in Heckman et al. (1998), since the estimates of intertemporal substitution in labor supply are small, adding a labor supply decision is not expected to have a significant impact on the analysis in this paper. See Heckman et al. (1998) page 9 and footnote 10 for the aforementioned explanation.

[14] Calculation of age-specific efficiencies are explained in Section A.1.

Immigrants

Similar to Heckman et al. (1998), immigrants are assumed to enter the economy past their schooling age.[15] They work until the age of 65 and retire at the age of 85. Immigrants with college and less than college education are represented by an average individual with ability levels $\overline{a}_m^c$ and $\overline{a}_m^h$, respectively. The utility maximization problem of an immigrant who enters the economy in period t is given by

$$\max_{\{c_{j,s}^{m,e},k_{j+1,s+1}^{m,e}\}} \sum_{j=23}^{J} \beta^{j-1} u(c_{j,s}^{m,e}) \tag{4}$$

subject to his budget constraints. Here the time index is $s = t + j - 23$ and m indicates that the individual is an immigrant. The budget constraints of a college graduate immigrant are

$$c_{j,s}^{m,c} + k_{j+1,s+1}^{m,c} \leq ((1-\tau_k)(r_s - \delta) + 1)k_{j,s}^{m,c} + (1-\tau_l)w_s^c \overline{a}_m^c \varepsilon_j^{m,c} \quad \text{for } j = 23, ..j^* \tag{5a}$$

$$c_{j,s}^{m,c} + k_{j+1,s+1}^{m,c} \leq ((1-\tau_k)(r_s - \delta) + 1)k_{j,s}^{m,c} + b_{j,s}^{m,c} \quad \text{for } j = j^* + 1, ...J \tag{5b}$$

Similarly the budget constraints of an immigrant with less than college education take the form

$$c_{j,s}^{m,h} + k_{j+1,s+1}^{m,h} \leq ((1-\tau_k)(r_s - \delta) + 1)k_{j,s}^{m,h} + (1-\tau_l)w_s^h \overline{a}_m^h \varepsilon_j^{m,h} \quad \text{for } j = 23, ..j^* \tag{6a}$$

$$c_{j,s}^{m,h} + k_{j+1,s+1}^{m,h} \leq ((1-\tau_k)(r_s - \delta) + 1)k_{j,s}^{m,h} + b_{j,s}^{m,h} \quad \text{for } j = j^* + 1, ...J \tag{6b}$$

[15]For simplicity, I assume that all immigrants that inflow to the economy are at age 40 which corresponds to age 23 in the model. This is the median age of a sample of immigrants above age 22 in the data which is constant between 1981 and 2008.

3.1.2 Schooling Choice

Natives

In the model, natives make a discrete college decision at the beginning of their lives. This decision is made by comparing the lifetime utility of being a college graduate and that of remaining a high school graduate. Let $V^{e}_{j,s}(a, k^{n,e}_{j,s})$ denote the value of lifetime utility of a native individual with ability a who is j years old at time s. If the individual is a college graduate ($e = c$), the recursive representation of his utility maximization problem is as follows

$$V^{c}_{j,s}(a, k^{n,c}_{j,s}) = \max_{\{c^{n,c}_{j,s}, k^{n,c}_{j+1,s+1}\}} u(c^{n,c}_{j,s}) + \beta V^{c}_{j+1,s+1}(a, k^{n,c}_{j+1,s+1}) \tag{7}$$

for $s = t + j - 1$ subject to Equations (2a-2c).

If the individual opts not to enroll in college ($e = h$), then the value function corresponding to his lifetime utility maximization problem is

$$V^{h}_{j,s}(a, k^{n,h}_{j,s}) = \max_{\{c^{n,h}_{j,s}, k^{n,h}_{j+1,s+1}\}} u(c^{n,h}_{j,s}) + \beta V_{j+1,s+1}(a, k^{n,h}_{j+1,s+1}) \tag{8}$$

subject to Equations (3a) and (3b).

Individuals solve their perfect foresight utility maximization problem using backward induction. Going back to age 1, the college choice of an individual with ability level a can be characterized by the following conditions

$$\begin{aligned} &\text{If} \quad V^{c}_{1,t}(a, k^{n,c}_{1,t}) > V^{h}_{1,t}(a, k^{n,h}_{1,t}) \text{ choose } e = c, \\ &\text{If} \quad V^{h}_{1,t}(a, k^{n,h}_{1,t}) > V^{c}_{1,t}(a, k^{n,c}_{1,t}) \text{ choose } e = h, \\ &\text{If} \quad V^{h}_{1,t}(a, k^{n,h}_{1,t}) = V^{c}_{1,t}(a, k^{n,c}_{1,t}) \quad \text{indifferent} \end{aligned} \tag{9}$$

There is a unique threshold ability level a_t^* which makes an individual indifferent between getting a college education and remaining a high school graduate for all t.

3.2 Demographics

In each period, a new birth cohort of natives enters the economy. The newborn natives replace the old cohort who left the economy one period before. I_t is the inflow of immigrants in period t. I denote the native population stock of age j at time t by $N_{j,t}$, the immigrant population stock of age j by $M_{j,t}$, and the total population by P_t. The following equations describe the law of motion for population

$$\begin{aligned} N_{1,t+1} &= N_{J,t} + M_{J,t} \\ M_{23,t+1} &= I_{t+1} \\ P_t &= \sum_{j=1}^{J} N_{j,t} + \sum_{j=23}^{J} M_{j,t} \\ P_{t+1} &= P_t + I_{t+1} \end{aligned} \tag{10}$$

The shares of immigrants and natives of all ages are defined as follows

$$n_{j+1,t+1} = \frac{N_{j+1,t+1}}{P_{t+1}} = \frac{n_{j,t}}{(1+i_{t+1})}, \quad n_{1,t+1} = \frac{n_{J,t} + m_{J,t}}{(1+i_{t+1})} \quad \text{for } j = 1, ..J-1 \tag{11}$$

$$m_{j+1,t+1} = \frac{M_{j+1,t+1}}{P_{t+1}} = \frac{m_{j,t}}{(1+i_{t+1})}, \quad m_{23,t+1} = \frac{i_{t+1}}{(1+i_{t+1})} \quad \text{for } j = 23, ..J-1 \tag{12}$$

where $i_{t+1} = \frac{I_{t+1}}{P_t}$

Using the definition of age shares of immigrants, the share of college-graduate and less than college-graduate immigrants at each age are given by

$$m^c_{j,t} = \varkappa^c_{t-j+23} m_{j,t} \tag{13}$$

$$m^h_{j,t} = \varkappa^h_{t-j+23} m_{j,t} \quad \text{for } j = 23, ..J-1 \tag{14}$$

where $\varkappa^c_{t-j+23}$ and $\varkappa^h_{t-j+23}$ denote the share of college graduates and less than college graduates among immigrants who arrived in period $(t - j + 23)$ respectively.

3.3 Firm's Problem

3.3.1 Production Technology

The production technology in the model incorporates complementarity between skilled labor and capital equipment à la Krusell et al. (2000). The production function is a nested CES aggregate of skilled and unskilled labor and capital as follows

$$Y_t = [\mu U_t^\theta + (1-\mu)\{\lambda(K_t)^\rho + (1-\lambda)(S_t)^\rho\}^{\frac{\theta}{\rho}}]^{\frac{1}{\theta}} \tag{15}$$

In this setting, $\rho < \theta$ implies the existence of complementarity between capital and skilled labor and $(\theta - \rho)$ measures the degree of this complementarity. The law of motion for the physical capital stock in the economy is

$$K_{t+1} = (1-\delta)K_t + I_t q_t \tag{16}$$

Here q_t represents the state of the technology for producing physical capital and it determines the amount of capital which can be purchased with one unit of consumption good. Hence $1/q_t$ is the relative price of physical capital in terms of the consumption good. An alternative formulation of the environment with declining relative price of equipment has been developed by Greenwood et al. (1997). In this alternative formulation, the relative price of capital equipment is constant but its productivity is increasing over time. Using transformed variables, the law of motion for capital equipment and the production function is given by

$$\widetilde{K}_{t+1} = (1-\widetilde{\delta})\widetilde{K}_t + I_t \text{ where}$$
$$(1-\widetilde{\delta}) = (1-\delta)\frac{q_{t-1}}{q_t} \text{ and } \widetilde{K}_t = \frac{K_t}{q_{t-1}} \tag{17}$$

The production function can be rewritten as

$$Y_t = [\mu U_t^{\theta} + (1-\mu)\{\lambda(\widetilde{K}_t)^{\rho}(q_{t-1})^{\rho} + (1-\lambda)(S_t)^{\rho}\}^{\frac{\theta}{\rho}}]^{\frac{1}{\theta}} \tag{18}$$

In this production environment where capital equipment is complementary to skilled labor, the fall in the relative price of capital equipment (or a rise in its productivity) implies an improvement in technology that favors skilled labor more. This is a feature that needs to be addressed since it yields positive demand side effects for the college-educated labor.

