ESSAYS IN MACROECONOMICS AND LABOUR MOBILITY

Ngandjou Kouyem, Doris

A Thesis
in
The Department
of
Economics

Presented in Partial Fulfillment of the Requirements
for the Degree of
Doctor of Philosophy (Economics) at
Montréal, Québec, Canada

November 2024

Concordia University
School of Graduate Studies

This is to certify that the thesis prepared

By: **Ms Ngandjou Kouyem, Doris**
Entitled: **Essays in Macroeconomics and Labour mobility**

and submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy (Economics)

complies with the regulations of this University and meets the accepted standards with respect to originality and quality.
Signed by the Final Examining Committee:

_____ Chair
Dr. Axel Watanabe

_____ External Examiner
Dr. Minjoon Lee

_____ Supervisor
Prof. Paul Gomme

_____ Examiner
Dr. Dambda Lkhagvasuren

_____ Examiner
Dr. Gabrielle Vasey

_____ Examiner
Dr. Panos Margaris

Approved by _____
Dr. Christian Sigouin, Chair
Department of Economics

_____ 2024

_____
Prof. Pascale Sicotte, Dean
Faculty of Arts and Science

Abstract

Essays in Macroeconomics and Labour mobility

Ngandjou Kouyem, Doris, Ph.D.
Concordia University, 2024

This thesis consists of three distinct chapters. The first chapter delves into the effects of tuition hikes on students' choice of majors in the United States. Traditionally, passion, interests, and talents have been the primary factors influencing high school graduates' decisions when choosing a major in college, without much concern for job prospects or the ability to repay student loans. It may be time to reassess this approach. Since the Great Recession, public universities in the United States have experienced a significant increase in tuition fees, leading to notable shifts in students' choice of majors. The STEM (Science, Technology, Engineering, and Mathematics) fields have gained popularity, with the share of STEM degrees awarded rising from 16% in the academic year 2009-10 to 43% in 2015-16, according to the National Center for Education Statistics (NCES). Conversely, the proportion of degrees awarded in the arts and humanities (ARTS) has significantly declined, with a 5% decrease in 2015 compared to the previous year and nearly a 10% decrease from 2012 (Jaschik (2017)). This decline in humanities and liberal arts degrees poses a significant issue for policymakers and universities in the United States, often leading to the discontinuation of certain programs. Building upon the previous work of Ionescu (2009), who examines the effects of financial aid policies on enrollment decisions and default rates, my research focuses on the costs associated with investing in higher education borne by students and optimal decisions in terms of major choices.

The second chapter of my research focuses on estimating the substitutability between public and private consumption in Canada. Using annual data from Statistics Canada, I estimate a model in which the annual data for government and private consumption from the Canada's National Statistical Agency is fitted into a constant elasticity of substitution (CES) consumption function. Through cointegration tests and estimation results, I have identified an Edgeworth complementarity between public

and private spending in Canada, suggesting that they are interdependent and exhibit a close relationship.

The third chapter analyzes interprovincial migration of skilled workers in Canada. It aims at explaining the out-migration of skilled workers in Quebec as skilled workers exodus has a serious impact on the tax revenue and the productivity. Although Quebec attracts students with high ability each year, as it hosts some of the best English-speaking universities in Canada, many of these individuals choose to leave the province after finishing their studies. This exodus is often due to language barriers that hinder their integration into the Quebec labor market. Retaining anglophone graduates in the province after they obtain their diplomas has become one of the most challenging problems faced by the Quebec government over the past decades. Notably, Quebec is the only province that has experienced net out-migration every year since 1963 and it has the highest out-migration. The issue has been a real problem for policy-makers as the province experiences losses through out-migration of its potential skilled workers. This paper shows that the out-migration of skilled workers not only results in a loss of tax revenue but also contributes to Quebec's debt-to-GDP ratio exceeding the recommended 45% threshold set by the International Monetary Fund. To explain Canadian interprovincial migration, I have constructed a model calibrated to Canadian economies and conducted policy simulations to identify effective strategies for retaining skilled workers.

Acknowledgments

I am deeply grateful to the individuals who have contributed to the completion of this thesis, and I would like to express my sincere appreciation to all of them. Their support, guidance, and encouragement have been indispensable throughout this journey.

First and foremost, I would like to extend my gratitude to Professor Paul Gomme for his exceptional guidance and supervision. His expertise, vast knowledge, and unwavering support have been crucial in shaping this thesis. I am also grateful to him for providing financial assistance that enabled me to carry out this research. His mentorship has not only deepened my understanding of economic theory and its practical implications but has also equipped me with essential skills in macroeconomic modeling and programming.

I would like to acknowledge the Department of Economics and its faculty members for the excellent training and the various financial aid packages they have provided. Their commitment to academic excellence has played a crucial role in my professional development. I would also like to express my sincere appreciation to Pr. Effrosyni Diamantoudi, my first Graduate Program Director, and Mrs. Elise Melancon, the former graduate program assistant, for their assistance and support.

I would like to thank Dr. Simplice Aime Nono for his words of encouragement and motivation throughout this project. His insights and feedback have been invaluable in shaping my research.

Lastly, I am deeply grateful to my family, especially my parents Mrs. Ngoualem Jeannette and Mr. Ngandjou Simeon. My late father's belief in me has been a constant source of inspiration, and the support from my family has been the foundation of my journey.

I am truly thankful to all those who have contributed to this thesis in various ways. Their contributions have played a significant role in its successful completion.

Contents

List of Figures

List of Tables

Chapter 1

The impact of rising tuition fees on students' choice of majors

Abstract

While extensive research has explored the relationship between tuition hikes and their impact on private investment in education, it often neglects their influence on students' college major decisions. The choice of a college major is a critical decision for students, significantly shaping their future job prospects and earnings potential due to the specialized knowledge and skills acquired in a specific field of study. This paper aims to address this research gap by analyzing the effects of tuition price hikes on college enrollment decisions and major choices within a heterogeneous agents' model of life-cycle earnings and skill accumulation. Through the examination of these factors, this research seeks to provide insights into how tuition increases, which surpass inflation rates annually, influence the decisions made by high school graduates. The findings of this study reveal that the rising costs of obtaining a college degree are leading some students to choose paths that offer greater financial rewards. The analysis sheds light on the consequences of increasing tuition fees and highlights the economic considerations that impact students' major choices in the face of these escalating costs.

Keywords: Tuition inflation, college, major choice, inequality, student loans, lifecycle.

JEL classification: A22, D31, E31, I26, I24

1.1 Introduction

The rising cost of tuition has become a pressing concern in higher education, prompting students to carefully consider the financial implications of their college choices. One significant factor influencing students' decision-making process is the potential for higher earning associated with certain majors. Scholars, degree seekers,

and families are now critically examining the value and escalating cost of higher education in terms of majors, degree levels, and college choices, as these decisions have a profound impact on students' college success and future incomes (Bengali, Daly, et al., 2014; Carnevale, Cheah, & Strohl, 2013). This critical examination is driven by the fact that policymakers assert their commitment to prioritizing the quality of college education and addressing issues such as low completion rates among four-year degree seekers, improving access for students from low-income backgrounds while ensuring financial stability within the education system.

Since the Great Recession, public universities have raised real tuition by 28% (National Center for Education Statistics (NCES)): majors in Science, Technology, Engineering, and Mathematics (STEM) have gained popularity compared to arts and humanities majors (ARTS). The decline in arts and humanities enrollment is often attributed to various educational policies, including tuition hikes and political criticism of liberal arts (Cowen, 2004; Deb, 2017; Obama, 2014). Additionally, federal funding cuts to liberal arts programs since the 1980s have further contributed to this trend (Molotsky, 1982). Consequently, university officials are currently confronted with such funding challenges, including a decline in demand for ARTS degrees, diminishing enrollment rates leading to substantial budget deficits. They face the challenge of prioritizing between the need for top-notch resources and facilities to boost U.S. innovation competitiveness globally and addressing other crucial aspects of schooling, such as improving general enrollment, research and development, and college affordability, while ensuring the financial stability of their institutions. The University of Wisconsin, in response to a $4.5 million deficit resulting from reduced tuition revenue in arts and humanities departments, has implemented a strategic measure to address the situation. They have made the decision to discontinue 13 majors in the humanities and social sciences. Simultaneously, they have introduced 16 disciplines in high-demand career fields. This restructuring aims to sustain and potentially increase enrollment by aligning the university's offerings with fields that have higher demand and potential for student enrollment. The university's decision reflects their efforts to adapt to changing market demands and financial realities while ensuring the institution's long-term sustainability (Strauss, 2018). The increasing demand for STEM degrees, which are among the most expensive to produce, combined with decreases in state funding and relaxed eligibility criteria for financial aid,[1] are considered the primary reasons for college tuition hikes. When financial aid eligibility expands, it

[1]Since 1992, high-income families' students are allowed to borrow for college (Ionescu, 2009).

provides more students with additional financial resources to cover their educational expenses, including tuition. This increased availability of financial aid has resulted in a higher demand for higher education, subsequently leading to upward pressure on tuition costs. As the cost of a bachelor's degree continues to rise, the demand for ARTS degrees and the individuals who receive them are particularly affected, raising questions about the influence of tuition hikes on students' passion-driven fields and their inclination towards financially lucrative majors. ARTS graduates are facing unfavorable postgraduate outcomes compared to their STEM counterparts. The burden of student loans, unemployment rates, and starting salaries differ significantly between ARTS and STEM graduates. For intance, recent ARTS graduates bear an average student loan debt of $29,400, with an unemployment rate of 5.6% and an average starting salary of $40,020. In contrast, their STEM counterparts start their careers with an average student loan debt of $32,900, with a 3% unemployment rate, and receive an average starting salary of $60,100 (see Digest of Education Statistics 2017, table 505.10).

These statistics prompt questions about the influence of tuition hikes on students' choices. To what extent do real tuition increases contribute to the observed decrease in ARTS enrollment and the rise in STEM enrollment? Is the decline in ARTS degrees the result of the fact that college major choice is becoming a considerable financial investment to (possibly) get a degree (Durante, Larrimore, Park, Tranfaglia, et al., 2017)?[2] To effectively address these issues, a quantitative assessment is required to examine the impact of tuition increases and post-graduation outcomes on college attendance decisions and major choices. To achieve this, I have built a model upon previous work (Ionescu, 2009) and extended it in several ways.

Firstly, I introduced the concept of need-based aid, in addition to merit-based aid, to enable a more comprehensive assessment of students' financial backgrounds in determining the level of tuition each student will pay. These additions to the agent's budget constraint allow to evaluate the role of financial aid in students' enrollment decisions.

Secondly, I considered the influence of individuals' subjective preferences or tastes in their initial characteristics. A passion for a specific career path is reflected in the lower disutility linked to studying and working in that field. It plays a role in determining the amount of time invested in the learning process and the choice of a field. As a result, some individuals may choose not to pursue a college education,

[2] 40% of student do not graduate within 6 years of beginning college (NCES)

even if they meet the admission requirements. This decision is influenced by their significant sense of burden or aversion to studying, as indicated by their personal preferences (taste). This acknowledges that the decision to enroll in college is not solely driven by expected lifetime income and academic achievement but also by personal interests. Financial considerations can often outweigh personal passions or interests, leading students to prioritize fields with higher earning potential like STEM, even if their true interests lie in the ARTS. This imbalance can result in students feeling pressured to make decisions based on financial stability rather than following their genuine passions. By incorporating these factors into the model, it offers a more comprehensive understanding of the dynamics of higher education enrollment and sheds light on potential policy interventions to promote accessibility and align educational choices with individuals' interests.

The findings presented in this paper align consistently with documented facts. The simulation model reveals a notable pattern: as tuition increases, a clear trend emerges in the distribution of enrollments across academic disciplines. Specifically, enrollment in arts and humanities is anticipated to decrease, contrasting with a projected increase in scientific fields. This pattern is attributed to the influence of financial factors on students' decisions regarding their academic pursuits. Exploring policy experiments aimed at increasing college enrollment, the results highlight a narrative. In a "ARTS tuition fees reduction" scenario, a substantial surge in college attendance is anticipated. This surge is characterized by a remarkable increase in arts and humanities enrollment accompanied by a significant decrease in STEM enrollment. These findings shed light on the considerable impact of financial constraints on educational decisions and emphasize the role of individuals' preferences in shaping their educational choices.

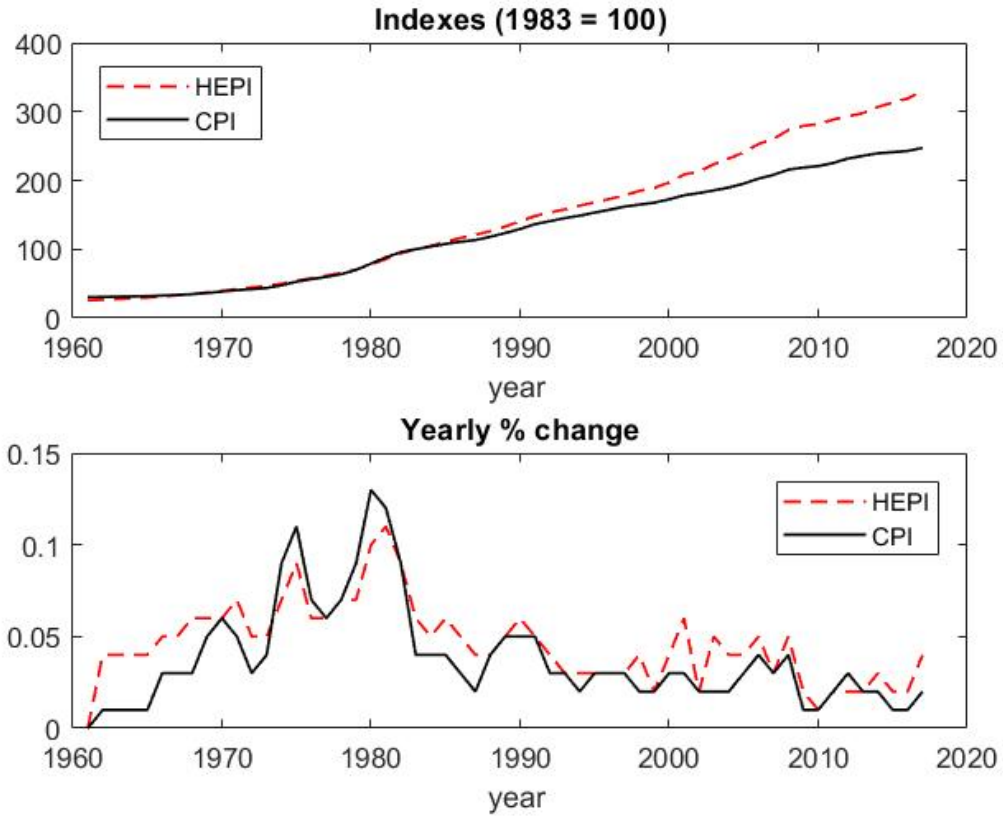
1.1.1 *Supply and demand side in education*

When examining the education sector, it is essential to consider both the supply and demand sides, as they significantly influence the educational landscape.

The Costs of Degree Production in Institutions

The production of degrees involves various costs that institutions need to bear. These costs provide insights into the financial realities faced by universities.

Figure 1.1: College costs inflation versus general inflation

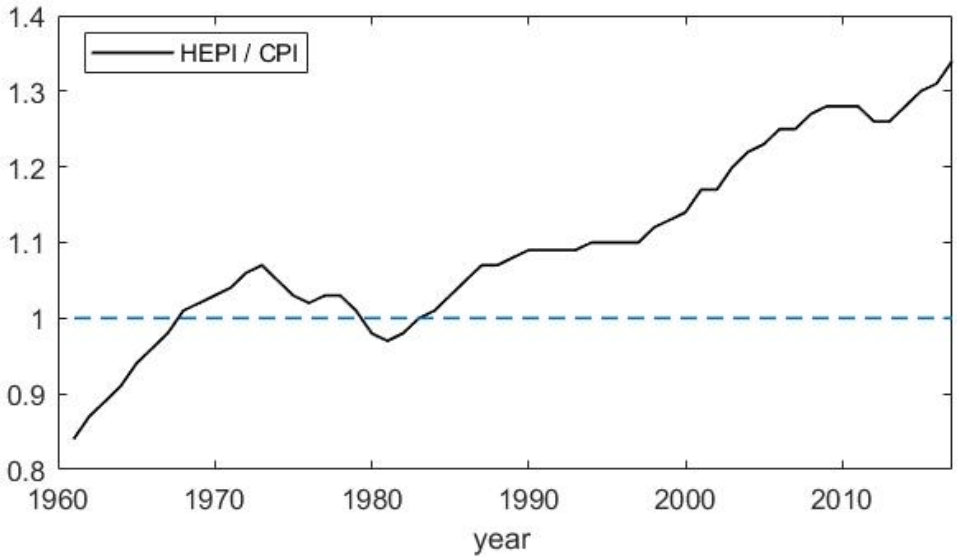


This chart presents the comparison between the general inflation measured by the consumer price index (CPI) and the higher education price index (HEPI). The HEPI is calculated annually by the Commonfund Institute (Halstead, 2007). Both the HEPI and the CPI are calculated using 1983 as the base year.
Sources: Bureau of Labor statistics and the Commundfund Institute.

The various cost pressures, such as faculty salaries, infrastructure maintenance, technological advancements, research funding, and administrative expenses, help universities understand how these rising costs impact their financial situation and enable them to demonstrate how tuition fees align with the actual costs they incur in delivering education. The Higher Education Price Index (HEPI) is an index that reflects the cost changes of a basket of goods and services used by colleges and universities in degree production. When compared to the base year of 1983, the HEPI has consistently increased at a faster rate than the Consumer Price Index (CPI) over the years. The yearly percentage change of the HEPI has consistently exceeded that of the CPI since 1983. Also, the ratio between the two indexes has followed a similar pattern. In 1983, the ratio between the HEPI and the CPI was 1. By 2003, the ratio

had increased to 20.4%, indicating that the cost of producing a degree at colleges and universities had experienced a greater relative increase compared to the overall cost of living. By 2017, the ratio further increased to 34%, indicating their continued divergence.

Figure 1.2: HEPI VS CPI



To construct the HEPI-to-CPI ratio, I divide the two indexes.
Sources: Bureau of Labor statistics and the Commundfund Institute.

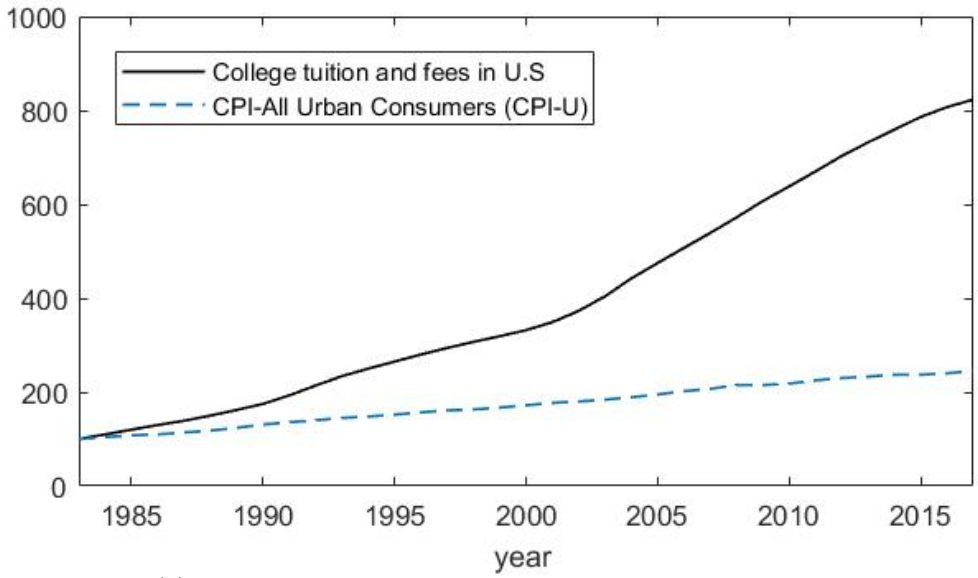
In a nutshell, the costs of operating a university are increasing at a faster rate than consumer prices, leading to a notable rise in the relative cost of providing education. This trend signifies that the expenses associated with higher education have been growing more rapidly compared to general consumer prices. Consequently, colleges and universities face substantial financial challenges in producing degrees. As the expenses involved in delivering a bachelor's degree at four-year institutions continue to rise, universities are compelled to charge students higher tuition fees to offset these costs.

Out-of-pocket expenses of students

College tuition and fees in U.S series refers to the direct expenses that households incur for college education, as measured by the U.S. Bureau of Labor Statistics. This metric captures the annual consumer expenditures associated with obtaining a

degree at colleges. Over time, the costs of college education, based on the out-of-pocket expenses borne by students, have significantly exceeded general inflation in the United States, as measured by the consumer price index (CPI).

Figure 1.3: College tuition inflation vs general U.S. inflation



Source: (1) College tuition and fees in U.S. city average, all urban consumers, Series Id: CUUR0000SEEB01.
(2) CPI-All Urban Consumers (CPI-U) Original Data Value, Series Id: CUUR0000SA0. Base Period: 1982-84=100, Years: 1983 to 2017, U.S. Department of Labor, Bureau of Labor Statistics.

From the early 1980s to 2016, these costs have grown at an annualized rate of 6.67%, which is significantly higher than the annualized rate of general inflation measured by the consumer price index (CPI), which stood at 2.72%. The overall effect over 35 years shows that tuition and costs increased by 8 times, while the Consumer Price Index (CPI) increased by 2.2 times.

