An Empirical Investigation of the Determinants of Human Capital among Canadian Youth

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Abstract

The objective of this thesis is to identify various determinants of human capital development among Canadian youth. Three mediating agents are examined: parents, schools, and government. Considerable attention is paid throughout to identifying causal relationships with empirical data.

The first chapter introduces the thesis by discussing its main goals, as well as the importance of the topic. This chapter also summarizes each of the following substantive chapters.

I explore the relationship between family size and various components of the child quality production function in the second chapter. The findings suggest that larger families lead to reduced parental investments in children. Despite this, standardized test scores do not decline with family size. Three possible reasons for this puzzle are explored.

In the third chapter, I estimate the relationship between fertility and the allocation of paid and unpaid labour among couples. Results indicate that additional children lead to a reduction in paid hours and to an even larger increase in unpaid hours among mothers. Additional children are not related to paternal paid hours, although fathers spend slightly more time performing unpaid childcare.

In the fourth chapter, I estimate the impact of schooling on academic performance in high school. Additional schooling is associated with significant improvements in

reading, mathematics, and science performance, but it confers the same benefits in each area to students across the conditional distribution of academic performance, as well as to both sexes and to students from high and low income families.

I examine the relationship between prospective student debt load and postsecondary attendance in the fifth chapter. The results indicate that reduced prospective debt load raise university enrolment only among students facing lower net returns to attending.

The final chapter summarizes the findings, highlights the contributions to the literature, discusses policy implications, and sets forth directions for future research.

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Chapter 1: Introduction

1.1 Overview of the thesis

In this thesis, I investigate the process of acquiring human capital at different stages in young people's lives. I do so by looking at three mediating players: parents, schools, and government. In the first two essays (Chapters 2 and 3), I estimate the relationship between family size and various aspects of child quality, such as academic test scores and parental investments in children (including financial and time investments). In the third essay (Chapter 4), I estimate the impact of schooling on academic performance for different groups of students. In other words, to what extent does more schooling generate improved academic performance, and how do returns vary by student characteristics? In the fourth essay (Chapter 5), I estimate the impact of prospective student debt load on postsecondary attendance among youth from low-income families, holding liquidity constraints constant. The contribution of the thesis is to provide empirical evidence to the relevant literatures. As a result, there is a strong focus on identifying causal relationships (rather than mere correlations) throughout the chapters. The thesis also has a Canadian focus throughout.

Understanding the process of human capital development has important policy implications. First, the benefit of human capital to individuals and society is largely unquestioned in the economics literature. For example, studies estimating the causal impact of schooling on individual earnings have yielded estimated returns in the neighbourhood of 10% per additional year of schooling (Card, 2001). This result also holds in Canada based on causal evidence by Lemieux and Card (2001). Recent studies have also linked education to improved civic participation. Using exogenous variation in compulsory school laws to instrument for education, Milligan, Moretti, and Oreopoulos (2004) find that educational attainment is linked to political interest and involvement in the United States (US) and the United Kingdom (UK). Higher educational attainment has also been linked to reduced hospitalization rates. Arendt (2008) uses a Danish school reform to identify the relationship, and finds that higher education reduces the probability of being hospitalized for women, and reduces the probability of being diagnosed with selected lifestyle related illnesses for men.

Second, there are also macroeconomic benefits to human capital. Literacy performance, one measure of human capital, has been linked to economic growth (as measured by Gross Domestic Product—GDP—per capita). Coulombe and Tremblay (2006) use data from 14 countries in the Organisation for Economic Co-operation and Development (OECD) and create synthetic cohorts based on literacy scores and GDP per capita. They find a positive and significant association between the two, although the authors readily admit to the possibility of endogeneity.

Third, understanding the factors associated with human capital acquisition provides policymakers with the *instruments* for influencing academic achievement and educational attainment. For example, in Chapters 2 and 3, I examine the role of family size on academic outcomes of children and parental investments in child well-being. However, family size can itself be a policy target since fertility may be malleable through financial incentives. In Chapter 4, I estimate the impact of schooling on academic outcomes. Many provincial jurisdictions in Canada and the world monitor academic progress of children by administering standardized tests to students in various school grades. However, as students age, their academic performance may improve for many reasons, including learning through the school system, but also perhaps through interactions with their parents, siblings, friends, or self-learning (watching television, reading, etc.) I adopt an approach that allows for estimating the role of additional schooling in shaping academic performance, essentially answering the question "How much learning occurs in *schools*?" Policymakers can use this information to determine if more resources need to be devoted to schools, or if other avenues should be explored. Finally, in Chapter 5, I estimate the impact of prospective student debt load on postsecondary access. This has obvious implications for policy, as governments around the developed world are heavily involved in determining not only the level of total aid provided to students, but also the mix of loans and grants.

The remainder of this chapter is devoted to briefly summarizing each of the essays. In Sections 1.2 to 1.5, I describe Chapters 2 to 5, respectively. I then conclude this chapter by setting the stage for the remainder of the thesis in Section 1.6.

1.2 Summary of Chapter 2

In Chapter 2, I estimate the impact of family size (i.e. number of children) on child quality measures, including academic performance (as measured by a standardized test in reading), as well as parental investments in the child (i.e. savings earmarked for postsecondary education—PSE, private school enrolment, and the number of computers in the home per child). All child quality measures are garnered at age 15 from a survey of youth.

The identification of the causal relationship between family size and child quality is an important consideration. Preferences for child quality may have a direct impact on optimal family size. For this reason, I instrument the number of children in the family with an event that is arguably exogenous: the incidence of a multiple birth on the second or later birth.

An important contribution of this chapter is to investigate possible reasons why family size doesn't necessarily have the same impact on child outputs as it does on child inputs. This is the first study to do so.

1.3 Summary of Chapter 3

Chapter 3 is a follow up to Chapter 2. Larger families are expected to contribute towards reducing investments in children for the simple reason that more children are drawing on fixed resources. However, larger families may also increase parental time spent at home (as opposed to the paid workplace). This may counter-balance the effect of spreading investments on children more thinly (assuming more parental contact benefits the child). Hence, this chapter looks at the impact of family size on the allocation of both paid and unpaid labour of the mother and the father.

Once again, identification is an issue since families with certain preferences for labour-leisure allocation may, as a result, have certain preferences for fertility. Using Census data, I instrument the number of children using the same approach as in Chapter 2 (i.e. the incidence of a multiple birth on the second or later birth). I also adopt an alternative instrumental variable approach used in this literature: the sex composition of the first two children. Families often prefer to have a boy and a girl; if they fail in achieving their goal after two children, they may be compelled to have a third child. Note that this approach is not typically used in the child quality literature since the sex of one's siblings may directly influence child quality.

This chapter represents the first study to look at the impact of family size on unpaid work patterns of the parents. This is important for two reasons. First, as mentioned above, increased parental contact with the child may counter-balance the effect of a decline in parental investments on child quality (following an increase in family size). Second, the theoretical literature regarding household labour supply decisions and fertility invariably incorporates decisions pertaining to unpaid work. The empirical evidence in this chapter will inform this aspect of the literature.

1.4 Summary of Chapter 4

In this chapter, I estimate the impact of schooling on academic performance. In other words, to what extent do students learn in school? The answer to this question is not obvious. School marks are based on different standards that depend on the school grade. Governments often assess students in different grades with standardized tests, but again, the content of the tests depends on the school grade. Even if one could administer the same test to a student in successive years, and assume that the student forgets the specific questions in the meantime, it would still not be possible to measure the impact that schooling has on the learning process. The reason is simple: in the intervening year between the tests, the student may have learned relevant material from multiple sources (e.g. parents, siblings, friends, media, books, museums, etc.)

The approach used in this chapter is to exploit a setting whereby students of very close age wrote the same tests (in reading, mathematics, and science), but were in different school grades because of the existence of school age of entry laws. To estimate the impact of schooling on academic performance, I apply a regression discontinuity estimator nested in an IV framework, based on the exact date of birth and the school entry laws.

An important advance in this chapter is the analysis of heterogeneity in the results (i.e. across the conditional distribution of academic performance, as well as by sex and parental income). To date, no study has placed such a heavy emphasis on the variation in school effects. Without a doubt, understanding for whom the school system works is of critical importance for education policy.

1.5 Summary of Chapter 5

Most of the work in the area of student financial aid and postsecondary access has focused on the impact of liquidity constraints (i.e. the total aid provided). However, the nature of the aid itself (grant or loan) may also influence decisions of youth since a higher debt load may prevent them from participating in certain activities following graduation (e.g. buying a home, starting a family, etc.), as well as the decision to attend in the first place (based on net returns). This chapter focuses on the latter of the two by estimating the impact of prospective student debt load on the probability of pursuing a postsecondary education.

To estimate this relationship, the ideal situation would be an exogenous increase in expected debt, but with no change in total student financial aid provided. Beginning in 2005, such programs were implemented in Canada.

Specifically, the government introduced large grants to students whose parental income fell below a certain threshold. If parental income was above the threshold, no grant was offered. A critical feature of the grant was that it did not provide additional aid; it was simply clawed back from loans. As a result, student debt decreased for eligible students, but liquidity constraints remained constant. To estimate the impact of this decline in student loans, I use longitudinal income tax data that matches youth to their parents, and allows one to ascertain whether the youth has pursued postsecondary education.

Two estimation approaches are used. The first is a differences-in-differences estimator (which examines changes in the gap in postsecondary enrolment between eligible and non-eligible youth over time in different jurisdictions—the programs were not introduced at the same time in each jurisdiction). The second approach is a regression discontinuity estimator, given the sharp discontinuity in grant eligibility based on parental income.

A small handful of studies around the world evaluate the impact of prospective debt on attendance, but given the nature of the policy changes examined, these are mainly limited to a differences-in-differences approach. This chapter represents the first study on the topic using a regression discontinuity approach.

Another important innovation is to consider specific circumstances where youth may be more sensitive to debt. I present a simple theoretical model to argue that although the net benefit to attending PSE should rise as loan repayment is lowered, the demand for PSE will only increase if students initially considered PSE to be a bad investment (relative to no PSE). I then argue that supply side constraints may result in no change in overall enrolment, but rather a re-allocation of students offered positions in PSE institutions. I test this hypothesis by estimating attendance effects for groups of students who may face lower net returns to PSE; specifically, males (who face lower labour market returns to PSE) and students who were raised far from a university (who face higher costs of attending).

1.6 Concluding remarks

This thesis seeks to add to the current knowledge in the literature on human capital acquisition. The actions of three agents are examined in particular: parents, schools, and government. Government may intervene directly in the human capital development of youth or it may attempt to influence outcomes through mediating players such as parents or schools.

The remainder of the thesis is as follows. In Chapter 2, I examine the impact of family size on child quality. A related topic appears in Chapter 3, where I investigate the relationship between family size and parental labour supply (including paid and unpaid work). In Chapter 4, I estimate the impact of schooling on academic performance. In Chapter 5, I examine the impact of prospective debt load on postsecondary attendance. Finally, the thesis is tied together and put into perspective in Chapter 6. To this end, I summarize the thesis, highlight the key contributions to our knowledge of human capital acquisition among youth, discuss their policy implications, and finally, list several possibilities for future research.

Chapter 2: The Impact of Family Size on Child Quality

2.1 Introduction

In this chapter, I estimate the impact of family size (i.e. number of children) on various measures of child quality. As with any production function, the child quality production function consists of some measure of child output (e.g. academic performance, educational attainment, labour market success, etc.), which is determined by child inputs. Child inputs may be initiated by the behaviour of parents, friends, teachers, governments, etc.

For the purposes of this chapter, I focus on academic performance as a measure of output. This is measured by results from a standardized test in reading.[1] On the input side, I consider parental behaviour since it is the parents who may be influenced by family size. Parental investments in children may be financial or non-financial in nature. In this chapter, I consider financial inputs. Measures of financial investments include private school enrolment, the number of computers in the home per child, and saving for the child's postsecondary education.

[1] The literature often uses the term 'cognitive ability' when studying test scores. When I refer to my own work, I opt to use the more neutral 'academic performance', which may encompass cognitive ability, but also non-cognitive abilities (e.g. motivation to perform well on tests). However, I often use the term 'cognitive ability' when referring to previous work to be consistent with their terminology. In all cases, however, I am referring to test scores.

Using a survey of 15 year old Canadian youth, I instrument fertility with the incidence of a multiple birth on the second or later birth. Parents who have twins on their first try may have always planned to have two children. In contrast, it is likely that a multiple birth on the second or later birth would generate more children than originally planned given the small size of the typical modern family. The findings suggest that increased family size is linked to lower parental investments in children, but is not negatively linked to child test scores. In fact, test scores improve by 16% of a standard deviation, which is significant at 10%.

The remainder of this chapter is as follows. In Section 2.2, I will review the literature on fertility and child quality. This review will describe both the theoretical and empirical works in the area. Next, I will undertake the empirical analyses of fertility and child quality in Section 2.3 (Methodology), Section 2.4 (Descriptive results), and Section 2.5 (Econometric results). In Section 2.6, I discuss and explore potential explanations behind the finding that increased family size is linked to lower parental investments in children, but is not negatively linked to child test scores. The chapter concludes in Section 2.7.

2.2 Literature review

Overview

The literature regarding fertility is multifaceted. Indeed, countless theoretical and empirical studies have examined several factors related to the determination of fertility, as well as the impact of fertility on various other outcomes. Moreover, this literature is multidisciplinary. Although demographers were the first to become interested in fertility (for obvious reasons), economists entered the field when it became clear that the existing demographic models of fertility were not designed to account for changing patterns of fertility in the postwar era (i.e. the baby boom). According to Becker (1960), socio-economic factors were largely absent from demographic models of fertility. These models were simple extrapolations of past trends, and at best would occasionally adjust for changes in the composition of age, sex, and marital status of the population. Consequently, economists such as Gary Becker and many others have undertaken to apply more stringent economic principles to the study of fertility. Incidentally, the works of Becker have been espoused by many sociologists, who have also become keen stakeholders in the broad field of fertility.

Providing an overview of all the dimensions of the fertility literature is beyond the scope of this review. The objective here is far more modest, albeit more focused: I will attempt to summarize and synthesize the major theoretical and empirical works in the literature related to this chapter.

The structure of this section is as follows. First, I will review the theoretical articles in the literature. The major aim here is to highlight the assumptions of the models and (perhaps more importantly) the testable hypotheses implied by the models. Second, I will move into the empirical branch of the literature. As we shall see, studies abound in this area. However, all studies face a major hurdle from the first: finding an exogenous source of variation in fertility. This point was actually implied much earlier by some of the theoretical work, although many of the early empirical works paid little attention to the identification of the causal effects of fertility. Finally, I will position the current chapter within the context of the literature reviewed in this section. Specifically, I will elaborate on how the chapter contributes to the literature.

Theoretical literature

The economic predictions underpinning the relationship between fertility and investment in children are based on Becker's "Quantity-Quality" theory. This model was first presented in Becker (1960), and was further elaborated upon by Becker and Lewis (1973) and Becker and Tomes (1976).

Prior to Gary Becker and subsequent work by other economists, fertility theory was largely the domain of demographers. However, these models failed to predict the rapid increase in fertility rates following the Second World War in many industrialized countries. As Becker (1960) notes, this may relate to the fact that the demographic models were quite crude. They were either simple extrapolations of past trends for the population as a whole, or for specific subgroups defined by sex, age, and marital status. The models were, in fact, largely devoid of economic content.

Becker began to remedy the situation by examining the relationship between household income and family size. Previously, the 18th and 19th Century political economist/demographer Thomas Robert Malthus had assumed that family size should increase with household income. In other words, Malthus assumed that children were normal goods. Moreover, he assumed that the elasticity between the two should be quite large for two reasons. First, child mortality rates typically decline as income rises. Second, a rise in income increases the prospects for marriage, and thus, the opportunity to produce children.

However, empirical data often suggested a negative relationship between the number of children and household income. Rather than simply assume that children were inferior goods or that higher income couples faced a higher price of producing a child, Becker began investigating other possibilities in a more structured economic framework.

Becker assumed that children are consumer goods rather than producer goods. This is because the net costs of children are likely to be positive (i.e. the total cost of having a child is likely greater than the total revenue). The total cost includes direct costs (i.e. food, clothing, and shelter) and parental time necessary to raise the child, which has implied opportunity costs related to market time. Total revenue includes revenue arising from child labour. The assumption that children are consumer goods allowed Becker to use the theory of demand for consumer goods, which proved to be quite useful.