The firm's profit maximization problem yields the following first order conditions

$$r_t = \lambda(1-\mu)\widetilde{K}_t^{\rho-1}Y_t^{1-\theta}(q_{t-1})^{\rho}\{\lambda(q_{t-1}\widetilde{K}_t)^{\rho} + (1-\lambda)S_t^{\rho}\}^{\frac{\theta}{\rho}-1} \tag{19}$$

$$w_t^c = (1-\mu)(1-\lambda)Y_t^{1-\theta}\{\lambda(q_{t-1}\widetilde{K}_t)^{\rho} + (1-\lambda)S_t^{\rho}\}^{\frac{\theta}{\rho}-1}S_t^{\rho-1} \tag{20}$$

$$w_t^h = \mu Y_t^{1-\theta}U_t^{\theta-1} \tag{21}$$

3.3.2 Aggregation of Human and Physical Capital

The production technology in Equation (18) uses skilled and unskilled labor as well as capital equipment to produce output. Skilled labor is the aggregate human capital provided by college graduates and unskilled labor is the aggregate human capital provided by individuals with less than college education. The formulation of aggregate skilled labor is

$$S_t = \sum_{j=5}^{j^*} N_{j,t} \int_{a^*_{t-j+1}}^{\infty} af(a)da + \sum_{j=23}^{j^*} M^c_{j,t} \overline{a}^c_m \tag{22}$$

Individuals with less than college education start working immediately. Hence the human capital provided by these individuals is

$$U_t = \sum_{j=1}^{j^*} N_{j,t} \int_{0}^{a^*_{t-j+1}} af(a)da + \sum_{j=23}^{j^*} M^h_{j,t} \overline{a}^h_m \tag{23}$$

Aggregate physical capital at time t is equal to the sum of age-specific assets by natives and immigrants i.e.

$$K_t = K^N_t + K^M_t \quad where \tag{24}$$

$$K^N_t = \sum_{j=2}^{J} N_{j,t} \int_{a^*_{t-j+1}}^{\infty} k^n_{j,t}(a) f(a)da + \sum_{j=2}^{J} N_{j,t} \int_{0}^{a^*_{t-j+1}} k^n_{j,t}(a) f(a)da \tag{25}$$

$$K^M_t = \sum_{j=23}^{J} M^c_{j,t} k^m_{j,t} + \sum_{j=23}^{J} M^h_{j,t} k^m_{j,t} \tag{26}$$

3.4 Government

3.4.1 Social Security

I follow İmrohoroğlu et al. (1999) and Chen et al. (2007) and assume that each individual receives a certain portion (ψ) of their average life time wage income as social security benefits. Accordingly the social security benefits of a native individual during his retirement years is as follows

$$b^{n,e}_{j',t+j'-1} = \left\{ \begin{array}{c} \psi \frac{1}{j^*} \sum_{j=1}^{j^*} w^h_{t+j-1} a \varepsilon^{n,h}_j \text{ if e} = h \\ \psi \frac{1}{j^*-4} \sum_{j=5}^{j^*} w^c_{t+j-1} a \varepsilon^{n,c}_j \text{ if e} = c \end{array} \right\} \text{for } j' = j^* + 1, ..J \tag{27}$$

For immigrants, the same social security income is defined as

$$b^{m,e}_{j',t+j'-23} = \left\{ \begin{array}{c} \psi \frac{1}{j^*-22} \sum_{j=23}^{j^*} w^h_{t+j-1} \overline{a}^h_m \varepsilon^{m,h}_j \text{ if e} = h \\ \psi \frac{1}{j^*-22} \sum_{j=23}^{j^*} w^c_{t+j-1} \overline{a}^c_m \varepsilon^{m,c}_j \text{ if e} = c \end{array} \right\} \text{for } j' = j^* + 1, ..J \tag{28}$$

The social security program is funded by the government. Tax revenue is used to finance the social security payments (B_t) and government expenditures (G_t). The government's budget equation is expressed in Equation (29) below

$$G_t + B_t = \tau_l(w^c_t S_t + w^h_t U_t) + \tau_k(r_t - \delta)K_t \tag{29}$$

where

$$\begin{aligned} G_t &= \xi Y_t \qquad (30) \\ B_t &= \sum_{j'=j^*+1}^{J} \{ n^h_{j',t} \int_0^{a^*_{t-j'+1}} b^{n,h}_{j',t}(a) f(a) da + n^c_{j',t} \int_{a^*_{t-j'+1}}^{\infty} b^{n,c}_{j',t}(a) f(a) da + m^h_{j',t} b^{m,h}_{j',t} + m^c_{j',t} b^{m,c}_{j',t} \} \end{aligned}$$

3.5 Definition of Equilibrium

Given the exogenous share of each age group among natives $\{n_{j,t}\}$ and immigrants $\{m_{j,t}\}$, government policy parameters $\{\xi, \psi, \tau_l, \tau_k\}$, the exogenous price of capital equipment relative to consumption goods $\{q_t\}$, and college tuition fees $\{T_t\}$, a competitive equilibrium is represented by a sequence of factor returns $\{w^c_t, w^h_t, r_t\}$ and a threshold ability level $\{a^*_t\}$, consumption and saving choices of all individuals $\{c^{n,e}_{j,t}(a), k^{n,e}_{j+1,t+1}(a), c^{m,e}_{j,t}, k^{m,e}_{j+1,t+1}\}$

such that;

1. The consumption and saving choices $\{c^{n,e}_{j,t}(a), k^{n,e}_{j+1,t+1}(a), c^{m,e}_{j,t}, k^{m,e}_{j+1,t+1}\}$ solve the individual's utility maximization problem subject to budget constraints expressed in Equations (2a-2c), (3a-3b), (5a-5b), (6a-6b).

2. The threshold ability $\{a^*_t\}$ satisfies the indifference condition in Equation (9).

3. Prices $\{w^c_t, w^h_t, r_t\}$ satisfy the first order conditions of the firm's profit maximization problem stated in Equations (19), (20), and (21).

4. Aggregate physical capital and human capital by unskilled and skilled labor in efficiency units are consistent with individual behaviors as stated in Equations (22), (23) and (24).

5. Government's budget constraint in Equation (29) is satisfied.

6. Goods market clears.

$$C_t + I_t + \mathfrak{T}_t + G_t = Y_t$$

where C_t is the aggregate consumption, I_t is the aggregate investment, $\mathfrak{T}_t$ is the aggregate tuition expenses.

$$\begin{aligned} C_t &= \sum_{j=1}^{J} N_{j,t} \int_{a^*_{t-j+1}}^{\infty} c^{n,c}_{j,t}(a) f(a) da + \sum_{j=1}^{J} N_{j,t} \int_{0}^{a^*_{t-j+1}} c^{n,h}_{j,t}(a) f(a) da \\ &\quad + \sum_{j=23}^{J} M^c_{j,t} c^{m,c}_{j,t} + \sum_{j=23}^{J} M^h_{j,t} c^{m,h}_{j,t} \\ \mathfrak{T}_t &= \sum_{j=1}^{4} N_{j,t} [1 - F(a^*_{t-j+1})] T_t \end{aligned}$$

3.6 Steady State

The model presented above is representative of the Canadian economy in which there are constant inflows of immigrants. The steady state can be characterized by the case in which the share of the foreign born population remains constant with continued inflows of immigrants to the economy i.e.