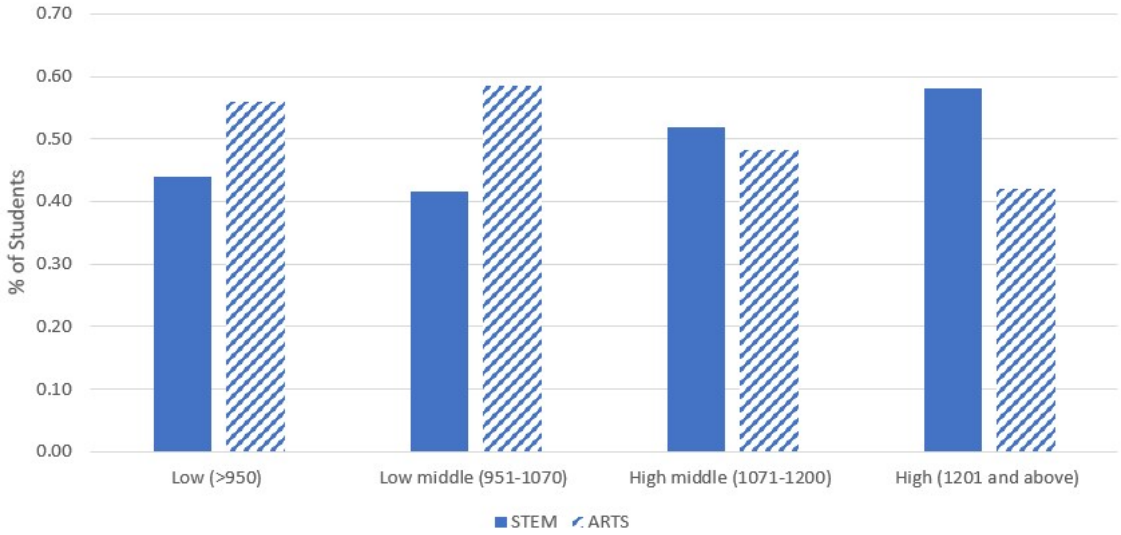
1.1.2 *Some facts*

Fact 1: STEM students tend to have higher Scholastic Aptitude Test (SAT) scores than ARTS students

These scores reflect a combination of verbal and quantitative skills. Previous studies have consistently shown that quantitative abilities are less important for the choice of ARTS majors and verbal abilities to STEM career choice (Turner & Bowen,

1999). However, Figure 1.4 illustrates an interesting fact: a higher proportion of students with high SAT scores are enrolled in STEM fields, while a larger fraction of students with low SAT scores are enrolled in ARTS. A higher concentration of high-performing students in STEM programs is due to the fact that admission to STEM programs frequently depends on attaining high SAT scores. It highlights the relationship between high SAT scores and admission to STEM programs.

Figure 1.4: The Scholastic Aptitude Test (SAT)

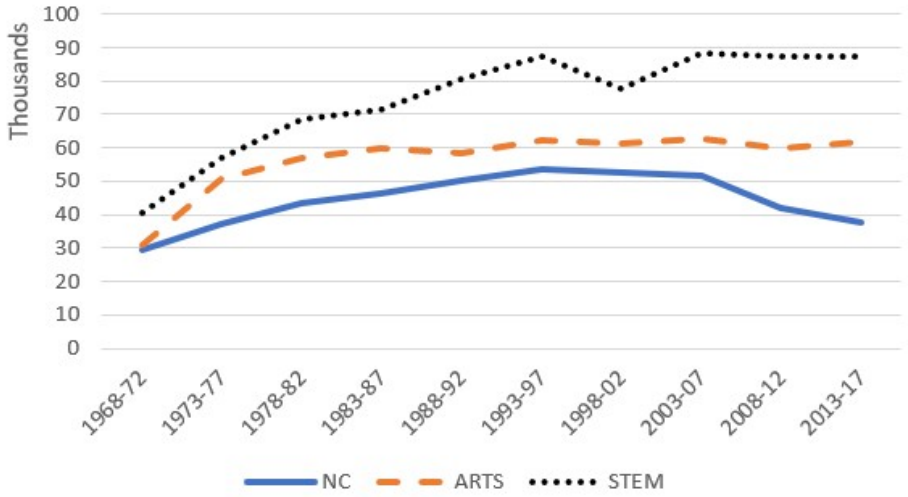


SOURCE: U.S. Department of Education, National Center for Education Statistics, 2008/12 Baccalaureate and Beyond Longitudinal Study (B&B:08/12).

Fact 2: On average, STEM graduates earn more than ARTS students over the life-cycle

Figure 1.5 presents lifetime income trajectories for different categories. Two notable observations can be made. Firstly, as documented in the literature, individuals' income generally increases over their lifespan, indicating that they earn more as they age. However, after reaching middle age, earnings tend to decline. The entry-level income and income growth in STEM fields consistently surpass those in the ARTS and for individuals without a college degree.

Figure 1.5: Mean Income per age (PSID 1968-2017)



Note: The statistics of lifetime earnings by categories are computed using the PSID data from 1968-2017. In PSID, the heads of household are 18 years old in 1968, 19 years old in 1969, 20 years old in 1970, and I follow them until 2017. Real values of earnings are computed using the 1983 CPI. I consider a five-year bin so I can get more observations. The first bin covers the years 1968 to 1972, the second bin covers 1973 to 1977, and so on... I sort the no-college individuals and the college individuals based upon the level of education completed: 12 years for no-college and 16 years for the college graduates. Then I use the variable "B4 work self/otr?' to remove self-employed, entrepreneurs and people out of the labor force. The variable "Field of First Degree" is used to distinguish between graduates in STEM and ARTS fields.
Source: Panel Study of Income Dynamics (PSID), public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI (1997).

This means that individuals who pursue STEM careers tend to have higher starting salaries and experience more significant income growth compared to those in the ARTS or individuals without a college degree.

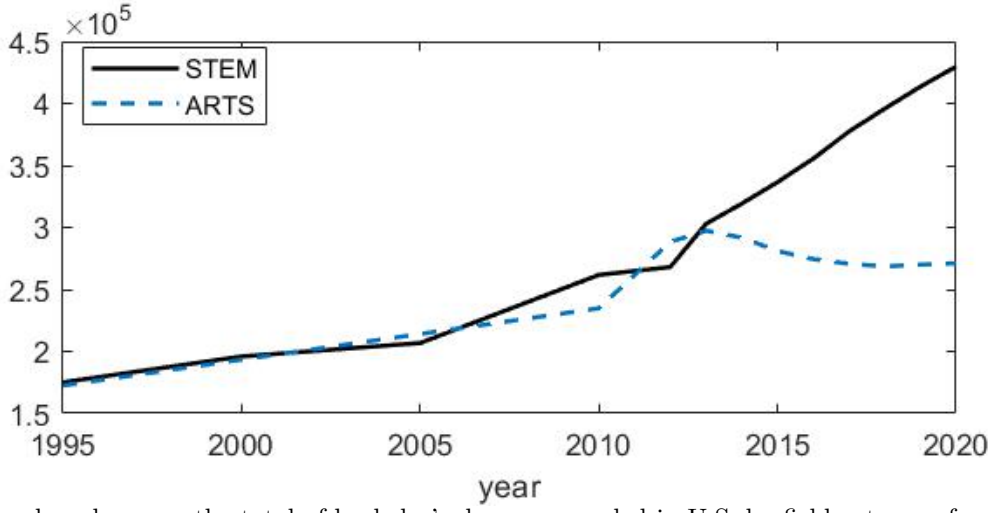
Fact 3: Degree trends

An important policy reform was the 1992 Higher Education Amendment (HEA 1992) which extended federal loans to previously ineligible students from high-income background families. It expanded eligibility to all families with students in college, specified the expected family contribution to studies and increased the total amount of federal funds for which the student might qualify.[3] The HEA 1992 marked the starting point of the rapid rise in the available funds to finance post-secondary education. In

[3]S.1150 - Higher Education Amendments of 1992

the meantime, at public four-year institutions, the in-state tuition and fees increase beyond inflation at an average rate of 3.1% per year (College board 2010-2016). As funds available to finance studies have risen since the above-mentioned amendment, so has the number of degrees awarded in STEM and ARTS as it is shown in fig.1.6.

Figure 1.6: Degree Trends



The numbers here are the total of bachelor's degrees awarded in U.S. by field category from the NCES data. Source: Table 318.20, U.S. Department of Education, National Center for Education Statistics, Projections of Education Statistics.

However, as the number of degrees awarded in STEM continues to rise, the number of degrees awarded in liberal arts and humanities has been declining at an average rate of -2.32% from 2013-14 to 2016-17. The number of degrees awarded in ARTS has decreased by a total of -8.80% since 2013-14 to 2019-2020.

1.1.3 *Related literature*

This research contributes to three interconnected areas of the economics of education literature: college enrollment determinants, major choices, and student aid policies.

Studies on factors influencing college enrollment and major selection often highlight the impact of pecuniary factors on degree attainment and field choice. However, a branch of the literature emphasizes non-pecuniary motives as primary drivers, placing less importance on expected earnings. This branch suggests that perceived enjoyment or personal preference often plays a pivotal role in decisions to pursue

higher education or select a specific major (Abramitzky, Lavy, & Segev, 2024; Arcidiacono, Hotz, Maurel, & Romano, 2020; Long, Goldhaber, & Huntington-Klein, 2015; Wiswall & Zafar, 2021).

The topic of college accessibility has also been a subject of research and policy interest, with notable contributions by Cai and Heathcote (2018) and Caucutt and Kumar (2003). Cai and Heathcote (2018) explore whether college tuition can explain income inequality. They investigate the types of students who enroll in college, the choices of colleges they make, and the tuition they are required to pay. For this purpose, they set a model of the college market in which the ability of students attending a college determines its quality. The positive correlation between the student background (income, ability) and tuition is one of the major results of their paper. Therefore, they conclude that the yearly increase in tuition can explain the greater income inequality observed in the U.S. which will decrease the graduation rate as college is becoming less affordable for students from low-income background. Caucutt and Kumar (2003) analyze the effects of increasing higher education subsidies in the US, on welfare, inequality and efficiency through a dynamic general equilibrium framework. They found that college attractiveness could be guaranteed by a subsidy scheme but the downside of the policy is that it decreases the efficiency of utilization of education resources.

A branch of the literature presents the determinants of college equality of opportunity in terms of financial aid packages intended to ease access to college education (Avery & Hoxby, 2004; Castillo, Collins, & Maynard, 2020; Ionescu, 2009; Nguyen, 2020; Scott-Clayton, 2011). Avery and Hoxby (2004) show how merit-based scholarship influence the college choices of high-aptitude students. They are attracted to those colleges that might be unappealing in the absence of a financial aid packages. Ionescu (2009) built a model to quantify the impact of the student loan policies on college enrollment and default rate. She finds that the combination of human capital stock and ability determine the college enrollment decision while the family contribution to college plays a minimal role on college enrollment. The results of her experiments on student loan policies show that if a new policy allows students to lock in interest rates on student loans, college enrollment will increase significantly because the policy. Locking in interest rates for the duration of the loan not only protects borrowers from future rises in the rate, but it also prevents them from benefiting from future declines.

For another branch of the economics of education literature that my model is part

of, the decision to enroll in college is less important than the decision to choose a field of study as the latter plays an increasingly significant role in shaping inequalities among bachelor's degree recipients (Darvishi, 2023; Davies & Guppy, 1997; Kim, Tamborini, & Sakamoto, 2015; Rumberger & Thomas, 1993). Kim et al. (2015) analyze the trajectories of yearly earnings following over 20 years, the same college graduates and then analyze the long-term effects of college major choices on earnings for U.S. men and women. New evidence is provided by their results, revealing large lifetime earnings gaps across fields of study. They found that income inequalities within a specific level of education (bachelor's degree) is becoming more important than inequalities across different levels of education in determining labor market outcomes over lifetime. In Davies and Guppy (1997), agents' decisions about the amount to invest in college and the choice of the fields is the reflection of their expectations of financial rewards in the labour market. According to Rumberger and Thomas (1993), family background, abilities, personal preferences, and expected earnings significantly influence the choice of college major. Darvishi (2023) paper examines how students decide on their college majors, particularly between STEM and ARTS fields, and whether educational policies that encourage high school graduates to pursue college influence their choice of major. STEM and ARTS are chosen as representative fields with distinct returns on educational investment and wage premiums, offering insight into how economic incentives affect students' academic and career decisions. To analyze this, the paper employs a heterogeneous life-cycle human capital model, solved with dynamic programming and calibrated to PSID data, to assess college students' characteristics and advantages. The findings reveal that college students typically have stronger learning abilities, which allow for more effective human capital accumulation. This learning advantage translates into higher skill prices and enhanced career prospects. Consequently, college students, especially those in STEM, achieve better wage, income, and consumption trajectories than those who do not attend college.

However, scholars have often neglected the effects of yearly changes in tuition on students' choice of majors. Unlike what is done in the literature, my model captures not only the monetary but also the non-monetary returns to education by allowing agents' passion or interests in a particular field to determine the growth of their human capital. In addition my model seeks to explain the income inequalities within a particular education level, namely the bachelor degrees recipients. To the best of my knowledge, this research paper represents the first attempt to address this

issue through a model that incorporates both pecuniary and non-pecuniary factors influencing college concentration and dropout behavior. Previous literature on the return to education has often focused primarily on the financial benefits of investing in human capital, considering non-monetary returns as insignificant or negligible.

1.2 Model Economy

The model is built on Ionescu (2009)'s life-cycle economy. The economy is populated by heterogeneous individuals who live for a finite number of periods J. In their lifetime, they can study and/or work and they retire after j_R age. A model period j equals to 5 years. Individuals are heterogeneous in their learning ability (a), initial assets, which include family contribution to college (x), their taste for a particular field of study (θ) their human capital (h) and their age. In period $j = 1$, students have to decide whether they want to further their studies or not, based upon their academic profile. If they decide to go to college, they must choose their field of study. Here, individuals who choose the no-college (NC) path go straight to the labor market and those who choose the college path must pick a major between ARTS (A) and STEM (S) given their financial background, their assets and their passion.

1.2.1 *Individuals*

Life starts upon high school graduation. Each period, individuals derive utility from consumption c_j given their taste θ_i.

$$\sum_{j=1}^{J} \beta^j u(c_j, s_j, n_j; \theta_i) \qquad i \in \{NC, A, S\} \tag{1}$$

The functional form of u is given by

$$u(c_j, s_j, n_j; \theta_i) = \ln c_j - \theta_i \frac{(s_j + n_j)^{1+\frac{1}{\kappa}}}{1+\frac{1}{\kappa}} \tag{2}$$

where κ is the constant Frisch labor supply elasticity, n and s respectively refer to the working and study time. θ_i captures the taste for a particular field which could be the reflection of agent's interests, passion, traditional perceptions of gender roles and identities. A passion for a specific path is reflected in a low disutility of studying and working in a field. It indicates that the person finds studying and working in that

field less burdensome and more enjoyable due to their genuine interest and passion.

The high school graduate problem

All decisions are made by high school graduates independently of their parents. At the beginning of life $j = 1$ which is the first period after high school graduation, they must decide whether or not they want to invest in their human capital (h_1) and if they decide to further their studies, they must choose a major. As in Ionescu (2009) the technology for human capital accumulation is given by

$$h_{j+1} = a(h_j s_j^i)^\alpha + (1 - \delta^i)h_j, \quad \alpha \in (0, 1) \tag{3}$$

Colleges assess the eligibility of individuals interested in college education based on their learning ability and their income level. The heterogeneity in ability and assets plays a role in determining the tuition paid by each individual in college. Students may be eligible for scholarships based on their academic achievements and performance $t(a)$ as well as grants based on their income background $g_r(x)$. College costs, after deducting scholarships and grants, is denoted as $f(a, x)$=tuition + living expenses - grant - scholarship. To simplify the model, I'll just refer to the colleges costs as $f(a, x)$.

In order to finance their studies, students can apply for a student loan $d_1(x)$ provided by the federal government, up to a maximum amount $\bar{d}(x)$ which covers the cost of college education minus their initial assets or parental contribution to their studies x_1. This loan is specifically allocated for educational expenses and cannot be used for other purposes.

$$d_1(x) = f(a, x) - x_1 \qquad d_1(x) \in D = [0, \bar{d}(x)] \tag{4}$$

Students can allocate a portion of their time to engage in market work n_1, where they earn a salary $w_1 h_1 n_1$, given by the product of the time spent working n_1 and the rental rate w_1 of their human capital h_1. The price of individuals' skills grows at a rate of g, and skill price growth depends on the chosen career path. Therefore, individuals' budget constraint is given by

$$c_1 + If(a, x) + x_1 = (1 + g_1)w_1 h_1 n_1 + Id_1(x) \tag{5}$$

$$I = \begin{cases} 0 \text{ for No-colleges} \\ 1 \text{ for Colleges} \end{cases} \tag{6}$$

for the first period of their life and by

$$c_j + x_{j+1} + Ip_j = w_j h_j n_j + x_j(1+r) \tag{7}$$

for the subsequent periods. From graduation until retirement ($j = 2, ..., j_R$), individuals work and earn an income $w_j h_j n_j$. They use a portion of that income, along with the return on riskless assets $(1+r)x_j$, to consume c_j, save x_{j+1}, and repay their student debt according to an exogenous repayment schedule p_j, similar to the income consolidation payment schedule outlined in Ionescu (2009),

$$p = I\lambda w_j h_j n_j \qquad j = \{1, ..., 4\} \tag{8}$$

where λ represents the fixed portion of income under the 20-year repayment plan of the Income-Based Repayment (IBR) program, as outlined on the StudentAid website. The problem is formulated within a dynamic programming framework, where a terminal condition is established with J representing the final period of an individual's life. After this terminal period, denoted as $J+1$, the value function $V(x, h, J+1; a, \theta) \geq 0$, reflecting that individuals are not required to fully deplete their assets, thereby allowing for the possibility that $x \geq 0$. The problem is solved backward, following the approach commonly used in the literature. Starting from the last period of individuals' lives and moving backward up to the retirement age, individuals do not engage in work or study.
for $j = J \rightarrow j_R$

$$V(x, h, j; a, \theta)^i = \max_{x'} \left[ln[x(1+r) - x'] + \beta V(x', h', j+1; a, \theta)^i \right] \tag{9}$$

$$x \geq 0, \quad i \in \{NC, A, S\}$$

for $j = j_R \rightarrow 2$ individuals work, save and those who have opted for college path start repaying p their student loan. Additionally, individuals continue to allocate time

to human capital accumulation.

$$V(x,h,d,j;a,\theta)^i = \max_{c,n,s,h',x'} \left[\ln c - \theta_i \frac{(s_j+n_j)^{1+\frac{1}{\kappa}}}{1+\frac{1}{\kappa}} + \beta V(x',h',d',j+1;a,\theta)^i \right] \quad (10)$$

subject to (3), (6), (7) and (8).
for $j = 1$

$$V(x,h,d,j;a,\theta)^i = \max_{c,n,s,h',x'} \left[\ln c - \theta_i \frac{(s_j+n_j)^{1+\frac{1}{\kappa}}}{1+\frac{1}{\kappa}} + \beta V(x',h',d',j+1;a,\theta)^i \right] \quad (11)$$

subject to (3), (4), (5) and (6).

The policy functions $c^\star(x,h,d,j;a,\theta)^i$, $h^\star(x,h,d,j;a,\theta)^i$, $s^\star(x,h,d,j;a,\theta)^i$, $n^\star(x,h,d,j;a,\theta)^i$ $x'^\star(x,h,d,j;a,\theta)^i$ represent the optimal choices of consumption, human capital investment, study time, work time, and next period assets for each career path, respectively. After solving the individual problem for each potential career path, the next step is to solve for career choice.

The education / major choice decision

The education decision takes place at the beginning of the lifecycle $j = 1$. Students choose a path (fields) based upon their abilities, their assets and their taste for the field of studies. Each profile type sees the wage growth over their life cycle before making the human capital accumulation decision. The decision rule to further college education and to choose a field of study is based upon the more rewarding value function of the three mutually exclusive choices.

$$V^*(x,h,d,j;a,\theta) = \underset{i\in\{NC,A,S\}}{\text{argmax}} \{V(x,h,d,j;a,\theta)^i\} \quad (12)$$

In other words, an individual will choose to attend college if

$$\begin{aligned} &V(x,h,d,j;a,\theta)^A > V(x,h,d,j;a,\theta)^{NC} or \\ &V(x,h,d,j;a,\theta)^S > V(x,h,d,j;a,\theta)^{NC} \end{aligned} \quad (13)$$

Conditional on attending college, an individual will choose ARTS if

$$V(x,h,d,j;a,\theta)^A > V(x,h,d,j;a,\theta)^S \quad (14)$$

These choices are important as they cannot change them over their lifecycle.

1.2.2 *Calibration*

The parametrization process of the model economy is discussed in this section: I first assume a set of fixed parameters that are standard in the literature and the remaining parameters are calibrated so that the model will display features of the PSID earnings growth and levels of the 3 groups of interest.

1.2.3 *Parameters*

The model has 10 periods and each period accounts for 5 years, so that the college period is 1, the retirement age j_R is 8 and the last age J is 10. In other words, a high school graduate will be 25 years old at college graduation, 65 years old at retirement and 75 years old at the end of their lives. The annual discount factor to 1.011 (Ríos-Rull, 1996).

Grants are awarded to students who demonstrate enough financial need. In 2016, according to the studentaid.gov website, the maximum Pell Grant eligible expected family contribution $\bar{x}$ for the 2016-2017 award year was \$5,234, and the maximum Pell Grant amount $\bar{g_r}(x)$ was \$5,815. This amount covered approximately 31% of college costs. If an individual's expected family contribution (EFC) exceeds $\bar{x}$, they are not eligible for a Pell Grant, so their grant amount is 0. If their EFC is less than or equal to $\bar{x}$, they qualify for a Pell Grant. $\bar{x}$ is set to 0.5, and the grid for x is set to [0.19, 1.5], such that $\bar{x} - x$ =0.5 - 0.19=0.31. This implies that the maximum grant amount covers 31% of college costs.

$$g_r(x) = \begin{cases} 0 & \textbf{if } x > \bar{x} \\ (\bar{x} - x) & \textbf{if } x \leq \bar{x} \end{cases} \tag{15}$$

According to the NCES data the tuition, fees, room and board in college is \$19,189 and 12% of students got a scholarship over the past years from their institution which represented about 33% of the full college costs. In the simulation, I have identified 12% of individuals with the highest abilities. Each of these high-ability individuals with the ability above the average a_{avg} was awarded an additional resource to cover their expenses. The maximum scholarship provided to them is 33% of the full college costs, depending on the abilities of each individual. a_{avg} is set to 1.27, and the grid

for a is set to [0, 1.6)

$$t(a) = \begin{cases} 0 & \textbf{if } a \leq a_{avg} \\ (a - a_{\text{avg}}) & \textbf{if } a > a_{avg} \end{cases} \tag{16}$$

Students leave college with not only their diploma but also a student loan which can be from 0% up to 100% of their full college costs.