The fundamental distinction between Becker's theory of children as consumer durables and a more standard approach is that Becker assumed that parents would purchase two aspects of "children": the number of children and the quality per child. The implications are that the household seeks to maximize utility as a function of the number of children (N), the quality per child (Q), and some composite good (X), subject to a nonlinear budget constraint, as shown below:

$$(2.1)\ Max U(N, Q, X)$$

Subject to:

$$(2.2)\ p_C NQ + p_X X = M\ ,$$

where U denotes the utility function, p refers to price, C refers to "children" (in a broad sense, including both the number and the average quality), and M denotes income. Note the interaction between the number of children and the quality per child.

Specifying the budget constraint in such a way addresses an important mischaracterization about the cost of children faced by higher income households. While it is true that these households spend more per child, this is simply because they aim for higher quality children. The cost per unit of total child goods (p_c) is not necessarily higher for them.

As noted by Hotz, Klerman, and Willis (1997) in their overview of the economics of fertility in developed countries, one implication of the consumer choice problem described above is:

$$(2.3)\ \alpha(\varepsilon_N + \varepsilon_Q) + (1-\alpha)\varepsilon_X = 1\ ,$$

where α is the share of household income spent on children and ε denotes income elasticity. If "children" (i.e. quantity multiplied by quality) are normal goods, then

$(\varepsilon_N + \varepsilon_Q) > 0$; however, this does not preclude the possibility that $\varepsilon_N < 0$ if ε_Q is positive enough. In other words, the oft-cited negative relationship between income and the number of children does not necessarily imply that children (as defined by quantity multiplied by quality) are inferior goods. The number of children may be an inferior good (i.e. $\varepsilon_N < 0$), but total child services is not necessarily an inferior good. Becker further argued that ε_N is likely positive, albeit somewhat small. The reasons he gives include the possibility that tastes vis-à-vis quality and quantity vary systematically by income (likely because of social pressures), as well as the positive relationship between income and knowledge of contraceptives. The latter point is a supply side argument, while the former lies on the demand side. To support the supply side argument, Becker cites several data sources suggesting that when knowledge of contraceptives is equal across the income distribution, fertility tends to rise with income.

The very real possibility that $\varepsilon_N \neq 0$ implies that fertility is endogenous to household income. Moreover, fertility may be endogenous to the well known correlates of income, such as education, work hours, labour market experience, etc. As a result, empirical studies examining the impact of fertility on other outcomes (such as work hours, as is envisioned in the next chapter) will necessarily have to deal with the underlying endogeneity of fertility. For the moment, however, this discussion is left for Chapter 3.

Returning to the consumer problem described above, the first order conditions were derived more formally in Becker and Lewis (1973). They are:

$$(2.4)\ MU_N = \lambda QMC_C = \lambda MC_N$$

and

$$(2.5)\ MU_Q = \lambda NMC_C = \lambda MC_Q,$$

where MU is the marginal utility, MC is the marginal cost, and λ is the marginal utility of income. Rearranging these equations, we obtain the following marginal rate of substitution between the number of children and the quality per child:

$$(2.6)\ MU_N / MU_Q = MC_N / MC_Q = Q / N .$$

So, the relative cost of the number of children rises as the ratio of quality to quantity rises. This has strong implications for the relationship between quantity and quality (i.e. fertility and child investments). First, as the relative costs change, there is a substitution between quantity and quality. For example, if the relative cost of quantity rises, consumers substitute quality for quantity. Second, as income rises, there is also a substitution of quality for quantity as long as $\varepsilon_Q > \varepsilon_N$.[2] Becker and Lewis (1973) and Willis (1973) believed this to be empirically plausible. This is due to an income effect (related to the elasticities), as well as a substitution effect (related to the implied change in the marginal costs resulting from the changing ratio of quality over quantity).

[2] Note that Hotz et al. (1997) mistakenly report on two occasions that the necessary condition is $\varepsilon_N > \varepsilon_Q$.

The upshot of this discussion is that the Quantity-Quality Model implies a trade-off between these two characteristics of "children". In other words, the theoretical expectation derived from this model is that increased fertility will lead to a reduction in child quality.

Empirical literature

This section considers the main empirical studies related to the impact of fertility on child quality. The main challenge faced by researchers has been the potential endogeneity of fertility to child quality. Consequently, an important feature of this part of the literature review consists of highlighting the development of identification strategies over the years. Another challenge faced by some studies relates to small samples resulting from the chosen identification strategy. For example, some authors use the event of a twin birth to identify the causal impact of fertility. Since twins are relatively rare, standard datasets often do not produce sufficient twin cases to yield reliable estimates.

The objective of the empirical studies on fertility and child quality is to test Becker's Quantity–Quality theory. In other words, the studies aim to test the implied negative relationship between the number of children and the quality per child. Child quality is often based on some measured outcome of child success, such as academic performance, educational attainment, or even labour market success later in life.

As noted by Cáceras-Delpiano (2006), these can be viewed as the outputs in a child production function. Most of the literature has actually adopted this approach. However, the spirit of Becker's Quantity–Quality theory is that parents faced with more children will reduce their investments in child quality. That is, family size will affect parental behaviour vis-à-vis child inputs, but the overall child output is somewhat beyond complete control of the parents. Other factors may enter the child production function, and some of these factors may be completely unrelated to parental investments in child quality. As a result, a desirable objective in this literature is to use data sources containing direct measures of parental investments, such as enrolling their children in private schools, purchasing learning equipment in the home (e.g. a computer or educational books), saving for postsecondary studies, etc.

Another empirical issue is the fact that family size and birth order are necessarily related. For purely mechanical reasons, children from larger families are, on average, later-born compared to children from smaller families. The end result is that the omission of a birth order control variable may lead to omitted variable bias in the estimate of the effect of family size on child quality. I will return to this point below when we encounter studies that fail to include a birth order variable.

Given the discussion above regarding the need for relatively large datasets in order to properly exploit the twin birth identification strategy, the total requirements from the data are quite limiting. The ideal study would utilize a large dataset with information on twin births, sibling birth order, and parental investments in child outcomes. Large datasets usually come in two forms: administrative data and census survey data. Fortunately, census survey and administrative data usually contain birth order information. However, administrative data contain little or no information on parental investments in child success, while census survey data may contain some limited information on parental investments. An alternative approach is to exploit surveys of children or youth, which usually contain all of the required information (i.e. information on twin births, birth order, and parental investments). The challenge is to find such a survey with a sufficient sample size to properly implement the twin birth identification strategy.

As noted earlier, most of the literature on fertility and child quality has focused on child outcomes. This is probably due to a lack of data, or perhaps to a more policy-oriented objective. Indeed, it may be argued that policymakers may only be interested in the final outcome related to child success. Whatever the motives behind the studies, I begin this section by reviewing them before transitioning into the more recent work looking directly at parental investments.

A significant portion of the early works can be found in the psychology literature. One example is Olneck and Bills (1979), who cite several earlier studies. In their paper, the authors study a sample of males who attended public schools in Kalamazoo, Michigan between 1928 and 1950. Students were initially administered sixth grade aptitude tests. They were then followed several decades later and asked questions regarding their educational attainment, occupation, and earnings. Using regression analysis, their findings suggest that family size is negatively related to aptitude test scores, educational attainment, occupational status, and earnings. These findings are consistent with the vast majority of earlier descriptive (i.e. non-causal) studies.

This is not to say that non-causal studies in this literature were completely ignorant of the identification issues. To illustrate, I turn to Blake (1981). Using a variety of small scale youth surveys primarily from the United States, she consistently finds a negative relationship between family size and child outcomes such as college plans and educational attainment. Although she adopts no identification strategy, she discusses the usefulness of controlling for detailed socio-economic background characteristics. Moreover, Blake notes that these controls may not be enough since couples may choose family size based on unobserved characteristics. As an example, she notes the possibility that couples may stop after their first birth if the child is of poor quality. In other words, there may be positive selection into larger families. Blake then proceeds to argue that if a negative relationship between family size and child outcomes is found, which is almost always the case in the literature, the positive selection into larger families implies an understatement (upward bias) of the negative effect of family size on child quality.

What Blake did not acknowledge was the possibility that the selection process could work in the opposite direction. For example, imagine a highly educated, highly motivated dual earner (high income) couple. It is quite possible that this couple may prefer to have fewer children if the marginal costs of doing so are high. Going back to Becker's early work on fertility (Becker, 1960), he noted that the income elasticity of fertility could very well be positive, but there is nothing in his model that suggested that this must be the case. If one assumes that there is a positive relationship between parental income and child quality (perhaps through genetic transmission), then a negative income elasticity of fertility would imply negative selection into larger families. If this were the case, then the common result that family size and child quality are negatively related would be overstated (biased downwards).

The consistency of the negative relationship between family size and child quality not only manifests itself from one study to the next, but also among different populations. For example, Wolfe (1982) examines the relationship among a largely black sample of the four and seven year olds who were born in two Philadelphia hospitals between 1959 in 1966. The sample was largely black since the maternity clinics in question provided inexpensive care. Wolfe finds that family size is negatively related to two measures of IQ (Intelligence Quotient) for black males and black females; however, the relationship is stronger for black females.

Although the studies by Olneck and Bills (1979), Blake (1981), and Wolfe (1982) paid little or no attention to the causal impact of family size on child quality, they cannot be faulted for omitting a key variable in their analysis, namely birth order. As noted above, birth order is an important control variable since larger families necessarily have higher birth orders. A more recent paper by Hill and O'Neill (1994) examines the relationship between family size and cognitive achievement from a nationally representative sample of young children in the United States. The authors find a large negative relationship, but they do not control for birth order. Why is this important? Studies of birth order effects typically find that first-borns have outcomes that are at least as good as later-borns. However, as noted by Kantarevic and Mechoulan (2006), most studies understate the effect of being a first born on outcomes. Why? Because these children had access to fewer parental resources in their infancy since their mothers were necessarily younger than later-borns. Once they control for maternal age at birth, Kantarevic and Mechoulan find that the average educational attainment of first-borns is significantly higher than that of later-borns. If it is indeed the case that birth order and child quality are negatively related, and birth order is positively related to family size, then omitting birth order in a child quality equation will bias the estimated relationship between family size and child quality downwards. In other words, one of the reasons why child quality is lower among larger families may simply be related to the fact that children in larger families have higher average birth orders.

Despite differences in model specification, a consensus was reached in the literature concerning the negative relationship between family size and child quality. Given the selection into marriage and the availability of contraceptives, family size is largely a choice. This raises the possibility that family size may depend on child quality, or that the two are co-determined by some extraneous factor. In any event, it became clear in the literature that more rigorous methods had to be applied than simple cross-sectional regressions. More specifically, the identification of the causal impact of fertility on child quality had to be addressed.

One attempt at doing so comes from Hanushek (1992). He uses data from the Gary Income Maintenance Experiment. This social experiment applied to low-income black families in Gary, Indiana. The experiment consisted of a negative income tax for the treatment group; however, this feature of the data was not (and probably could not be) used by Hanushek. Instead, the author exploited the longitudinal nature of the data. School-age students of the families in the experiment were tested in reading and vocabulary achievement on two occasions, with a four year interval. Hanushek examined changes in the test scores in relation to changes in family size, which he called a value added approach. This approach yields two benefits over a standard cross sectional regression. First, it "differences out" time invariant individual traits that may affect child quality. This may resolve the selection into larger families; however, the decision to change one's family size may also be a selective process. As a result, the value added approach may still suffer from endogeneity. Second, cross-sectional studies do not consider the timing of the inputs into the child quality production function. They simply aggregate the inputs over past history, and associate them with current output. The value added approach considers the introduction of the inputs and its contemporaneous impact on the output.

Once again, the findings from the Hanushek study confirm previous studies. An increase in family size is associated with a decrease in reading and vocabulary achievement. For the reasons cited above, Hanushek's value added approach is superior to the descriptive regression approach adopted by most previous studies. However, the value added approach still does not convincingly solve the identification puzzle. To find a method that comes closer to doing so, we need to consider studies that have used the event of twin births as an exogenous increase in family size.

The rationale behind the exogeneity of twin births is relatively straightforward: having twins is largely an unplanned event. Couples may expect a higher probability of having twins if they seek fertility treatment, or if there is a family history of twins. In the majority of cases, however, a twin birth is unexpected. As a result, it may generate a larger family than originally planned. If that is the case, the number of children would be exogenously determined. Furthermore, the effect of family size on various outcomes (including child quality) could then be examined in a more causal framework.

The first study to use twin births as an exogenous shift in the number of children was by Rosenzweig and Wolpin (1980a). They examine the impact of twinning on years of schooling among children by using a dataset consisting of Indian households. The actual specification of the twin variable is noteworthy. They use the twin ratio, which is the number of twin births divided by the total number of births. They argue that the incidence of twins causes a selection bias for two reasons. First the probability of having a twin rises with the total number of births even if the probability of having a twin is the same for each birth. Put in different terms, $P(A \text{ or } B) > P(A)$ even if $P(A) = P(B)$, where P is the probability and A and B denote the incidence of twins on given births, and B is a later birth than A. In the event that $P(A) = P(B)$, the twin ratio will not be endogenous to family size. Second, there is evidence in the United States that the probability of having a twin increases with each successive birth. However, in this case, *both* the incidence of twins and the twin ratio are endogenous to family size.

Another criticism of Rosenzweig and Wolpin's twin variable specification is that twins on the first birth may not necessarily generate more children than originally planned. A simple example can help clarify this point. Suppose a couple marries and plans to have two children. On their first birth, the wife delivers twins. Since the couple met their original goal of having two children, they decide to stop after the first birth. Now suppose that the very same couple did not have twins on the first birth, but rather, they had a singleton birth. Since they haven't met their original goal of having two children, they decide to try once more. This time around, the wife delivers twins, and the couple is left with three children (one more than originally planned). In this example, where the desired number of children equals two, only a twin birth on the second birth will generate more children than originally planned. Since most couples who choose to have children have at least two, a twin birth on the second or later birth is more likely to generate an exogenous increase in family size compared to having twins on the first birth. It is for this very reason that subsequent studies that have adopted a twins identification strategy have focused on twin births occurring on the second or later birth.

Rosenzweig and Wolpin find that twinning is negatively related to years of schooling. Introducing the twin variable directly into the child quality equation marks a departure from other studies in the literature. The authors do not attempt to estimate the role of family size on the child outcome. The advantage of including the twins variable directly is that there is no need to be concerned about whether or not twinning has a direct effect on the dependent variable (years of schooling in this case).

An alternative approach would have been to use the twin variable as an instrument for fertility. This would, in effect, be a rescaling of the twins effect into the metric of family size. From both the policy and theoretical point of view, this rescaling would have been preferred. The authors do note that the twin variable is positively related to family size. However, they do not present standard errors. As a result, it is not clear if their twin variable would be a strong instrument (i.e. strongly correlated with the problem variable – fertility). In the end, all we can conclude is that years of schooling declines as twinning rises. Little can be assumed about the role of fertility on years of schooling.

Another criticism of the study relates to the low sample size. Once all the sample selection criteria are applied, the authors are left with 25 twins, which the authors claim are sufficient. Although they find large and significant results, there is no guarantee that their findings are not driven by sampling error (i.e. the possibility that the 25 twins in the sample are not necessarily representative of all twins in the population).

The next study to adopt the twins approach in the fertility and child quality literature was Black, Devereux, and Salvanes (2005). They look at the educational attainment in adulthood of all Norwegian children from administrative data. This study offers several advantages over previous ones. First, it considers the entire population as opposed to a sample. This can be particularly important when looking at variables such as twin births or even birth order. Second, the authors instrument family size with the multiple birth variable. In other words, the study expresses the impact of multiple births on child outcomes in the metric of family size. Finally, the specification of the twin birth variable is somewhat different than the one adopted by Rosenzweig and Wolpin (1980a). Black et al. only consider twin births on the second or later births. They also only consider twin births if it is the last birth (otherwise, the twin birth could not possibly yield the desired number of children unless the subsequent singleton birth was not planned). Another important distinction in the study by Black et al. is that they do not consider child outcomes for children involved in the last birth. This is important since the last birth includes some twins, who may be different than singletons for biological or environmental reasons.