$$\frac{M_{t+1}}{P_{t+1}} = \frac{M_t}{P_t} = \varkappa \tag{31}$$

This equality implies a constant growth rate of the population. Using Equation (10), the growth rate of the population is given by

$$\frac{P_{t+1}}{P_t} = 1 + \frac{I_{t+1}}{P_t} = 1 + g$$

The relation between g and $\varkappa$ is the following

$$g = \frac{m_J}{1 - \varkappa} \tag{32}$$

where $m_J = \frac{M_{J,t}}{P_t}$ $\forall t$. A stationary demographic structure requires that the age shares are constant i.e. $m_{j,t} = m_{j,t+1}$ $\forall t$. Using this condition and the age shares defined for immigrants and natives in Equations (11) and (12), I get the following

$$\begin{aligned} m_{23} &= \frac{g}{(1+g)},\ m_{j+1} = \frac{m_j}{(1+g)} \forall j = 23, ...J-1 \\ m_J &= \frac{g}{(1+g)^{J-22}} \end{aligned} \tag{33}$$

Inserting m_J in Equation (32), the growth rate of the population is found as

$$g = \left(\frac{1}{1 - \varkappa} \right)^{(1/(J-22))} - 1 \tag{34}$$

The share of native age groups are

$$\begin{aligned} n_1 &= \frac{n_J + m_J}{(1+g)}, \; n_{j+1} = \frac{n_j}{(1+g)} \forall j = 1, ...J-1 \\ n_J &= \frac{m_J}{((1+g)^J - 1)} \end{aligned} \tag{35}$$

A stationary equilibrium is characterized by the system of equations where all variables are expressed in per capita terms and the growth rate of the population is defined in Equation (34).

4 Quantitative Analysis

The objective of the quantitative analysis is to examine how the change in the relative size and composition of immigrants affected the earnings inequality among natives as well as their college education choice and welfare. To accomplish this goal, I first calibrate the model to an initial steady state then evaluate its fit to 2008 Canadian data. Following this, I construct counterfactual 2008 economies that answer the following questions: How would the 2008 economy look like if

1. the relative size of immigrant population did not increase between 1981 and 2008?

2. the share of college-graduates among the immigrant population stayed constant at its 1981 level?

3. neither the size nor the education composition of immigrant population changed between 1981 and 2008?

4.1 Calibration

The initial steady state of the model economy is calibrated to match some data moments of the Canadian economy. The 1981 Survey of Consumer Finances Microdata set is used to calculate the data moments at the initial steady state unless otherwise stated. Model parameters can be classified into the following groups.

4.1.1 Production function parameters.

The share parameters (μ, λ) and the elasticity of substitution parameters (θ, ρ) are the production function parameters that need to be specified. I set $\rho = -0.495$ which is the value estimated by Krusell et al. (2000) using the U.S. data. For θ, there is a range of estimates. Duffy et al. (2004) use a panel of countries and estimate θ to be around 0.8, while Krusell et al. (2000)'s estimate for this parameter is 0.401. Polgreen and Silos (2008) estimate the same parameter to be 0.89 using U.S. data. The value I pick for θ is 0.695 which is the mean value of these estimates. μ is calibrated to match the relative share of college graduates among natives. College graduates are 8.6 percent of the the native population in 1981 as reported in Table (3). λ is chosen to match the capital output ratio in the business sector. The value of this ratio in 1980 is reported as 1.4 by Bentolila and Gilles (2003).

4.1.2 Parameters of the ability distribution of natives

The ability distribution of natives is assumed to be log normal with parameters m, v. i.e. $a \in F(a) \sim \log N(m, v)$.[16] I normalize the mean of the ability distribution to 1 and calibrate the dispersion of the distribution to match the log difference between the

[16] In this model distribution of ability determines the income distribution. Log-normal is a widely accepted parameter approximation for income distribution. See Limpert et al. (2001) and the references therein on the use of log normal distribution to approximate income distribution. Also see Pinkovskiy and Sala-i Martin (2009) that uses log normal to approximate world income distribution.

average earnings of the college educated and less than college-graduate natives in 1981. The log wage gap between these two education groups in 1981 is presented in Table (3) as 0.34. This corresponds nearly to an average college premium of 1.41 in the data.

4.1.3 Government Expenditure Parameters and Tax Rates

The condition for a balanced government budget is presented Equation (29). The government expenditures is a constant fraction of output as specified in Equation (30). The parameter ξ in this equation is set to the average share of government expenditures in Canadian total output between 1980 and 1990.[17] The other component of the government budget is social security benefits. I refer to Gruber (1999) to calibrate the replacement rate (ψ) i.e., the fraction of average income which is paid out to an individual upon his retirement.[18] Gruber (1999) computes the expected net present discounted value of Social Security Wealth which includes future entitlements from the four main social security programs in Canada. Using the median earnings history of a synthetic cohort from 1973-1993 SCF data, Gruber (1999) calculates the replacement rates for all ages between 55 and 70.[19] I set ψ to 0.375, which is the replacement rate reported for a single individual with asset income at the age of 65.

The revenue of government comes from taxes on labor τ_l, and capital income τ_k. McDaniel (2014) computes the average tax rate on labor and capital income for 15 OECD countries for the 1950-2000 period. Based on McDaniel (2014)'s calculations for Canada, I set $\tau_k = 0.285$ to its 1980 level and pick τ_l so that the government budget

[17]Source: OECDStat: National Accounts at a Glance

[18]Gruber (1999) provides a brief summary of Canada's public pension plans. The public pension plans for seniors can be categorized under two main groups. The first one is the Old Age Security Program which includes the Old Age Security Pension and Guaranteed Income Supplement. The other category is the Canada and Quebec Pension Plans.

[19]In the paper the social security wealth is calculated by projecting all benefits out until the age of 100 and then taking a weighted sum which discounts future benefits by both the individual discount rate and the prospects that the worker will live to a given future age. The results are presented in tables 1-6.

constraint in Equation (29) is satisfied.[20]

4.1.4 Parameters Related to Demographics

Equation (34) gives the long run population growth rate as a function of the share of immigrant stock $\varkappa$ in the total population. To pin down $\varkappa$, I select the sample of immigrants who are aged between 22 and 85 from SCF 1981 data and find the sum of their relative weight in the total population. With the value of $\varkappa$ specified, the age shares of natives and immigrants can be calculated as a function of the population growth rate using Equations (33) and (35).

4.1.5 Parameters Related to Immigration

The average ability levels of college-graduate and less than college educated immigrants are calibrated to match the average wage gap between natives and immigrants of the same education level. The model implied average wages of natives and immigrants of these education groups are given by the following equations

$$\begin{aligned}
\overline{w}^{n,c} &= w^c . \int_{a^*}^{\infty} a f(a) \frac{1}{1 - F(a^*)} da_i \\
\overline{w}^{n,h} &= w^h . \int_{0}^{a^*} a f(a) \frac{1}{F(a^*)} da \\
\overline{w}^{m,c} &= w^c . \overline{a}_m^c \\
\overline{w}^{m,h} &= w^h . \overline{a}_m^h
\end{aligned}$$

[20]The capital tax data is from her original series. In the updated series the value for capital tax rate in 1980 is 29.3 percent. Using this tax rate does not affect the results of the model.

so the log wage gap between college-graduate natives and immigrants is

$$ln\left(\frac{\overline{w}^{n,c}}{\overline{w}^{m,c}}\right) = \ln\left(\frac{\int_{a^*}^{\infty} a_i f(a_i)\frac{1}{1-F(a^*)}da}{\overline{a}_m^c}\right)$$

similarly the log wage gap between less than college-educated natives and immigrants is

$$\ln\left(\frac{\overline{w}^{n,h}}{\overline{w}^{m,h}}\right) = \ln\left(\frac{\int_{0}^{a^*} af(a)\frac{1}{F(a^*)}da}{\overline{a}_m^h}\right)$$

Table (4) presents the data values of these two moments.[21]

The initial assets of immigrants: Immigrants are assumed to arrive with a certain amount of savings in the model. Considering the current regulations for immigration in Canada, this is a reasonable assumption. Citizenship and Immigration to Canada lists 'having enough money to support yourself and your dependents after you arrive in Canada' as one of the criteria to be admitted as a skilled worker and professional immigrant. The minimum amount required during the initial settlement period is set as \$11,931 for a single individual (See Citizenship and Immigration to Canada (2015)). Three quarters of immigrants are reported to bring savings to the country upon their arrival. The median amount of these savings by federal skilled workers is \$15,000 in 2001.[22] I assume that this amount did not change significantly from 1981 to 2001 and compute the median amount of savings by immigrants in 1981 as \$7,600 in 1981 dollars. I calibrate the immigrants' initial assets as a fraction η of the average labor earnings the immigrant individuals. The median amount of savings is nearly 38.7 per-

[21]The log wage gap between natives and immigrants for the two education groups is found by regressing log hourly wages on age, age squared, a dummy variable for males and a dummy variable indicating whether the individual is a native separately for college graduates and less than college educated.