1.2.4 *Human capital*

The dataset employed in this study is derived from the Panel Study of Income Dynamics (PSID), which has collected annual interviews from households and families since 1968. As the longest continuous panel dataset in the United States, the PSID was created specifically to monitor changes in income over time, making it highly suitable for this study's objectives. First, I uniquely identify individuals in the sample so that I can track them throughout their lifecycle. The dataset is declared as a panel using a variable that uniquely identifies individuals and a year variable that indicates time periods. The heads of households in this dataset were 18 years old in 1968, 19 years old in 1969, 20 years old in 1970, and so forth. Subsequently, self-employed individuals, entrepreneurs, and those not in the labor force are excluded from the analysis. Individuals are further categorized based on their educational attainment: no-college agents (high school graduates completing 12 grades) and college agents (completing 16 grades). In the PSID sample, there are 230 individuals who graduated from high school. Among these, 50 individuals also hold a college degree. Throughout the analysis, I use sampling weights to make sure that the PSID sample accurately reflects the broader U.S. population. This method helps to ensure that the data remains representative over time, thereby strengthening the reliability of the study's results. I analyze the annual income of heads of households across different education groups spanning from 1968 to 2017. To calculate real earnings, I adjust for inflation using the 1983 Consumer Price Index (CPI). Individuals who graduated (16 grades) with degrees in fields such as Engineering, Drafting, Computer Programming, Electrical, Mechanical, and Health-related fields (e.g. nursing, medical office assistants, pharmacist assistants) are categorized as STEM. Those who graduated in fields such as Art, Music, Drama, Dance, Foreign Language, Religion, Advertising, Photography, and Cosmetology are categorized as ARTS.

The next step is to compute change in real annual income for the three categories.

One can notice that the wage curve increases during early career and tends to stabilize during mid-career through an average growth rate. Real income as in Huggett, Ventura, and Yaron (2006) can be expressed as

$$E_j = w_j h_j n_j \tag{17}$$

This paper closely follows the approach taken in the lifecycle literature by assuming time-invariant initial human capital and number of hours worked for all college graduates (Ionescu, 2009). Therefore earnings of college graduates at time t:

$$E_{c,t} = \sum_{j=1}^{j_R} w_{t+j} h_j n_j \tag{18}$$

where w_{t+j} is the skill price paid to a person who is j years old at time t. This skill price w_{t+j} grows exogenously over time. The payment of this skill price to a person of age j may vary depending on the time period. The equation sums across all agents in the economy. The stationarity assumption mentioned in Ionescu (2009) suggests that there is no time index t for either human capital or hours worked. This means that these factors remain constant over time, implying that individuals' human capital and hours worked do not change as time progresses. Therefore at time $t+1$, the earnings of all college graduates is given by :

$$E_{c,t+1} = \sum_{j=1}^{j_R} w_{t+j+1} h_j n_j \tag{19}$$

which can be rewritten as

$$E_{c,t+1} = (1+g_c) \sum_{j=1}^{j_R} w_{t+j} h_j n_j \tag{20}$$

Therefore, changes in earnings at time t are solely determined by the growth in skill price g_c. Combining eq.18 with eq. 20 yields

$$E_{c,t+1} = (1+g_c) E_{c,t} \tag{21}$$

for college graduates and by

$$E_{nc,t+1} = (1 + g_{nc})E_{nc,t} \tag{22}$$

for no-college individuals.

Earnings by career path are used to infer the growth in skill prices over time. To achieve this, I compute the change in real annual income, denoted as g, which represents the mean arithmetic growth rate of earnings from t to $t+1$. This calculation provides insights into how the value of different skill sets evolves, reflecting broader economic trends and shifts in the labor market. Given this growth, I get an estimate of the human capital depreciation rates by looking at earnings late in life, so that the model generates the rate at which average real earnings decrease at the end of the working career.

Table 1.1: Parameter Values

symbol	Name	Value	Target/Source
β	Discount factor	$(1.011)^5$	Ríos-Rull (1996)
r	gross interest rate	$(1.04)^5$	Ionescu (2009)
α	Production function elasticity	0.7	Ionescu (2009)
κ	Frisch elasticity	0.4	Reichling and Whalen (2012)
σ	Risk aversion coef.	2	Ionescu (2009)
J	Model periods	10	1 period is 5 years
$gr(x)$	Grants (as % of net tuition)	$[0, 0.31]$	Studentaid
$t(a)$	Scholarship (as % of net tuition)	$[0, 0.33]$	Ionescu (2009)
g_{nc}, g_A, g_S	Skill prices growth	$(0.00134)^5, (0.00347)^5, (0.00532)^5$	Average growth rate PSID
$\delta_{nc}, \delta_A, \delta_S$	Depreciation rate	$(0.0471)^5, (0.0219)^5, (0.0497)^5$	decrease at end of life-cycle PSID
λ	Income-Based Repay. (as % of E)	0.1	U.S. Gov. Accountability Office

The average annual growth rates are $(0.00134), (0.00347), (0.00532)$ for no-college, ARTS, and STEM college graduates, respectively. This calculation enables me to determine the average annual wage decay rate towards the end of individuals' careers in the cross-sectional distributions: 0.0471 for those without a college degree, 0.0219 for ARTS college graduates, and 0.0497 for STEM graduates.

Initial assets (parental contribution to college), human capital and ability grids are chosen so that the model will replicate the college enrollment and the distribution of people who borrow to finance their studies. The ability grid, consisting of m points, is selected to correspond to SAT overall scores $a \in [0, \bar{a})$. Similarly, the human capital grid also comprises m points, with $\bar{h}$ denoting the maximum level of human capital. Additionally, the time choice variables grids and assets consist of m points.

Taste or preference in the model is characterized by two values each for STEM $\{\theta_S^l \ ; \ \theta_S^h\}$ and ARTS $\{\theta_A^l \ ; \ \theta_A^h\}$, while the preference for the no-college path θ_N is held

constant.

Given that θ in the model is used with Frisch preferences and the sign in front of θ is negative, I assigned the following values to: $\theta_N = 0.2, \quad \theta_A^l = 0.5, \quad \theta_A^h = 0.1, \quad \theta_S^l = 0.3, \quad \theta_S^h = 0.05$. These values represent the preferences associated with different career paths in the model. They will influence the decision of individuals regarding their educational and career choices based on their perceived disutilities associated with each path. Therefore individuals $(\theta_N, \theta_A^l, \theta_S^l) = (0.2, 0.5, 0.3) \rightarrow NC$ are more likely to choose the No-college path. Those with $(\theta_N, \theta_A^h, \theta_S^l) = (0.2, 0.1, 0.3) \rightarrow ARTS$. Finally profiles $(\theta_N, \theta_A^l, \theta_S^h) = (0.2, 0.5, 0.05)$ and $(\theta_N, \theta_A^h, \theta_S^h) = (0.2, 0.1, 0.05) \rightarrow STEM$. The probabilities are calibrated using data from NCES, where the enrollment rate is 68.1%, implying that the share of individuals not attending college (No-college) is 31.9%. The values assigned to the probabilities values are $P(\theta_N, \theta_A^l, \theta_S^l) = 0.319$, $P(\theta_N, \theta_A^h, \theta_S^l) = 0.251$. The sum of $P(\theta_N, \theta_A^l, \theta_S^h)$ and $P(\theta_N, \theta_A^h, \theta_S^h) = 0.43$ refers to the combined probability of individuals choosing the STEM path under two different sets of conditions (theta values). This sum represents the overall likelihood of individuals opting for STEM across these specific scenarios as modeled.

Table 1.2: θ combinations

Fields	θ **combinations**	θ **values**	**Probabilities**
NC	$(\theta_N, \theta_A^l, \theta_S^l)$	(0.2, 0.5, 0.3)	0.319
ARTS	$(\theta_N, \theta_A^h, \theta_S^l)$	(0.2, 0.1, 0.3)	0.251
STEM	$(\theta_N, \theta_A^l, \theta_S^h)$	(0.2, 0.5, 0.05)	0.430
	$(\theta_N, \theta_A^h, \theta_S^h)$	(0.2, 0.1, 0.05)	

From those grid points and using the appropriate parameters values, the optimal choice of education path is chosen so is the stream of income for each profile type and for the three groups. Determining the education decision path allows the model to solve for the optimal debt given individual profile type. To do so I compute the "sticker price" or tuition that colleges will charge each individual by profile type. Two financial aid packages are considered in this step: grants $gr(x)$ (need-based aid) and scholarship (merit-based aid) $t(a)$. The model identifies low-income background students eligible for grants and high ability students eligible for scholarships. Then it subtracts the value of the aid packages to the average tuition fees that each student has to pay. Those who do not qualify for scholarships and/or grants can apply for student loans to cover their full college costs. The model determines the level of debt for eligible students.

1.2.5 *Distribution of ability and human capital*

Using the parameters in Table 1.1, I solve for agents' education decision and I restrict the ability and human capital to be normally distributed. Following the approach in Ionescu (2009), I determine a set of parameters

$$\gamma = (\mu_a, \sigma_a, \mu_h, \sigma_h, , \mu_x, \sigma_x, \rho_{ah}, \rho_{xh}, \rho_{xa}, \rho_{a\theta}, \rho_{x\theta}, \rho_{a\theta})$$

to characterize the distribution of the benchmark model. Here, μ and σ refer to the mean and standard deviation, respectively, and ρ denotes the correlation. This set of parameters minimizes the discrepancy between the model and the empirical data by solving the following minimization problem:

$$\min_{\gamma} \sum_{j=2}^{J} \left(|log(m_j/m_j(\gamma))|^2 + |log(g_j/g_j(\gamma))|^2 \right) \tag{23}$$

where m_j and g_j are the empirical data points. $m_j(\gamma)$, $g_j(\gamma)$ are the model predictions based on the parameter set γ. I found a positive correlation between the ability and human capital of 0.7932 for all groups in the model. However, I found no correlation between taste and ability/human capital, nor between assets and ability/human capital. As stated before, in the model, individuals may exhibit different combinations of assets and human capital or abilities. Some individuals are situated at the higher end of the assets distribution but possess low human capital or abilities and vice-versa. Others have both high assets and high human capital or ability. This aligns with Ionescu (2009), where wealth does not determine the decision to attend college. Instead, it is the combination of human capital and ability that drives individuals to pursue higher education. Even if an individual receives significant financial support from their parents for college, if they fall below the threshold of learning ability required for enrollment, additional funds will have no impact on their decision to enroll, she thinks.

Additionally, I found no correlation between tastes and abilities either. For example, in my calibration, some individuals have a strong preference for STEM fields but limited learning abilities. Conversely, some individuals may have both a strong preference for STEM subjects and high learning abilities. This disparity arises due to different combinations of taste and ability or human capital, and different combinations of assets and ability or human capital, and different combinations of assets

and taste to represent all the possible student profiles observed. The fit of the model is evaluated in sections 1.3.3 and 1.3.4.

1.3 Results

1.3.1 *Benchmark economy*

In this section, I discuss the quantitative results of the model economy. Table 1.3 assess the performance of the model economy at $j = 1$ with respect to the data. Overall, the model closely replicates the data moments, mostly the enrollment rate of individuals aged 16 to 24 who graduated from high school.

Table 1.3: Targets: Data and Model

	Data (2016)	Model
Enrollment rate	0.698	0.695
Percentage of people borrowing for college	69	70
Fraction of ARTS entrants (as % of total enrollments)	0.403	0.371
Fraction of STEM entrants (as % of total enrollments)	0.597	0.629

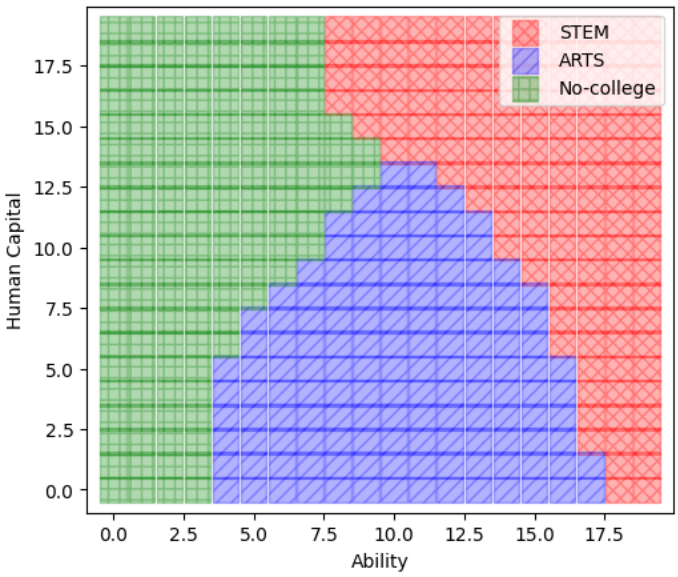
The model predicts a fraction of 0.371 of ARTS entrants, while the observed fraction in the data is 0.403. This suggests that the model underestimates the proportion of ARTS entrants. Conversely, the model predicts a higher fraction 0.629 of STEM entrants compared to the observed fraction of 0.597. This indicates that the model overestimates to some extend the proportion of STEM entrants. The model forecasts that 70% of individuals will borrow money for college, closely aligning with the 69% observed in actual data. This indicates that the model effectively captures borrowing behavior related to college education.

1.3.2 *Initial distribution*

The model generates three value functions for each individual, based on their theta combinations. At each grid point, the individual's problem is solved three times: once for their taste value for No-College (NC), once for their taste value for ARTS, and once for their taste value for STEM. Each individual then compares their three value functions and chooses the most rewarding option. The initial states (a and h) of the resulting value function are illustrated in the following figure. Individuals

choosing STEM are marked in red, those opting for NC are marked in green, and those following the ARTS path are marked in blue.

Figure 1.7: Initial distribution



This distribution reflects various combinations of an individual's initial states, which ultimately shape the educational paths individuals may pursue, thereby highlighting differences in skill levels and educational attainment. In fig. 1.7, individuals with low learning ability and high human capital choose not to further their studies because they perceive that the additional investment in education will not yield significant returns in terms of increased earnings, especially since they already possess a high level of human capital. They have sufficient knowledge and expertise to succeed in their chosen field without the need for further education. Additionally, the opportunity cost (significant time and financial investment) of further studies against potential benefits is too high, and thus pursuing other opportunities, such as gaining work experience or starting a career, is more advantageous. Those with low learning ability and low human capital also see the additional investment in education as a waste of time and financial resources due to their low learning ability. Furthermore, some individuals have personal preferences, that align more closely with entering the workforce or pursuing alternative paths rather than continuing formal education.

The line separating NC and ARTS (oriented from South-West to North-East) indicates that as individuals' ability increase, they are more likely to choose ARTS over not attending college. This boundary reflects the increasing returns to education

as ability improves, making ARTS a viable option for those with moderate levels of both. Thus, individuals with "medium" ability and up to "medium" human capital are more likely to choose ARTS that align with their abilities and interests. Their moderate ability and human capital make ARTS education a suitable balance between the cost of education and potential future earnings. These individuals perceive ARTS education as providing a good return on investment given their specific skills and initial human capital endowment. Their unique combinations of abilities and human capital are better suited to artistic or creative fields than technical or scientific disciplines. They are motivated to pursue careers that allow them to express their creativity and fulfill their artistic aspirations.

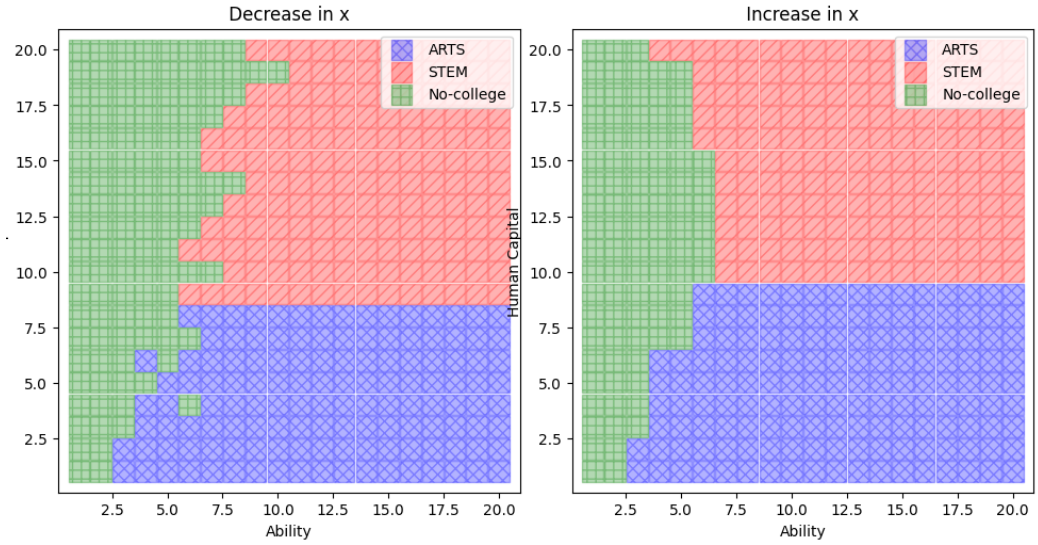
The line between ARTS and STEM education choices shows that individuals with higher levels of human capital and/or ability are more likely to choose STEM fields. This division suggests that STEM fields require higher initial human capital and/or ability, likely due to the more demanding nature of these disciplines and the higher potential returns on investment in STEM education. As a result, people who have a strong aptitude for learning but limited human capital tend to see the pursuit of further education, particularly in STEM fields, as a wise investment. They perceive it as a strategic investment that can unlock the lucrative career paths associated with STEM occupations. They recognize that dedicating more time and resources to their education can lead to substantial future earnings. In essence, they view education as a means to enhance their skill set and open up lucrative career opportunities that align with their aptitude for learning. Recognizing the limitations posed by their current level of human capital, they view college as an avenue to further develop their skills and knowledge. Through higher education, they aim to acquire specialized expertise, broaden their understanding of STEM disciplines, and ultimately strengthen their position in the job market. Individuals with higher initial levels of human capital and ability tend to gravitate towards careers in STEM fields, capitalizing on their strong proficiency and taste in these subjects. Their advantageous starting point affords them greater access to educational pathways that align with their skills and interests, thereby amplifying their potential for future earnings.

The line separating NC and STEM, and the absence of ARTS choices in between, indicate that the model captures a threshold where ARTS education becomes optimal for individuals within a specific range of ability and human capital. For those outside this range, choosing either no college or STEM education becomes a more economically rational decision. This phenomenon is influenced by the varying returns to

education in different fields.

The initial distribution enables asset simulation (see figure 1.8). When assets are high, fewer individuals opt for the No-College (NC) path. This shift suggests that higher assets increase access or inclination towards pursuing higher education. The increase in overall enrollment rates in this model experiment suggests that higher assets facilitate greater participation in educational pursuits. When financial barriers are reduced, individuals are more motivated to invest in education. However, there is not a significant difference between the proportions of individuals choosing ARTS versus STEM.

Figure 1.8: Change in assets and enrollment trends



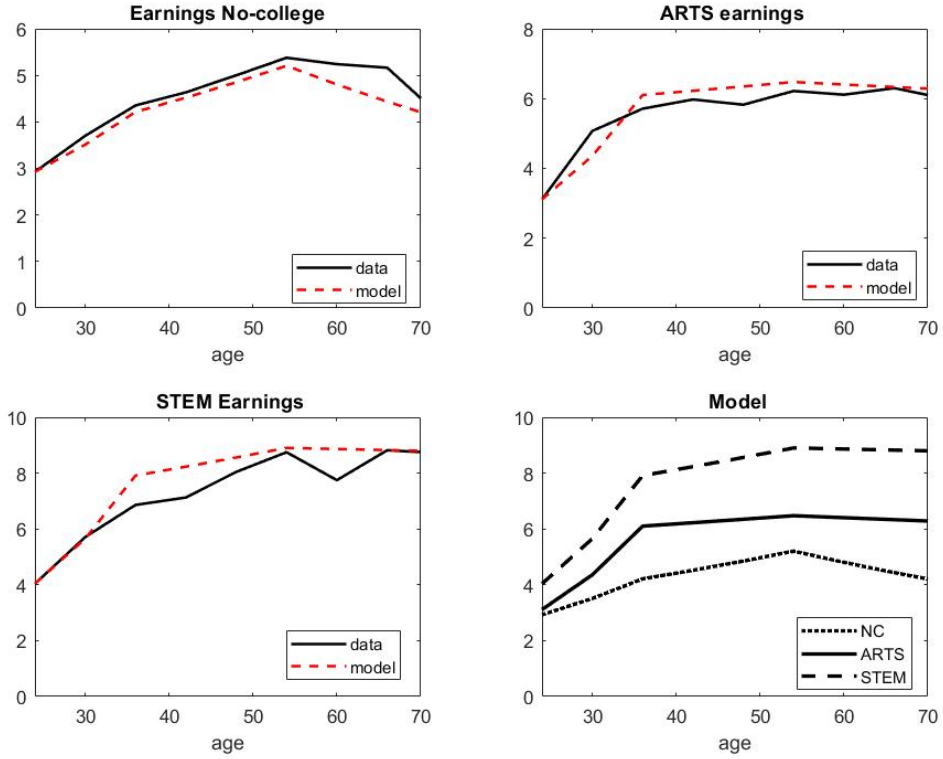
On the other hand, when assets are low, it is observed that more individuals opt for the No-College (NC) path. This phenomenon suggests that limited assets may restrict access or inclination towards pursuing higher education since individuals face financial barriers. However, it's worth noting that there is a significant difference between the proportions of individuals choosing ARTS versus STEM. People tend to gravitate more toward STEM fields than ARTS because STEM education is seen as a more direct path to higher salaries.

1.3.3 *The life-cycle earnings*

The section explores a comparative analysis between the model's outcomes and real-world data, specifically focusing on individuals' income levels and growth. This

evaluation serves to identify any similarities or disparities and evaluating the model's ability to capture the characteristics of the real economy.