In part because of their superior data, but also because of their methodological improvements, the Black et al. study is likely the most convincing empirical work in the area to date. This is important given their findings. They initially find a negative relationship between family size and educational attainment in their basic regressions. However, the magnitude of this relationship becomes much smaller (albeit still statistically significant) once birth order is added to the model. Furthermore, the relationship disappears once the multiple birth instrumental variable approach is adopted.

In a very recently published study, the same authors use similar, but more recent Norwegian data to investigate the link between fertility and cognitive ability (Black, Devereux, and Salvanes, 2010). In contrast to their earlier work, they find a negative relationship. They attribute this finding to the fact that they examine more recent birth cohorts. This highlights the importance of taking into account not only the country, but also the period of the data when considering the evidence in this or any other literature.

Angrist, Lavy, and Schlosser (2005) use the same multiple birth IV strategy as Black et al. (2005 and 2010) to investigate a broader range of outcomes, including educational attainment, labour market outcomes (hours of work and earnings), and marriage and fertility from Israeli census data.[3] They come to the conclusion that there is no trade-off between child quantity and quality.

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[3] They also use the sex composition of the first two children as an IV. I return to this point in the methodology section.

A more direct approach to testing the Quantity-Quality theory is to assess the impact of additional children on parental investments per child. This is the approach adopted by Cáceras-Delpiano (2006), who uses US census data to study the impact of family size on child outcomes (grade retention), parental investments (private school enrolment), and parental labour supply (maternal labour force participation). The study also uses the incidence of a multiple birth on the second or later birth as an instrument for fertility. Cáceras-Delpiano demonstrates that increased family size has little impact on grade retention. This might be the result of potentially counterbalancing effects that are also noted in the study, namely that family size is negatively related to private school enrolment and maternal labour force participation.

Contributions of the present chapter to the literature

The chapter contributes to the literature in many ways. First, it is only the second study to consider academic performance and fertility using quasi-causal methods. This is important given that performance on tests and fertility decisions may be co-determined.

Second, I also look at direct parental investments in child quality (enrolment in private school, computers per child, and parental savings for postsecondary education). To the best of my knowledge, the only other study to date that has looked at child investments is Cáceras-Delpiano (2006), who does not consider parental savings for postsecondary education or computers per child. Clearly, more research is needed on child investments since it provides the framework for a more direct test of Becker's Quantity-Quality theory.

Third, I will begin exploring various potential explanations behind the findings in the literature, suggesting that increased family size is negatively related to parental investments in children, but is not always negatively related to overall child quality. Three possible explanations are noted. First, parental investments in child quality are not necessarily associated with improved child quality. In fact, the empirical literature suggests that there is no relationship for the measures of parental investments that have been investigated. Second, there may be economies of scale associated with rearing more children and/or in selecting effective sibling interactions. A third possibility, which was noted by Cáceras-Delpiano (2006), suggests that larger families may entice parents to stay home, which may help foster child development. To investigate this possibility, a different framework based on parental labour supply is required. This is left for Chapter 3.

Finally, I will add Canadian evidence to the body of knowledge. Most of the studies to date have been based on US data. Adding evidence from additional countries is important because it speaks to the robustness of the US findings in a global context.

2.3 Methodology

The data are drawn from the Canadian Youth in Transition Survey (YITS), Cohort A. This survey was developed by Statistics Canada in conjunction with the Programme for International Student Assessment (PISA), a project of the Organisation for Economic Co-operation and Development. PISA consisted of standardized tests in reading, mathematics and science. Although several countries participated in PISA, the YITS component was unique to Canada.

The target population consisted of students enrolled in an educational institution on December 31, 1999 who were 15 years old on that day—that is, they were born in 1984. The assessment took place in April or May 2000, depending on the sampled school. Furthermore, background questionnaires were administered to students through PISA and YITS. Parents and schools were also administered questionnaires through YITS and PISA, respectively. The parent most knowledgeable about the child answered the parent questionnaire, while the principal of the school answered the school questionnaire. Students were followed up every two years afterwards, although that information is not needed in this chapter.

Students living in the territories or on Indian reserves, students who were deemed mentally or physically unable to perform in the PISA assessment, as well as non-native speakers with less than one year of instruction in the language of assessment were excluded. These exclusions account for less than 4% of the overall population of 15 year old students.

The survey design consisted of a two-stage approach. In the first stage, a stratified sample of schools was selected to ensure adequate coverage in all of the 10 Canadian provinces (including adequate coverage of minority school systems in certain provinces). The stratification was based on the enrolment of 15 year olds in the school in the previous academic year. In the second stage, a simple random sample of 15-year-old students within the school was selected. Given this complex survey design, the standard errors are calculated using 100 bootstrap weights designed by Statistics Canada specifically for this purpose. Note that bootstrapping provides a consistent estimate of the standard errors, and as such, will also correct for heteroscedasticity if it is present. See Appendix A2.1 for more details on bootstrapping standard errors.

The objective of this chapter is to estimate the impact of family size on child quality measures. The identification strategy is based on instrumenting family size with a variable indicating the presence of a multiple birth on the second or later birth, as described in Appendix A2.2 (Wald estimate) and Appendix A2.3 (Instrumental variable, or two-stage least squares, regression). Note that an important limitation of instrumental variables is described in Appendix A2.4.

The data offer several useful pieces of information for the purposes of this section. For example, the survey contains various measures of child quality (including parental investments in child quality), the age of every member of the household, the relationship between the sampled youth and every member of the household, and various other background characteristics.

The first measure of child quality I consider is a measure of child output, namely the PISA reading score. In 2000, the PISA assessment focused primarily on reading, but there were also assessments in mathematics and science.[4] All students wrote the reading exam, while about one half wrote the mathematics exam and the other half wrote the science exam. Since only half of the students wrote the mathematics or science tests, I focus exclusively on the reading scores in this chapter, as it allows me

[4] A description of the three tests and sample questions are shown in Appendix A2.5.

to maintain the largest possible sample. The sample size is crucial here because I use a multiple birth IV. In any event, the reading portion accounted for about two thirds of the total testing time, and was clearly the main objective of PISA for the year 2000.

The assessment was administered in the language of instruction of the school, which was either English or French. The reading test consisted of having students perform a range of tasks with different kinds of text that included retrieving specific information, interpreting text, and reflecting on the content and features of the text. The texts included standard prose passages and various types of documents such as lists, forms, graphs and diagrams. The test score was standardized to have a mean of 0 and a standard deviation of 1, as described in Appendix 2.6.

In the survey, there are several measures of parental investments in child quality (i.e. child inputs). The first measure of parental investment that I consider is a binary indicator of enrolment in a private school. The principal of the child's school is asked:

- "Is your school a public or a private school?"

The two options were:

- "A public school. (This is a school managed directly or indirectly by a public education authority, government agency, or governing board appointed by government or elected by public franchise.)"

- "A private school. (This is a school managed directly or indirectly by a non-government organization; e.g., a church, trade union, businesses, other private institutions.)"

As we shall see, the majority of Canadian private schools are sectarian. If it is the case that enrolment in private schools largely depends on the parents' religious affiliation, as opposed to a desire to enhance the child's academic experience, then this variable may not serve as a useful input into the child educational production function. For robustness, I also look at private, non-sectarian schools. To do so, I also consider answers to the question (asked of the principal):

- "What type of school is your institution?"

Again, two options were possible:

- "Non-sectarian (no religious affiliation)"
- "Sectarian/separate (with religious affiliation, for example Anglican, Catholic, Mennonite, etc.)"

The next measure of parental investment is the number of computers in the home per child. Students were asked:

- "How many of these do you have at you home?"

d) “Computer”[5]

The choices were:

- “None”
- “One”
- “Two”
- “Three or more”

The number of computers is thus right-censored at three in the survey. About 10% of responses fall in the top category. However, according to Statistics Canada’s 2001 General Social Survey, Cycle 14, which asks households how many computers they have in the home, 70% of households with children who report having three or more computers in the home in fact only have three computers. As a result, there is only very little actual censoring in the YITS data.

The third measure of parental investment is a binary indicator of the presence of parental savings earmarked for the child’s postsecondary studies. The parent was first asked:

- “Have you (or your partner) done anything specific to ensure that {child} will have money for further education after high school?”

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[5] The list included other items which did not necessarily signal an intention to invest in children (e.g. television, bathroom, etc.)

If the answer is yes, they are then asked:

- "What have you (or your partner) done? (MARK ALL THAT APPLY.)"

The list of choices included:

- started a savings account
- started a Registered Education Savings Plan (RESP)
- set up a trust fund for this child
- made investments, such as mutual funds or Canada Savings Bonds
- started working or took an additional job
- encouraged child to earn money/get a job
- encouraged child to work toward a scholarship
- other, specify

The measure I created for this chapter includes the first four options, which involve actual savings. The remaining categories do not necessarily involve any savings earmarked for the child's education.

I also create variables indicating the number of children in the household, the birth order of the sampled youth, and an indicator of a multiple birth in the household (used as an IV).

It is worth noting that some studies in the child quality literature have used the sex composition of children of the first two children as an instrument for fertility (e.g.

Angrist, Lavy, and Schlosser, 2005; Conley, 2004; Goux and Maurin, 2005). The idea is that families may prefer having at least one child of each sex, so having two same sex children will incite them to try for another. However, several studies suggest that sex composition may have a direct impact on child outcomes, including Butcher and Case (1994), Deschênes (2007), Dahl and Moretti (2004), and, ironically, Conley (2000). As noted by Black et al. (2005), this suggests that sex composition may not be a valid instrument for fertility. For this reason, I do not use the sex composition of the first two children as an IV. It will, however, be used as an instrument in the next chapter, when the outcome is parental labour supply.

Since the number of siblings, birth order, and the multiple birth indicator are all intricately related, I will discuss them in unison below. Before doing so, however, it is worthwhile stating the precise definition of a multiple birth used in this study. The multiple birth variable is set to 1 if the following three conditions hold:

- There are multiple birth siblings in the household.
- The multiple birth siblings must have occurred on the second or later birth (multiple birth siblings on the first birth are unlikely to yield additional children).
- The multiple birth siblings must have occurred on the last birth (otherwise, they could not possibly generate additional children since the couple chose to have more children following the multiple birth).

The YITS parent questionnaire contains information on the age of each member of the household. From this, it is relatively straightforward to calculate the number of siblings in the household. It is also straightforward to calculate birth order; however, age is measured in discrete years. This means that two children who were the same age in years cannot be distinguished in terms of birth order. The reporting of age in discrete years may also pose a challenge for the identification of multiple birth siblings.

The incidence of siblings of the same age in years is likely to be more common in blended families where the husband and wife each have children from a previous marriage. To address this, I restrict the sample to youth in families where all siblings in the household are living with their biological mother. Using an extraneous data source containing household member relationships and exact birth dates, I demonstrate in Appendix A2.7 that this measure succeeds in identifying true multiple birth siblings in about 98% of the cases.

While this measure addresses the issue of birth order among singleton birth children, it does not guarantee a proper measure of birth order among multiple birth siblings. However, as I will discuss below, I exclude from the analysis any youth who is part of a multiple birth. In other words, the youth may have multiple birth siblings, but if the youth was part of a multiple birth, I drop him or her.

In the preferred sample described below, I classify 119 youth as having multiple birth siblings. Although this is far less than the studies using the US Census (e.g. Cáceras-Delpiano, 2006) or Norwegian administrative data (Black et al., 2005 and 2010), it is far greater than the 25 reported by Rosenzweig and Wolpin (1980a).

The other variables used in the analysis include the child's age (reported in this case in months by the student, but rescaled to years in the analysis), the child's sex, an immigrant dummy for the child, the mother and the father's age (reported in discrete years) and their highest level of education, a set of dummy variables indicating whether neither of the parents were immigrants, only one parent was an immigrant, or both were immigrants, and, finally, the household's province of residence.[6] Note that the parental age variables are in quadratic form since their range is potentially quite high. For the child, a linear specification is used since the age range is quite narrow, as all children in the sample were born in 1984.

All of these variables are potential determinants of child quality, whether on the input or output side. Although the youth in the sample were all born in the same year, there is a literature suggesting that children who are relatively old for their grade tend to perform better. The child sex is important to take into account since we know that girls tend to outperform boys according to many studies. The immigrant indicators are important since immigrants may face difficulties in learning a new language, thus hindering their performance on a reading test in that language. Even if the child does speak the language, they may not receive as much help from their parents if they are

[6] One variable that is absent from this list is parental income. The reason is that family size may influence child quality directly or indirectly through parental income. For example, maternal labour supply may decline as family size increases. If parental income were included as a covariate in the model, this indirect channel may be removed from the family size coefficient. I return to this point after the IV results are shown in Tables 2.9a and 2.9b. Note, however, that the regressions to follow will include the standard set of variables that comprise a Mincer wage equation (i.e. the age and education level of the mother and father). Unlike income, these variables are not likely to be influenced by the number of children.

immigrants and do not know the language very well. Finally, the province of residence is necessary since education falls under provincial jurisdiction in Canada.

The initial sample consists of all youth with two opposite sex parents in the home, including the biological mother of the child.[7] As shown on the left side of Table 2.1, this includes 18,913 youth. The mean and standard error of each variable used the analysis are shown. The process of selecting the final sample involved three more steps. In each of the steps, it is important to verify how the selection affected the composition of the sample. I do this by tracking the sample statistics for each of the variables in each step.

[7] Since the YITS only contains information on the father if he is present in the household, it is not possible to account for paternal characteristics in lone mother families. It may be argued that increased fertility can result in divorce, and thus lone mother families; however, I find no such evidence in the YITS. Appendix A2.8 shows the results of an IV regression of lone motherhood on the number of children, using the multiple birth strategy described in this chapter as an instrument. The p-value on the coefficient representing the impact of the number of children on lone motherhood is 0.654, suggesting that focusing on households with couples should not bias the results.

Table 2.1: Means and standard errors of variables used in the analysis by sample selection criteria

	Initial sample of youth with two opposite sex parents in the home		Drop if part of a multiple birth		Drop if only one birth in family		Drop if first birth is a multiple	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Reading score	537.814	1.322	537.946	1.346	539.255	1.344	539.295	1.344
Attends a private school	0.065	0.011	0.065	0.011	0.064	0.011	0.064	0.011
Attends a private, non-sectarian school	0.014	0.005	0.015	0.005	0.014	0.005	0.014	0.005
Computers per child	0.654	0.007	0.658	0.007	0.564	0.006	0.564	0.006
Parents have saved money for PS schooling	0.606	0.005	0.607	0.005	0.610	0.006	0.610	0.006
Number of children	2.351	0.012	2.337	0.012	2.576	0.011	2.573	0.011
Multiple birth	0.012	0.001	0.006	0.001	0.007	0.001	0.007	0.001
Child's birth order	1.585	0.009	1.586	0.009	1.691	0.010	1.687	0.010
Child's age (months/12)	15.789	0.003	15.788	0.003	15.788	0.003	15.788	0.003
Child is a female	0.497	0.006	0.496	0.006	0.493	0.006	0.494	0.006
Child is an immigrant	0.092	0.006	0.092	0.006	0.091	0.006	0.090	0.006
Mother's age (years in integers)	43.118	0.068	43.124	0.069	43.000	0.072	42.995	0.072
Father's age (years in integers)	45.632	0.072	45.640	0.073	45.486	0.078	45.484	0.078
Mother has less than a high school diploma	0.117	0.004	0.116	0.004	0.106	0.004	0.105	0.004
Mother has a high school diploma	0.393	0.006	0.394	0.006	0.396	0.006	0.397	0.006
Mother has a college certificate	0.301	0.005	0.301	0.005	0.304	0.005	0.304	0.005
Mother has a bachelor's degree	0.144	0.005	0.143	0.005	0.148	0.005	0.147	0.005
Mother has a professional degree	0.011	0.001	0.011	0.001	0.012	0.001	0.012	0.001
Mother has a master's degree	0.030	0.002	0.030	0.002	0.031	0.003	0.031	0.003
Mother has an earned doctorate	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.001
Father has less than a high school diploma	0.148	0.005	0.148	0.005	0.138	0.005	0.138	0.005
Father has a high school diploma	0.310	0.005	0.311	0.005	0.311	0.006	0.311	0.006
Father has a college certificate	0.302	0.005	0.302	0.005	0.305	0.006	0.305	0.006
Father has a bachelor's degree	0.151	0.005	0.150	0.005	0.155	0.005	0.155	0.005
Father has a professional degree	0.024	0.002	0.025	0.002	0.027	0.003	0.026	0.003
Father has a master's degree	0.047	0.003	0.047	0.003	0.048	0.003	0.048	0.003
Father has an earned doctorate	0.017	0.002	0.017	0.002	0.017	0.002	0.016	0.002
No immigrant parents	0.713	0.010	0.714	0.010	0.708	0.010	0.708	0.010
One parent is an immigrant	0.186	0.004	0.185	0.004	0.189	0.004	0.103	0.004
Both parents are immigrants	0.021	0.010	0.021	0.010	0.020	0.010	0.189	0.010
Newfoundland and Labrador	0.006	0.001	0.006	0.001	0.006	0.001	0.020	0.001
Prince-Edward-Island	0.033	0.000	0.033	0.000	0.032	0.000	0.006	0.000
Nova Scotia	0.029	0.001	0.029	0.001	0.028	0.001	0.032	0.001
New Brunswick	0.227	0.001	0.227	0.001	0.217	0.001	0.028	0.001
Québec	0.380	0.004	0.381	0.004	0.391	0.005	0.217	0.005
Ontario	0.037	0.007	0.037	0.007	0.039	0.008	0.391	0.008
Manitoba	0.041	0.001	0.041	0.001	0.041	0.001	0.039	0.001
Saskatchewan	0.109	0.001	0.109	0.001	0.109	0.002	0.041	0.002
Alberta	0.118	0.003	0.117	0.003	0.118	0.003	0.109	0.003
British Columbia	0.117	0.004	0.117	0.004	0.117	0.005	0.118	0.005
N	18,913		18,558		15,598		15,555	

Source: Youth in Transition Survey, Cohort A.