[22]Source: Longitudinal Survey of Immigrants to Canada: A Portrait of Early Settlement Experiences (2005)

cent of the average wage income of FTFY foreign born workers in 1981, therefore I set $\eta = 0.387$.

4.1.6 Tuition Costs

TLAC (Tuition and Living Accommodation) data, available through Statistics Canada Centre for Education Statistics provides weighted average tuition fees for full-time Canadian undergraduate students. For calibration purposes, I formulate tuition cost as $T = \kappa w^h \varepsilon_1^{n,h}$ i.e. the fee paid for college is a certain fraction (κ) of the average wage earnings of high school graduate individuals who opt not to enroll in college and start working for wages. In the data, I find that the ratio of the average undergraduate tuition fees to the average annual wage earnings of 18 year old FTFY wage and salary workers is 9.02 percent. Hence I set the tuition parameter κ to 0.0902.

4.1.7 Other Parameters

The remaining parameters are the discount factor β, the CRRA parameter σ, the depreciation rate for physical capital δ, and the initial relative price of capital equipment $1/q_o$. The discount factor β is calibrated to match an average annual interest rate of 4 percent. I set the CRRA parameter σ to 1.5, which is a common value in the literature. I borrow the depreciation rate of capital from Tang et al. (2010) that reports the depreciation rate used by Statistics Canada for aggregate physical capital as 0.16. Lastly the relative price of capital equipment in 1981, $1/q_o$, is normalized to 1.

Table (5) presents the calibrated parameters along with the targeted data moments. These results show that the model does well in matching the data moments. The college graduates constitute 8.6 percent of the native population. The model predicts this ratio to be 9 percent. The 1981 value for college premium is 1.41 and the model generates a value of 1.44 for this moment. I also get an interest rate of 4.02 percent and a capital output ratio of 1.39 that are close to their data values.

4.2 Comparison With Benchmark 2008 Economy

The next step of the quantitative analysis is an assessment of the model's performance in explaining the 2008 economy. Table (6) compares the 2008 data values for the relative share of college graduates among natives, the ratio of average wage earnings of this group to the non-college and the growth rate of college premium between 1981 and 2008 with their model counterparts. From the beginning of the 1980's until 2008, college attainment rate increased among native Canadians. In 1981, the share of college graduates was 8 percent, that later soared to 24 percent in 2008. The model generates a similar increase in the college education attainment among natives. The predicted ratio of college graduates to non-college graduates for the 2008 economy is 21.50 percent in the model, that is close to the 24 percent observed in the data. A significant portion of the increase in the wage inequality between the two education groups is also explained well by the model. As reported in Table (3), the ratio of average wage earnings of college educated to less than college educated natives rises by 8 percent in the data. The model generates a 6.9 percent rise in this ratio capturing 85 percent of the realized increase. Overall, the model performs well in explaining the simultaneous increase in college premium and college attainment rate among natives between 1981 and 2008.

How much did immigration contribute to the changes in the earnings inequality and college attainment of native Canadians observed between 1981 and 2008? What were the welfare impacts of immigration on the native population? To answer these questions, I simulate counterfactual 2008 economies, where I shut down the changes observed in the immigrant population. Recall that these changes are an increase in the immigrants' share among the total population and a shift in the composition of immigrants towards college graduates. Based on these observations, the first counterfactual experiment investigates the impacts of an increase in the relative share of college-educated immigrants on natives. The second experiment analyzes the counterfactual economy in which the relative share of immigrants among the labor force is kept at its 1981 level. The results of the counterfactual exercises are presented in Table (7) and a discussion of the results is provided in the following subsection.

4.3 Findings

As mentioned previously, one objective of this paper is to assess the immigrants' effect on earnings inequality between college-graduate and non-college natives. The wage ratio between these two education groups in the model is

$$\frac{w^c}{w^h} = \frac{(1-\lambda)(1-\mu)}{\mu}\{\lambda(qK)^\rho + (1-\lambda)(S)^\rho\}^{\frac{\theta-\rho}{\rho}}\frac{(S)^{\rho-1}}{(U)^{\theta-1}} \tag{36}$$

This wage ratio measures 'the relative price of skill' in the economy. In other words, it is the wage earnings of a skilled worker relative to an unskilled one per efficiency units of labor. The formula for the college premium among natives, which is comparable to the one observed in the data, depends on this relative price as well as the ratio of the average ability of college-graduate to non-college natives. Therefore the college premium is given by

$$\frac{w^c.\int_{a^*}^{\infty} af(a)\frac{1}{1-F(a^*)}da}{w^h.\int_{0}^{a^*} af(a)\frac{1}{F(a^*)}da} \tag{37}$$

The growth rate of the skilled to unskilled wage ratio is approximately equal to

$$g_{\frac{w^c}{w^h}} \simeq (\theta - 1)g_{\frac{S}{U}} + (\theta - \rho)\lambda g_{\frac{qK}{S}}(\frac{qK}{S})^{\rho} \tag{38}$$

Here g_x denotes the growth rate of the variable x. The equation decomposes the change in relative price of skill into two parts. The first part shows the *relative quantity effect,* which refers to the change in the share of skilled labor relative to unskilled labor. The second part is the *capital-skill complementarity effect*, that is mainly driven by the change in the efficiency units of capital per skilled labor. With $\theta < 1$ and $\rho < \theta$, the relative quantity effect implies that an increase in the relative supply of skilled labor (S/U) exerts a downward pressure on college premium. On the other hand, capital-skill complementarity effect dictates that a rise in capital per skilled labor moves the college premium upwards. The interplay between these two effects are important for analyzing how earnings inequality between skilled and unskilled natives respond to changes in the foreign-born population.

The first counterfactual exercise investigates the impacts of a shift in the composition of the foreign born labor force towards college-graduate individuals between 1981 and 2008. The question I answer with this exercise is the following: If immigrants are still 30 percent of the total population in 2008, but the relative share of college graduates among the immigrant population remains at its 1981 value of 12 percent, what are the implications of this for the native population? In this economy, labor markets are loaded with more non-college immigrants compared to the benchmark economy in 2008. The increase in the share of workers below college education results in a decline in their wages. In other words, the *relative quantity effect* works in the direction of increasing the relative price of skill. An increase in the share of unskilled immigrants also has implications for the physical capital stock for the economy. Immigrants with less than college education save less than their college-educated counterparts. This leads to a smaller physical capital stock in the economy which drags the wage ratio, so the relative quantity and capital skill complementarity effects work in opposite directions on the wage ratio between skilled and unskilled labor.

How does college attainment among natives respond to these changes? Under this counterfactual scenario, the relative wage of college-graduate labor is higher compared to the benchmark. Along with this, tuition fees for college education are lower. These two factors yield a 7 percentage points higher college graduate share compared to the benchmark. This implies that if the composition of immigrants in Canada did not shift towards college graduates, 7 more natives out of every 100 would be willing to get a college education.

These additional natives who opt for college education in the counterfactual economy have lower ability levels. Therefore they do not provide enough human capital to recover the loss of skilled human capital due to having less college-graduate immigrants. Consequently, there is a decline in total skilled human capital and its ratio to unskilled human capital in the economy. The relative scarcity human capital provided by college graduates leads to an increase in its relative price from 1.19 to 1.21. Accordingly, a slightly higher college premium is observed in this economy. As presented in Equation (37), the ratio of the average ability levels of these workers also affects the college premium besides the wage ratios. In this case, this ratio mitigates the impact of a higher relative skill price on college premium because natives with lower ability levels opt for college education. As a result keeping the educational composition of the immigrant population fixed, college premium increases by 7.1 percent. The simulated model generates a 6.9 percent rise in college premium between 1981 and 2008. Hence the model predicts that the increase in the relative share of college graduate immigrants decreases the growth rate of college education premium among natives by 0.2 percentage points.