Figure 1.9: Age-earnings profile in PSID versus in the model



(Source: Panel Study of Income Dynamics (PSID), public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI (1997). Note: The Chi-squared calculated as the difference between observed and expected values from the model is less than the critical value at 1% with 1 *df*. Thus, the difference between the expected and observed samples is not statistically significant. The model fits the data.)

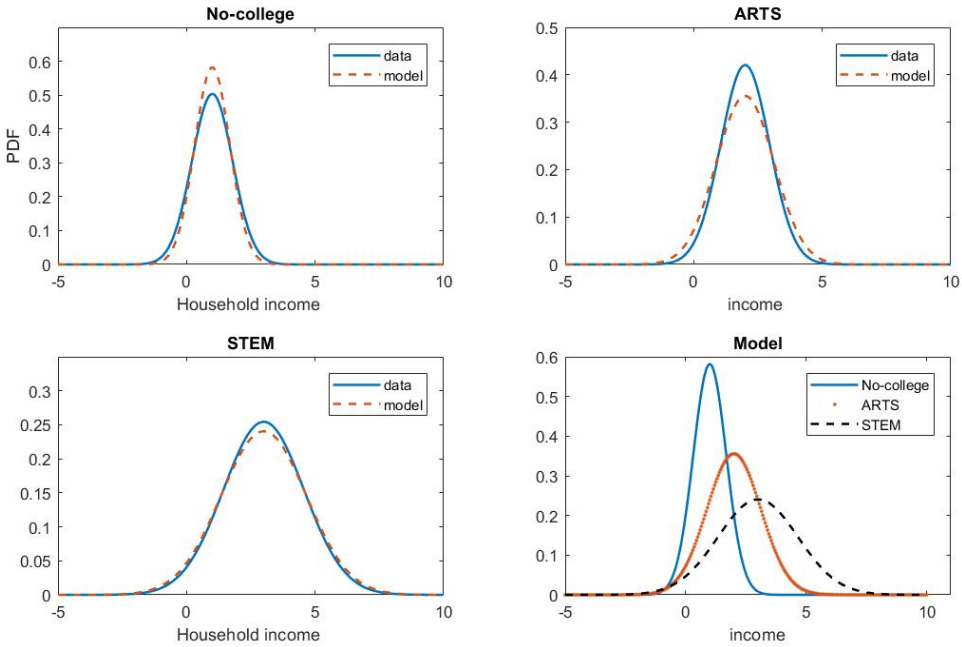
The model demonstrates good performance in replicating the life-cycle earnings profiles. The figures presented in three panels of figure 1.9 illustrate the initial earning levels immediately after graduating from college, as well as the earnings trajectories over the life cycle for three distinct categories. The panels serve as a valuable tool for understanding how the model captures the dynamics of earnings for different categories. One noteworthy observation is that although graduates in the ARTS start their careers with lower salaries compared to STEM graduates, they typically earn higher salaries than those who choose not to pursue further education. As they advance in their careers, the rate of earnings growth for ARTS graduates tends to

decelerate compared to that of STEM graduates. This underscores the differential earning patterns between ARTS and STEM graduates throughout their careers, shedding light on the long-term dynamics of wage growth in these fields. Additionally, the results highlight a consistent disparity in earnings between high school graduates and college graduates over the life-cycle, with high school graduates consistently earning lower incomes compared to those who have obtained a college degree. This disparity in the model is attributed to the varying income growth trajectories across different career paths. This further reinforces the importance of higher education in attaining higher earnings potential throughout one's working life.

1.3.4 *Individuals income distribution versus data*

Fig. 1.10 presents the distribution of the model versus the data. Overall, the model fits well the data by construction.

Figure 1.10: Individual income distribution in PSID versus in the model ($j = 2$)



The following chart presents the distribution function of the three categories of agents. To construct the distribution, I simulated a probability distribution object by specifying parameter values γ of the model.

Table 1.4: γ parameters

Parameters	$No-college$		$ARTS$		$STEM$	
	μ	σ	μ	σ	μ	σ
Data	4.4433	0.7924	5.6312	0.9485	7.4447	1.5679
Model	4.2340	0.6858	5.5865	1.1223	7.3812	1.6593

After the school period, STEM agents, on average, have the highest income, followed by ARTS agents, and then the no-college agents. The dispersion in income, which follows the same ranking, provides an additional perspective to describe inequality within each group. The distribution of STEM graduates is more dispersed than the other two categories for several reasons. Unlike the no-college individuals, who generally have similar earnings within their group, the income spread among STEM graduates reflects the income inequality observed in the data. This suggests that factors beyond a college degree play a significant role in determining their income. In this model, variations in agents' abilities and human capital contribute to the observed differences in income. This result is consistent with the literature where productivity and idiosyncratic shocks are said to generate the disparity among STEM graduates over their lifetime (Xu, 2015).

1.4 Policy experiments

This section discusses policy simulations conducted within the model economy. These simulations involve implementing various policy scenarios to observe their potential effects on the three groups of economic agents of interest. The discussion primarily focuses on the outcomes of these policy experiments, offering insights into the potential implications and trade-offs associated with different policy choices. The calibrated model serves as a valuable benchmark for evaluating and comparing outcomes resulting from different policies on students' choices. In this context, two policies are of particular interest and concern for policymakers: the effects of tuition hikes and ARTS tuition fees reduction.

1.4.1 *Increase in tuition*

This section outlines the policy experiments carried out on the benchmark economy. Once again, these policy experiments are done to quantify the effects of tuition and financial support on high school graduate's decision to attend college at $j = 1$. The reason behind this choice lies in the fact that enrollment decision occurs in the first period when the education decision is made. That's why college dropout rate and other variables affecting the graduation rates are not considered here. In-state tuition and fees at public four-year institutions experienced an average annual increase of 3.5% above inflation between 2006 and 2016. This is compared to a 3.9% increase between 1986 and 1996 and a 4.2% increase between 1996 and 2006, as stated in the College Board's Trends in College Pricing 2016.

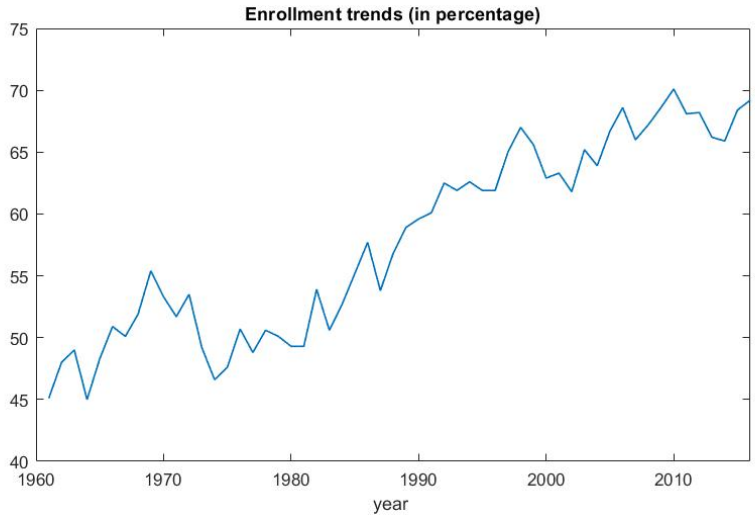
Table 1.5: Enrollment and Tuition Increase

Year	**Enrollment (%)**	**Tuition Increase (%)**
2006-2016	67.86	3.50
1996-2006	64.72	4.20
1986-1996	59.79	3.90

Source: CollegeBoard - Trends in College Pricing 2016.
NCES Table 302.10. Recent high school completers and their enrollment in college, by sex and level of institution: 1960 through 2018.

Meanwhile enrollment generally increased between 1986 and 2016 (see figure 1.11).

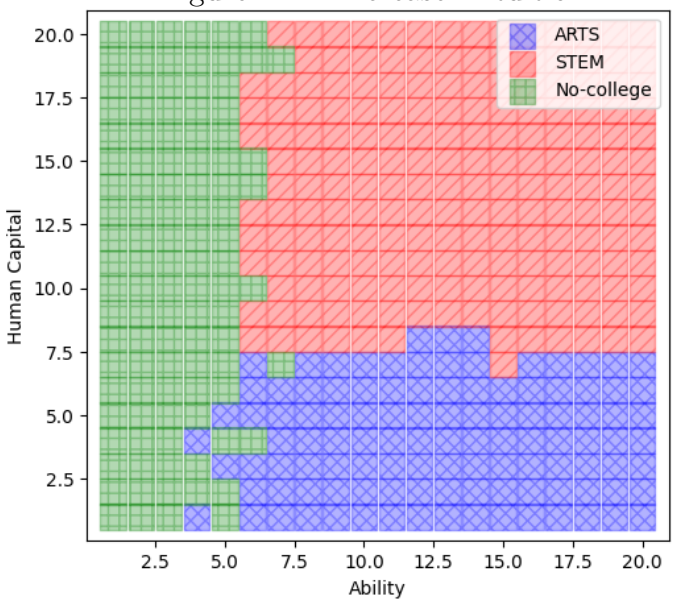
Figure 1.11: Enrollment trends



Source: NCES Table 302.10. Recent high school completers and their enrollment in college, by sex and level of institution: 1960 through 2018.

The total undergraduate enrollment in public four-year institutions peaked in 2010 and has since experienced fluctuations. The average yearly change in enrollment across the entire period from 2006 to 2016 was 0.06%. In the experiment (1) for instance, when policymakers increase tuition by 3.5% there is a subsequent decrease in enrollment in the Humanities and Arts fields by 2.3% and the STEM degrees demand increase by 5.7%. In addition, 0.5% of NC people will choose to enroll in college.

Figure 1.12: Increase in tuition



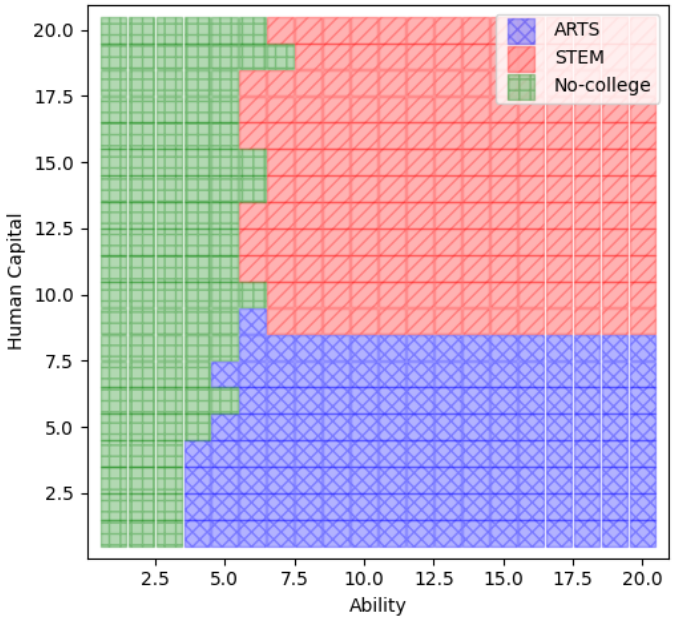
These results indicate that the increase in tuition leads to a shift in enrollment preferences as shown in figure 1.12 . As tuition fees increase, the demand of degrees diminishes in the ARTS fields, making STEM fields more attractive. This shift can be explained through the lens of taste or preferences. Some individuals (with high taste in ARTS, medium human capital and abilities) perceive the higher cost of education as a more significant investment, and thus, they re-evaluate their preferences and choose fields that associated with higher financial returns, such as STEM. They are fully aware of the initial levels and growth patterns of salaries throughout their life cycle. They prioritize their future consumption and income, which are influenced by their educational path. Students opting for STEM fields aim to maximize the benefits of their educational investment, particularly in terms of financial returns. Some individuals with high taste in ARTS and moderate abilities and low human capital choose the NC path. For those individuals the investment is not worth it.

These findings highlight the sensitivity of enrollment decisions to changes in tuition costs within the model. Overall, this experiment demonstrates how tuition hikes impact enrollment patterns and major choice decisions, highlighting the relationship between financial considerations and educational choices within the model's framework.

1.4.2 *ARTS tuition fees reduction*

The reduction in ARTS tuition fees primarily impacts individuals who are on the margin between choosing No-College and pursuing higher education in ARTS as shown in figure 1.13. It demonstrates the change of demand for ARTS education in response to changes in tuition costs.

Figure 1.13: ARTS tuition fees reduction



Conversely, those committed to STEM fields are less influenced by the cost of ARTS education, underscoring the different motivators and preferences driving their choices. A reduction in ARTS tuition fees leads to a decrease in the proportion of individuals choosing the NC path. Lower tuition fees for ARTS education reduce financial barriers, making higher education more accessible. Individuals who previously considered college unaffordable may now see ARTS education as a viable option. The affordability of ARTS education becomes a compelling factor, drawing more students

to these fields. This trend highlights that many students have a genuine interest or taste for ARTS but are deterred by high costs. By lowering tuition fees, the perceived value of ARTS education increases relative to its cost, making it an attractive option for students with varying levels of human capital and abilities. These students may see ARTS education as a worthwhile investment in their future, now that the financial burden is reduced. The reduction in ARTS tuition fees does not significantly affect the proportion of individuals choosing STEM fields. Students who opt for STEM fields are primarily driven by factors other than tuition costs, such as their high human capital, abilities, and the high financial returns associated with STEM careers. This suggests that even if ARTS education becomes more affordable, the inherent appeal and perceived value of STEM fields remain strong for these individuals. They are motivated by the higher potential salaries and career opportunities in STEM, which outweigh the reduced costs of ARTS education.

1.5 Conclusion

I built a lifecycle model of heterogeneous agents calibrated to fit the enrollment decisions and earnings distribution of U.S. no-college and college agents. The goal was to quantify the importance of tuition costs in explaining their education decisions. The model was consistent with a wide set of calibration targets on education distribution and subsequent income distribution. The model suggested that family income background, human capital, and academic ability affected high school graduate decisions to enroll in college. The model reveals that as tuition fees increase, the demand for ARTS degrees diminishes, while STEM fields become more attractive. This shift is primarily driven by individuals re-evaluating their preferences and prioritizing fields with higher financial returns, given the higher costs of education. Students with ARTS taste, medium human capital, and abilities tend to gravitate towards STEM fields to maximize the benefits of their educational investment, particularly in terms of financial returns. The ARTS fees reduction experiment has decreased the proportion of individuals choosing the NC path, making higher education more accessible and reducing financial barriers, although it did not significantly affect the proportion of individuals choosing STEM fields. Enrollment in ARTS fields increases, demonstrating that many students have a genuine interest in ARTS but are deterred by high costs. The affordability of ARTS education becomes a compelling factor, drawing more students to these fields.

Chapter 2

Substitutability between private and public consumption: the case of Canada

One branch of fiscal literature examines the substitutability between public and nondurable private consumption expenditures and its quantitative implications for policy decisions. This paper contributes to this field by shedding light on the nature of the relationship between private and public consumption in Canada. It estimates a model in which annual data for government and private consumption from Canada's national statistical agency are fitted into a two-good permanent-income model. The intertemporal elasticity of substitution between private and public consumption in Canada is examined using a generalized method of moments. The estimation results suggest that, for plausible values of the intratemporal elasticity, public and private spending in Canada exhibit an Edgeworth complementarity.

Keywords: Public goods, Private goods, National Government Expenditures
JEL classification: H41, H50

2.1 Introduction

How does private consumption respond to changes in government expenditures in Canada? What is the degree of substitutability between government and private consumption in the country? The answers to these questions hinge on the elasticity of substitution parameters, a crucial factor influencing the impact on economic

growth. In Canada, public spending is distributed between federal and provincial governments, with ongoing financial support from the Canadian government to assist in program and service provision at territorial and provincial levels. The efficacy of fiscal policy can be gauged by examining the relationship between public and private consumption. The impact of government consumption rests on whether it increases or decreases the marginal utility of private consumption, determining whether government and private consumption act as Edgeworth-Pareto complements or substitutes. In economic terms, two goods are considered Edgeworth substitutes if the marginal utility of one diminishes as the quantity of the other increases, while they are complements if the reverse holds true, as established in the literature.

Over recent decades, the response of private consumption to fluctuations in government expenditures has drawn a great deal of researchers' attention (Aiyagari, Christiano, & Eichenbaum, 1992; R. Amano & Wirjanto, 1994). The main impact of an expansionary (contractionary) fiscal policy is to increase (decrease) the aggregate demand and thus positively (negatively) affects output. However, a consensus among scholars and policymakers on how public spending precisely influences private spending remains elusive. The extent to which government expenditures on goods and services impact aggregate economic activity remains a subject of debate in both econometric and economic literature. In the econometric realm, Ahmed (1986) analyzes the effects of government spending on the UK economy in an intertemporal substitution model. The estimation of these effects shows a significant degree of interaction between public and private consumption. He found that public spending crowds out private spending. In the economic theory literature, Aiyagari et al. (1992), argue that an increase in public expenditures leads to a decrease in private consumption, reinforcing the concept of crowding out. The argument presented by Aiyagari et al. (1992) underscores the potential consequences of crowding out, suggesting that the government's increased demand for funds may limit the availability of financial resources for private entities. Meanwhile, Devereux, Head, and Lapham (1996) posit that an elevation in public expenditures results in an endogenous increase in total factor productivity.

The goal of this paper is to determine the empirical relationship between the two types of aggregate consumption in Canada's economy. To analyze this relationship, I study the case of Canada. Most studies have tested this relationship by focusing on the *intratemporal* (across goods and within a period) elasticity of substitution. This paper updates and adds a new dimension to this category of research by estimating

the parameter values of both the *intertemporal* (across time) and the *intratemporal* (across goods and within a period) elasticity of substitution. The results of this study show that public and private consumption in Canada display a strong Edgeworth complementarity.

The rest of the paper is organized as follows: section 2.2 discusses the relevant fiscal policy literature, section 2.3 details the empirical strategy, section 2.3.4 presents and discusses the results, and section 2.4 is dedicated to the conclusion.

2.2 Literature review

Estimating the substitutability between public and private consumption has gained an interest in the fiscal literature and in policy environment, with significant contributions by Dawood and Francois (2018). Their paper studies the empirical relationship between private and public consumption in a panel of 24 African countries by following Ogaki (1992)'s approach. Their pooled results, when combined with plausible values for the relevant intertemporal elasticity, imply that public and private consumption are Edgeworth substitutes in African economies. Those results have some policy implications. For example, many African countries face fiscal consolidation as foreign aid supports a substantial share of their public spending, making them vulnerable to reductions in aid-financed public spending. Therefore, Dawood and Francois (2018) conclude that countries facing fiscal consolidation can expect private consumption to offset cuts in government spending.

Esteve and Sanchis-Llopis (2005) highlight the consumption patterns of Spain's economy from 1960 to 2003. They update previous studies by addressing the question of whether the relationship between private and public consumption is stable over time, or exhibits a structural break, allowing the instability to happen at a point in time. Their findings show the existence of a long-run relationship between the two types of expenditures. The estimated elasticities of substitution between government and private consumption in Spain suggest that they are Edgeworth-Pareto substitutes.

Public and private consumption expenditures for the six Australian states, in a panel framework, are examined by Brown and Wells (2008) to determine the elasticity of substitution between them. They found an intratemporal elasticity of substitution of 0.17 by performing cointegration tests and by using the panel unit root tests. By combining this estimated value with values for the intertemporal elasticity of substitution, they concluded that the two variables in Australia are complements. Similarly,

Katsaitis (1987) examined whether there is any substitutability between government spending and private consumption expenditures in Canada through a life-cycle/rational expectations model. He found that for Canada, the two types of consumptions are best described as complements. The findings suggest that public expenditures substitute poorly for private consumption expenditures. Therefore, temporary increases in public spending will result in an expansion of real output.

2.3 Empirical analysis

The empirical analysis of this paper closely follows R. A. Amano and Wirjanto (1998)'s approach. The representative consumer lifetime utility of aggregate consumption $C_t(c_t, g_t)$ at time $t = 0$ is given by

$$U(C) = u(c, g) \tag{24}$$

where E_t and $\beta \in (0, 1)$ are respectively the expectations operator and the discount factor. Consider the functional form of $u(C_t)$ is

$$U(C_t) = \begin{cases} \frac{C_t^{1-\gamma}}{1-\gamma}; & \frac{1}{\gamma} > 0 \text{ and } \frac{1}{\gamma} \neq 1 \\ ln\big[C_t\big]; & \frac{1}{\gamma} = 1 \end{cases} \tag{25}$$

The intraperiod utility of the consumption aggregator $C_t(c_t, g_t)$ is concave and is a function of the real government consumption g_t and the real private expenditures c_t at time t. Thus,

$$C_t = \begin{cases} \left[\phi c_t^{1-\alpha} + (1-\phi) g_t^{1-\alpha}\right]^{1/1-\alpha}; & \frac{1}{\alpha} > 0 \text{ and } \frac{1}{\alpha} \neq 1 \\ c_t^{\phi} g_t^{1-\phi}; & \frac{1}{\alpha} = 1 \rightarrow \alpha = 1 \end{cases} \tag{26}$$

The preference parameter $\phi \in [0, 1]$ represents the relative weight assigned to private goods. $\frac{1}{\alpha}$ represents the intratemporal (across goods and within a period) elasticity of substitution between private c_t and public consumption g_t and $\frac{1}{\gamma}$ gives the intertemporal (across time) elasticity of substitution for the consumption aggregate. If the intertemporal elasticity of substitution is less (greater) than the intratemporal elasticity of substitution, then private and public consumption are Edgeworth substitutes (complements). Changes in public expenditures have no impact on the marginal utility of private consumption if the two preference parameters are equal.

The representative consumer lifetime utility of consumption is subject to the period-by-period budget constraint:

$$p_t^c c_t + T_t + (1+r)^{-1} A_{t+1} = Y_t + A_t \tag{27}$$

where r is a time invariant real interest rate, A_t is real financial assets net real public debt at the beginning of period t.