In the first step, I drop youth who were part of a multiple birth. This is important since multiple birth siblings may be different than singleton births for biological or environmental reasons. Since youth who have only singleton birth siblings in the household cannot possibly be multiple birth siblings themselves, this sample selection criterion is necessary to avoid an asymmetry between youth with or without multiple birth siblings in the household. The impact of applying this criterion is minimal. The sample declines moderately by 355. The average values of the outcome variables are virtually unchanged as a result. The average number of children is marginally lower, but this is expected since some youth with a multiple birth sibling were deleted (specifically those cases where the sampled youth was part of a multiple birth). The proportion of youth with a multiple birth sibling is cut in half, from 0.012 to 0.006. Again, this is expected since we dropped sampled youth who were part of a multiple birth. All of the other variables in the analysis have similar average values after the criterion is applied.

The second step consists of dropping youth in families with only one birth. This measure is adopted since multiple birth siblings are more likely to occur in larger families. Moreover, a multiple birth on a second or later birth is obviously not possible when there is only one birth. The impact on the sample size is a bit larger this time: from 18,558 to 15,598. The number of computers per child is somewhat lower, which is an early indication of the relationship between family size and this variable. Not surprisingly, the average family size and birth order increase. The proportion of youth with a multiple birth in the family also increases, but only slightly. All of the other variables are largely unaffected.

The fact that the analysis is limited to families with at least two births means that the child effect is mainly the result of differences observed between the second and the third child (or between the third and fourth, etc.) From this, we cannot draw any conclusions about the effect of the first or second child, which may be more policy relevant. A priori, it is not clear how the effect varies by number of children. Economies of scale might apply, in which case the effect on parental investments might diminish with each additional child. On the other hand, additional costs may need to be borne by families when certain milestones are reached. For example, a third child might require an additional row of car seats (thus requiring a larger and more expansive vehicle). Although the literature has not yet developed an appropriate strategy for identifying the effect of first or second children, I will show descriptive evidence on the relationship between number of children and the measures of child quality used in this chapter for smaller families (i.e. those with one child).

The third step consists of dropping youth in families with a multiple birth on the first birth. This action is also necessary to implement the multiple birth strategy since many families may want to stop at two children (and thus, a multiple birth on the second may have an optimal impact on family size if it follows a singleton). However, this resulted in a small decline of 43 and virtually no change to the sample statistics.

To summarize, the sample selection criteria I adopt has very little impact on the explanatory variables used in the analysis, other than for specific variables where an impact is expected for mechanical reasons. For that reason, the remainder of the analysis in this section will be based on the sample described in the rightmost column of Table 2.1: all youth with two opposite sex parents in the home, including the biological mother of the child, who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).

2.4 Descriptive results

I begin the section on descriptive results by simply showing the means of the outcome variables by the number of children in the family (Table 2.2). Although the main focus from here on will be on youth in families with more than one birth, I include those with no siblings in this table since no identification strategy is applied yet. The patterns displayed in the table are quite interesting. First, there is no clear direction for the reading score. In fact, the reading score follows an alternating pattern of rising and falling with additional children. In terms of private school attendance, the rates are fairly consistent across different family sizes (except when we go from 5 to 6 children, which is a rare event). This may simply reflect preferences for larger families among religious households. When I focus on private, non-sectarian school attendance, the rates fall as families become larger. The decline is small in absolute terms, but this is because the enrolment rates are quite low to begin with. In relative terms, the declines are large. Family size and the number of computers per child are also negatively related. One could argue that there are economies of scale associated with computers since children may share the same computer by negotiating computer time. However, Table 2.2 suggests that on average, families with one child have access to 1.19 computers, while families with six children share 1.39 computers. It is difficult to imagine that children in larger families have the same access to a computer as children in smaller families. Finally, the decline in the proportion of parents saving for PSE (postsecondary education) is also quite large, going from 0.591 with one child to 0.276 with six children.

Table 2.2: Means of outcome variables by the number of children in the family

	Number of children					
	1	2	3	4	5	6
Standardized reading score	-0.079	0.017	0.010	0.031	-0.065	0.040
Attends a private school	0.068	0.064	0.066	0.064	0.065	0.044
Attends a private, non-sectarian school	0.017	0.016	0.014	0.012	0.005	0.000
Computers per child	1.188	0.659	0.469	0.361	0.278	0.232
Parents have saved money for PSE	0.591	0.639	0.607	0.511	0.396	0.276
N	2,960	8,866	4,868	1,392	292	137

Note: The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the first birth is a singleton.
Source: Youth in Transition Survey, Cohort A.

The results in Table 2.2 suggest that as families become larger, academic performance of children is unchanged, despite the fact that parental investments in child quality decline, at least based on the various measures shown in the table.

Of course, the evidence in Table 2.2 is very crude since the number of children is largely a choice given the widespread availability of contraceptives. In Table 2.3, I focus on the multiple birth IV to begin identifying the impact of fertility on the outcomes. From this point forward, I focus on families with more than one birth. Youth in a family with a multiple birth have higher reading scores, but a lower probability of attending a private school, fewer computers per child in the home, and a lower probability of having parents who saved money for postsecondary studies. It is interesting to note the large dichotomy in the relationship between (chosen) family size and private school enrolment on the one hand (Table 2.2), and the incidence of twins and private school enrolment on the other (Table 2.3).

Table 2.3: Means of outcome variables by presence of a multiple birth in the family

	Multiple birth=0	Multiple birth=1	Δ
Standardized reading score	-0.002	0.284	0.286
Attends a private school	0.065	0.013	-0.051
Attends a private, non-sectarian school	0.014	0.000	-0.014
Computers per child	0.565	0.393	-0.173
Parents have saved money for PSE	0.611	0.504	-0.107
N	15,436	119	

Note: The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

The results in Table 2.3 strongly suggest that a multiple birth is associated with an increase in the child output (i.e. the reading score) and a decrease in child inputs. But what impact does a multiple birth have on the number of children and the family? To answer this, I generated the average number of children by the presence of a multiple birth in the family (Table 2.4). The result suggests that a multiple birth is associated with 1.211 additional children in the family.

Table 2.4: Mean number of children by the presence of a multiple birth in the family

	Multiple birth=0	Multiple birth=1	Δ
Number of children	2.565	3.776	1.211
N	15,436	119	

Note: The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

In Table 2.5, I rescale the impact of a multiple birth on the measures of child quality by calculating the Wald estimate. This effectively shows the impact of one additional child generated by a multiple birth on the child quality measures. Since a multiple birth is associated with roughly one additional child (Table 2.4), the Wald estimates are actually quite close to the results in Table 2.3. Standard errors are also shown in the table. Altogether, the results suggest that one additional child generated from a multiple birth is associated with about one quarter of a standard deviation increase in the reading score, but a 4.2 (1.2) percentage point decrease in the probability of attending a private (private, non-sectarian) school, a 0.142 decline in the number of computers per child, and an 8.9 percentage point decline in the probability of having parents who saved money for the child's postsecondary studies. However, significance is either quite low (10%) or simply not achieved.

Table 2.5: Wald estimates

	Multiple birth=0		Multiple birth=1			
	Mean	s.e.	Mean	s.e.	Wald	s.e.
Standardized reading score	-0.002	0.008	0.284	0.091	0.236	0.117
Attends a private school	0.065	0.002	0.013	0.010	-0.042 *	0.011
Attends a private, non-sectarian school	0.014	0.001	0.000	0.000	-0.012 *	0.004
Computers per child	0.565	0.003	0.393	0.022	-0.142 *	0.031
Parents have saved money for PSE	0.611	0.004	0.504	0.046	-0.089	0.056
Average number of children	2.565		3.776			
N	15,436		119			

Note: Statistical significance for the Wald estimate is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

The analysis so far has not taken into account differences in other covariates. This is important for at least two reasons. First, although multiple births are likely exogenous, it is possible that they are not fully exogenous. Although multiple births have occurred naturally throughout history, they have been associated with fertility drugs in recent years. Second, it is still possible that there exist differences in socioeconomic characteristics between youth with and without a multiple birth in the family. This is especially so in small samples, where sampling variability is likely. For both reasons, it is important to account for differences in observable characteristics. In Table 2.6, I show the mean values of the relevant covariates by multiple birth status.

Table 2.6: Means of explanatory variables by presence of a multiple birth in the family

	Multiple birth=0	Multiple birth=1	Δ		s.e.
Child's birth order	1.689	1.359	-0.330	***	0.070
Child's age (months/12)	15.788	15.785	-0.003		0.033
Child is a female	0.494	0.506	0.013		0.069
Child is an immigrant	0.091	0.031	-0.059	***	0.023
Mother's age (years in integers)	43.003	41.835	-1.169	***	0.369
Father's age (years in integers)	45.498	43.454	-2.044	***	0.600
Mother has less than a high school diploma	0.105	0.141	0.036		0.052
Mother has a high school diploma	0.397	0.367	-0.030		0.061
Mother has a college certificate	0.304	0.304	-0.001		0.056
Mother has a bachelor's degree	0.148	0.118	-0.029		0.042
Mother has a professional degree	0.012	0.038	0.026		0.038
Mother has a master's degree	0.031	0.032	0.002		0.029
Mother has an earned doctorate	0.004	0.000	-0.004	***	0.001
Father has less than a high school diploma	0.138	0.132	-0.006		0.047
Father has a high school diploma	0.311	0.276	-0.035		0.062
Father has a college certificate	0.305	0.321	0.016		0.056
Father has a bachelor's degree	0.156	0.070	-0.086	**	0.040
Father has a professional degree	0.026	0.119	0.093	**	0.046
Father has a master's degree	0.047	0.072	0.024		0.034
Father has an earned doctorate	0.017	0.009	-0.008		0.009
No immigrant parents	0.708	0.729	0.021		0.063
One parent is an immigrant	0.102	0.168	0.065		0.054
Both parents are immigrants	0.190	0.103	-0.087	*	0.050
Newfoundland and Labrador	0.020	0.019	0.000		0.009
Prince-Edward-Island	0.006	0.008	0.003		0.003
Nova Scotia	0.032	0.053	0.021		0.017
New Brunswick	0.028	0.012	-0.016	***	0.006
Québec	0.217	0.199	-0.018		0.048
Ontario	0.392	0.338	-0.054		0.081
Manitoba	0.039	0.032	-0.007		0.012
Saskatchewan	0.041	0.043	0.002		0.013
Alberta	0.108	0.130	0.022		0.042
British Columbia	0.117	0.164	0.047		0.038
N	15,436	119			

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

Table 2.6 also shows the differences in mean values with the associated standard errors. In general, the differences are quite small, but some are worth noting. For instance, the average birth order is lower among youth with multiple birth siblings.

This is tautological: I code multiple births to 1 only if it is on the last birth (i.e. higher birth orders) and exclude youth who are themselves part of a multiple birth. Therefore, youth with a multiple birth in the family cannot be last born children by definition.

The average age of the parents is also lower among youth with a multiple birth sibling. Mothers are about one year younger on average, while fathers are about two years younger. Again, this is related to the definition of a multiple birth, which implies that youth with a multiple birth in the family cannot be last born children. Moreover, all youth in the sample were born in 1984. Combining these two facts, one can conclude that parents in the sample who had a multiple birth had fewer children prior to 1984 than parents without a multiple birth (i.e. they are likely younger).

The remaining covariates are all similar in mean values, with the exception of a few select variables. Although the means are generally similar, the differences that do exist are non-negligible. As a result of this, it is imperative to verify if the results reported so far hold when they are taken into account. This is precisely what I do in the next section, which considers econometric evidence. Once again, I will consider evidence from both OLS and IV regressions, with the preferred set of results stemming from the latter.

2.5 Econometric results

OLS approach

I begin this section by estimating ordinary least squares (OLS) regressions of the child quality variables on the number of children and other covariates (Tables 2.7a and 2.7b). One additional child is associated with higher reading scores (significant at 1%), but is negatively associated with the number of computers per child and the presence of parental savings for PSE (both significant at 1%). In terms of private school attendance, there is a slight positive relationship (significant at 10%), and no significant relationship with private, non-sectarian school enrolment.[8]

[8] Some of these dependent variables are binary, yet I use ordinary least squares rather than logit or probit models. The same holds true for later chapters. While logit and probit models mechanically bound predicted probabilities within the [0, 1] range, they are more prone to misspecification and are inconsistent in the presence in the presence of heteroscedasticity. Thus, OLS is preferred when one is interested in obtaining coefficient estimates (as is the case here), as opposed to predicted probabilities. See Moffitt (1999) for more details.