In the second exercise, I analyze the effects of having a higher share of immigrant population on natives in 2008. To achieve this, I construct a counterfactual 2008 economy in which the relative share of immigrants is kept constant at its 1981 level. The results of this experiment are presented in column 4 of Table (7). An immediate impact of having fewer immigrants in the economy is a decline in the labor supply by two education groups. This leads to an increase in the wage earnings of both college graduates and those with less than college education. The wage earnings of skilled labor relative to unskilled labor turns out to be slightly lower in this economy. Recall that this wage ratio depends on the *relative quantity effect* and *capital-skill complementarity effect*. The model predicts the per capita physical capital in the economy with a smaller immigrant population to be higher. Under this scenario, the increase in capital per skilled labor pulls up the relative skill price. On the other hand, the relative quantity effect works in the opposite direction. In the counterfactual economy with fewer immigrants, the total human capital supplied by skilled and unskilled immigrants is lower. Natives who are added to the college-graduate pool make up for the decline in skilled human capital however the total human capital by unskilled labor becomes short compared to the benchmark. Therefore an improvement in the skilled human capital and its ratio to unskilled human capital is observed. The resulting relative quantity effect offsets the positive impact of a higher physical capital stock on the wage ratio. As a result the wage ratio is 1.7 percent lower than the benchmark 2008 economy.

As mentioned above a smaller immigrant population incentivizes more natives to get college education. Despite the fact that the relative skill price is slightly less than the benchmark case, the interest rates are lower by 0.20 percentage points as an outcome of the higher per capita physical capital. This makes the loans borrowed to cover tuition expenses more affordable for natives and hence increases the net value of college education. Therefore with fewer immigrants in the economy, around 3 more natives out of 100 are willing to get a college education. The growth rate of college premium between 1981 and 2008 among natives becomes 4.3 percent in this case. This growth rate is lower than the one observed in the benchmark 2008 economy because relative skill price and the average ability of college-graduate natives is lower compared to the economy with a larger immigrant population.

Lastly an evaluation of the impacts of all changes observed in the immigrant population between 1981 and 2008 is reported in the last column of Table (7). This counterfactual scenario illustrates the case in which the immigrant population does not change between 1981 and 2008. In accordance with the previous two counterfactual experiments, college attainment among natives is 7 percentage points higher compared to the benchmark economy. This increase in college attainment is an outcome of the higher net value of being a college graduate. Comparing the relative wage earnings of skilled labor with the benchmark 2008 economy shows that the relative skill price is slightly lower. On the other hand, interest rates and tuition costs are also lower. This generates a lower cost for college education that drives the higher college graduate share among natives. With no change in the foreign born population, the college premium among natives rises by 4.79 percent between 1981 and 2008.

To sum up, the changes in the immigrant population observed between 1981 and 2008 in Canada have remarkable impacts on the native population. The selective nature of the policy that explicitly targets high-skilled immigrants creates significant disincentives for natives to get college education. The compositional change alone yields a 7 percentage points lower share of college graduates among natives. The changes in the immigrant population have impacts on the earnings inequality between the two education groups as well. The model predicts that the size and compositional changes in immigrant population together generate a 2.15 percentage points higher growth rate of college premium between 1981 and 2008. The main driver of this outcome is the growing share of immigrants in the economy.

Besides its impacts on college premium, wage earnings and college education choice of natives, it is important to study the long-run impact of immigration on natives through changes in all factor returns and taxes. For this analysis, compensating differentials are computed by equating the life-time utility of an individual living in 2008 economy to the utility obtained from the consumption of the counterfactual 2008 economy multiplied by a constant $(1 + \Delta)$.[23] The equation expressing this is given by

$$\sum_{j=1}^{J} \beta^{j-1} u(c_{o,j}(a)) = \sum_{j=1}^{J} \beta^{j-1} u((1 + \Delta) c_{1,j}(a)) \tag{39}$$

Equation (39) yields

$$\Delta = \left(\frac{\sum_{j=1}^{J} \beta^{j-1} \frac{c_{o,j}(a)^{1-\sigma}}{1-\sigma}}{\sum_{j=1}^{J} \beta^{j-1} \frac{c_{1,j}(a)^{1-\sigma}}{1-\sigma}} \right)^{1/1-\sigma} - 1$$

In this formulation $c_{1,j}(a)$, $c_{o,j}(a)$ denote the consumption of a native individual at age j, and ability level a who is born in the counterfactual and benchmark 2008 economies, respectively. Δ measures the percentage permanent change in consumption that the individual experiences due to the changes in immigrant population. Table (8) reports the values of Δ for the highest, median and lowest ability individuals in the economy.

[23] This analysis shows which economy is more preferable for a new-born native individual by comparing the discounted value of life-time utility he enjoys in both environments.

Panel A presents the computed Δ's for the 2008 economy where the share of college graduates among the foreign born is at its 1981 level of 12 percent. These results show that median and low ability individuals benefit from a welfare increase equivalent to a 1.19 percent permanent increase in their consumption between this economy and the benchmark. In the counterfactual economy, there are more immigrants with below college education that results in a reduction in unskilled wages compared to the benchmark 2008 economy. Along with lower unskilled wages, the labor tax rates are higher. These two changes jointly create the observed outcome. On the other hand, the individual with the highest ability level, who is a college graduate, suffers a small welfare reduction that corresponds to a 0.037 percent permanent decrease in his consumption. Keeping the skill composition of immigrants fixed, a smaller stock of skilled human capital relative to unskilled human capital is obtained despite the fact that more natives go to college in this economy. This results in higher after-tax skilled wages accompanied by higher interest rates and capital income in the counterfactual economy. All these factors generate the small loss that skilled natives face moving from the counterfactual 2008 to the benchmark economy.

Panel B reports the welfare effects of an increase in the relative share of the immigrant population. All three types of natives enjoy a lower life-time utility in the benchmark economy than the counterfactual economy with a smaller foreign-born population. For median and low ability individuals, the loss due to the bigger size of the immigrant population corresponds approximately to a 5.14 percent permanent decrease in their consumption. The highest ability native faces a 3.54 percent permanent reduction in his consumption. The main reason for this loss is that labor taxes are lower in the counterfactual economy. Along with this, higher unskilled wages and slightly lower skilled wages and interest rates are observed in the economy with a smaller immigrant population. For the highest ability native, the impact of lower interest and wage rate has been offset by lower taxes. However, due to these counterbalancing effects, the benefit they derive from a smaller immigrant population is not as high as an unskilled native.

Finally I examine how the increase in the size of the immigrant population along with a shift in its composition towards college graduates affects the welfare of natives. The results of this analysis are presented in Panel C. The overall effect of immigration on all three types of natives is equivalent to a 3.59 to 4.45 percent permanent decline in their consumption. Similar to the previous case, the main driver of this loss is higher labor tax rates in the benchmark economy. Unskilled natives bear an additional loss since their wage rates are higher in the counterfactual economy with no change in the immigrant population.

Borjas (1995) is one of the first studies that examines the welfare impacts of immigration. The increase in income accruing to natives due to immigration, i.e., an 'immigration surplus' is calculated in this paper. An immigration surplus occurs because although there is a reduction in the wages of natives, the rise in interest rates results in an increase in capital income. This soar in capital income more than compensates the reduction in the labor earnings of natives which in the end creates net positive gain for the native population. The paper reports the increase in the income accruing to the native population resulting from a 10 percent increase in the labor force due to immigration to be on the order of 0.1 percent of GDP, assuming that labor and capital are not perfectly substitutable. However, other studies point out that the immigration surplus becomes smaller with endogenous physical capital.[24] The welfare analysis results in this paper which show that a larger foreign born population creates a welfare loss for natives are consistent with the findings of studies that endogenize physical capital. Individuals adjust their saving decisions in response to an immediate

[24]See Ben-Gad (2004, 2008).

rise in the interest rates which increases the physical capital stock in the economy. This in turn drives down the increase in capital income accruing to the native population. The results in Table (7) show that in the benchmark 2008 economy, the interest rates are higher compared to the counterfactual economy with no change in the immigrant population. However the higher labor income tax rates and the decline in unskilled wage rate outdoes the impact of higher interest rates. Consequently both skilled and unskilled natives experience a welfare loss due to having a larger immigrant population.