The government budget constraint is given by

$$T_t = p_t^g g_t \tag{28}$$

p_t^g and p_t^c refer respectively to government and private consumption prices. The benevolent planner's problem can be solved as follow

$$E_t \sum_{t=0}^{\infty} [\beta^t u(c_t, g_t) + \mu_t \{Y_t + A_t - p_t^c c_t - p_t^g g_t - A_{t+1}(1+r_t)^{-1}\}] \tag{29}$$

where μ_t is the Lagrange multiplier. The necessary first-order conditions are given by

$$c_t : \frac{u_1(c_t, g_t)}{p_t^c} = \mu_t \tag{30}$$

$$g_t : u_2(c_t, g_t) = \mu_t p_t^g \tag{31}$$

$$A_{t+1} : -\mu_t (1+r_t)^{-1} + E_t(\mu_{t+1}) = 0 \tag{32}$$

$$A_{t+1} : \frac{u_1(c_t, g_t)}{p_t^c} = E_t[\beta(1+r)\frac{u_1(c_{t+1}, g_{t+1})}{p_{t+1}^c} \tag{33}$$

Intratemporal First-Order Condition

In the first step, a static first-order condition and the optimal consumption bundle are found by equating the marginal rate of substitution (MRS) between government and private consumption and the ratio of prices $\frac{p_t^g}{p_t^c}$:

$$\frac{\partial u / \partial g}{\partial u / \partial c} \equiv \frac{p_t^g}{p_t^c} = \frac{(1-\phi) g_t^{-\alpha}}{\phi c_t^{-\alpha}} \tag{34}$$

An estimate of $\frac{1}{\alpha}$ can be done by taking logs in equation (34) and by rearranging

one can obtain the equation below.

$$ln\left[\frac{p_t^g}{p_t^c}\right] = \mu + \alpha\ ln\left[\frac{c_t}{g_t}\right] + v_t \tag{35}$$

In eq. 35, $\mu = ln\left(\frac{1-\phi}{\phi}\right)$ is the constant term and v_t is the error term. $ln(c_t/g_t)$ and $ln(p_t^g/p_t^c)$ refer respectively to the logarithm of the ratio of private to public consumption and the logarithm of the relevant inverse price ratio.

Intertemporal First-Order Condition

If one expresses the gross return on assets as R_{t+1} and rearranges eq. 33, then the intertemporal first order condition for the typical household choosing consumption optimally is given by

$$E_t\beta\Big[\frac{u_1(c_{t+1}, g_{t+1})}{u_1(c_t, g_t)}.\frac{p_t^c}{p_{t+1}^c}\Big]R_{t+1} = 1 \tag{36}$$

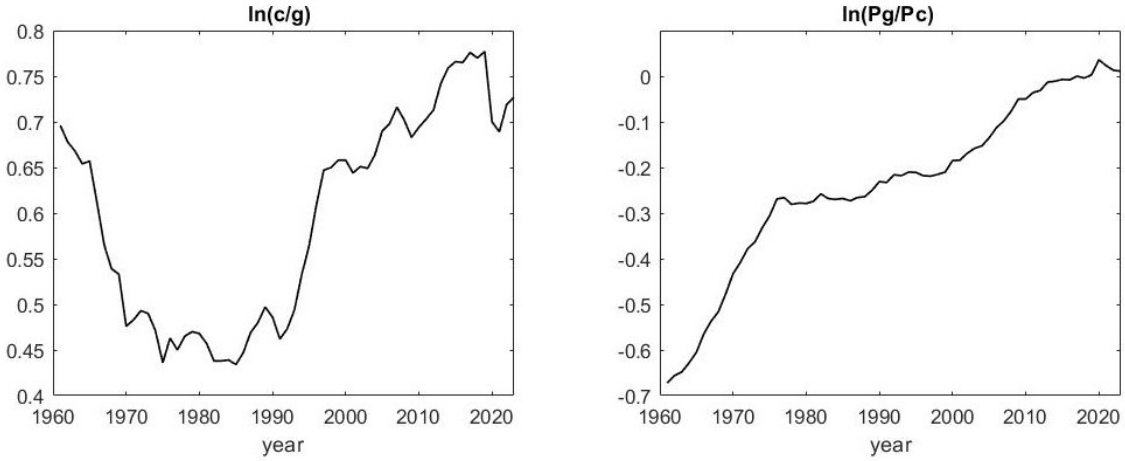
In the second step, the estimation of the discount factor β and the intertemporal elasticity of substitution $\frac{1}{\gamma}$ is done by plugging the estimate of $\frac{1}{\alpha}$ and ϕ in the Euler's equation (36). Then the Euler's equation is estimated by the Generalized Methods of Moments (GMM) procedure (Hansen, 1982).

2.3.1 *Data*

The study relies on data from Statistics Canada. The private and public consumption series are seasonally adjusted in 2017 constant dollars, with the consumption series found in table 36-10-0123-011 and their implicit price deflators identified in table 36-10-0106-01 (2017=100).

As a measure of the variable c_t/g_t, real household consumption of nondurable goods and services is divided by real government consumption expenditure. The variable p^g/p^c can be obtained by dividing the implicit price deflators of public and nondurable private goods and services respectively. These Statistics Canada series cover a period from 1961Q1 to 2023Q3. The below graph shows the log of the ratio of the two consumptions and the log of their relative prices.

Figure 2.1: Log transformation of c/g and p^g/p^c



$ln(c/g)$ is constructed by dividing the log of private real household consumption of nondurable goods and the services by the log of real government consumption expenditure. $ln(p^g/p^c)$ is obtained by dividing their relative implicit price deflators.

Figures prepared by the author using data obtained from Statistics Canada.

Data source: Statistics Canada. Table 36-10-0106-01 Gross domestic product price indexes, quarterly Statistics Canada. Table 36-10-0123-01 Gross domestic product, expenditure-based, at 2017 constant prices, quarterly (x 1,000,000). Sample 1961Q1 - 2023Q3 Canada.

2.3.2 *Unit roots tests*

Dealing with time series data requires pre-processing and understanding the raw data before starting the actual modeling. Time series pre-processing techniques play a crucial role in determining the quality and accuracy of the modeling and subsequent analysis. Common pre-processing steps for time series involve examining its stationary properties, including the detection of unit roots. In the literature, the Augmented Dickey and Fuller (1979) test is commonly used for unit root detection. The two series used in this paper appear to be "first-difference stationary" rather than covariance stationary.[1] To check these assumptions, a Phillips and Perron (1988) test will also be used. A trend in the specification will be included, given the pattern of the plot in the fig.(2.1).

Table 2.1 presents the estimates of the Augmented Dickey–Fuller (ADF) and the Phillips-Perron tests performed at levels and at the first differences.

In *case 1*, the two unit root tests are performed on the series at levels with a trend term. The results reveal that the ratio of the aggregate private to public consumption

[1] A time series is covariance stationary if its mean and variance are constant over time.

Table 2.1: Unit root tests

	Levels		First Differences	
	$ln(c_t/g_t)$	$ln(P_t^g/P_t^c)$	$\Delta ln(c_t/g_t)$	$\Delta ln(P_t^g/P_t^c)$
Augmented Dickey-Fuller	- 2.620	-2.294	-18.724 ***	-22.091***
	[0.2709]	[0.4372]	[0.0000]	[0.0000]
Phillips–Perron test	-2.637	-2.244	-18.684***	-21.890***
	[0.2631]	[0.4649]	[0.0000]	[0.0000]

Note: Sample 1961Q1 - 2023Q3 Canada.
H_0: Variable has a unit root;
H_1: Variable is trend stationary.
P-values are in brackets and the significance levels are defined as: *10%; **5%;***1%.
Unlike the tests performed on the first differences, the Augmented Dickey-Fuller test and the Phillips-Perron tests performed at levels are unable to reject the null hypothesis of $I(1)$ at any conventional level of significance.

and their relative prices in Canada are not stationary even at 10% significance levels. Therefore, the null hypothesis that the series have unit root cannot be rejected. In other words, the stationarity of these series at levels is rejected at the significance levels stated above.

In *Case 2*, the presence of unit root in the models with a trend at first differences is examined. The results show that at first differences none of the tested variables have a unit root. In summary, the results of all tests indicate that none of the series are stationary at their levels, regardless of the chosen level of significance. However, when considering the first differences, all the variables exhibit stationarity. Therefore, based on both forms of unit root tests, the findings suggest that the examined variables are integrated of order one, denoted as $I(1)$.

2.3.3 *Cointegration*

Is there a long-run economic relationship between the two variables? A cointegration test will help to identify the nature of the relationship between two non-stationary time series variables. Cointegration implies a long-term relationship between the variables, even if they individually display random fluctuations in the short term. To identify the relationship among the explanatory variables, the Engle-Granger test will be used.

Table 2.2 presents the results of the Engle-Granger test for cointegration. The test statistic is reported as -3.544. Critical values are provided for different levels of significance, represented by 1%, 5%, and 10%. These values are used to determine if

the test statistic is statistically significant.

Table 2.2: Engle-Granger test for cointegration

		Critical values		
	Test statistic	1%	5%	10%
$z(t)$	-3.544	-3.941	-3.361	-3.061

To conclude on cointegration, the absolute value of the test statistic must be bigger than the corresponding critical value(s). In this case, the absolute value of the test statistic exceeds the 5% critical value. Therefore, we conclude that the variables are cointegrated.

2.3.4 *Parameters estimation*

Table 2.3 displays the results of the parameter estimates from the cointegrating regression.

Table 2.3: Parameter Estimates

	Parameters Est.	*95% Conf. Interval*	
$\hat{\mu}$	-0.6465***	[-0.7563	-0.5368]
	(0.0559)		
$\hat{\alpha}$	0.68877***	[0.50756	0.86997]
	(0.0924)		
$\hat{\phi}$	0.6562	-	

Standard errors are reported in parentheses and the significance levels are defined as: *10%; **5%;***1%.

The parameters μ and α are estimated in STATA, while ϕ is determined by plugging the estimated value of μ into the equation $\mu = ln[(1-\phi)/\phi]$. All estimates are significant at the conventional significance levels. The α estimate is 0.68877 which implies an intraperiod elasticity of substitution parameter $1/\alpha$ equal to 1.4519.

In the next step, the estimate of $\alpha = 0.68877$ and $\phi = 0.6562$ are plugged into the Euler equation 36 to estimate β and γ. The equation is solved using the general method of moments GMM. Equation 36 is estimated using the following instrument set: a constant, $g_{t-1}/g_{t-2}, c_{t-1}/c_{t-2}$ and R_{t-1} of different lag structures.

Table 2.4: GMM estimates of the structural parameters

Instruments set	lags	β	γ	J_T
(1)	1 to 2	0.9723***	0.6546*	1.6239
		(0.0029)	(0.051)	
(2)	1 to 3	0.9740***	0.6558**	1.6218
		(0.0111)	(0.023)	
(3)	2 to 3	0.9744***	0.6650**	1.6511
		(0.0114)	(0.027)	

Standard errors are reported in parentheses and the significance levels are defined as: *10%; **5%; ***1%.

H_0: Overidentifying restrictions are valid. This means that all instruments used are exogenous (i.e., uncorrelated with the error term) and that the excluded instruments are appropriately excluded from the estimated equation.
H_1: At least one of the overidentifying restrictions does not hold.
The J-tests $p-value$ for (1), (2) and (3) are respectively 0.9436, 0.9510 and 0.9488, all greater than 5% (0.05) implying, that we fail to reject H_0, that is all instruments are valid, and the overidentifying restrictions hold.

The GMM estimation results are reported in table (2.4). The estimated discount factor is about 0.97 and is found to be statistically significant at the 1% level. The parameter γ is sensitive to the lag structure of the instrument variables used in this study. It is on average equal to 0.658 which implies that the intertemporal elasticity of substitution $1/\gamma$ is about 1.52.

In the post-estimation phase, the J-test is employed to examine overidentifying restrictions. In this context, the test results indicate a failure to reject the overidentifying restrictions that were utilized to assess the validity of the instruments (see table 2.4).

How easy it is to substitute between private and public goods in Canada? This paper follows R. A. Amano and Wirjanto (1998) approach to determine the substitutability. If $\frac{1}{\gamma} < \frac{1}{\alpha}$ then private and public consumption are Edgeworth-Pareto substitutes; if $\frac{1}{\gamma} > \frac{1}{\alpha}$ then the two goods are Edgeworth-Pareto complements; and if $\frac{1}{\gamma} = \frac{1}{\alpha}$ then these goods are not related.

By comparing the values of the intertemporal elasticity of substitution to the intratemporal elasticity of substitution, the findings of this study suggest that private and public consumption in Canada exhibit an Edgeworth-Pareto complementarity

relationship.

2.4 Conclusion

This study estimates the substitutability relationship between public and private consumption in Canada. The data used for this assessment is sourced from Statistics Canada, covering the period from 1961Q1 - 2023Q3. The first step involves examining the properties of the series, followed by applying cointegration techniques to check the model assumptions. The results indicate the existence of a long run and strong relationship between private and public consumption in the Canada economy. The unit root tests, such as the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron test, indicate that the ratio of aggregate private to public consumption and their relative prices in Canada are not stationary at any level of significance. Although the examined aggregate variables are not stationary at the levels, this study demonstrates that at the first differences, all these series become stationary. The results indicate that the two series are stationary of order one, denoted as $I(1)$. Furthermore, this study identifies a strong cointegrating relationship between private and public consumption, suggesting they evolve together in the long run. The results of the estimation provide efficient values for the elasticity of substitution, ultimately characterizing private and public consumption in Canada as Edgeworth-Pareto complements.

Chapter 3

Anglophone brain drain: getting a degree in Quebec and becoming a taxpayer elsewhere

Abstract

Getting a job and integrating in Quebec can be very challenging for unilingual English speakers because of French language barriers they face. Quebec anglophone graduates exodus is a rising concern among scholars, policymakers and firms as it has a serious impact on the tax revenue and the productivity. Each year, the province is attracting new students and losing its best and brightest graduates to the other provinces, the U.S, or the world. How to retain anglophone graduates in the province after they get their diploma in hand, is certainly one of the most challenging problems that the Quebec government has been trying to solve over the past decades. This paper explores the impact of Quebec's language policies on migration decisions among English-speaking graduates. Through model simulations of linguistically diverse economies, this study presents two policy solutions—bilingual programs at English-speaking universities in Quebec and loan forgiveness incentives—that effectively reduce interprovincial migration, thereby supporting Quebec's efforts to retain a larger share of skilled graduates within the province.

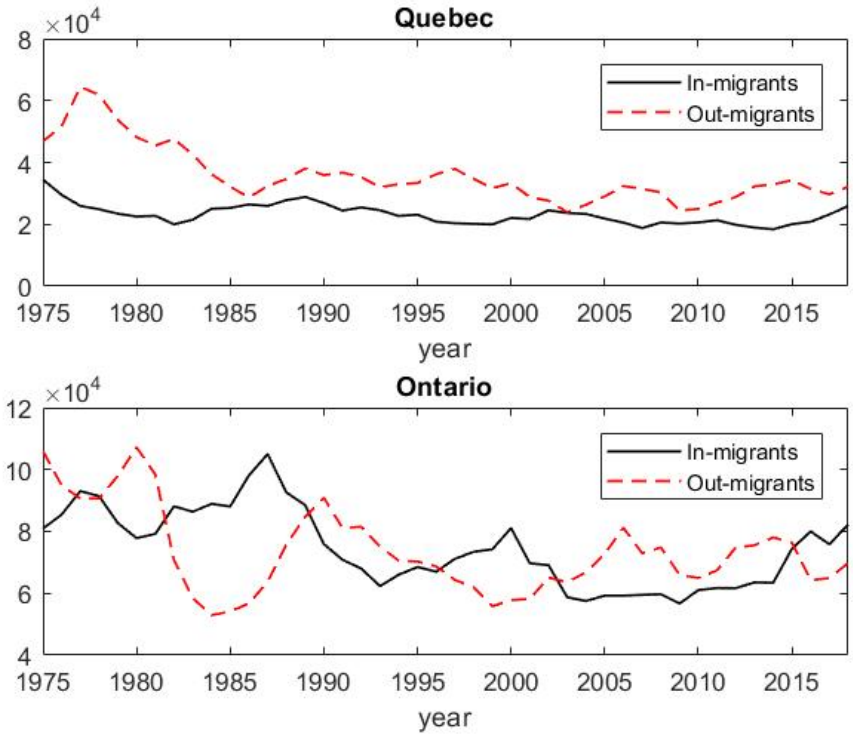
Keywords: Public and private goods, Labour mobility, Human capital, Inequality, Immigrants, Economics of language.
JEL classification: D31, G51, H41, I22, J15, J61, Z13

.

3.1 Background and motivation

Quebec's loss of skilled workers to the other provinces is a hot topic drawing significant attention of policymakers and scholars for decades (see figure 3.1). The Quebec government has been launching over the years several programs and research projects to address this issue. One of the latest is the one launched in 2018 by Kathleen Weil, the minister responsible for relations with English-speaking Quebecers: a partnership project through a near-million dollar investment to study the possible means of retention of recent anglophone degree holders before they decide to leave the province. Each year, the province is attracting high ability students from other provinces and from all over the world as it hosts many French and English-speaking Cegeps but also some of the most prestigious universities in the country (Racine, Villeneuve, & Thériault, 2003).

Figure 3.1: 40 years of interprovincial migration

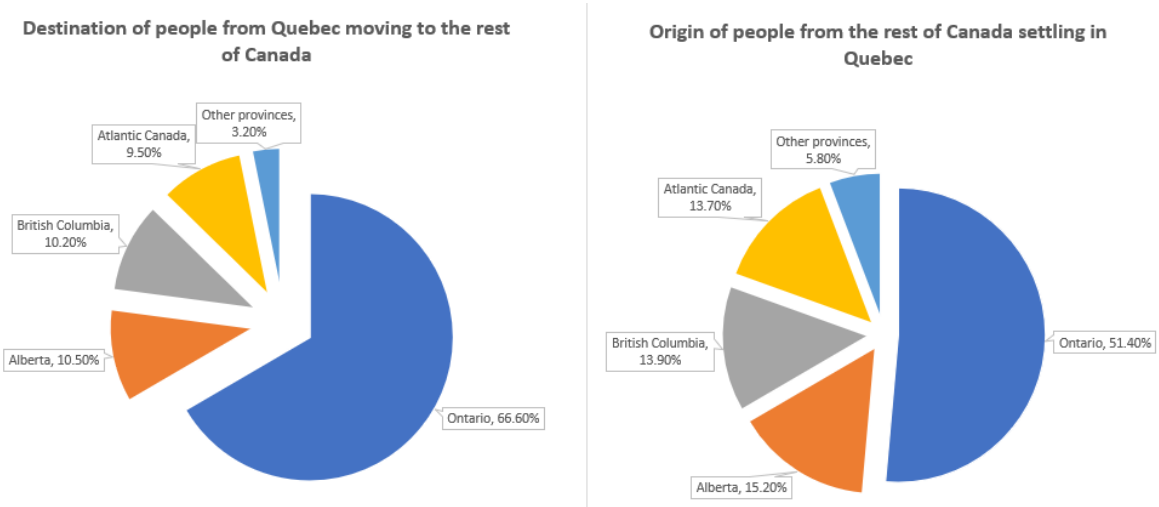


Statistique Canada defines *interprovincial migration* as "movements from one province or territory to another, involving a change in usual place of residence". A person who takes up residence in another province or territory is an out-migrant with reference to the province or territory of origin, and an in-migrant with reference to the province or territory of destination (Statcan). Source: Author's calculations based on data from Statistics Canada. Estimates of the components of inter provincial migration, quarterly (1963-2017).

At the graduate level, French-language universities of the province are accepting anglophone (people with English as their first official language spoken or mother tongue) students with limited knowledge in French (Tourism & the Centre for Education Statistics Division Council of Ministers of Education (Canada), 2019). Not only Quebec does provide high quality education but it is among the provinces that charge the lowest tuition fees to its residents but not to out-of-province or out-of-country students. Quebec is the jurisdiction that has the highest proportion (63.2%) of young STEM (Science, technology, engineering, and mathematics) degree holders aged 25 to 34, followed by Newfoundland and Labrador (57.7%) and Alberta (55.7%) (Census 2016). Although Quebec is attracting many bright students, it has consistently been losing most of its best and brightest potential skilled workers (Forget, 2014). Quebec is the only province to experience net out-migration every year since 1963 and it has the highest out-migration (582,470) on a cumulative basis over the past four decades.

In Quebec's migration exchanges with other jurisdictions, Ontario is the main beneficiary. In 2017, nearly half Canadian who move in Quebec were living in the neighboring province and the rest were living mostly in British Columbia, Alberta, and Atlantic Canada (Dupuis & Bégin, 2018).

Figure 3.2: Quebec's migration exchanges with other provinces



Sources: Statistics Canada & Institut de la statistique du Québec and Desjardins, Economic Studies (2017).

The movements out of Quebec mimic the movement in. The vast majority of Quebec residents moving out of the province to settle elsewhere in the country choose Ontario as their main destination, and then the rest, in equal numbers will settle in Alberta, British

Columbia and Atlantic Canada (see figure 3.2). The Quebecers preference for Ontario could be explained by the geographic proximity, the presence of the federal capital and the bilingualism, particularly for people in the greater Ottawa–Gatineau area. The Alberta percentage increases usually during periods of high oil prices (Dupuis & Bégin, 2018). The graduates that are leaving the province for economic opportunities elsewhere are potential high skilled individuals with little or no knowledge in French from English CEGEP and universities but also from French universities (Bourhis & Bourhis, 2008). The income of migrants outside the province is 16.6% higher than that of similar workers who choose to stay in Quebec and 9.5% higher than that of similar workers in Ontario. In other words, migrants from Quebec to Ontario are, on average, above-average income earners. This means that Quebec is losing relatively highly skilled workers to other provinces, primarily Ontario, the most popular destination for Quebec migrant. Restricting the sample to young workers (individuals between the ages of 16 and 30), young people leaving the borders of Quebec earn 30.3% more than those who remain in the province (Gomme, Jamil, Koreshkova, Lkhagvasuren, et al., 2019).