Table 2.7a: OLS regressions of standardized reading score on the number of children and other controls

	b		s.e.
Number of children	0.071	***	0.014
Child's birth order	-0.184	***	0.020
Child's age (months/12)	0.178	***	0.034
Child is a female	0.341	***	0.024
Child is an immigrant	-0.301	***	0.060
Mother's age (years in integers)	0.135	***	0.044
Mother's age^2 (years in integers)	-0.001	***	0.000
Father's age (years in integers)	0.020		0.027
Father's age^2 (years in integers)	0.000		0.000
Mother has a high school diploma	0.263	***	0.038
Mother has a college certificate	0.353	***	0.044
Mother has a bachelor's degree	0.548	***	0.057
Mother has a professional degree	0.445	***	0.141
Mother has a master's degree	0.792	***	0.083
Mother has an earned doctorate	0.805	***	0.163
Father has a high school diploma	0.255	***	0.039
Father has a college certificate	0.330	***	0.037
Father has a bachelor's degree	0.494	***	0.045
Father has a professional degree	0.694	***	0.070
Father has a master's degree	0.541	***	0.068
Father has an earned doctorate	0.815	***	0.107
One parent is an immigrant	0.043		0.041
Both parents are immigrants	-0.031		0.041
Prince-Edward-Island	-0.104	**	0.052
Nova Scotia	-0.074		0.046
New Brunswick	-0.237	***	0.043
Québec	0.151	***	0.048
Ontario	0.019		0.045
Manitoba	0.070		0.049
Saskatchewan	0.110	**	0.050
Alberta	0.255	***	0.050
British Columbia	0.111	**	0.053
Intercept	-7.419	***	0.958
Adjusted R^2	0.165		
N	15,555		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

Table 2.7b: OLS regressions of parental investments on the number of children and other controls

	Attends a private school		Attends a private, non-sectarian school		Computers per child		Parents have saved money for PSE	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Number of children	0.007 *	0.004	-0.002	0.002	-0.148 ***	0.005	-0.049 ***	0.008
Child's birth order	-0.010 **	0.004	0.001	0.002	-0.003	0.006	-0.060 ***	0.008
Child's age (months/12)	-0.003	0.008	0.007 *	0.004	0.010	0.013	-0.035	0.024
Child is a female	-0.012 **	0.006	-0.005	0.003	-0.033 ***	0.007	0.014	0.010
Child is an immigrant	-0.026 *	0.015	-0.003	0.007	-0.044 **	0.021	-0.124 ***	0.026
Mother's age (years in integers)	-0.002	0.009	0.000	0.005	0.008	0.013	0.047 **	0.020
Mother's age^2 (years in integers)	0.000	0.000	0.000	0.000	0.000	0.000	0.000 **	0.000
Father's age (years in integers)	-0.007	0.009	-0.013 *	0.007	0.018 **	0.007	0.000	0.014
Father's age^2 (years in integers)	0.000	0.000	0.000 *	0.000	0.000 **	0.000	0.000	0.000
Mother has a high school diploma	0.036 ***	0.009	0.011 *	0.006	0.052 ***	0.014	0.129 ***	0.023
Mother has a college certificate	0.044 ***	0.012	0.015 *	0.008	0.063 ***	0.014	0.182 ***	0.023
Mother has a bachelor's degree	0.059 ***	0.015	0.016 **	0.007	0.105 ***	0.016	0.193 ***	0.026
Mother has a professional degree	0.041 *	0.021	0.021 *	0.012	0.121 **	0.047	0.289 ***	0.058
Mother has a master's degree	0.071 **	0.028	0.018	0.012	0.130 ***	0.028	0.239 ***	0.036
Mother has an earned doctorate	0.213 ***	0.077	0.025	0.029	0.185 **	0.075	0.238 ***	0.077
Father has a high school diploma	0.017 ***	0.006	0.003	0.004	0.074 ***	0.010	0.059 ***	0.019
Father has a college certificate	0.024 ***	0.007	0.001	0.003	0.117 ***	0.012	0.080 ***	0.021
Father has a bachelor's degree	0.051 ***	0.012	0.005	0.006	0.181 ***	0.013	0.122 ***	0.024
Father has a professional degree	0.091 ***	0.030	0.018 *	0.011	0.216 ***	0.029	0.182 ***	0.031
Father has a master's degree	0.094 ***	0.023	0.015 *	0.008	0.241 ***	0.024	0.145 ***	0.027
Father has an earned doctorate	0.125 ***	0.046	0.021 *	0.012	0.247 ***	0.039	0.129 **	0.057
One parent is an immigrant	0.031 ***	0.011	0.010	0.006	0.060 ***	0.014	0.011	0.019
Both parents are immigrants	0.038 **	0.017	0.027 *	0.015	0.057 ***	0.013	0.019	0.019
Prince-Edward-Island	0.004	0.003	-0.001	0.001	0.042 ***	0.012	0.003	0.023
Nova Scotia	-0.010 ***	0.003	0.002	0.001	0.077 ***	0.012	0.022	0.020
New Brunswick	-0.007 ***	0.003	-0.001	0.001	0.033 **	0.013	0.011	0.021
Québec	0.167 ***	0.037	0.048 **	0.020	0.057 ***	0.011	-0.122 ***	0.021
Ontario	-0.005	0.013	-0.011 **	0.005	0.167 ***	0.012	0.112 ***	0.021
Manitoba	0.062 ***	0.021	0.016	0.013	0.092 ***	0.013	0.103 ***	0.022
Saskatchewan	0.019 *	0.011	0.006	0.007	0.104 ***	0.012	0.101 ***	0.019
Alberta	0.001	0.013	-0.005	0.003	0.130 ***	0.012	0.100 ***	0.022
British Columbia	0.060 **	0.028	0.005	0.013	0.144 ***	0.014	0.059 **	0.023
Intercept	0.110	0.218	0.172	0.132	-0.229	0.337	-0.001	0.513
Adjusted R^2	0.105		0.045		0.217		0.100	
N	15,555		15,555		15,555		15,555	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

The coefficients associated with the control variables are also worth mentioning. In terms of reading scores, factors with a positive influence include the child’s age, being a female, the mother’s age, the parents’ level of education, and living in certain provinces (Québec, Saskatchewan, Alberta, and British Columbia) relative to Newfoundland and Labrador (the omitted category). Factors with a negative influence include the child's birth order, being an immigrant, and living in Prince-Edward-Island and New Brunswick.

With respect to attending a private school, the child's birth order, being female, and being an immigrant, as well as living in Nova Scotia and New Brunswick exert a negative influence. Factors with a positive influence include parental education, having immigrant parents (one or both), and living in Québec, Manitoba, Saskatchewan, and British Columbia.

For private, non-sectarian school enrolment, fewer coefficients are statistically significant. The child's age has a moderate positive influence, as does the level of parental education, and having two immigrant parents. Living in Québec exerts a larger positive influence, although it still pales in comparison to its effect on enrolment in private schools more broadly defined. The only characteristics with a negative influence are the father's age and living in Ontario.

Not surprisingly, higher levels of parental education are positively linked to the number of computers per child. Also, living anywhere but in Newfoundland and Labrador (the omitted category) is positively associated with more computers per child, as is the father's age. Being a female or an immigrant are the only the factors exerting a negative influence.

Several factors are positively linked to having parents who save money for the child's education, including the mother's age, the parents' education, and living in Ontario or the western provinces (Manitoba to British Columbia). Factors with a negative influence include the child's birth order, being an immigrant, and living in Québec.

IV approach

I now turn to the instrumental variable (IV) approach. In Table 2.8, I show the first-stage regression results. Here, I regress the number of children on the multiple birth IV, and other covariates. The findings suggest that a multiple birth is associated with 1.3 additional children, which is significant at 1%. The F-statistic (i.e. the square of the t-statistic on the multiple birth coefficient) is 183.689, which is well above the thresholds for strong IVs established by Stock and Yogo (2005)—in most instances, an F-statistic of 16 is sufficient.

Table 2.8: First-stage regression of the number of children on the multiple birth instrumental variable and other controls

	b		s.e.
Multiple birth	1.301	***	0.096
Child's birth order	0.516	***	0.014
Child's age (months/12)	-0.008		0.034
Child is a female	-0.018		0.015
Child is an immigrant	0.054		0.052
Mother's age (years in integers)	-0.113	***	0.031
Mother's age^2 (years in integers)	0.001	**	0.000
Father's age (years in integers)	-0.010		0.018
Father's age^2 (years in integers)	0.000		0.000
Mother has a high school diploma	-0.033		0.032
Mother has a college certificate	-0.019		0.035
Mother has a bachelor's degree	0.074	*	0.041
Mother has a professional degree	0.174		0.132
Mother has a master's degree	0.056		0.054
Mother has an earned doctorate	0.184	*	0.104
Father has a high school diploma	0.052	**	0.026
Father has a college certificate	0.076	***	0.028
Father has a bachelor's degree	0.119	***	0.032
Father has a professional degree	0.316	***	0.070
Father has a master's degree	0.190	***	0.051
Father has an earned doctorate	0.297	***	0.092
One parent is an immigrant	0.063	**	0.026
Both parents are immigrants	0.008		0.030
Prince-Edward-Island	0.304	***	0.037
Nova Scotia	0.111	***	0.029
New Brunswick	0.083	***	0.030
Québec	0.117	***	0.032
Ontario	0.180	***	0.032
Manitoba	0.227	***	0.035
Saskatchewan	0.262	***	0.028
Alberta	0.209	***	0.038
British Columbia	0.119	***	0.032
Intercept	5.324	***	0.647
F-statistic	183.689		
Adjusted R^2	0.222		
N	15,555		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

In Tables 2.9a and 2.9b, I show the second stage results of the IV regressions. These estimates are considered the preferred ones since the number of children draws its variation from the presence of a multiple birth, and several covariates are taken into account in the model.

Table 2.9a: IV regressions of standardized reading score on the number of children and other controls

	b		s.e.
Number of children	0.158	*	0.092
Child's birth order	-0.229	***	0.045
Child's age (months/12)	0.178	***	0.035
Child is a female	0.342	***	0.024
Child is an immigrant	-0.305	***	0.060
Mother's age (years in integers)	0.144	***	0.045
Mother's age^2 (years in integers)	-0.001	***	0.000
Father's age (years in integers)	0.021		0.027
Father's age^2 (years in integers)	0.000		0.000
Mother has a high school diploma	0.266	***	0.039
Mother has a college certificate	0.355	***	0.044
Mother has a bachelor's degree	0.542	***	0.057
Mother has a professional degree	0.430	***	0.137
Mother has a master's degree	0.788	***	0.084
Mother has an earned doctorate	0.790	***	0.165
Father has a high school diploma	0.251	***	0.039
Father has a college certificate	0.323	***	0.038
Father has a bachelor's degree	0.484	***	0.046
Father has a professional degree	0.663	***	0.080
Father has a master's degree	0.523	***	0.073
Father has an earned doctorate	0.789	***	0.115
One parent is an immigrant	0.037		0.042
Both parents are immigrants	-0.032		0.041
Prince-Edward-Island	-0.130	**	0.063
Nova Scotia	-0.084	*	0.048
New Brunswick	-0.244	***	0.045
Québec	0.141	***	0.051
Ontario	0.003		0.051
Manitoba	0.051		0.054
Saskatchewan	0.087		0.061
Alberta	0.236	***	0.056
British Columbia	0.100	*	0.055
Intercept	-7.873	***	1.106
Adjusted R^2		0.161	
N		15,555	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being
Source: Youth in Transition Survey, Cohort A.

Table 2.9b: IV regressions of child quality measures on the number of children and other controls

	Attends a private school			Attends a private, non-sectarian school			Computers per child			Parents have saved money for PS schooling		
	b		s.e.	b		s.e.	b		s.e.	b		s.e.
Number of children	-0.041	***	0.012	-0.010	**	0.004	-0.143	***	0.029	-0.109	**	0.050
Child's birth order	0.014	**	0.007	0.005	*	0.003	-0.006		0.017	-0.029		0.027
Child's age (months/12)	-0.003		0.008	0.007	*	0.004	0.010		0.013	-0.036		0.024
Child is a female	-0.013	**	0.006	-0.005		0.003	-0.033	***	0.007	0.013		0.010
Child is an immigrant	-0.024		0.015	-0.002		0.007	-0.044	**	0.021	-0.121	***	0.026
Mother's age (years in integers)	-0.006		0.009	-0.001		0.005	0.009		0.013	0.040	**	0.021
Mother's age^2 (years in integers)	0.000		0.000	0.000		0.000	0.000		0.000	0.000	**	0.000
Father's age (years in integers)	-0.007		0.009	-0.013	*	0.007	0.018	**	0.007	-0.001		0.014
Father's age^2 (years in integers)	0.000		0.000	0.000	*	0.000	0.000	**	0.000	0.000		0.000
Mother has a high school diploma	0.034	***	0.009	0.010	*	0.006	0.053	***	0.014	0.127	***	0.024
Mother has a college certificate	0.042	***	0.012	0.015	*	0.008	0.063	***	0.014	0.180	***	0.024
Mother has a bachelor's degree	0.062	***	0.015	0.016	**	0.007	0.105	***	0.016	0.197	***	0.027
Mother has a professional degree	0.050	**	0.022	0.022	*	0.013	0.120	**	0.047	0.300	***	0.057
Mother has a master's degree	0.073	***	0.028	0.018		0.012	0.129	***	0.028	0.242	***	0.036
Mother has an earned doctorate	0.221	***	0.077	0.026		0.029	0.184	**	0.076	0.248	***	0.081
Father has a high school diploma	0.019	***	0.006	0.003		0.004	0.073	***	0.011	0.062	***	0.020
Father has a college certificate	0.027	***	0.008	0.001		0.003	0.117	***	0.012	0.085	***	0.022
Father has a bachelor's degree	0.057	***	0.013	0.005		0.006	0.181	***	0.013	0.129	***	0.025
Father has a professional degree	0.108	***	0.032	0.021	*	0.012	0.214	***	0.031	0.203	***	0.036
Father has a master's degree	0.104	***	0.025	0.016	*	0.009	0.240	***	0.025	0.157	***	0.030
Father has an earned doctorate	0.140	***	0.048	0.023	*	0.012	0.245	***	0.040	0.147	**	0.060
One parent is an immigrant	0.034	***	0.011	0.010		0.006	0.060	***	0.014	0.015		0.020
Both parents are immigrants	0.039	**	0.017	0.027	*	0.015	0.057	***	0.013	0.020		0.019
Prince-Edward-Island	0.019	***	0.005	0.001		0.002	0.040	***	0.015	0.022		0.029
Nova Scotia	-0.004		0.003	0.003	*	0.001	0.076	***	0.013	0.029		0.022
New Brunswick	-0.003		0.003	0.000		0.001	0.032	**	0.013	0.015		0.022
Québec	0.173	***	0.037	0.049	**	0.020	0.056	***	0.012	-0.115	***	0.023
Ontario	0.003		0.014	-0.009	*	0.005	0.167	***	0.013	0.123	***	0.023
Manitoba	0.072	***	0.022	0.017		0.014	0.091	***	0.014	0.117	***	0.026
Saskatchewan	0.032	***	0.011	0.008		0.007	0.103	***	0.014	0.117	***	0.025
Alberta	0.011		0.015	-0.003		0.003	0.129	***	0.013	0.113	***	0.025
British Columbia	0.066	**	0.029	0.006		0.013	0.143	***	0.015	0.067	***	0.025
Intercept	0.361		0.224	0.214		0.133	-0.257		0.370	0.314		0.606
Adjusted R^2	0.085			0.042			0.217			0.092		
N	15,555			15,555			15,555			15,555		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

The results suggest that one additional child is associated with an improvement in the reading test score equivalent to 0.158 (16%) of a standard deviation, although the coefficient is only statistically significant at 10%. In contrast, an additional child is associated with lower parental investments in child quality. Specifically, the additional child reduces the probability of the youth attending a private (private, non-sectarian) school by 4.1 (1) percentage points, which is significant at 1% (5%). The number of computers per child declines by 0.143 (significant at 1%). We also see a large reduction in the probability that the parents save money for the youth's postsecondary education (a decline of 10.9 percentage points, which is significant at 5%).

One notable variable that is absent from the child quality regressions is parental income. This is because we know from the literature that maternal labour supply declines as family size increases. Thus, parental income may also decline as family size increases. Furthermore, the regressions already include the age and educational levels of each parent, both of which are key variables in a Mincer wage equation. However, parental income may still exert an additional influence on child quality not captured by parental age and education. In Appendix 2.9, I add parental income and its squared value to the models. As shown in Tables A2.9.1a and A2.9.1b, this has no tangible impact on the relationship between family size and the measures of child quality in the IV regressions.

The preferred set of results has strong implications for child quality and parental behaviour. Additional children are found to reduce parental investments per child according to all metrics of child inputs investigated here. As noted by Cáceras-Delpiano (2006) this is a superior test of Becker's Quantity-Quality model compared to simply looking at child outcomes. However, it is interesting to note the dichotomy: fertility induces parents to invest less in children, yet we see no decline in the reading scores. In fact, we see an increase, albeit one that is only statistically significant at 10%. Why don't we see a negative relationship? The next section examines potential candidates.

It is also important to compare the size of the IV estimates (in Tables 2.9a and 2.9b) to those obtained from OLS (in Tables 2.7a and 2.7b). The IV estimates are generally in the same direction as the OLS estimates, with the exception of private school attendance (which is not surprising given the potential for selection effects in enrolment in such schools regarding family size). Furthermore, even when the IV and OLS coefficients are in the same direction, they are not always of the same magnitude. For example, the impact of family size on academic performance and the incidence of parental savings for PSE is about twice as large according to IV compared to OLS. The impact of family size on private, non-sectarian school enrolment is also much larger according to IV compared to OLS.

2.6 Explanations that may reconcile the findings

What factors may explain why family size is negatively associated with inputs into child quality, yet is not negatively associated with child quality *per se*? In this section, I discuss three potential candidates.

The first possibility is that, despite the best intentions of the parents, their investments in children may simply exert little or no influence on the measured child output. For example, Neal (2009) reviews the literature on the effects of private schools on academic achievement and attainment (including experimental evidence based on voucher programs), and concludes that there is no evidence suggesting that private schools are generally superior to public schools. The one exception is with private schools that serve minority students in the United States, although this finding is likely the result of the poor funding for urban public schools.