How do the welfare impacts of immigration compare to other general equilibrium models which take the human capital of natives as exogenous? Ben-Gad (2008) runs some experiments for the U.S. economy where the impact of skilled and unskilled immigration are examined. One of these experiments computes the compensating differentials to move from a baseline economy to one with a higher unskilled immigration rate. The results of this experiment show that, with higher unskilled immigration rate, unskilled households face a drop in their permanent consumption levels and skilled households enjoy an increase in their welfare. The benefit of this policy change to skilled individuals is almost equal in magnitude to the cost of it for unskilled households in the model.

The results of this experiment can be qualitatively compared with the scenario where the relative share of skilled immigrants are kept at their 1981 value in this model. The reason for the increase in the permanent consumption of skilled households in Ben-Gad (2008) is that with more unskilled immigrants in the economy, the skilled labor force becomes more scarce. The resulting higher skilled wage rate is the main reason for the permanent increase in the consumption of skilled individuals. However in his setting, the endogenous human capital channel is absent. Therefore the possibility that more natives get college education is not taken into account. This channel mitigates the impact of the rise in unskilled immigration rate on the skilled wages and hence the benefit for skilled households. The current model predicts a small loss for skilled natives moving from the counterfactual economy with relatively more unskilled immigrants to the baseline 2008 economy. However, this loss corresponds to only 3 percent of the permanent increase in the unskilled individual's consumption. A reinterpretation of this is that, skilled natives benefit a small welfare gain and unskilled natives face a welfare loss as they move to the counterfactual economy with relatively (more) less (un)skilled immigrants. As mentioned previously, more natives opt for college education in this counterfactual economy. Therefore, the positive impact of having less skilled immigrants on skilled wage rate is extenuated. Accordingly, the benefit for a skilled individual of having less skilled immigrants is weakened when we endogenize the human capital decisions of natives.

To sum up, I infer that the overall changes of the immigrant population created a loss for both skilled and unskilled natives in Canada between 1981 and 2008. As mentioned above, these losses are an outcome of lower wages and higher labor income tax rates. The results of the counterfactual experiments in Panels A and B show that the welfare loss of natives is mainly due to the increase in the relative size of the foreign born population. On the other hand, the compositional change in the immigrant population benefits unskilled natives at the middle and lower end of the ability distribution. The highest ability individual who is a college-graduate faces a slight welfare loss due to the decline in skilled wages. However this loss, being only 3 percent of the benefit enjoyed by median and low ability, is comparably very small.

4.4 Sensitivity Analysis

It has been mentioned in the calibration that there is a range of estimates for the elasticity of substitution parameter θ. The estimates of this parameter vary from 0.401 to 0.89. The value I use in the baseline calibration is 0.695 which is the average of the existing estimates of this parameter in Duffy et al. (2004), Krusell et al. (2000), and Polgreen and Silos (2008). To show how sensitive the results of the model are to the value of this parameter, I simulate the benchmark 2008 economy and run the counterfactual experiments using the recalibrated model with alternative values of θ. The results from the sensitivity analysis are presented in Table 9.

In economies with both a low (0.401) and high (0.8) elasticity of substitution parameter θ, the model underperforms in matching the observed increase in college-graduate share among natives between the 1981 and 2008. However it is still observed that the size and compositional changes in the immigrant population contribute positively to the increase in college premium between 1981 and 2008. In the baseline calibration, immigration accounts for 2.15 percentage points higher increase in college premium. In the low θ economy this contribution is 2.8 percentage points and in the high θ economy it is 1.35 percentage points.

The impact of immigration flows on the college education of natives is also reported for different values of θ. The results from the baseline calibration show that if the skill composition of immigrant population did not change, more natives would opt for college education. This result also holds for the high and low elasticity of substitution cases. The model recalibrated with a low elasticity of substitution parameter does not match the simultaneous increase in skill premium and college graduate share. However, keeping the relative share of college-graduate immigrants constant in the counterfactual 2008 economy, an 8-8.5 percentage points higher share of college-graduate natives is obtained for high and low values of θ. Although these numbers do not exactly match the 7 percentage points higher college graduate share in the baseline calibration, they are close in magnitude.

Lastly looking at the long-run compensating differentials, when θ=0.401 the welfare loss induced by immigration corresponds to a 4.43 and 5.01 percent permanent reduction in the consumption of natives at the bottom and top of the ability distribution. For θ=0.801 case these losses amount to 3.96 and 3.88 percent permanent consumption reduction for the low and high ability natives, respectively. These results suggest that in both cases immigration generates a loss for natives similar to the baseline calibration.

To sum up, the model recalibrated with a low and high elasticity of substitution parameter yields quantitatively similar impacts of immigration on the skill premium, college education decision and long-run welfare of natives.

4.5 Labor Income Uncertainty

In the current version of the model labor income is deterministic. A possible extension could be incorporating idiosyncratic shocks to the labor income process. In this case an increase in the level of uncertainty from 1980 to 2008 results in higher savings due to precautionary motive hence physical capital in the economy will be higher as well. A larger stock of physical capital implies more premium paid to college-educated workers however through general equilibrium effects the share of natives opting for college education will also rise. The latter effect will offset some part of the increase in skill premium. In equilibrium the model might produce a bigger rise in skill premium between 1980 and 2008 depending on how strongly natives' college education decisions will respond to a larger physical stock in the economy. Slavík and Yazici (2015) explain the rise in U.S. skill premium between 1960's and the 2000's with a model that incorporates a technology-education race model into a standard incomplete markets model. They overestimate the rise in skill premium and their findings suggest that the rise in wage risk explains 9 or 17 percent of this rise depending on the decomposition method. On the other hand technology and the increase in the relative supply of skilled labor (which is exogenous in their setting) explains a bigger bulk corresponding to 84 or 76 percent of the rise.

These results suggest that the uncertainty channel has a less significant impact on the rise of skill premium compared to the technology and education channels. Besides these findings, incorporating an uncertain labor income process is not essential for the current paper because in the counterfactual experiments everything but the immigrant labor force is kept fixed. Therefore even if the model included iid shocks to the labor income process, these shocks would remain at their benchmark 2008 in all counterfactual scenarios.

5 Conclusion

Canada is a country well-known for its selective immigration policy that explicitly targets skilled individuals. Between 1981 and 2008, remarkable changes were observed in the foreign born population of the country. In addition to the significant increase in their relative share among the total population, the country's selective immigration policy attracted many highly educated workers. This paper builds a quantitative life-cycle model to evaluate the impacts of this selective immigration policy on the native population. In particular, I quantify the impacts of targeting skilled individuals and the increase in the relative size of foreign born labor force on the college attainment and the welfare of natives as well as the wage inequality between college graduates and non-college graduates.

The quantitative analysis part evaluates the impacts of immigration by simulating some counterfactual scenarios where the relative size and the skill composition of immigrants are kept at their 1981 levels. The results from these counterfactual exercises show that the immigration flows to the country between 1981 and 2008 discouraged natives from college education. The counterfactual experiments that isolate the impact of the increase in the relative share of immigrants and the shift in their composition towards college graduates reveal that the compositional change in the foreign-born labor force is the main factor leading to a lower level of college graduates among natives. The analysis also suggests that had the size and the skill composition of the immigrant population not changed, the college premium among natives would grow at a 2.15 percentage points slower rate between 1981 and 2008. In other words, immigration generated a 2.15 percentage points additional increase in skill premium during this period. The increase in the relative share of the foreign born labor force is the main driver of this increase.

When evaluating the impacts of immigration on the native population, the natural question to ask is whether natives are better or worse off with immigrants in their country. The answer to this question is given by computing the compensating differentials that make a new-born native individual indifferent between baseline and counterfactual economies in 2008. The results from this analysis shows that natives at both ends as well as the middle of the ability distribution face a loss that amounts to 3.59 to 4.45 percent permanent decline in their consumption because of the size and compositional changes of the immigrant population. Unskilled natives face this loss because labor taxes are higher and unskilled wage rates are lower in the baseline economy. The highest ability individual's reduction in consumption comes out as a result of higher labor taxes. The compositional change of the foreign born population benefits low and median ability individual and generates a very slight loss for the highest ability native. Based on this decomposition, I can argue that the increase in the relative size of immigrants is the key factor generating the welfare loss for natives.