Yet, the labor shortage in Quebec is of great concern, especially in fields that require specialized skills, such as the health sector. According to the Canadian post-MD education registry census, 52% of recent medical graduates from McGill are working outside of Quebec, mostly in Ontario, where 22% are settled, despite Quebec high demand of medical doctors (MDs). The average emergency wait times at hospitals in Quebec is 16 hours and it outranks the other provinces (Canadian institute for health information). Unilingual English speakers face the greatest unemployment rate in the province (8.9%) which is 2% points higher than the unemployment rate of unilingual French speakers (6.9%), and is also higher than the unemployment rate in Quebec as a whole (7.2%) (Provincial Employment Roundtable). Being taxpayers and part of a linguistic minority, English speakers face language barriers in accessing services, in accessing employment opportunities and in integrating into Quebec society which are the factors that determine their sense of attachment and belonging to the jurisdiction. Scholars (Clemens, 2016; Stevenson, 2000) have termed this phenomenon the "brain drain," arguing that the root causes are Quebec's tax system, language laws, constitutional policies, and relative economic decline (see tables 3.1 and 3.2).

Table 3.1: Income tax rates in Quebec vs Ontario

	Personal income			**Capital gains**		
	Quebec	Ontario	*Difference*	Quebec	Ontario	*Difference*
42k	16%	5.05%	10.95%	14.26%	10.03%	4.23%
42k-84k	20%	9.15%	10.85%	18.56%	14.83%	3.73%
84k $\rightarrow \infty$	24%	11.16%	12.84%	22.86%	16.95%	5.91%

Source: Deloitte.

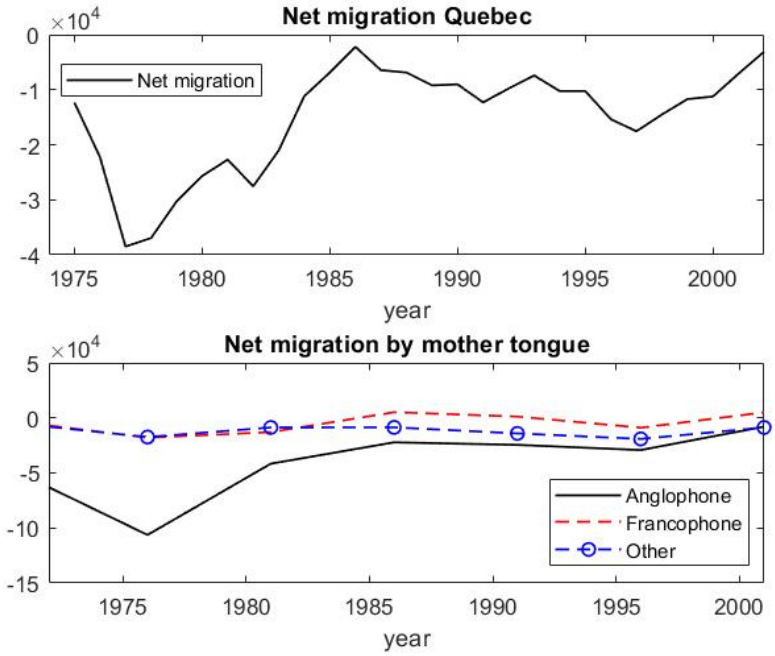
Table 3.2: Consumption Tax Rates in Quebec vs Ontario

	Quebec	Ontario	*Difference*
τ_c	14.975%	13%	1.975%

Source: Retail Council of Canada.

In fact, Quebec experienced many years of political and cultural turmoil related to sovereignty, during which concerns over the out-migration of highly skilled Anglophone workers from Quebec were at their peak.

Figure 3.3: Net migration (arrivals minus departures)

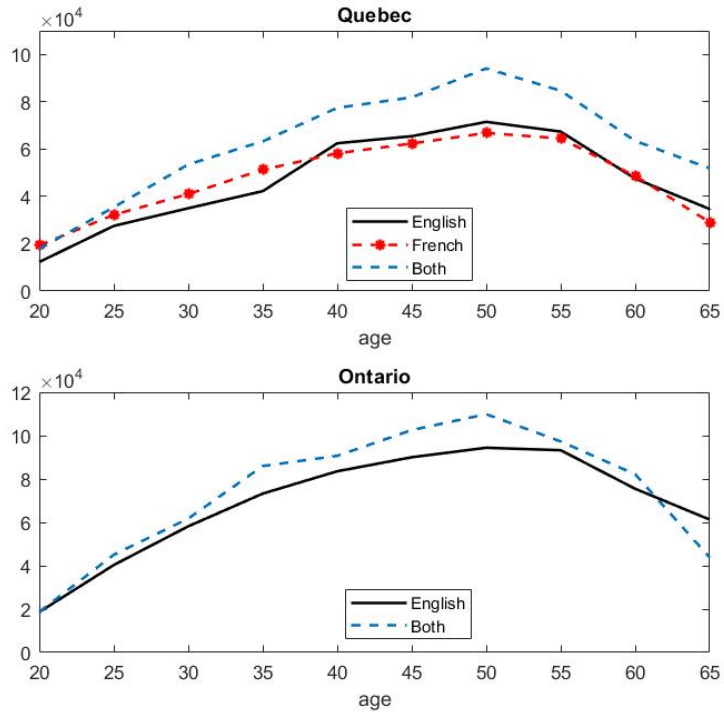


Five-year bin observations are used in the second panel as statistique canada provides only such data. For instance, the point 1976 is the sum of net migration for each type from 1971-76. The point 1982 in the axis corresponds to the sum of net migration from 1976-82 and so on... Source: Statistics Canada, censuses of population 1971 to 2006.

The peak occurred the year after the election of the Parti Québécois (PQ) in 1976 (see figure 3.3). That year, Bill 101 was passed, making French compulsory for the education of immigrants, regardless of their origin from other provinces or outside the country, and the official language of all institutions, workplaces, and businesses. Bill 101's language provisions caused dissatisfaction among Anglophones and relief among nationalists, resulting in 64,453 individuals leaving the province's borders the following year. Most of them were Anglophones (see figure 3.3). The lowest outflow occurs in 2003/04 after the defeat of the Parti Québécois by The Parti libéral du Québec (PLQ) during the Quebec general election. The net interprovincial migration that fiscal year was nil. This outward migration of college graduates has an impact on Quebec's economy, as language legislation restricts job prospects for a considerable portion of its young Anglophone population, particularly those who are starting or in the early stages of their careers as the knowledge of the second official language in Quebec is associated with enhanced earnings.

Among the bachelor's degree holders, unilingual English speakers who choose to work in Quebec after their studies, earn on average less than their francophone peers in their early career's stages up to their mid-career (see figure 3.4).

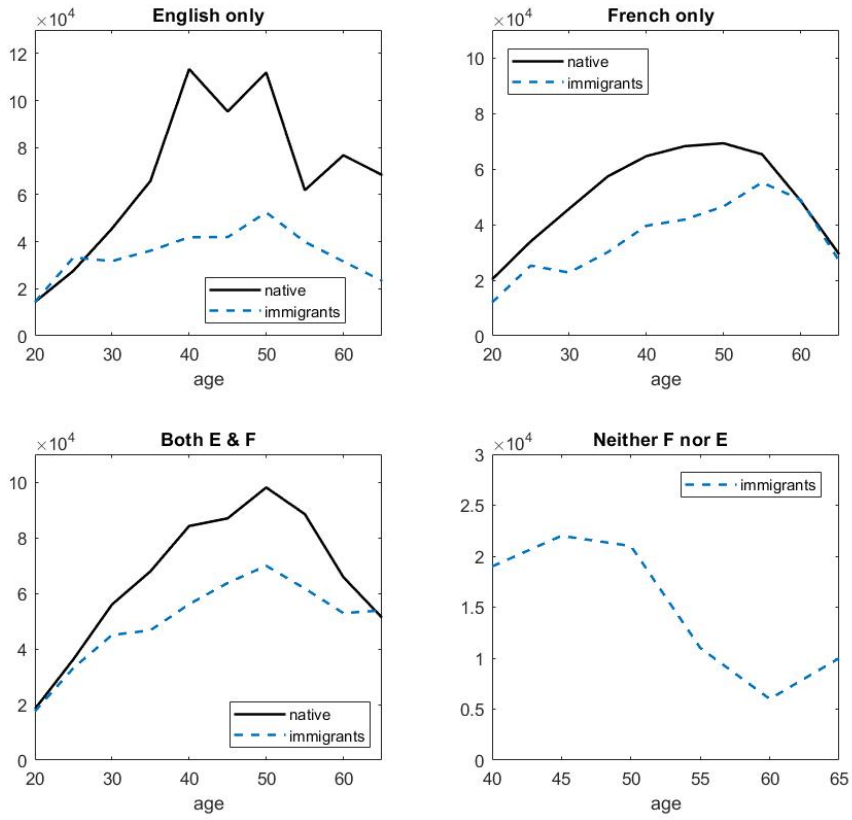
Figure 3.4: Income by knowledge of official languages in Quebec.



Source: Author's calculations based on Census 2016 (Public Use Microdata File (PUMF)). To control for the level of education, I selected the highest level of education as "Bachelor's degree."

Although French is dominant in Quebec, bilingual workers earn persistently more than unilingual English speakers and unilingual French speakers over their career lives (PUMF-2016). In Ontario, among those with a bachelor's degree, bilingual workers earn more than unilingual Anglophones up to age 60. The age-income profile of unilingual French speakers is missing from the graph for Ontario due to the lack of observations. They make up about 0.008% of the population (bachelor's degree holders) and earn, on average, less than the two language subgroups over their career lives. Income inequalities observed in Quebec are even more pronounced depending on immigration status, as shown in the bottom right panel of figure 3.5.

Figure 3.5: Income by knowledge of official languages and by immigration status in Quebec.



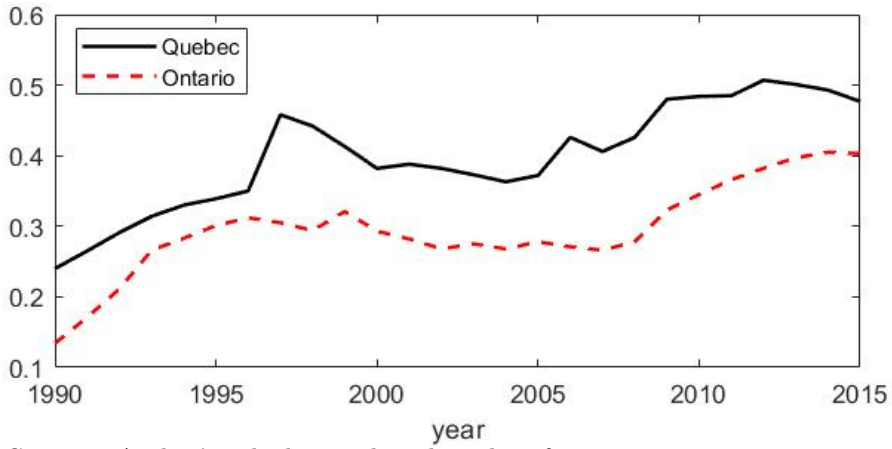
Source: Author's calculations based on Census 2016 (Public Use Microdata File (PUMF)). To control for education, I selected the highest level of education as "Bachelor's degree." Note: up to 40 years old, there is no observations for people knowing "Neither French nor English".

Not knowing either of the two official languages results in lower earnings compared to

those who speak one or both languages. Native French speakers start their careers with higher salaries than anglophones and bilingual individuals (The Census 2016-PUMF). However, earnings of bilingual immigrants are nearly as high as those of French natives during their mid-career. Immigrants earn less than Quebec natives over the lifecycle regardless of their linguistic profile, with anglophone immigrants being particularly affected. These income disparities are cited as one of the reasons why anglophones choose to leave Quebec after obtaining their degree(s).

As a result, the province experiences on a yearly basis a lost productivity, a loss of tax revenue and consequently, the net-debt-to-GDP ratio is above the recommended IMF target of 45% (see figure 3.6).

Figure 3.6: Net debt-to-GDP ratio



Source: Author's calculations based on data from
(1) Fiscal reference tables (Department of Finance Canada), Provincial and Territorial Governments Public Accounts and
(2) Statistics Canada, table 36-10-0222-01 Gross domestic product, expenditure-based, provincial and territorial, annual (x 1,000,000)

From the figure 3.6, one can see that Quebec's net debt-to-GDP ratio is higher than that of Ontario. From these facts arise a couple of questions. To what extent can proficiency in French and the student debt repayment schedule influence the departure of Anglophone graduates from Quebec? What policies can the Quebec government implement to retain these potential qualified workers?

3.2 Related literature

The links between language proximity and the destination choice of immigrants has been studied by Adsera and Pytlikova (2015). Their analysis is based upon immigration

flows from 233 source countries to 30 OECD countries, for the years 1980-2009. They found that people are more attracted to a place where they will not face language barriers. They reported that linguistic proximity is a statistically significant and robust in determining migration flows. Cohen-Goldner and Eckstein (2008) investigate human capital accumulation and the labour mobility from the former Soviet Union to Israel, of male immigrants. They built a model that follows the dynamic programing approach of schooling and labour supply by Eckstein and Wolpin (1999) and Keane and Wolpin (1997), where an individual arriving in a new country must choose amongst a finite set of mutually exclusive labour market alternatives over a finite horizon. Each period, immigrants choose one alternative and randomly receive training program and job offers in two occupations. Cohen-Goldner and Eckstein (2008) built an estimable dynamic choice model for employment and training in low skilled and high skilled occupations where the imported human capital and the knowledge of the host country languages have an effect on the immigrants' job offer probabilities and their average income. They estimated the return to the host country language namely the Hebrew and the return to English knowledge in both occupations. Their main findings show that the return to knowledge of Hebrew is high whether individuals are working in white-collar or blue-collar occupations, while the knowledge of English only positively affects wages in high skilled jobs.

The idea that language skills is a form of human capital that can explain labour mobility is not new. Mou and Olfert (2015) analyze the extent to which income, cultural (including languages) and relational characteristics influence the inter-provincial migration decisions of physicians in Canada. Vanasse, Scott, Courteau, and Orzanco (2009) show that high skilled workers' decision to move to other provinces in Canada is the reflection of their dissatisfaction with professional relationships and professional life in general. Numerous studies have shown that the knowledge of official language play an important role in the migration decision of skilled workers. For instance, unilingual French-speaking medical doctors are less likely to move, as they will face language barriers in integrating in other provinces labour market (Bernard, Finnie, St-Jean, et al., 2008).

Chiswick and Miller (2003) use the 1991 Census data to study the effects of the destination language skills on income among immigrants in Canada. The objective of their paper is to explore whether destination language skills act as substitutes or complements in generating income, particularly in relation to other forms of human capital, such as pre- and post-migration labor market experience and education. Their main findings show that the greater proficiency in the destination language increase immigrants' income by enabling them to find a better labour market match. Hence, immigrants' income is a rising function of their proficiency in the destination language as it has direct impact on productivity through

more efficient communication (orally and verbally with all entities in the market). Immigrants who lack official language skills have earnings around 10 to 12 percent lower than immigrants who are fully proficient. Among those who completed their schooling prior to immigrating, the earnings gap is larger, 12 to 14 percent. Destination language proficiency have a complementary relationship to other forms of human capital, namely schooling and pre-immigration labour market experience. Those other forms of human capital returns may be of little value to an immigrant with no knowledge of the destination language. This immigrant may be little different from an unskilled worker despite a high level of schooling and job training, as far as the destination labour market is concerned.

3.3 Economic environment

An individual's problem in a partial equilibrium setting is being studied in this section. Specifically, the wage and return to savings are taken as given.

3.3.1 *Households*

Individuals in the economic environment are recent college graduates. They are fully fluent in their primary language and have no or little knowledge of the second language. Individuals live a maximum of J periods and are free to move from one place to another regardless of their skills, for work or for educational purposes. Individuals want to maximize their discounted lifetime utility given by

$$\sum_{j=1}^{J} \beta^j u(C_j, l_j) \tag{37}$$

where C_j, and l_j refers respectively to the individual's aggregate consumption and leisure time and β is the discount factor.

The functional form of u is given by

$$u(C,l) = \begin{cases} lnC + lnl & \text{if } \lambda = 1\ . \\ \frac{[Cl]^{1-\lambda}}{1-\lambda}, & \text{if } \lambda \in (0,1) \cup (1,\infty). \end{cases} \tag{38}$$

$C(c_p, c_g)$ is a consumption aggregator:

$$C(c_p, c_g) = \begin{cases} \left[\phi c_p^{1-\zeta} + (1-\phi) c_g^{1-\zeta}\right]^{1/1-\zeta}; & \frac{1}{\zeta} > 0 \text{ and } \frac{1}{\zeta} \neq 1 \\ c_p^{\phi} c_g^{1-\phi}; & \frac{1}{\zeta} = 1 \rightarrow \zeta = 1 \end{cases} \tag{39}$$

The preference parameter ϕ represents the relative weight assigned to private goods. It

is the parameter measuring the relationship between real private consumption c_p and real government expenditure c_g. ζ is a parameter that determines the elasticity of substitution between the two goods. Individuals can learn the second official language to improve their attractiveness in the labour market. Similarly, the *second* language skills are accumulated over time following the technologies given by

$$f_{j+1} = A_f(s_j^{\eta} e_j^{\mu} f_j^{\alpha}) + (1 - \delta_f) f_j \qquad \alpha + \eta + \mu < 1 \tag{40}$$

Acquiring language skills is not free of costs: it requires a considerable amount of individuals' time s_j and money e_j. According to the French Language Institute, it would take an English-speaker approximately 575 - 600 hours or about 23-24 weeks to become fully fluent in the French language which is almost 6 months. In other words, if a unilingual English speaker decides to learn French right after getting his college degree, he will spend 6 months to be fully fluent. The second language learning period also marks the end of the student loan grace period. Recent graduates have 6 months after leaving colleges to start repaying p_j their student debt d_j principal and interest r_{dj} that decumulates according to

$$d_{j+1} = (d_j - p_j)(1 + r_{dj}) \tag{41}$$

Student loan debt and the grace period can exert financial pressure, leading Anglophone graduates to consider leaving a French-speaking province with limited job opportunities for them. Individuals may decide to stay in a particular jurisdiction and learn the most spoken language to reach the level that will make them employable or they can decide to leave in which case they will bear a moving cost q_j. The government can issue a set of language policies aiming at promoting implicitly or explicitly certain language(s). Therefore it can intervene in the language acquisition by giving a subsidy v_j. Individuals' resources are derived from their labour from which they receive a real wage $w_j(f_j)$. The proficiency in French can be a significant factor in determining salary in the French-speaking province due to its importance in the local job market (demand for these linguistic abilities), and legal requirements (such as those outlined in the Charter of the French Language, Bill 101)

Additionally, individuals' resources are derived from their asset holdings x_j which pay a risk-free interest rate r_j and the government transfers T_j. Those resources are used for private consumption c_{pj}, investment x_{j+1} and purchase inputs e_j. They must also repay $p_j = (\lambda \times \text{income})$ their student loan (where λ represents a share of their income), following an exogenous repayment schedule. Individuals' budget constraint, whether they decide to stay or leave, is therefore

$$(1+\tau_c^i)c_{pj} + I(1-v_j^i)e_j + x_{j+1} + (1-I)q_j + p_j = (1-\tau_w^i)w_j^i(f_j)n_j + [1+(1-\tau_x^i)r_j]x_j + T_j^i \tag{42}$$

$$I = \begin{cases} 0 \text{ for leavers} \\ 1 \text{ for stayers} \end{cases} \tag{43}$$

$$i = \begin{cases} O \text{ for leavers} \\ Q \text{ for stayers} \end{cases} \tag{44}$$

The indexing of i in this equation indicates that by choosing to remain in a specific area, individuals are subject to an income tax rate τ_w^i, a capital tax rate τ_x^i, a market consumption tax rate τ_c^i, each specific to that area, as well as area-specific transfers T_j^i. Government tax net returns to assets. Individuals may also choose to leave the jurisdiction in which case they will bear a cost q_j which include the cost of moving their assets and/or their family. Individuals face a time constraint

$$n_j + s_j + l_j = 1 \tag{45}$$

where the right-hand side of the equality is the time endowment. The model has many non-negativity constraints

$$s_j \geq 0; \quad n_j \geq 0; \quad 1 \leq j \leq J \tag{46}$$

and boundary conditions

$$d_1 \geq 0, \; x_{J+1} \geq 0 \tag{47}$$

meaning they start their careers with student debt greater or equal to 0 and end with non-negative assets holdings. The household problem can be written using the language of dynamic programming and solved as follows:

$$\begin{aligned} V(x,f,d)^i = \max_{c_p,e,n,p,d',f',x'} \Bigg\{ & u[C(c_p,c_g),(1-n-s)] + \beta[V(x',f',d')] \\ & + \xi_1 \Bigg\{ (1-\tau_w^i) w^i(f) n + [1 + (1-\tau_x^i) r] x + T^i - (1+\tau_c^i) c_p - I(1-v^i) e \\ & - x' - (1-I) q - p \Bigg\} \\ & + \xi_2 \big\{ f' - A_f (s^\eta e^\mu f^\alpha) - (1-\delta_f) f \big\} \\ & + \xi_3 \big\{ d' - (d-p)(1+r_d) \big\} \Bigg\} \end{aligned}$$

and subject to (43), (44), (46) and (47). The ξ's are the Lagrange multipliers. $\xi_1, \quad \xi_2, \quad \xi_3$ functions can be found by taking respectively the first order conditions of c_p, e and p. By

plugging them into the optimal conditions, one can found the Euler's equations for

$$x': \quad u_c(c,l) = \beta u_c(c',l')\big[1+(1-\tau_x)r\big] \tag{48}$$

$$d': \quad u_c(c,l) = \beta u_c(c',l')(1+r_d) \tag{49}$$

$$n: \quad u_n(c,l) = \frac{u_c(c,l)}{(1+\tau_c)}(1-\tau_w)w(f) \tag{50}$$

$$f': \quad \frac{u_c(c,l)I(1-v)}{\mu A_f(s^{\eta}e^{\mu-1}f^{\alpha})} = \beta\left\{\frac{u_c(c',l')I(1-v')}{\mu A_f s'^{\eta}e'^{\mu-1}f'^{\alpha}}(\alpha A_f(s'^{\eta}e'^{\mu}f'^{\alpha-1}+(1-\delta_f))+\frac{u_c(c,l)}{(1+\tau_c)}((1-\tau_w)w'(f)n)\right\} \tag{51}$$

The migration decision

The decision to move or stay takes place at the beginning of the lifecycle at $j = 1$: graduates choose the path that is most rewarding given their language skills. The decision rule is based upon the most rewarding value function of the two mutually exclusive choices: leave (L) or stay (S)

$$V(x,f,d)^{\star} = arg\max\left\{V^S(x,f,d);\ V^L(x,f,d)\right\} \tag{52}$$

The choice to settle in a particular province is important not only as it involves costs but also as it cannot change over their lifecycle.