In terms of computer use, perhaps the most credible study comes from Angrist and Lavy (2002). The authors examine the randomized introduction of computers in Israeli elementary and middle schools in the 1990s. They conclude that although the introduction of computers raised the use of computer-aided instruction among teachers, it did not have any effect on pupil test scores.

With regards to parental savings for the child's postsecondary schooling, there are no studies devoted to credibly estimating its relationship with test scores. However, it is hardly a stretch of the imagination to assume that parents who save for their child's education do so at least partly in response to their child's abilities.

Although it is quite possible that the measures of child inputs used in this study are not associated with test scores, their relationship with family size nevertheless signals parental behaviour or intentions. There may be other measures of child inputs that parents attempt to manipulate, and perhaps these are associated with test scores. Consequently, more research is needed in this area. Specifically, further studies highlighting the impact of family size on a broader spectrum of parental investments would be particularly useful.

A second possibility is that there may be economies of scale in rearing children and/or selecting effective sibling interactions in larger families. With regards to rearing children, more children may reduce available resources per child, but the productivity of these resources may improve. Siblings may share the same toys or clothes, leaving more resources available for other household goods, some of which may be related to learning activities. Also, there may be economies of scale regarding the time allocation of parents. For example, parents may read to two siblings close in age at the same time.

In terms of selecting effective sibling interactions, the likelihood of finding a sibling who may be beneficial to interact with might rise with sibling size. A child may benefit from an older sibling by acquiring information or aspiring to be like them. Alternatively, a child may also benefit from a younger sibling by feeling the pressure to serve as a role model, or by reinforcing knowledge through teaching the younger sibling.

It is plausible that economies of scale are more likely to occur when the siblings are close in age. One way to reduce the potential impact of economies of scale is by re-estimating the child output IV model on a sample of youth who have no siblings who are close in age. Going back to the YITS data, I focus on youth with no siblings who are within two years in age. The results appear in Table 2.10.

Table 2.10: IV regression of the standardized reading score on the number of children and other controls - no siblings within two years of age

	b		s.e.
Number of children	0.016		0.141
Child's birth order	-0.123		0.141
Child's age (months/12)	0.272	***	0.066
Child is a female	0.294	***	0.049
Child is an immigrant	-0.348	***	0.105
Mother's age (years in integers)	0.140		0.098
Mother's age^2 (years in integers)	-0.001		0.001
Father's age (years in integers)	0.092	*	0.053
Father's age^2 (years in integers)	-0.001	*	0.001
Mother has a high school diploma	0.301	***	0.073
Mother has a college certificate	0.453	***	0.083
Mother has a bachelor's degree	0.595	***	0.123
Mother has a professional degree	0.811	***	0.218
Mother has a master's degree	1.021	***	0.136
Mother has an earned doctorate	0.920	***	0.267
Father has a high school diploma	0.207	***	0.066
Father has a college certificate	0.260	***	0.067
Father has a bachelor's degree	0.408	***	0.067
Father has a professional degree	0.481	***	0.179
Father has a master's degree	0.511	***	0.122
Father has an earned doctorate	0.732	***	0.201
One parent is an immigrant	0.085		0.074
Both parents are immigrants	0.022		0.076
Prince-Edward-Island	-0.172	**	0.070
Nova Scotia	-0.128	*	0.071
New Brunswick	-0.322	***	0.074
Québec	0.049		0.062
Ontario	-0.073		0.070
Manitoba	0.061		0.076
Saskatchewan	-0.022		0.086
Alberta	0.188	**	0.077
British Columbia	0.014		0.072
Intercept	-10.347	***	2.078
Adjusted R^2		0.169	
N		4,313	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

The weak positive association shown in Tables 2.9a and 2.9b is not present at all in Table 2.10. Nevertheless, the relationship is still not negative even after removing children with siblings who are close in age (i.e. who are most likely to be affected by economies of scale). Therefore, economies of scale may explain some of the puzzle, but not all of it.

A third possibility is that, following a child, parents (especially the mother) reduce their paid labour supply in favour of unpaid work. The resulting increased maternal contact with the child may foster child quality. In fact, Waldfogel (2006) reviews the literature and concludes that children fare better if their mothers do not work full-time in the first year of life.[9] Since this draws on the parental labour supply literature, a different framework is needed. This is left for Chapter 3.

2.7 Concluding remarks

In this chapter, I have explored the relationship between family size and various measures of child quality. The child quality measures include both a measure of output (i.e. test score data) and various measures of inputs (i.e. parental investments in children, including private school enrolment, the number of computers in the home per child, and parental savings earmarked for the child's education).

[9] As noted by Baker and Milligan (2008), however, this research does not employ causal or quasi-causal methods. In their study, Baker and Milligan examine variation in maternal employment in the child's first year of life that is drawn from policy changes regarding maternity leave expansion. They conclude that maternal employment has a negligible impact on motor-social development and a small negative impact on temperament. Unfortunately, they did not have access to cognitive assessments in their data.

Using a survey of 15 year old Canadian youth, I instrument family size with the incidence of a multiple birth on the second or later birth. The findings suggest that larger families lead to reduced parental investments in children. Despite these reductions in parental investments, test scores are not negatively affected by larger families. In fact, test scores improve by 16% of a standard deviation (significant at 10%).

The chapter contributes to the literature in several ways. First, it is only the second study to look at the relationship between family size and academic performance using quasi-causal methods. Second, there is only one other study that examines parental investments in children as a function of family size (Cáceras-Delpiano, 2006). Third, the chapter looks at various possible explanations behind the finding that larger families are negatively associated with parental investments in children, yet they are not negatively related to child test scores. Fourth, it is the first comprehensive study of family size and child quality using Canadian data.

In terms of reconciling this apparent puzzle, three explanations were discussed and/or explored. First, parental investments in child quality are not necessarily associated with improved child quality. In fact, the best empirical studies (based on credible identification strategies) suggest that there is no link, at least for certain types of investments (computers and private schools).

Second, there may be economies of scale associated with rearing more children and/or selecting effective sibling interactions. Empirical investigation suggests that these factors alone are not likely to fully reconcile the findings.

A third possible explanation, which was noted by (Cáceras-Delpiano, 2006), is that larger families may entice parents to stay home, which may help foster child development. Cáceras-Delpiano (2006) only had data on paid labour supply. However, this argument critically rests on the availability of the parent in the home. In the next Chapter, I will investigate this issue empirically using a data source that contains detailed information on both paid and unpaid work patterns of the parents.

Chapter 3: The Impact of Family Size on the Allocation of Paid and Unpaid Labour Supply among Couples

3.1 Introduction

In Chapter 2, I estimated the impact of family size on different components of the child quality production function (i.e. measures of child inputs and output). Paradoxically, I found that increased family size is associated with reduced parental investments in children, but does not lead to a reduction in child test scores. These findings are similar to those of Cáceras-Delpiano (2006), although he used grade retention as his measure of child output, and the measures of child inputs were also somewhat different.

Two potential explanations were examined, including the possibility that the measured inputs are simply not associated with test scores, as well as the opportunities for larger families to reap economies of scale in childrearing and/or selecting efficient sibling interactions.

In the current chapter, I examine another possible explanation. Faced with more children, parents may spend more time at home. Based on Becker's theory of specialization in the sexual division of labour (Becker, 1985), complemented with Lundberg and Rose's theory of home intensity (Lundberg and Rose, 1999), the mother is expected to spend more time at home following an increase in family size, but the expectations are ambiguous for the father. If, in fact, overall parental contact increases as family size increases, there are important implications for the child quality literature. This is because Waldfogel (2006) concludes that children generally fare better if their mothers do not work full-time in the first year of life.

For these reasons, the current chapter can be seen as complementary to Chapter 2. However, understanding the labour supply response of parents to additional children is also important in its own right. Fertility is one potential policy lever that could be used to alleviate labour shortages. The argument supporting this point of view actually begins with a population that is largely not involved with fertility decisions: the elderly.

It is no secret that the population in the industrialized world is aging. One of the main concerns associated with an aging population is a possible rise in the dependency ratio, which is the ratio of the non-working age population to the working age population. Holding all else constant, the dependency ratio will increase as baby boomers enter their retirement years. One strategy for mitigating the impact of the aging population is to take in more working-age immigrants who are qualified to enter the labour force. This is in fact what has occurred in the case of Canada, as the proportion of skilled immigrants has increased dramatically in recent decades. However, research on immigrant labour market outcomes has been very conclusive regarding their level of success. Immigrants have generally not adapted well to the Canadian labour market, especially in light of their higher levels of education compared to the Canadian-born population (Baker and Benjamin, 1994; Bloom, Grenier, and Gunderson, 1995; Grant, 1999; Frenette and Morissette, 2003; Aydemir and Skuterud, 2005).

An alternative approach to easing the impact of the aging population in the years to come is to create financial incentives for families to have more children. There is some evidence that financial incentives are positively linked to fertility. From an identification point of view, perhaps the best available evidence comes from Milligan (2005), who examines the Allowance for Newborn Children (ANC) introduced in the Canadian province of Québec in 1988. By implementing a quasi-experimental strategy, he finds strong evidence that the financial incentives associated with the ANC raised fertility rates in Québec. Zhang, Quan, and van Meerbergen (1994) use Canadian time-series data from 1921 to 1988 to estimate the impact of the personal tax exemption for children, the child tax credit, family allowances, and maternity leave benefits on fertility. The authors find that the exemption, the child tax credit, and family allowances all had significant and positive effects on fertility. Milligan (2005) notes several other studies around the world, most of which find a positive link between financial incentives and fertility.

Although increased fertility may help alleviate the looming retirement crunch when the newborns enter the labour force, this effect may be partially offset in the short to medium term. First, in a purely mechanical fashion, the dependency ratio increases with the number of children. Second, additional children encourage women to stay at home, as per Becker (1985) and Lundberg and Rose (1999).

Using the 2006 Canadian Census, I estimate the role of family size in determining the allocation of paid and unpaid labour among couples. To identify the impact of family size, I instrument fertility with the incidence of a multiple birth on the second or later birth (as in Chapter 2), as well as with the sex composition of the first two children (following Angrist and Evans, 1998). Parents who have two children of the same sex may be more likely to try for a third if they prefer having at least one boy and one girl.

I find that additional children lead to a reduction in paid hours and to an even larger increase in unpaid hours among mothers. In contrast, additional children are not related to paternal paid hours, although there is evidence of a small increase in unpaid hours spent on childcare.

The remainder of this chapter is organised as follows. In Section 3.2, I will review the literature on fertility and parental labour supply. This review will describe both the theoretical and empirical works in the area. Next, I will undertake empirical analyses of fertility and parental labour supply in Section 3.3 (Methodology), Section 3.4 (Descriptive results), and Section 3.5 (Econometric results). In Section 3.6, I attempt to assess the validity of the instruments used in this chapter by exploiting retrospective data available in the Census. The chapter concludes in Section 3.7.

3.2 Literature review

Overview

The structure of this section is the same as the literature review in Chapter 2. First, I will review the theoretical articles in the area. The goal here is to point out the assumptions of the model, as well as the testable hypotheses that are derived from these assumptions. Second, I will move into the empirical branch of the literature.

Once again, all studies must contend with finding an exogenous source of variation in fertility in order to establish their credibility. Finally, I will elaborate on how the current chapter contributes to the literature.

Theoretical literature

I consider the theoretical relationship between fertility and parental labour supply. To this end, Becker's theory of specialization within households (Becker, 1985) and Lundberg and Rose's theory of home intensity (Lundberg and Rose, 1999) will be discussed as complementary theories. The implications of the specialization theory are that increased fertility lead women (who are relatively more productive in household production) to spend more time taking care of children, and men (who are relatively more productive in market production) to spend more time in market work. However, this assumes that market versus home hours remains fixed for the couple. According to Lundberg and Rose, additional children should increase the demand for home production from the couple as a whole, yielding more childcare from both the father and the mother. Thus, the unified theories predict that fertility is unambiguously related to paid labour supply of the mother in a negative sense since the specialization and home intensity effects work in the same direction. For the father, the theories predict an ambiguous impact since the specialization and home intensity effects work in opposite directions.

I now turn to describing the theories in somewhat more detail, including some earlier work on time allocation in general. The goal here is to highlight the main assumptions of the models, as well as the relevant testable hypotheses with respect to this chapter.

The first generation of economic models examining time allocation (including labour supply) and fertility considered fertility as the outcome of market wage rates of women. Following on the work of Mincer (1963) and Becker (1965), Willis (1973) provides a framework for deriving relevant testable hypotheses. In his model, utility is derived from “adult standard of living” and child services (the number and quality of children). As Becker (1965) notes, households use non-market time and purchased goods as inputs in the production of the two utility generating outputs. Decisions are made jointly by the couple, although the husband’s income is exogenous, while the wife must decide how much time to spend in market versus household work. A key assumption of the model is that the production technology for children is time intensive.

For the purposes of this chapter, there is one notable prediction that can be derived from this model. Specifically, an increase in the wife’s market wage leads to increases in total household income, as well as the opportunity cost of having children. An increase in household income will raise child services consumed through an income effect, while the increased opportunity cost of having a child will tend to lower child services consumed through a substitution effect. Thus, fertility may be affected by the wife’s wage offer if the income effect does not equal the substitution effect. It follows that fertility may also be affected by factors that are likely to determine the wife’s wage offer, such as human capital (i.e. education and labour market experience), labour supply (i.e. hours willing to work at given wage rates), etc. This result is similar to the one derived from the Quantity-Quality Model in Chapter 2, except that the focus now is on the wife’s wage, as opposed to the household’s income. In any event, it simply highlights the fact that fertility is very likely to be an endogenous variable (vis-à-vis many variables), and should be treated with caution in any empirical analysis.

As important as this note of caution may be, this particular strand of the literature yields no insight into the anticipated impact of fertility on labour supply, which is the primary goal of this chapter. A more fruitful avenue begins with Becker's theory of specialization in the sexual division of labour (Becker, 1985).[10]

Becker began by postulating that for some exogenous reason (perhaps discrimination), there historically has been a sexual (or gender) division of labour within households. Women spend more time doing housework (including childcare), while men spend more time doing market work. In his pioneering book *Human Capital*, Becker states that it is this division of labour that creates an incentive for each member of the couple to invest in human capital specific to their main activity (Becker, 1964).

In his book *A Treatise on the Family*, Becker postulates that investments in specific human capital produce increasing returns to scale (i.e. productivity rises in the main activity), and thus, additional time is spent in that activity in order to capitalize on the increased productivity (Becker, 1981). Furthermore, with more time spent performing childcare, productivity in market work declines since childcare requires more effort than other household activities, such as leisure.

[10] Note that Becker does not actually name his theory. I provide a descriptive name simply for convenience.

As a result, the gender division of labour is further engrained in household behaviour. This is the case even if men and women are otherwise identical. It is the original exogenous reason for the gender division of labour that triggered this series of events.

What does the theory of specialization in the sexual division of labour imply about the effect of childbirth on labour supply? Following a birth, the mother, who spends more time working in the home for historical/exogenous reasons, will simply substitute childcare for non-childcare housework. Since childcare requires more effort than other household activities, her productivity in market work declines. As a result, she spends even more time at home and less time in market work. The decrease in the wife's market productivity implies that her comparative advantage in housework relative to the husband will increase. Put differently, the husband's comparative advantage in market work will increase. As a result, he substitutes market work for household work.

A key assumption in Becker's theory of specialization in the sexual division of labour is that households maintain their total time spent doing both market and household work. The members of the couple simply act as economic agents who must decide how to allocate market and household activities between them.

But what if childbearing requires that the couple spend more time at home with the child (or doing work related to the child, such as cleaning up after them)? This was proposed by Lundberg and Rose (1999), who postulated that children result in increased value of total parental time as inputs to childcare. As a result, the couple as a whole will spend more time doing household activities rather than market work. There is no distinction here between the mother and the father: the value of both parents' time at home increases following childbirth. In contrast, Becker's theory of specialization only involved a re-allocation of resources vis-à-vis home and market work.