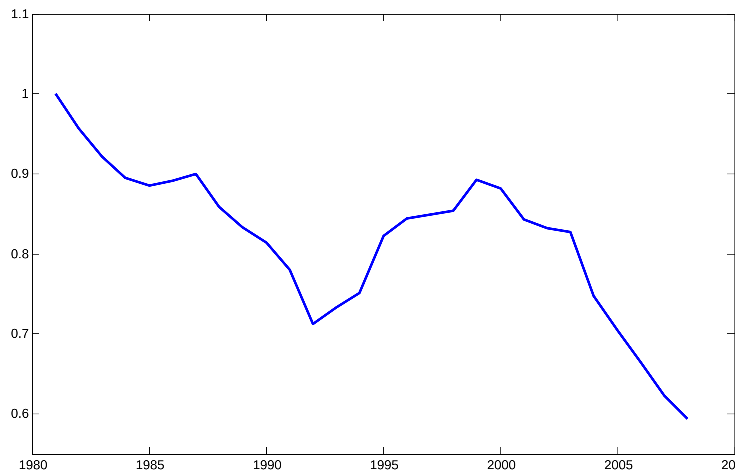

Figure 1: Price of machinery and equipment relative to consumer nondurables. The relative price in 1980 is normalized to 1. Source: *Statistics Canada and Author's Calculation*

	Relative share of immigrants (in %)		College-graduate Immigrants (in %)	
	Canada	U.S.	Canada	U.S.
1981	20	7	12	17
1991	18	9	17	21
2001	28	12	18	25
2008	31	15	30	27

Table 1: Stock of immigrants in Canada. The relative share of immigrants is calculated as a fraction of the total population. The share of college-graduate immigrants is calculated as a fraction of the foreign born population. Sources: Canada - Survey of Consumer Finances (1981, 1991), Survey of Labor and Income Dynamics (2001, 2008) provided by StatCan and Census data (1971,1981,1991,2001) by IPUMS. US - CPS (1981, 1991, 2001, 2008) by IPUMS.

Entry period	Share of College Graduate Immigrants (in %)
1961-1971	14
1971-1981	18
1981-1991	20
1991-2001	36
2000-2008	44

Table 2: Inflows of skilled immigrants to Canada. Units are in percentages. Sources: Canada - Survey of Consumer Finances (1981, 1991), Survey of Labor and Income Dynamics (2001, 2008) provided by StatCan and Census data (1971,1981,1991,2001) by IPUMS. US - CPS (1981, 1991, 2001, 2008) by IPUMS.

	College premium	Share of College Graduates (in %)
1981	0.34	8.6
1991	0.36	13.3
2001	0.39	19.4
2008	0.42	24.4

Table 3: Log wage gap between college graduate and less than college graduate natives and the percentage share of college graduates among natives.

Education group	Log wage ratio
College graduates	0.034
Less than college graduates	0.029

Table 4: Wage gap between natives and immigrants.

Parameter	Moment	Data	Model
$\mu = 0.615$	Share of college graduates among natives	8.60%	9.00%
$\lambda = 0.902$	Capital output ratio	1.4	1.39
$\beta = 0.987$	Interest Rate	4.00%	4.02%
$\nu = 0.15$	College premium	1.41	1.44
$\overline{a}_m^c = 2.002$	Log wage gap-native and immigrants, college graduates	0.03	0.03
$\overline{a}_m^h = 0.867$	Log wage gap-native and immigrants, less than college	0.03	0.03
$g = 0.49\%$	The share of immigrant stock (age≥ 22)	20.00%	20.00%

Table 5: Calibrated parameters and target moments

	2008 economy	
Variable	Model	Data
CG native/total native	21.50%	24.40%
College premium	1.54	1.52
Change in college premium: 1981-2008	6.94%	8.00%

Table 6: Model fit to 2008 Canadian economy

Variable	Benchmark economy	2008 economy under counterfactual scenarios		
	2008	No change in CG share among FB	No change in the size of FB	No change in FB population
Wage ratio- college to non-college	1.19	1.21	1.17	1.18
Share of college graduates among natives	21.50%	28.50%	24.50%	28.50%
Capital per skilled human capital	15.99	16.02	16.00	16.02
Ratio of college to non-college human capital	0.40	0.38	0.43	0.42
Capital output ratio	1.89	1.86	1.94	1.92
College premium	1.54	1.55	1.502	1.509
Interest rate	6.75	6.84	6.55	6.61
Skilled wage	0.90	0.91	0.89	0.898
Unskilled wage	0.755	0.749	0.766	0.762
Tuition	0.0288	0.0281	0.029	0.0286
Tax rate	57.16%	57.47%	55.06%	55.25%

Table 7: Counterfactual experiments: Column 3 is the 2008 economy in which the the relative share of college graduates among the immigrants is the same as in 1981. Column 4 represents the case in which the relative size of the foreign born labor force is kept at its 1981 level and column 5 reports the results for the case in which the foreign born population remains the same as in 1981.

Percentage change in the permanent consumption of natives	
A. No change in college graduate share among immigrants	
Highest ability	-0.037
Median ability	1.19
Lowest ability	1.19
B. No change in the relative size of immigrants	
Highest ability	-3.54
Median ability	-5.14
Lowest ability	-5.14
C. No change in immigrant population	
Highest ability	-3.59
Median ability	-4.45
Lowest ability	-4.45

Table 8: Welfare effects of immigration

	Skill Premium	College Graduate Share
Baseline Calibration		
Benchmark 2008 Economy	1.54	21.5%
Fixed share of skilled immigrants	1.55	28.5%
Fixed size of FB population	1.502	24.5%
No change in FB population	1.509	28.5%
$\theta = 0.401$		
Benchmark 2008 Economy	1.501	8%
Fixed share of skilled immigrants	1.48	16.5%
Fixed size of FB population	1.46	12%
No change in FB population	1.505	16%
$\theta = 0.8$		
Benchmark 2008 Economy	1.59	32.5%
Fixed share of skilled immigrants	1.57	40.5%
Fixed size of FB population	1.58	34.5%
No change in FB population	1.58	38.5%

Table 9: Sensitivity Analysis

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A Appendix

A.1 Data Sources and Construction

Measurement of college graduates and less than college graduates

As mentioned in the paper the data for the initial state in 1980 is extracted from 1981 SCF (Survey of Consumer Finance) and the data for the final state in 2008 is extracted from SLID (Survey of labor and Income Dynamics). 1981 SCF Microdata has a variable called *educ* which indicates the education level of individuals. The education categories available are no schooling or elementary, 9 or 10 years of elementary school 11 years of elementary school 12 years of elementary school, 13 years of elementary school some post secondary , post secondary certificate and university degree. The data set does not provide any information on the years of schooling of individuals therefore I consider individuals with a university degree as college graduates and all the remaining ones as less than college graduates. To keep the definition of a college graduate consistent across two data sets, I also consider the individuals with a bachelor's degree and above as college educated and all individuals below bachelor's degree as less than college graduate. The education variable used to classify individuals is *hleveg*. This variable can have 12 (01-12) different values in 2008 SLID data. A value of 11 indicates that the individual has a bachelor's degree and a value of 12 indicates that the individual has a university certificate above bachelor's degree. So I classify an individual with hleveg≥11 as a college graduate and everyone else as less than college educated.

Measurement of Immigrants

I include individuals aged above 22 in my immigrant population. The variable *immig* gives information about the immigration status of an individual in the 1981 SCF sample. *immig* takes 8 values(1-8) indicating the immigration status of an individual. *immig>1* implies that the individual is immigrant and each value indicates the 10 year interval during which the individual entered Canada. 2008 SLID microdata set has two different variables for the immigrant status of an individual. These two variables are *immst* and *yrimmg*. For immigrants *immst* takes a value of 1 and *yrimmg* gives information about how many years ago the individual came to Canada. To categorize individuals into natives and immigrants, I use the*immst* variable.

Use of sample weights

To find the relative share of each group, I calculate the total weight of the relevant group and find the ratio of this sum to the total weight of the bigger group. The variables which indicate the sample weight of each individual are *revweig* and *wtcsld* in the 1981 SCF and 2008 SLID samples, respectively.