Investment of a Unilingual Graduate in the Second Official Language

The decision to migrate and invest in the second language occurs simultaneously. Regardless of the province, bilingual individuals earn more than French-speaking or English-speaking unilinguals. For a young graduate anglophone who has just received their diploma, possibly attached with student debt, the objective is to leave the French-speaking province if their proficiency level in French is too low because they will face restrictions in the job market. They may choose to stay if the cost of leaving is too high (such as those married to Quebecers with or without children, or those who already have considerable assets such as houses) and decide to invest in learning French. Being unilingual has disadvantages such as fewer jobs to apply for, reduced pay (see fig. 3.4), limited career progression and limited interprovincial mobility. A limited career progression has a significant impact on the growth rate of wages. Moreover, language laws prevent unilingual minority workers from occupying management positions in companies in Quebec and thus set a limited career progression

for unilingual workers. Unilingual English speakers will be willing to settle in Quebec after graduating if they are willing to break down the language barriers that will prevent their career progression, interprovincial mobility and access to jobs that require knowledge of the second language or both languages.

Investment in the acquisition of a second official language involves costs such as time s_j, expenditures e_j and forgone earnings which are some functions of the language proficiency $w(f)$. During the language training time, individuals who may face language barriers in getting earnings that reflect their human capital because of language requirements, but they can get low skills jobs requiring low language skills for low earnings. To illustrate this point, consider two medical school graduates with the same level of human capital. They apply to get a job in a predominantly French hospital. Individual 1 meet the $\bar{f}$ language requirements and get the job while individual 2 has a $\underline{f}$ profile for the job and thus is ineligible. Individual 2 can decide to learn the second language while working as a cashier to become bilingual to later receive a salary that reflects his human capital. Language investment decision, can be formulated as choosing time s_j and expenditures e_j to minimize the total costs involved in the learning process

$$\begin{aligned} &\min_{s_f, e_f} \quad \left[w(\bar{f}_j) - w(\underline{f_j})\right] + (1 - v_f)e_f \\ &\text{s.t.} \quad f_{j+1} = A_f(s_j^{\eta} e_j^{\mu} f_j^{\alpha}) + (1 - \delta_f)f_j \end{aligned} \tag{53}$$

3.4 Calibration

The model's parameters are listed in tables 3.1, 3.2 and 3.3. The model has 9 periods and each period accounts for 5 years, so that the working life starts at period 1 and the retirement period j_R is 9. In other words, individuals are 25 years old when they become economically active and they are 65 years old at retirement. This is consistent with the Canadian data which indicates that the average age at graduation is 25, the retirement age is 65 years old and lifespan is 80 years.[1] The breakdown of fiscal revenue is used to calculate the ratio of federal government transfers to provincial revenue. Government transfers as a percentage of provincial revenue are set at 0.1958 in Quebec and 0.1812 in Ontario for the 2016-17 period (see Quebec and Ontario Public Accounts 2016-17). The discount factor β is taken from the previous chapter and is set to 0.97. According to the Quebec Student

[1]Statistics Canada. Table 37-10-0031-01 Postsecondary graduates, by location of residence at interview and level of study.
Table 14-10-0060-01 Retirement age by class of worker, annual.
Table 13-10-0114-01 Life expectancy and other elements of the complete life table, three-year estimates, Canada, all provinces except Prince Edward Island.

Financial Assistance, the interest on student loans equals the Bank of Canada preferential rate plus 0.50%.

To avoid language barriers and to find a good match in the labour market, unemployed agents can enroll in language training classes at no cost. In Quebec, full-time and part-time French classes are free for anyone holding an immigration status. In Ontario, English and French as a second language classes are free and available to any resident. To calibrate the other parameters of the language acquisition, I retrieve from the Quebec Public accounts, data on the total amount allocated to francization and on how those resources are used. The expenditure share of that income μ is about 22.4% and 33.7% is allocated to labour η.

Table 3.3: Parameter Values

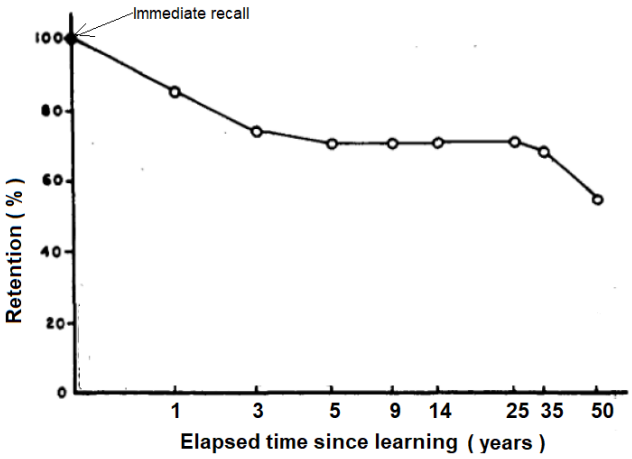
Symbol	Name	Value	Source
Utility			
β	Discount factor	$(0.97)^5$	(See chapter 2)
ϕ	Private goods param.	0.3692	(See chapter 2)
ζ	Elasticity of subst. param.	0.7625	(See chapter 2)
Time			
	Model period length	5	Model specification
	Model number of periods	9	Model specification
Language			
δ_f	Depreciation rate	0.15	Bahrick (1984)
η	Time share	0.337	QC public account
μ	Expenditure share	0.224	QC public account
v	Subsidy	1.102	
Grids			
q	Moving expenses	[0.1, 1.5]	TurboTax
f	Second language proficiency	[0.1, 1.0]	Model specification
Other param.			
T^Q	Government transfers	0.1958 (as% of provincial rev.)	QC Ministry of finance
T^O	Government transfers	0.1812 (as% of provincial rev.)	Ontario Public Accounts
λ	income-driven repay.	0.1 (as % of income)	Ministère de l'Éducation
r_d	interest on debt	the Bank of Canada preferential rate (3.9%) + 0.50%	QC student financial assistance

Students enrolled in French classes receive transfers/financial aid throughout the learning. Therefore, the subsidy v to the language acquisition is set to 1.070.[2] One of the challenging parameters to calibrate is the language depreciation rate δ_f, which could be defined as the decline of language skills occurring whenever the learner does not practice

[2]Students enrolled in full-time (5 days) French classes may receive $230 per week, a maximum reimbursement of $25 per learning day for each child requiring childcare, and $25 per week for transportation, depending on individual circumstances, totaling approximately $1,070 per week (see Aide financière pour les cours de français à temps complet).

and/or rehearse what he has studied. How much time is required for a learner's memory performance to fall to a lower level from any level it reached? To my knowledge, there is no paper in the economics of language literature addressing this issue. So, in absence of papers in economics literature addressing language attrition rate, I find myself constrained to turn to linguistic and psychology (learning memory and cognition) literature. In the literature, there is a consensus that individual retention is boosted by the usefulness and the relevancy of the content, the methodology used to present the material and the practice time. The experimental psychologist of memory Bahrick (1984) shows, through his forgetting curve, the poor durability of stored memories in time if there are no active attempts to retain them. Over a fifty years periods, Bahrick (1984) tested the retention of the *second* language namely Spanish learned in school (U.S.A).

Figure 3.7: Bahrick forgetting curve



Source: Bahrick (1984)

The figure (3.7) shows the rate at which forgetting of a language learned occurs. He performed several experiments on 733 individuals. Compared to those just completing the course, a year out of the training learners will forget about 15% of the second language they have learned. Compared to the long-ago group, those who learned Spanish three years ago did not recall much more.

The only remaining parameters are those included in the consumption aggregator function. The estimation results presented in the previous section of this dissertation (Chapter 2) indicate that the parameter values obtained are $\phi = 0.6562$ and $\zeta = 0.6888$.

The parameter values are used to solve the Euler's equations. The Euler equations are solved simultaneously. Each profile type observes wage growth over their life cycle

before making a decision to settle in a specific jurisdiction. By determining the province of residence, the model calculate the optimal choice of assets, time allocation, second language expenditures etc. The income stream for each profile type and the three linguistic groups is computed at each point point in time.

The model generates individuals' value function. To accomplish this, a grid is imposed on the second language proficiency level $f \in [\underline{f}...f_{avg}...\bar{f}]$ and another grid is imposed on the cost of leaving the French province $q \in [\underline{q}...f_{avg}...\bar{q}]$ both consisting of m numbers of points. The second official language grid encompasses individuals with diverse levels of French proficiency, ranging from those with basic skills to get by ($\underline{f}$), to those with average proficiency (f_{avg}), and those with higher levels of proficiency like native speakers ($\bar{f}_j$). The grid aims to capture all language proficiency profiles [0.1...1], thereby providing various wage profiles. The relocation costs, represented by the variable q, include various factors, including moving expenses, job search costs, the necessity to sell or dispose of family assets, and the overall process of transitioning their lives to a new province. It's important to note that the variable q may vary from one individual to another, reflecting the unique circumstances and requirements of each person. Individuals with families and/or assets tend to incur higher costs, while those who are single and have no attachments to the province tend to have lower costs. To capture all these diverse circumstances, the relocation cost q grid ranges from 0.1 to 1.5, where 0.1 represents the lowest cost and 1.5 represents the maximum cost for leavers.

Individuals then make a migration decision, expressed in equation 52, based on their value functions. In other words, at each grid point, the individual's problem is solved twice: once for Quebec and once for Ontario. Individual from state (x, f, d) chooses to stay in Quebec if $V^S(x, f, d) > V^L(x, f, d)$, where $V^L(x, f, d)$ gives the maximum present value of utility if he chooses to leave Quebec after graduating, and $V^S(x, f, d)$ gives the maximum present value of an agent's utility if he stays.

3.5 Results

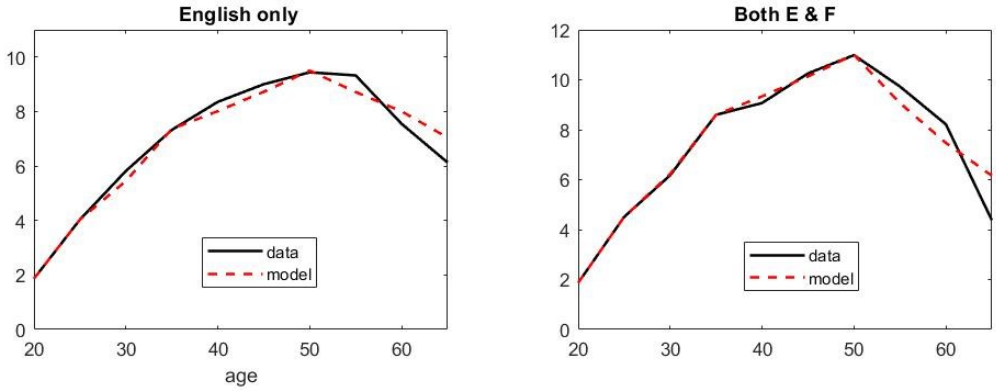
In this section, I discuss the interprovincial migration drivers of recent graduates in the benchmark economy, with a particular focus on English-speaking graduates leaving Quebec. The analysis begins by assessing whether the model accurately replicates the life cycle earnings patterns for individuals with different linguistic profiles. Subsequently, the model explores the behavior of unilingual workers in Quebec. The final part of the section is dedicated to conducting policy experiments to better understand the implications of various policies. Since the purpose of this paper is to analyze the reasons behind the departure of English-speaking graduates from Quebec after completing their studies, the main focus will

be on examining the behavior of the linguistic minority within Quebec.

3.5.1 *Household income path versus data*

The literature documents that lifecycle earnings typically exhibit a hump shape, characterized by initial growth, a plateau in the middle of one's career, and a decline towards the end. Therefore I impose a hump shape on wages. Regardless of the province, individuals tend to experience similar patterns of income growth and decline over the course of their careers. By acknowledging these common patterns in earnings trajectories, the model accounts for the general trends observed in the data and aims to replicate these patterns when simulating the income paths of individuals in Quebec and Ontario (see figures 3.8 and 3.9).

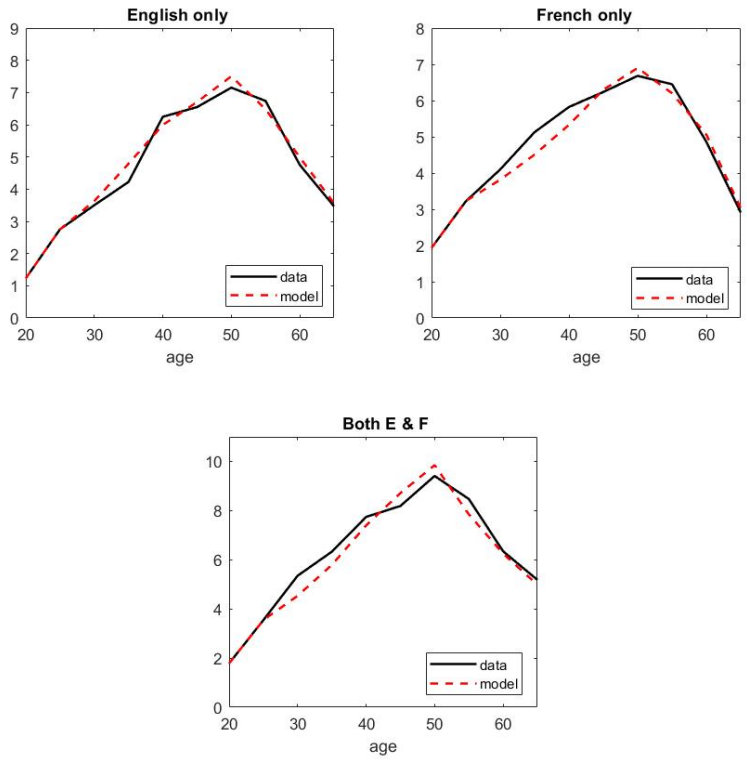
Figure 3.8: Lifecycle income per language knowledge in Ontario



The Chi-squared calculated as the difference between observed and expected values from the model is less than the critical value at 1% with 1 *df*. Thus, the difference between the expected and observed samples is not statistically significant. The model fits the data.

The model successfully captures and replicates the life-cycle earnings of individuals from various linguistic backgrounds in both Ontario and Quebec. It reflects the observed trend that bilingual individuals in both provinces tend to earn more throughout their careers compared to other linguistic categories. Moreover, the model reveals that being bilingual is financially advantageous in both Ontario and Quebec, but the advantage is relatively higher in Ontario. This aligns with the empirical evidence that highlights the earning disparities between individuals based on their language proficiency. Overall, the model's ability to replicate these patterns of differential earnings based on linguistic background in both provinces provides valuable insights into the economic implications of language proficiency and its impact on individuals' income trajectories.

Figure 3.9: Lifecycle income per language knowledge in Quebec



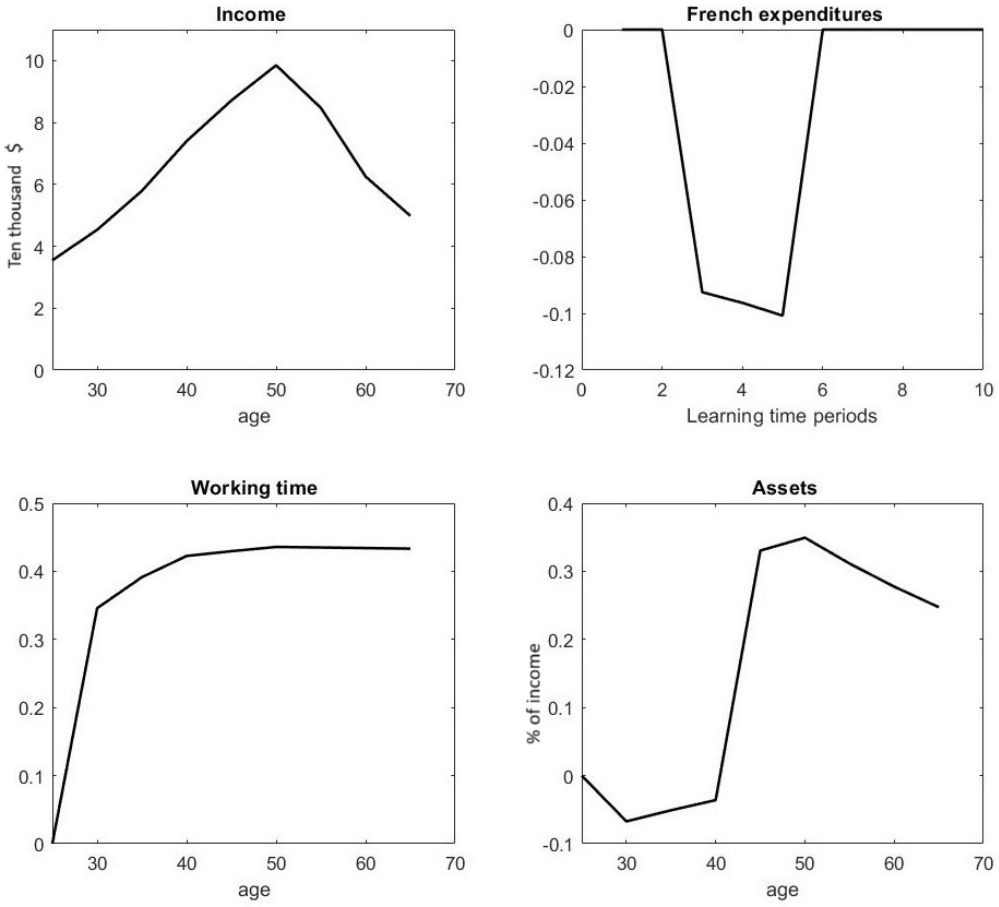
(The Chi-squared calculated as the difference between observed and expected values from the model is less than the critical value at 1% with 1 *df*. Thus, the difference between the expected and observed samples is not statistically significant. The model fits the data.)

3.5.2 *Household decision rules*

This subsection focuses on solving for optimal decision rules, specifically by determining the optimal levels of time allocation, French expenditures, and savings. The model provides a visual representation of these life cycle paths through Figure (3.10). This figure illustrates the income path, asset path, working time, and French expenditures over the course of an individual's career who decides to stay in Quebec. One can observe the life cycle paths of these variables and gain insights into individuals' optimal decision-making processes. Analyzing the asset path allows us to understand how individuals' savings evolve over time. The average working time indicates how individuals allocate their time between work and other activities throughout their careers. Lastly, the French expenditures represent the amount of resources individuals allocate towards French language-related activities. In the upper left panel of figure (3.10), one can observe the average income trajectory of unilingual

English speakers as generated by the model.

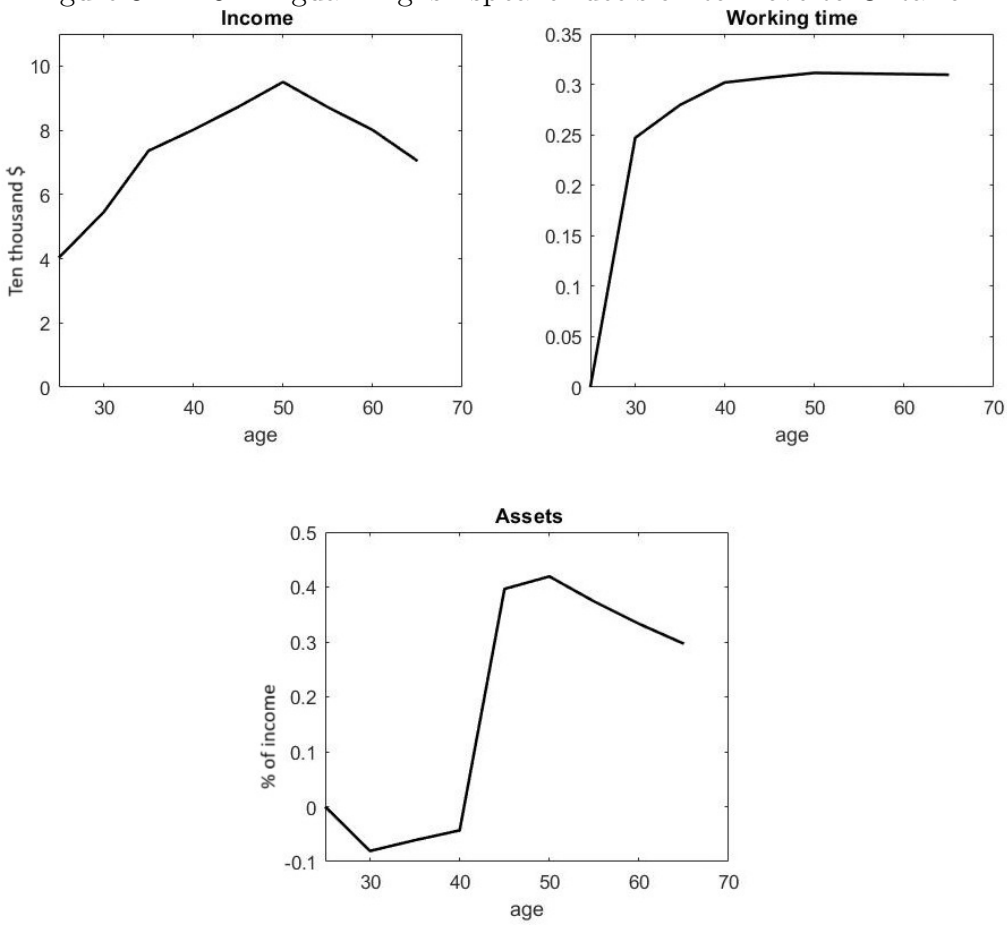
Figure 3.10: Unilingual English speaker decision rules in Quebec



The average working time of unilingual English speakers is depicted in the lower left panel of the same figure. It shows that, on average, these individuals allocate approximately 35% of their time to work during the early stages of their working lives. From mid-age to the retirement age, their average working time increases to around 40%. It is essential to note that this measure encompasses the time spent on language skills accumulation, as individuals continue to enhance their skills through practice even after the training stage. The model also replicates the financial aid received by students when they enroll in language training, as shown in the expenditures panel of the upper right graph. The expenditures are depicted below zero because students are credited a certain amount of money to cover their language training costs, as well as subsidies that fully cover their language-related expenses. This reflects the financial support provided to students throughout their language training period. After the language training period ends, the expenditures converge to zero. Lastly, the lower right panel represents the assets of unilingual English speakers over their career

span. At the beginning of their careers, their assets are below zero, indicating that they start with student loan debt and face challenges in integrating into a predominantly French-speaking labor market. However, as they progress in their careers and accumulate skills, their assets begin to grow, reflecting their improved financial position.