Lundberg and Rose term this the home- (relative to market-) intensity effect. It is important to note that the authors do not propose this as an alternative to Becker's theory of specialization in the sexual division of labour. Rather, they treat both theories as complementary. Both effects co-exist, but unfortunately, the predictions from the unified theory are less definitive than in Becker's theory alone, at least in the case of men. For them, the specialization and home intensity effects work in opposite directions, rendering the anticipated total effect of fertility on labour supply ambiguous: market work and housework may go up or down following the birth of a child. For women, both effects work in the same direction, implying an unambiguous effect: fertility is negatively related to market work and positively related to housework.

Empirical literature

This section considers the main empirical studies related to the impact of fertility on parental labour supply. The main challenge faced by researchers has been the potential endogeneity of fertility to the outcomes in question. Consequently, an important feature of this part of the literature review consists of highlighting the development of identification strategies over the years. Another challenge faced by some studies relates to small samples resulting from the chosen identification strategy. For example, some authors use the event of a twin birth to identify the causal impact of fertility. Since twins are relatively rare, standard datasets often do not produce sufficient twin cases to yield reliable estimates.

This literature has been spearheaded mainly by labour economists, who are accustomed to dealing with identification issues. This, in addition to the fact that labour supply and childbearing are so intricately linked (and thus, highly prone to causality in both directions), has resulted in much earlier attempts at solving the identification problem than was the case in the child quality studies. Note, however, that there is a sizable literature involving many prominent economists that treat fertility as purely exogenous (e.g. Heckman and MaCurdy, 1980; Hausman and Ruud, 1984). Adopting this philosophy has provided researchers with a simple solution to the sample selection bias associated with the study of female wages (i.e. the exogeneity of the presence of children is used as an exclusion restriction in a Heckman selection model). Since I treat fertility as potentially endogenous (as do most studies), I will not review this literature any further.

In his review of the literature on the effects of fertility on labour supply, Browning (1992) discusses two schools of thought regarding empirical approaches. The standard approach is to estimate the impact of fertility on labour supply, while accounting for the endogeneity of fertility. Most studies have followed this route. Other studies have adopted what Browning calls the ‘purist’ approach. In this case, researchers estimate a reduced form labour supply equation, where the number of children does not appear on the right hand side. Rather, the cost of rearing those children appears in the equation. This approach more closely follows demand theory. Specifically, the demand for leisure (the residual of market work) is a function of income, its price, and the price of other commodities, such as children. If one were to include the number of children in the labour supply equation, this would be akin to modeling demand for one good as a function of purchases of another. It is the price of obtaining those purchases that matter. However, as we shall see, the number of children is not always determined by its price. Researchers using the standard approach have tried to identify natural experiments whereby the choice of family size was, to some extent, taken away from the parents.

The purists also argue that the cost of children is more amenable to policy intervention then the number of children per se. This is not necessarily the case. Declining fertility rates in industrialized countries has been an issue of policy concern for some time. This is especially so given the aging population in these countries, and the difficulties related to replacing older workers with immigrant labour. Consequently, the fertility rates may itself be the policy objective. If this is the case, then understanding the impact of achieving a particular fertility rate on other outcomes such as labour supply is of the utmost importance.

In one example of the purist approach, Carliner, Robinson, and Tomes (1980) use data on Canadian wives between the ages of 35 and 60 years old and living with their husbands to study the relationship between variables linked to the cost of childcare and female labour supply, measured by labour force participation, hours per week, and weeks per year. They hypothesize that Catholics face lower costs to having children since their psychic cost of using effective birth control techniques are greater.

They also argue that the cost of childcare should decline as the possibility of child employment increases, such as is the case when we move from a city, to a town, to a rural area, to a farm (in that order). Childcare costs should be positively linked to female labour supply since lower costs induce all women to have children and spend less time doing market work.

Carliner et al.'s results generally do not support their hypotheses. One reason might be because the childcare costs they hypothesize to exist are somewhat indirect, and likely quite small. They do make reference to a potentially more substantial cost associated with children: the opportunity cost from lost wages. Since they do not have a direct measure of the female wage, they lean on variables that are correlated with the wage, such as education and province of residence. In this instance, the results are more supportive of the notion that higher childcare costs encourage increased labour supply among women.

Several other studies have adopted the purist approach (Mincer, 1963; Schultz, 1978 and 1980; Moffitt, 1984; Ermisch, 1989). The main objective of this section, however, is to review studies based on the standard approach since that is the one adopted in this chapter.

Early efforts in the standard approach attempted to model labour supply, fertility, and at times other outcomes such as wages in a system of simultaneous equations. In an early study, Cain and Dooley (1976) use US data on black and white wives to model the three outcomes listed above in a system of equations. With respect to the impact of fertility on labour force participation, the instrumental variables include religion, urban/rural status of residence, and local industrial structure. Although the authors find no impact of fertility on labour force participation for black and white wives, this might be because the instruments they use are not valid. In other words, they might be direct determinants of labour supply. This is almost certainly the case with the urban/rural status and industrial structure, and it is plausibly the case for religion as well. They also note that endogenizing various aspects of household behaviour adds considerable complexity to the models and substantially increases the data requirements to estimate them.

Despite the difficulties in estimating all-encompassing, flexible systems of equations noted by Cain and Dooley, other economists followed suit. Fleisher and Rhodes (1979) also endogenize fertility, labour supply, and wage rates in a system of equations for black and white US wives. Their identification strategy was slightly different, however, in that the husband's education was used to instrument fertility. Regardless, they also find that fertility has no impact on labour supply. However, they do note that this result may be due to the absence of an appropriate instrumental variable.

Miller and Volker (1983) adopt a similar strategy with Australian Data. In their case, religion and available part time work in the area were used as instrumental variables for fertility. Once again, these variables may not be valid instruments. The value added of their study was to look at the differential impact of fertility on labour supply by the age of the mother. Labour supply is defined as labour force participation. They find that fertility has a negative impact on labour supply among women below the age of 35, but it has no impact on older women.

Economists were not the only ones interested in the impact of fertility on labour supply. Several sociologists also endeavoured to study the issue. Although the methods were generally similar in the early days, in that both groups tended to favour simultaneous equation models, the approach was slightly different. For example, Waite and Stolzenberg (1976) examine the impact of planned fertility on planned labour force participation among a sample of young women from the US. Given the prospective nature of the data, the instrumental variables used were quite different from the ones mentioned above in the economics literature. Specifically, the authors used the ideal family size and the number of current siblings as instruments for planned fertility. The ideal family size is likely not a valid instrument, as it may be correlated with preferences for labour supply. The number of current siblings, on the other hand, is less at the discretion of the young women in the study; however, it is clearly at the discretion of the parents of those young women, and to the extent that parents and children share the same preferences, the validity of the instrument is once again put into question. They find that planned fertility has a small negative impact on planned labour force participation. Unfortunately, it is impossible to make any inferences on real (actualized) outcomes from intentions of young women.

Another interesting study from the sociology literature is Smith-Lovin and Tickamyer (1978). They also estimate a simultaneous equation model where the labour supply outcome is the number of years in the labour force since marriage. The innovation in their study lies in one of the instruments used: fecundity (religion was the other instrument). To measure fecundity, the authors use a unique dataset of 30 year old women from the United States. Respondents were asked if they or their husband were unable to have a child (or another child). The authors only coded couples who were involuntarily sterile as being not fecund. The reason was that couples who chose to be sterilized likely have different preferences for the number of children, and this might be correlated with some unobserved preference for labour supply. In this case, the authors find that fertility has a substantial negative effect on labour supply.

Of all the studies reviewed so far that use simultaneous equation models, Smith-Lovin and Tickamyer stand alone in finding a substantial negative effect on labour supply. The other factor that distinguishes this study from the previous ones is the quality of the fecundity instrumental variable. The studies by Cain and Dooley (1976), Fleisher and Rhodes (1979), Miller and Volker (1983), and Waite and Stolzenberg (1976) can all be quite reasonably criticized for lacking valid instruments. As noted earlier, Fleisher and Rhodes actually question their own instrument. The lesson to be learned from these early attempts at estimating the role of fertility in determining labour supply is that solving the endogeneity issue is of critical importance.

It is for this very reason that more recent studies have narrowed their lens to focus on the impact of fertility on labour supply in a two-stage model. In other words, the more recent studies are less concerned with modeling a vast array of household behaviour. This is a reasonable approach since there is a trade-off between the quality of the identification strategy and the need to include (potentially endogenous) variables in one's model. If an instrumental variable is adequate, the Wald estimate (the unconditional analogue to the two-stage least squares estimator) has a causal interpretation (Angrist, 1990). Thus, the relatively successful quest for instruments has reduced the need for complex simultaneous equation models.

The genesis of this most recent strand of the literature actually dates back to 1980. Rosenzweig and Wolpin (1980b) use a sample of US mothers to study the role of having twins on the first birth on the probability of working. Having twins on the first birth presumably leads to a larger family. Their results show that the incidence of twins on a first birth reduces the probability of work for women under the age of 25 only. There is no significant effect on older women.

This study can be criticized from two angles. First, there are only 87 cases of first birth twins in the data. I also criticized Rosenzweig and Wolpin (1980a) in the child quality literature (Chapter 2) for using a dataset containing very few twins (25). Second, the incidence of a twin on the first birth may not be associated with an unanticipated increase in family size since many couples may prefer to have two children. This same comment was made in critiquing Rosenzweig and Wolpin (1980a) who considered the proportion of all births who were twins, including first births. In a sense, the strategy of focusing exclusively on first births may very well be inferior to their other approach. The authors defend the use of first birth twins by stating that the probability of having a twin birth increases with the number of births. However, conditioning on a minimum number of births (e.g. Black et al., 2005) would address this issue when the sample is large enough.

To date, I have criticized the use of first birth twins as an instrument for fertility based on intuition. Rosenzweig and Wolpin (1980b) actually provide some evidence supporting this critique. They show that having twins on the first birth is only weakly correlated with completed family size. Furthermore, the correlation is not statistically significant. In other words, the incidence of twins on a first birth would make for a weak instrument for completed fertility. Nevertheless, they do show that their twin variable is positively linked to incomplete fertility (i.e. family size by age 25), which is one of the outcomes used in their study.

Despite the methodological issues in Rosenzweig and Wolpin (1980b), the concept of looking at twin births has spawned several follow-up works based on slight modifications of this instrumental variable. One example is Bronars and Grogger (1994), who were the first to apply the twins strategy with the US Census data. The advantage of using the Census data lies in the large sample size, which is required to study twins. Although Bronars and Grogger also primarily focus on twins at first birth (they do briefly mention results from twins on the second birth), their study is somewhat different from Rosenzweig and Wolpin (1980b) in that they focus on the effects of fertility per se. Their results suggest that there are large short term effects on labour force participation for black and white unwed mothers. However, the effects dissipate over time (except for unwed black mothers).

Another twins study is Gangadharam and Rosenbloom (1996). They also use the US Census and apply the same strategy as Rosenzweig and Wolpin (1980b), which is to estimate the reduced form effect of twins on the first birth on labour supply. They find that having a twin on the first birth has a negative effect on labour force participation and the number of weeks worked per year.

I have already discussed Cáceras-Delpiano (2006) in the section on child quality. This study also looked at the impact of fertility on female labour force participation. The main difference in the methodology between this study and previous twin studies relates to the definition of the twins variable. Cáceras-Delpiano only looks at the incidence of a twin birth on the second or later birth. This is a substantial improvement from looking at first birth twins since having a twin on a later birth is more likely to lead to an unanticipated increase in family size. Following Black et al. (2005), Cáceras-Delpiano also conditions on a minimum number of births (two, in his case). This addresses the possibility noted above that a twin birth is more likely with subsequent births. He finds a strong negative relationship between fertility and female labour force participation.

While most of the studies in the literature focused on some version of the twin birth strategy, Angrist and Evans (1998) were busy developing a different instrumental variable. They use the sex composition of the first two children as an instrumental variable for the total number of children. The idea is that the sex of the children is almost certainly random, and that couples may prefer to have at least one child of each sex. They may thus plan on having more children if they have not achieved their 'opposite sex' goal after the first two. The authors find that mothers in the US tend to reduce their labour supply in response to an increase in the number of children generated by the sex composition of the first two. Angrist and Evans also demonstrate that the labour supply effect is larger when using the same sex instrumental variable then when they use the incidence of a twin birth on a second or later birth. They hypothesize that this is likely because a third child born as a twin from the second birth is older (and thus requires less maternal attention) than a third child generated from the sex composition of the first two children, conditional on the second child having the same age in both cases. This may very well be part of the reason, but another possible explanation relates to economies of scale in rearing twins as opposed to singletons. Siblings of the exact same age may be more likely to participate in similar extracurricular activities, which may reduce demands on the mother's time, allowing her to spend more time performing market work. Yet another reason is the differences in the quality of the instruments themselves. As noted by Angrist and Evans, the sex composition of children is almost certainly random. In contrast, twin births may have genetic foundations, or can even result from fertility treatments. Conditioning on socioeconomic background characteristics may address the first issue, while restricting the sample to families with a minimum number of distinct births may help alleviate the second. Despite such efforts, it is difficult to automatically dismiss the possibility that twin births may be related to labour supply since twinning is not completely random (unlike the sex composition). On the other hand, twin births necessarily come in pairs: parents do not have one of the two twins, and then decide if they will have the other. The same cannot be said for additional children generated from the sex composition instrument. When the second child is born, if it is of the same sex as the first, parents have to decide if they will pursue having another child. It is this level of discretion that opens the door for selection bias. Two sets of parents who have the same preferences for achieving opposite sex children may make different choices regarding the pursuit of a third child if they have different preferences vis-à-vis desired family size in general, which may be correlated with labour supply preferences.

To date, I have only reviewed studies that have looked at the impact of fertility on female labour supply. This is representative of the state of the literature: most studies consider female labour supply since it is women who are still largely responsible for the care of children. Nevertheless, there are a couple of recent studies that have considered the impact of childbearing on paternal labour supply. Lundberg and Rose (1999) propose the theory of home intensity, which suggests that the impact of childbearing on men's labour supply is ambiguous (when combined with Becker's theory of specialization). Using US longitudinal data from the Panel Study of Income Dynamics (PSID), the authors find that fatherhood has a significant positive impact on annual hours of work for men (Lundberg and Rose, 2002). Interestingly, they find that men's labour supply increases more in response to sons than to daughters. The only identification strategy used in this study is to relate changes in fertility to changes in labour supply (i.e. to exploit the longitudinal nature of the data). This approach is similar to the one used by Hanushek (1992) in his study of child quality. As I noted at the time, Hanushek's study can be criticized on the grounds that changes in fertility may be endogenous to changes in labour supply. The same criticism applies to Lundberg and Rose (2002).

Another study looking at the impact of fertility on men's labour supply is Kim and Aassve (2006). Using data from Indonesia, they instrument fertility with a variety of variables, including religion, presence of other adults in the home, and schooling of both spouses. They find that higher fertility is linked to an increase in men's work hours in rural areas only. It is argued that this affect is specific to rural areas because of the lower cost of child care in those areas; specifically, households in rural Indonesian areas contain more adult women who may participate in the task of childcare. The extent to which this holds in industrialized countries is less clear. As a result, some caution should be exercised in generalizing the findings of this study to other countries.

Contributions of the present chapter to the literature

The chapter contributes to the literature in many substantive ways. First, it is the only work in the area that considers the supply of both paid and unpaid work. The impact of fertility on housework in most studies is, at best, implied in a residual fashion (i.e. a decline in paid labour supply implies an increase in unpaid labour supply). This is an important omission in the literature since theories of labour supply are based on the substitution between market work and housework. Despite this, no studies to my knowledge look at both effects. Related to Chapter 2, unpaid work patterns may help explain why larger families are negatively associated with child inputs, but are not always negatively associated with child outputs. Cáceras-Delpiano (2006) alluded to this possibility, but he could only examine paid labour supply.

Second, this chapter considers the labour supply effects for both the wife and the husband. To the best of my knowledge, only the studies by Lundberg and Rose (2002) and Kim and Aassve (2006) look at the labour supply response of husbands. Clearly, more evidence is needed in this area

Third, the study contributes to the evaluation of the two primary instruments used in the literature: the sex composition and the incidence of a twin birth on the second of later birth. Specifically, I will evaluate not only the strength of the instruments (i.e. the correlation between the instruments and fertility in the first stage of a two stage least squares regression), but I will also propose a methodology to evaluate their validity (i.e. the extent to which they do not belong in the labour supply equation). To the best of my knowledge, no studies have evaluated the validity of the instruments proposed in the literature. Validity is usually established on conceptual grounds.