Efficiency units

The efficiency units are calculated for 4 different groups which are college graduate natives and immigrants and less than college graduate natives and immigrants. To calculate the age efficiency units for each group, I follow Krusell et al. (2000) methodology and compute the average value of hourly wages between 1981 and 2008 as efficiency weights for each group at all ages. The sample includes full time full year wage and salary workers aged between 18-65 (22-65 for college graduate natives and immigrants). I also exclude all individuals with an hourly wage below $1. The first step is the calculation of hourly wages for each individual in the sample. 1981-1997 SCF microdata does not provide information about the hourly wages of individuals. However the variable *wagsal* is the total wage and salary earnings of the individual. To find the hourly wages,weekly hours worked (*hrswrk*) and the weeks worked in a given year (*wkswrk*). Having obtained total hours worked, I divide the annual wage and salary earnings by the total hours worked and get the hourly wages. In Krusell et al. (2000) notation, I compute $w_{i,t} = \frac{y_{i,t}}{l_{i,t}}$ where $y_{i,t}$ total annual income and $l_{i,t}$ is the total hours worked by each individual. For the SLID data between 1999 and 2008 has a variable which indicates the hourly wages of an individual so I do not need to make the same calculation for this period. Instead I use the the variable *cmphrw* variable. Having merged all samples, I find the weighted average hourly wage for each group at all ages between 18 and 65. To formulate this weighted average, $w_j^{o,e} = \frac{\sum_i w_{i,j}^{o,e}\mu_i^{o,e}}{\sum_i \mu_{i,j}^{o,e}}$ where i indicates the individual, $j = 18, ..65$ and $o \in \{n, m\}$ $e \in \{c, h\}$. Lastly I normalize the weighted hourly wage of each age, nativity, and skill group by the weighted hourly wage of the age 40 individuals in the same nativity and skill group. So the efficiency weights used in the model are as follows;

$$\varepsilon_j^{o,e} = \frac{w_j^{o,e}}{w_{40}^{o,e}}$$

The following figure illustrates the age efficiency units for the natives.

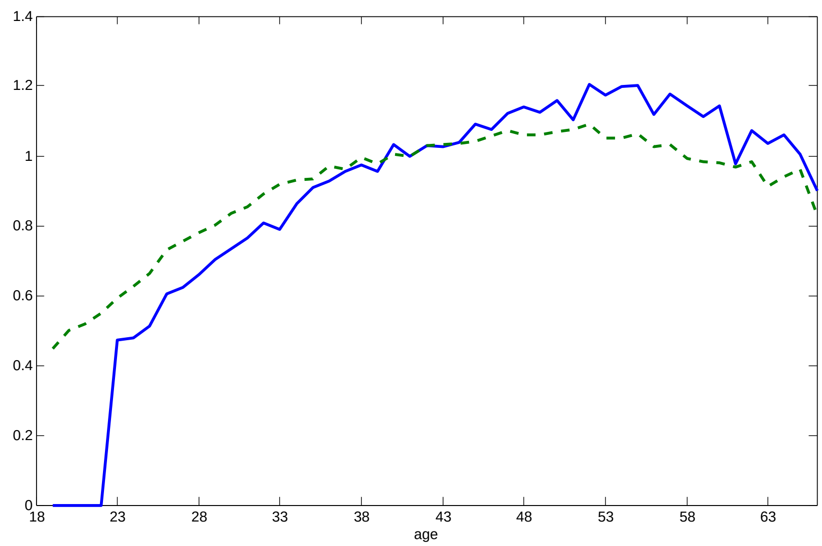

Figure A.1: Age-efficiency units for college graduate and high school graduate natives

Relative price of machinery and equipment

The price of machinery and equipment relative to consumer nondurables illustrated in Figure (1) is calculated using the price index for machinery and equipment and the price index for consumer non-durables available through StatCan. The price index for machinery and equipment between 1980 and 2008 is the combination of two different price index series. The first one covers the period between 1980 and 2005. The source is table 327-0016- machinery and equipment price indexes (MEPI), base year 1986. The second data set covers the period between 1997-2008. The source is the Table 327-0042 Machinery and equipment price indexes (MEPI) base year 1997. The price index for consumer non-durables between 1980 and 2008 is extracted from table 326-0021 CPI 2005 basket with base year 2002. Both machinery and equipment price index series are quarterly therefore as a first step in calculating the relative price of machinery and equipment, I average across quarters in a year to find the annual price index for machinery and equipment. The second step is to form a uniform base year across the three price index series. To achieve that, I normalize the two price series for machinery and equipment by the value of the price index in 2002, and convert the machinery and equipment price indices to base year 2002. To get a machinery and equipment price index which covers the whole period between 1980 and 2008, I combine the two price indices for machinery and equipment. Comparing the common data points (1997-2005) of the two series shows that there is a difference in the levels of the two series. In order to avoid any jumps that may occur in the combined data set, I compute the annual growth rate of the price index for machinery and equipment between years 2005 and 2008. Applying these growth rates to the data points starting from 2005 I extrapolate the price index of machinery and equipment until 2008. The next step is to find the relative price of machinery and equipment. I divide the machinery and equipment price index series by the CPI for consumer nondurables which gives me the relative price of machinery and equipment between 1980 and 2008.

Log hourly wage	1981	1991	2001	2008
education dummy	0.346*	0.36*	0.394*	0.422*
age	0.065	0.078	0.100	0.11
age^2	-0.001	-0.001	-0.001	-0.001
male dummy	0.335	0.270	0.204	0.183

Table A.1: Regression results of log hourly wages on a college education dummy, age, age squared, and a male dummy. * indicates significance at 1 percent

A.2 Computational Algorithm

The computation of stationary equilibrium consists of two nested functions. The outer function starts with an initial guess of the aggregate capital stock and the labor income tax rate and computes their equilibrium levels. The inner function finds the cutoff ability level given an initial guess of a^* . We can explain the algorithm in a more detailed way as follows:

1. Given the parameter values of the model in Table (5), start with an initial guess of the capital stock k_o and the labor income tax rate $\tau_{l,o}$ that clears the government budget.

2. Form a grid of size N for the ability level of natives: To achieve this first create M (M large) observations that are drawn from a log normal distribution with a unit mean and a variance of v. Sort this vector in ascending order. Then take the mean of consecutive (M/N) numbers starting from the first element of the random vector. (i.e. mean of 1st to (M/N)th then (M/N)+1th the to 2*(M/N)th elements and etc. in the random vector.)

3. Compute the population shares of immigrants and natives using Equations (33),

and (35). Then make an initial guess of the threshold ability level a^* and calculate the skilled and unskilled labor using Equations (22) and (23) and the ability vector of size N.

4. Using the initial guess of capital stock, skilled and unskilled labor inputs, compute the prices expressed in Equations (19), (20), and (21).

5. Given prices calculated using the initial guess of the threshold ability level (a^*), check if the lifetime utility of getting college education and remaining as a high-school graduate is equal at this ability level for a native individual. To do this solve the lifetime utility maximization problem of a skilled and unskilled individual at these prices. First start from the last period (J) and guess (k_J). Using the fact that savings in period J (k_{J+1}) are 0, solve the individual's optimization problem backwards using the budget constraints and the Euler equation until period 1 where the individual also starts with zero assets (k_0=0).[25] If the indifference condition in expressed in Equation (9) is satisfied stop, if not update the initial guess for a^* and go back to Step 3.

6. Recalculate prices with the updated labor inputs and solve the value function problem of each type of agent (skilled and unskilled, natives and immigrants) in the economy starting from age J as explained in Step 5 and get the asset holdings at each age j for both education and nativity groups.

7. Using the age-dependent distributions $k^{n,e}_{j,s}(a)$ and $k^{m,e}_{j,s}$ and the age shares $\forall a, j, s, e$, compute the aggregate capital stock in the economy as expressed in Equation (24). Also check the government budget balance expressed in Equation (29). If the initial level of capital k_o is close enough to the computed aggregate capital

[25] We can make use of the Euler equations and solve for optimal consumption and asset profiles directly since there are no borrowing constraints.

stock, and $\tau_{l,o}$ satisfies the budget balance, stop. If not update your guesses k_o and $\tau_{l,o}$ and go back to Step 1.

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