Figure 3.11: Unilingual English speaker decision to move to Ontario



When unilingual English speakers decide to move to Ontario, they experience a higher income profile and consequently accumulate higher assets compared to their peers in Quebec (see fig. 3.11). Additionally, they spend less time working, as there is no need to allocate time to improve their second language skills.

3.5.3 *Benchmark economy*

From the Census 2016-IPUMS, one can see that among anglophone workers whose location of study is in Quebec, 40.6% still reside in Quebec, 40.3% moved to Ontario, and the rest elsewhere. Table 3.4 assesses the performance of the model economy at t =

1 with respect to the data. Overall, the model replicates the data moments although it overestimates to some extent the percentage of francophone leaving the Quebec province. Various combinations of initial second language proficiency and cost of leaving (f, q) yield distinct profiles and determine the movements in and out of the province.

Table 3.4: Targets: Data and Model

	Data (2016)	Model
Anglophone leavers	0.594	0.580
Francophone leavers	0.001	0.020
Bilingual leavers	0.061	0.060

Those combinaisons are $(\bar{f}, \bar{q})$, $(\bar{f}, \underline{q})$, $(\bar{f}, q_{avg})$, $(\underline{f}, \bar{q})$, $(\underline{f}, \underline{q})$, $(\underline{f}, q_{avg})$, $(f_{avg}, \bar{q})$, $(f_{avg}, \underline{q})$, (f_{avg}, q_{avg}). I maintain the same average debt level across all profiles since, in this model, it represents the cost of education borne by everyone. This approach enables me to apply uniform reductions and evaluate the effects of reduced education expenses on migration decisions in the policy experiment section.

The majority of individuals who initially possess second language skills below the acceptable threshold in the Quebec labor market $(\underline{f}, \bar{q})$, $(\underline{f}, \underline{q})$, $(\underline{f}, q_{avg})$ tend to give up on learning the language, making them the predominant group among Anglophone individuals who leave in the simulated model. This is due to the limited perceived benefits compared to the costs and challenges of learning the second language, which include time, expenses, and reduced or forgone wages. It is less advantageous to stay in Quebec than to leave in terms of career prospects and overall economic outcomes. The combination of limited salary potential, linguistic barriers, and language time investment and opportunity costs makes the decision to leave Quebec a more viable option for these individuals. The reverse is true for unilingual French speakers.

Those initially with average second language skills $(f_{avg}, \bar{q})$, $(f_{avg}, \underline{q})$, (f_{avg}, q_{avg}) typically aim to narrow the wage gap between themselves and individuals with higher language proficiency $\bar{f}_j$. Bilingual workers earn more over their lifetimes than unilingual English and French speakers, as shown in Figure 3.4 for both locations. They meet the thresold language skills required by language laws and thus are eligible for the Quebec labor market. In the model as in the data, Quebec offers competitive subsidies for those willing to learn french. By working in Quebec, they have the opportunity to enhance their second language skills, eventually achieving bilingual proficiency. Moreover, choosing to learn French in a French-speaking province, such as Quebec, provides the added benefit of complete immersion in the

language, making Quebec advantageous. Being surrounded by native speakers and having daily exposure to the language can greatly enhance the learning process. The investment costs is less in Quebec than in Ontario due to these added benefits. Therefore, for individuals who are willing to become bilingual, the costs associated with leaving Quebec tend to outweigh the costs of staying, as the immersion and support available in the province make it an advantageous environment for acquiring the necessary language skills.

The remainder of individuals who initially possess sufficiently high second language skills $(\bar{f}, \bar{q})$, $(\bar{f}, \underline{q})$,$(\bar{f}, q_{avg})$, do not encounter any language barriers in the Quebec labor market and face no issues in securing and maintaining bilingual positions throughout their careers in Quebec. However, some profiles $(\bar{f}, \underline{q})$ still choose to leave, as the decision to move, as stated before, is a combination of many factors such as relocating costs and potential wages. Bilingual individuals earn more in Ontario than in Quebec as stated before. Individuals leave the province in the simulated model when the benefit of leaving is greater than their "individual relocating cost" q. They choose to move when the potential wage gap between jurisdictions compensates for the relocation costs. Given the dynamics and considerations mentioned, the model predicts that 42% of individuals will choose to stay in Quebec (referred to as "stayers"), while 58% of individuals will decide to leave the province. These proportions suggest that a significant portion of individuals, particularly those with limited second language skills, opt for relocation elsewhere with better earning potential and perceived opportunities.

3.6 Policy experiments

The calibrated model provides a sensible benchmark for assessing and comparing outcomes from different policies on the Quebec anglophone graduates' choices. The focus is on two policies that could be suggested to Quebec policymakers: the launch of bilingual programs in English universities and giving workers a lump sum if they spend the first 10 years of their work lives in Quebec. The policies that this paper focuses on are those that seek to achieve the maximum retention of anglophone graduates in Quebec and are those that work toward equality of opportunity for all graduated students regardless of their linguistic background. Again the behavior of anglophone graduates is at the center of interest in these experiments. The policy simulations listed in the table are conducted independently of each other.

Table 3.5: Policy experiments in simulated Quebec Economy

Calibration		Stayers	Leavers
2016	*Baseline (model = 2016 data)*		
	Anglophone migration decision	0.42	0.58
(1)	*Launching bilingual programs at low costs*		
	Migration decision	0.71	0.29
(2)	*Student debt cancellation after 10 years*		
	Migration decision	0.89	0.11

3.6.1 *Launching bilingual programs at English-speaking Universities*

What if instead of asking indebted graduated students concerned about the repayment of their loan with 6 months of grace period to stay in the province of study where they know very basic French to get by, Quebec English universities would launch bilingual programs and reduce the tuition fees of those programs by 20%? Most students cannot afford to pay for their college education out of pocket and thus offering a 20% reduction on their student debt could be a good strategy to promote the learning of French. The proposed policy aims to address their concerns about loan repayment and language barriers in accessing the labor market. By making college education more affordable and promoting bilingualism, the policy aims to increase the share of graduates who choose to stay in Quebec after completing their studies. The policy is particularly appealing to the majority of graduates, as it not only reduces their debt burden but also provides them with the opportunity to benefit from higher wage growth throughout their careers due to the advantages of bilingualism.

In the model, this corresponds to reducing the student loan amount by 20% and setting the anglophone mimimum French level at graduation to the average f_{avg} due to the bilingual nature of these programs. The profiles $(\underline{f}, \bar{q})$, $(\underline{f}, \underline{q})$, $(\underline{f}, q_{avg})$ disappear from the model, leaving the profiles $(f_{avg}, \bar{q})$, $(f_{avg}, \underline{q})$, (f_{avg}, q_{avg}), $(\bar{f}, \bar{q})$, $(\bar{f}, \underline{q})$, $(\bar{f}, q_{avg})$. According to the model, implementing this policy would result in 71% of graduates deciding to stay in the province, while 29% would still choose to leave. Among the leavers are individuals mostly with profiles $(\bar{f}, \underline{q})$ and $(f_{avg}, \underline{q})$. Despite benefiting from reduced tuition fees and bilingual programs in Quebec's English universities, these profiles still find better wage opportunities in Ontario compared to Quebec. The relatively low cost of leaving Quebec makes the decision to move to Ontario for better opportunities more feasible, especially

since the reduced debt level and the higher wages in Ontario increase the perceived benefits of leaving. Your reasoning aligns with economic decision-making where individuals weigh costs and benefits when choosing to migrate. The relatively low cost of leaving Quebec (both financially and socially) and higher wages in Ontario improve the net benefit of moving, making the migration decision more attractive. Their low cost of leaving prompts them to leave early, in the first period, to benefit from the higher bilingual wage profile available in Ontario.

By lowering college tuition and encouraging bilingualism, the policy generates an income effect. Graduates not only experience reduced financial pressure but also gain eligibility for the French labor market, opening up additional opportunities for career growth and advancement. The proposed policy will cost Concordia University, for instance, roughly $42,069,000, representing the total reduction in tuition fees in case all of the 35,404 undergraduates choose to enroll in bilingual programs. A year post-graduation, the income tax revenue from the 71% stayers will be $349,452,350, resulting in a net gain of $307,383,349.

In sum, the proposed policy will address the concerns and barriers faced by anglophone graduates in Quebec. By making college education more affordable and promoting bilingualism, it aims to increase the retention of skilled workers in the province and enhance their long-term career prospects.

3.6.2 *Student debt cancellation after 10 years*

Leaving college with a significant amount of student debt, especially with the burden of interest rates, can be a substantial liability for many students. It not only creates stress about maintaining good standing and repayment, but also creates a strong desire to eliminate the debt and avoid being tied to it for the rest of their lives. Therefore, the concept of cancelling student debt after a certain period, such as 10 years, holds broad appeal. Student debt forgiveness entails relieving borrowers from their obligation to repay a portion of their student loan debt. This policy aligns with initiatives like the US public service loan forgiveness program, which forgives loans after 10 years of full-time service.

In the second experiment, a policy is implemented where students, regardless of their linguistic background, have their student loans set to zero after 2 model periods of being taxpayers in the province of Quebec. According to the model's predictions, after the implementation of this policy, the percentage of graduates choosing to leave Quebec decreases significantly. Only 11% of the graduate population decides to leave in the first period, compared to 59% before the policy. They are mostly people with profiles types $(\underline{f}, \underline{q})$, $(\underline{f}, q_{avg})$. Their departure is primarily influenced by the pressure of debt repayment, compounded by their relatively low cost of leaving and their low proficiency in French, which limits

their access to the predominantly French labor market. As a result, they seek opportunities elsewhere to start meeting their obligations. Even with the financial incentive of loan forgiveness, those individuals prioritize career opportunities in Ontario that lead them to leave Quebec. Some of the remaining 89% are willing to stay in Quebec and take advantage of the free French classes offered to bridge the gap in language skills between them and native French speakers. The opportunity for debt cancellation implicitly increases the cost associated with leaving Quebec, making Quebec attrative to them.

After the loan forgiveness, some of the $(\bar{f}, \underline{q})$ and $(f_{avg}, \underline{q})$ profiles will leave Quebec due to better wage opportunities in Ontario. In essence, while loan forgiveness reduces the financial burden, other factors career prospects may still influence individuals' decisions to leave Quebec, especially for those with lower personal ties. Additionally, although the model does not address it directly, the policy is expected to attract many students to Quebec who are interested in avoiding the burden of student loans throughout their lives. Quebec universities can leverage their screening process to admit high-ability students who might have otherwise chosen to study in other provinces. Overall, this policy has the potential to significantly impact graduate retention in Quebec, increase tax revenue, and attract talented students interested in avoiding long-term student loan obligations. In this simulation, the cost to the Quebec government will be $5,524.20 per borrower, representing the total amount forgiven. It will receive $139,020 as income revenue per stayer over the course of 10 years, resulting in a net benefit of $133,495.80 per stayer. If we account for the entire population of Concordia graduates who stay, the cost to the Quebec government will be $174,065,111, representing the amount forgiven. It will receive $4,380,459,031 as income tax revenue from the 89% (stayers) over the course of 10 years, resulting in a net benefit of $4,206,393,920.

3.7 Conclusion

This chapter delves into the effects of Quebec's language policies on the migration decisions of English-speaking graduates. The first part of the chapter focuses on statistical analysis, using data from the Public Use Microdata File (Census 2016). The analysis reveals that, despite Quebec's predominantly French labor market, bilingual workers consistently earn higher incomes than unilingual French and English speakers. This underscores the importance of learning the second official language, not only in Quebec but also in Ontario, where knowledge of both official languages is associated with increased earnings. Conversely, not knowing either official language has a detrimental effect on income, making individuals significantly poorer over their lifetime. In the second part of the chapter, linguistically diverse economies are simulated to assess the impact of language policies on individuals'

migration decisions. The model closely tracks income patterns throughout individuals' lifecycles and serves as a benchmark for policy experiments. The study identifies two policies that are found to be highly effective in reducing interprovincial migration among graduates. Firstly, launching bilingual programs at English universities in Quebec is projected to retain at least 71% of the graduate population within the province. This initiative aims to provide opportunities for English-speaking students to acquire proficiency in the second official language and encourages them to remain in Quebec. Secondly, a policy proposal suggests canceling student loans for borrowers after ten years. This policy is predicted to retain 89% of graduates in the province. By implementing these policies, Quebec not only becomes an attractive destination for college education but also retains a larger proportion of skilled workers after graduation.

References

Abramitzky, R., Lavy, V., & Segev, M. (2024). The effect of changes in the skill premium on college degree attainment and the choice of major. *Journal of Labor Economics*, *42*(1), 245–288.

Adsera, A., & Pytlikova, M. (2015). The role of language in shaping international migration. *The Economic Journal*, *125*(586), F49–F81.

Ahmed, S. (1986). Temporary and permanent government spending in an open economy: some evidence for the united kingdom. *Journal of Monetary economics*, *17*(2), 197–224.

Aiyagari, S. R., Christiano, L. J., & Eichenbaum, M. (1992). The output, employment, and interest rate effects of government consumption. *Journal of Monetary Economics*, *30*(1), 73–86.

Amano, R., & Wirjanto, T. S. (1994). *An empirical investigation into government spending and private sector behaviour* (Tech. Rep.). Bank of Canada.

Amano, R. A., & Wirjanto, T. S. (1998). Government expenditures and the permanent-income model. *Review of Economic Dynamics*, *1*(3), 719–730.

Arcidiacono, P., Hotz, V. J., Maurel, A., & Romano, T. (2020). Ex ante returns and occupational choice. *Journal of Political Economy*, *128*(12), 4475–4522.

Avery, C., & Hoxby, C. M. (2004). Do and should financial aid packages affect students' college choices? In *College choices: The economics of where to go, when to go, and how to pay for it* (pp. 239–302). University of Chicago Press.

Bahrick, H. P. (1984). Semantic memory content in permastore: fifty years of memory for spanish learned in school. *Journal of experimental psychology: General*, *113*(1), 1.

Bengali, L., Daly, M. C., et al. (2014). Is it still worth going to college? *FRBSF Economic Letter*.

Bernard, A., Finnie, R., St-Jean, B., et al. (2008). *Interprovincial mobility and earnings*. Statistics Canada Ottawa.

Bourhis, R. Y., & Bourhis, R. Y. (2008). *The vitality of the english-speaking communities of quebec: From community decline to revival*. Canadian Institute for Research on Linguistic Minorities, Univerité de Moncton.

Brown, A., & Wells, G. (2008). Substitution between public and private consumption in australian states. In *Conf paper, australasian meeting of the econometric society, wellington, new zealand.*

Cai, Z., & Heathcote, J. (2018). College tuition and income inequality.

Carnevale, A. P., Cheah, B., & Strohl, J. (2013). Hard times: College majors, unemployment and earnings: Not all college degrees are created equal.

Castillo, W., Collins, G. J., & Maynard, R. (2020). A systematic review of evidence on the effectiveness of targeted college access programs offering no-cost or subsidized college enrollment. *Improving research-based knowledge of college promise programs*, 69–91.

Caucutt, E. M., & Kumar, K. B. (2003). Higher education subsidies and heterogeneity: A dynamic analysis. *Journal of Economic dynamics and Control*, *27*(8), 1459–1502.

Chiswick, B. R., & Miller, P. W. (2003). The complementarity of language and other human capital: Immigrant earnings in canada. *Economics of Education review*, *22*(5), 469–480.

Clemens, J. (2016). *Interprovincial migration in canada: Quebeckers vote with their feet*. Fraser Institute.

Cohen-Goldner, S., & Eckstein, Z. (2008). Labor mobility of immigrants: Training, experience, language, and opportunities. *International Economic Review*, *49*(3), 837–872.

Cowen, T. (2004). *How the united states funds the arts*. National Endowment for the Arts.

Darvishi, F. (2023). *The effects of tuition hikes on the choices of college majors* (Unpublished doctoral dissertation). Concordia University.

Davies, S., & Guppy, N. (1997). Fields of study, college selectivity, and student inequalities in higher education. *Social forces*, *75*(4), 1417–1438.

Dawood, T. C., & Francois, J. N. (2018). Substitution between private and government consumption in african economies. *Economic Modelling*, *73*, 129–139.

Deb, S. (2017). Trump proposes eliminating the arts and humanities endowments. *The New York Times*, *15*.

Devereux, M. B., Head, A. C., & Lapham, B. J. (1996). Monopolistic competition,

increasing returns, and the effects of government spending. *Journal of Money, credit and Banking*, *28*(2), 233–254.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, *74*(366a), 427–431.

Dupuis, F., & Bégin, H. (2018). Quebec's net migration with other provinces is improving.

Durante, A., Larrimore, J., Park, C., Tranfaglia, A., et al. (2017). *Report on the economic well-being of US households in 2016* (Tech. Rep.). Board of Governors of the Federal Reserve System (US).

Eckstein, Z., & Wolpin, K. I. (1999). Why youths drop out of high school: The impact of preferences, opportunities, and abilities. *Econometrica*, *67*(6), 1295–1339.

Esteve, V., & Sanchis-Llopis, J. (2005). Estimating the substitutability between private and public consumption: the case of spain, 1960–2003. *Applied Economics*, *37*(20), 2327–2334.

Forget, C. E. (2014). The case of the vanishing québec physicians: how to improve access to care. *CD Howe Institute Commentary*(410).

Gomme, P., Jamil, G. M., Koreshkova, T., Lkhagvasuren, D., et al. (2019). *An analysis of the ins and outs of migration within canada* (Tech. Rep.). CIRANO.

Halstead, K. (2007). *The higher education price index (hepi).* Research Associates of Washington. Washington, DC (https://www.commonfund.org/higher-education-price-index.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica: Journal of the econometric society*, 1029–1054.

Huggett, M., Ventura, G., & Yaron, A. (2006). Human capital and earnings distribution dynamics. *Journal of Monetary Economics*, *53*(2), 265–290.

Ionescu, F. (2009). The federal student loan program: Quantitative implications for college enrollment and default rates. *Review of Economic dynamics*, *12*(1), 205–231.

Jaschik, S. (2017). Humanities majors drop. *June*, *5*.

Katsaitis, O. (1987). On the substitutability between private consumer expenditure and government spending in canada. *Canadian Journal of Economics*, 533–543.

Keane, M. P., & Wolpin, K. I. (1997). The career decisions of young men. *Journal of political Economy*, *105*(3), 473–522.

Kim, C., Tamborini, C. R., & Sakamoto, A. (2015). Field of study in college and

lifetime earnings in the united states. *Sociology of Education*, *88*(4), 320–339.

Long, M. C., Goldhaber, D., & Huntington-Klein, N. (2015). Do completed college majors respond to changes in wages? *Economics of Education Review*, *49*, 1–14.

Molotsky, I. (1982). Reagan expected to cut spending for the arts. *New York Times*.

Mou, H., & Olfert, M. R. (2015). Inter-provincial migration intentions of family physicians in canada: the roles of income and community characteristics. *Healthcare Policy*, *11*(2), 58.

Nguyen, H. (2020). Free college? assessing enrollment responses to the tennessee promise program. *Labour Economics*, *66*, 101882.

Obama, B. (2014). Remarks by the president on opportunity for all and skills for america's workers. *January*, *30*, 2014.

Ogaki, M. (1992). Engel's law and cointegration. *Journal of Political Economy*, *100*(5), 1027–1046.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346.

Racine, N., Villeneuve, P. Y., & Thériault, M. (2003). Attracting foreign students: The case of two universities in québec. *Journal of Studies in International Education*, *7*(3), 241–252.

Reichling, F., & Whalen, C. (2012). Review of estimates of the frisch elasticity of labor supply.

Ríos-Rull, J.-V. (1996). Life-cycle economies and aggregate fluctuations. *The Review of Economic Studies*, *63*(3), 465–489.

Rumberger, R. W., & Thomas, S. L. (1993). The economic returns to college major, quality and performance: A multilevel analysis of recent graduates. *Economics of Education Review*, *12*(1), 1–19.

Scott-Clayton, J. (2011). On money and motivation: A quasi-experimental analysis of financial incentives for college achievement. *Journal of Human resources*, *46*(3), 614–646.

Stevenson, M. (2000). Canada's other brain drain: the continuing exodus from quebec. *POLICY*, *63*.

Strauss, V. (2018). A university of wisconsin campus pushes plan to drop 13 majors—including english, history and philosophy. *The Washington Post*.

Tourism, S. C., & the Centre for Education Statistics Division Council of Ministers of Education (Canada). (2019). Education indicators in canada: an international

perspective 2019.

Turner, S. E., & Bowen, W. G. (1999). Choice of major: The changing (unchanging) gender gap. *ILR Review*, *52*(2), 289–313.

Vanasse, A., Scott, S., Courteau, J., & Orzanco, M. G. (2009). Canadian family physicians' intentions to migrate: associated factors. *Canadian Family Physician*, *55*(4), 396–397.

Wiswall, M., & Zafar, B. (2021). Human capital investments and expectations about career and family. *Journal of Political Economy*, *129*(5), 1361–1424.

Xu, Y. (2015). Focusing on women in stem: A longitudinal examination of gender-based earning gap of college graduates. *The Journal of Higher Education*, *86*(4), 489–523.