Fourth, I will add some Canadian evidence to the existing body of knowledge. Most of the studies to date have been based on US data. Adding evidence from additional countries is important since it provides an opportunity for testing the robustness of the results.

3.3 Methodology

For the analysis in this chapter, I rely on the long-form of the 2006 Canadian Census of Population, which is a 20% sample of households developed by Statistics Canada. The Census is intended to be a simple random sample based on pre-census enumeration of households. However, sample weights are adjusted moderately following the Census as the number of households may change disproportionately in certain regions of the country between enumeration and Census day. Nevertheless, it is virtually a simple random sample, and authors categorically treat it as such in their research. The same approach is used here.

Although the survey design should not pose any challenges in estimating standard errors, heteroscedasticity is still a potential issue. To correct for heteroscedasticity in this chapter, I calculate robust standard errors using the standard Huber-White sandwich estimator.

The objective of this chapter is to estimate the impact of family size on parental labour supply. For identification purposes, two instrumental variables are used: the incidence of same sex siblings among the first two children and the incidence of a multiple birth on the second or later birth, as described in Section 1.2.[11] The multiple birth IV is constructed in a similar fashion as in the empirical analysis of fertility and child quality. Specifically, three conditions have to be met for a multiple birth to have occurred in this IV framework:

- There are multiple birth siblings in the family.
- The multiple birth siblings must have occurred on the second or later birth (multiple birth siblings on the first birth are unlikely to yield additional children).
- The multiple birth siblings must have occurred on the last birth (otherwise, they could not possibly generate additional children since the couple chose to have more children following the multiple birth).

The Census contains information on the sex of the child, which is used to construct the sex composition of the first two children (a dummy variable indicating whether they are of the same sex or not). The Census also contains information on the exact date of birth, which is used to identify multiple births on the second or later birth within families. A dummy variable is created to indicate this status.

[11] Recall that the same sex IV was not used in the child quality analysis in Chapter 2. This was because previous studies suggested that the sex composition of siblings has a direct influence on childhood outcomes. Of course, this is plausible with respect to parental labour supply as well. In Appendix A3.1, I investigate this hypothesis, and conclude that it is likely not the case.

Two or more children living in the same census (or nuclear) family and sharing the same date of birth are deemed to be multiple birth siblings. Although it is impossible to identify birth siblings with the Census (since we don't know the exact relationship between the mother and her children, whether it be biological, adoptive, or step), they comprise 96.5% of all children of married mothers who gave birth to or raised two or more children in their lives according to the 2006 version of Statistics Canada's Survey of Labour and Income Dynamics (SLID). This suggests that in the vast majority of instances, children reporting the same mother (by birth or otherwise) and who were born on the same day are indeed birth siblings, and thus, multiple birth siblings.

The Census contains information on the hours spent at work (in either paid or self-employment) during the reference week (the week prior to Census Day: May 7th to 13th, 2006). Respondents were asked the following question:

- "**Last week**, how many hours did this person spend working for pay **or** in self-employment?"

Respondents are next prompted to report the number of hours to the nearest hour.

The Census also contains information on paid or self-employment patterns in the year prior to the Census (2005) based on the following question:

- "In how many **weeks** did this person work **in 2005**? Please enter the total number of weeks worked for pay or in self-employment at all jobs held in 2005. Include **those weeks** in which this person: was **on vacation** or **sick leave with pay**; worked **full time** or **part time**; worked for **wages**, **salary**, **tips** or **commission**; was **self-employed**; worked directly towards the operation of a **family farm or business** without formal pay arrangements"

We also know if the person worked mainly full time or part time in the previous year based on the question:

- "During most of those weeks, did this person work **full time** or **part time**"

The two possible responses are:

- "Full time (30 hours or more per week)"
- "Part time (less than 30 hours per week)"

Note that for simplicity, and to distinguish them from unpaid work, I will collectively refer to all measures of paid or self-employment outcomes as 'paid' work.

There is also information on the hours spent taking care of children or doing housework.[12,13] Specifically, respondents were asked:

[12]The Census also includes information on time spent taking care of an elderly individual without remuneration, but it is not included in this analysis since it is not directly related to children.

- “**Last week**, how many hours did this person spend doing the following activities:

  a) doing **unpaid** housework, yard work or home maintenance for members of this household, or others?
  b) looking after one or more of this person’s own children, or the children of others, **without pay**?”

The number of hours spent on childcare and housework is categorical: none, less than 5 hours, 5 to 14 hours, 15 to 29 hours, 30 to 59 hours, and 60 hours or more. In order to facilitate comparisons with the paid work results, I imputed continuous values for the measures of unpaid work. In Appendix A3.1, I describe the imputation approach and demonstrate that it has very high predictive power.

The models also contain several other covariates, including the mother’s and the father’s age, their highest level of completed education, their ethnicity, and the local unemployment rate they face (calculated at the census sub-division level, separately for men and women aged 25 to 54).

The initial sample is restricted to married or common-law opposite sex couples with at least one child. I then drop couples who only had one birth since multiple births are more common in larger families, and a multiple birth on a second or later birth is

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[13] Respondents are told that they can report the hours associated with two or more activities taking place at the same time.

impossible with only one birth. This action is also necessary to construct the same sex IV strategy. Finally, I delete couples who had a multiple birth the first time, which is necessary to construct the multiple birth IV (since many families may want to stop at two children, and thus, a multiple birth on the second may have an optimal impact on family size if it follows a singleton). Although not necessary to construct the same sex IV, it is applied nonetheless in order to achieve identical samples (facilitating comparisons). In any event, the restriction is not very binding since almost all births (including first ones) are singletons. No restrictions are imposed in terms of work patterns (paid or unpaid). In other words, non-participants are included throughout the study. This avoids endogenous selection of any sub-group based on work patterns. For example, an increase in the number of children may encourage some mothers to stop working in a paid job in order to stay home.

As in Chapter 2, focusing on families with at least two births means that the child effect is mainly the result of differences observed between the second and the third child (or between the third and fourth, etc.) We cannot draw any conclusions about the effect of the first or second child, which may be more policy relevant. It is possible that the first child has the largest impact on parental labour supply since a parent may already be home when additional children are born (and thus, not further reducing paid labour supply). On the other hand, if parents have little flexibility in choosing their hours of paid work, and must decide between paid work or staying home to take care of their children, then it is conceivable that their exists for each family a specific number of children that represents the breaking point between working outside of the home (and paying for childcare) or staying at home (and saving on childcare costs). In other words, it is not clear a priori how the effect varies by the number of children (including smaller family sizes). Although the literature has not yet developed an appropriate strategy for identifying the effect of first or second children, I will show descriptive evidence on the relationship between number of children and parental labour supply for smaller families (i.e. those with zero or one child).

To examine the impact of the sample selection criteria, I show the mean and standard error of each of the variables used in the analysis by sample selection criterion (Table 3.1). By dropping couples with only one birth, which is necessary for the multiple birth IV strategy, the sample declines from 514,371 to 332,011. Although most variables maintain their mean values, there are some expected changes. For example, work patterns are somewhat different: couples with at least two births generally work more, both at home and in market work. This is true for the mother and the father. Obviously, the average number of children increases, from 1.894 to 2.375. As suggested by Rosenzweig and Wolpin (1980a), multiple births are more likely among couples with more than one birth. Finally, couples with at least two births are slightly older than those with only one birth, again for obvious reasons. The other sample statistics do not change in any meaningful way as a result of this selection criterion.

Table 3.1: Means and standard deviations of variables used in the analysis by sample selection criteria

	Initial sample of married or common-law couples with at least one child		Drop if only one birth		Drop if first birth is a multiple	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
Mother's hours per week of paid work	23.081	0.027	22.999	0.034	23.008	0.034
Mother's hours per week of childcare	36.168	0.031	37.195	0.037	37.183	0.037
Mother's hours per week of housework	25.721	0.026	27.580	0.033	27.559	0.033
Father's hours per week of paid work	40.234	0.027	41.171	0.034	41.172	0.034
Father's hours per week of childcare	21.696	0.028	22.221	0.034	22.216	0.034
Father's hours per week of housework	13.461	0.018	13.963	0.023	13.958	0.023
Number of children	1.894	0.001	2.375	0.001	2.371	0.001
Same sex	0.496	0.001	0.494	0.001	0.493	0.001
Multiple birth	0.010	0.000	0.015	0.000	0.015	0.000
Mother's age	37.154	0.010	37.447	0.011	37.444	0.011
Father's age	39.834	0.011	40.086	0.012	40.083	0.012
Mother has less than a high school diploma	0.102	0.000	0.101	0.001	0.101	0.001
Mother has a high school diploma	0.232	0.001	0.235	0.001	0.235	0.001
Mother has a college certificate	0.392	0.001	0.396	0.001	0.396	0.001
Mother has a bachelor's degree	0.215	0.001	0.214	0.001	0.214	0.001
Mother has a professional degree	0.046	0.000	0.042	0.000	0.041	0.000
Mother has a master's degree	0.008	0.000	0.008	0.000	0.008	0.000
Mother has an earned doctorate	0.006	0.000	0.005	0.000	0.005	0.000
Father has less than a high school diploma	0.130	0.000	0.126	0.001	0.126	0.001
Father has a high school diploma	0.214	0.001	0.213	0.001	0.213	0.001
Father has a college certificate	0.394	0.001	0.400	0.001	0.400	0.001
Father has a bachelor's degree	0.183	0.001	0.183	0.001	0.183	0.001
Father has a professional degree	0.057	0.000	0.055	0.000	0.055	0.000
Father has a master's degree	0.009	0.000	0.010	0.000	0.010	0.000
Father has an earned doctorate	0.013	0.000	0.012	0.000	0.012	0.000
Mother is white	0.773	0.001	0.779	0.001	0.779	0.001
Mother is black	0.018	0.000	0.019	0.000	0.019	0.000
Mother is Asian	0.144	0.000	0.136	0.001	0.136	0.001
Mother is Arab	0.012	0.000	0.013	0.000	0.013	0.000
Mother is Latino	0.012	0.000	0.012	0.000	0.012	0.000
Mother is Aboriginal	0.034	0.000	0.035	0.000	0.035	0.000
Mother is other non-white	0.006	0.000	0.006	0.000	0.006	0.000
Father is white	0.779	0.001	0.783	0.001	0.782	0.001
Father is black	0.021	0.000	0.022	0.000	0.022	0.000
Father is Asian	0.137	0.000	0.131	0.001	0.131	0.001
Father is Arab	0.013	0.000	0.014	0.000	0.014	0.000
Father is Latino	0.011	0.000	0.011	0.000	0.011	0.000
Father is Aboriginal	0.032	0.000	0.033	0.000	0.033	0.000
Father is other non-white	0.006	0.000	0.006	0.000	0.006	0.000
Local unemployment rate (women, 25 to 54)	0.056	0.000	0.055	0.000	0.055	0.000
Local unemployment rate (men, 25 to 54)	0.052	0.000	0.051	0.000	0.051	0.000
N	514,371		332,011		330,269	

Notes: In the sample of married or common-law couples with at least one child, only 336,434 have two or more children. Forcibly, the same sex dummy variable is only based on these cases.
Source: Census of Population, 2006.

The second measure taken is to drop couples where the first birth is a multiple. In this case, the sample loss is minimal, going from 332,011 to 330,269. Moreover, the sample statistics are stable for each variable.

3.4 Descriptive results

The empirical analysis begins with descriptive evidence. In Table 3.2, I show parental work measures by the number of children. Although the main sample from now on will be couples with at least two children, I include couples with one child in this table since no identification strategy is applied yet. In general, the mother's paid work declines by about three or four hours per week on average with each additional child. Interestingly, this is only true after the second child. There is very little difference in paid hours between the first and second child. However, her unpaid childcare and housework rises by a larger total amount. In contrast, the father's paid work hours remains stable between two and four children, but declines afterwards. The father's unpaid hours of childcare and housework rise with each additional child. In other words, the paid work hours of the father appears more resilient, only declining in very large families (five or more children). This is despite the fact that unpaid paternal work hours rise between families with two and four children. However, it is always the case that additional children result in more total work hours for the mother than the father.

Table 3.2: Means of outcome variables by the number of children

	Number of children					
	1	2	3	4	5	6 or more
Mother's hours per week of paid work	23.229	24.272	20.974	17.063	12.834	10.344
Mother's hours per week of childcare	34.229	35.808	39.584	43.630	45.522	47.785
Mother's hours per week of housework	22.271	25.850	30.532	35.326	38.630	42.400
Father's hours per week of paid work	38.498	41.026	41.868	41.228	37.993	36.331
Father's hours per week of childcare	20.675	21.913	22.675	23.625	24.904	26.412
Father's hours per week of housework	12.517	13.599	14.471	15.651	17.273	19.945
N	177,937	231,306	74,793	17,554	4,287	2,329

Note: The sample consists of married or common-law couples with at least one birth, and the first is a singleton.
Source: Census of Population, 2006.

Although the results in Table 3.2 are interesting and generally in agreement with the predictions of the unified theories of Becker (1985) and Lundberg and Rose (1999), the magnitude of the differences may be difficult to interpret. The reason is that family size is largely a choice, and may thus be endogenous to the couples' work preferences.

To begin addressing this identification issue, I recalculate the mean parental work patterns along two dimensions of exogenous variation in family size below in Table 3.3 for couples with at least two births. Among couples who had two same sex singleton children on the first two births, the mother spends 0.413 fewer hours per week in paid work, 0.476 additional hours per week doing unpaid childcare, and 0.335 additional hours per week doing unpaid housework. For the father, the response is far smaller: we see virtually no change in paid work hours, a moderate increase in unpaid childcare, and a slight increase in unpaid housework.

Table 3.3: Means of outcome variables by instrumental variable value

	Same sex		
	0	1	Δ
Mother's hours per week of paid work	23.212	22.799	-0.413
Mother's hours per week of childcare	36.949	37.425	0.476
Mother's hours per week of housework	27.394	27.729	0.335
Father's hours per week of paid work	41.215	41.129	-0.086
Father's hours per week of childcare	22.111	22.325	0.215
Father's hours per week of housework	13.923	13.995	0.072
N	164,636	165,633	
	Multiple birth		
	0	1	Δ
Mother's hours per week of paid work	23.057	19.820	-3.237
Mother's hours per week of childcare	37.122	41.149	4.026
Mother's hours per week of housework	27.497	31.599	4.103
Father's hours per week of paid work	41.165	41.653	0.488
Father's hours per week of childcare	22.189	23.993	1.804
Father's hours per week of housework	13.941	15.058	1.117
N	325,090	5,179	

Note: The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Breaking the numbers down by the incidence of a multiple birth on the second or later (and last) birth in Table 3.3, we see similar patterns in a qualitative sense, but the magnitude of the differences are much larger. Why might this be the case? The reason is demonstrated below in Table 3.4, where the child generating properties of each IV is shown. In short, a multiple birth is associated with substantially more additional children than having same sex children on the first two births (1.113 versus 0.073).

Table 3.4: Mean number of children by instrumental variable value

	0	1	Δ
Same sex	2.335	2.408	0.073
Multiple birth	2.354	3.486	1.133
N - same sex	164,636	165,633	
N - multiple birth	325,090	5,179	

Note: The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

The fact that there is a such a large difference in the child generating properties between the IVs suggest that the numbers in Table 3.3 should be adjusted to account for this if one wants to gauge the impact of additional children on work patterns. This is precisely what the Wald estimate does.

The Wald estimates appear below in Table 3.5. In this case, the impact of an additional child on parental work patterns is actually greater when using the same sex IV. Angrist and Evans (1998) hypothesize that this is likely because a third child born as a twin in a second birth is older (and thus requires less maternal attention) than a third child generated from the sex composition of the first two children, conditional on the second child having the same age in both cases. Earlier, I noted two other possibilities. First, there may be economies of scale in rearing twins as opposed to singletons. Siblings of the exact same age may be more likely to participate in similar extracurricular activities, which may reduce demands on the mother's time, allowing her to spend more time performing market work. Second, there is a difference in the quality of the instruments themselves that may yield different estimates. Nevertheless, both sets of results tell the same story. Specifically, additional children are negatively related to the mother's paid work hours, but positively related to her unpaid hours of childcare and housework. In contrast, there is no clear effect on the father's paid work patterns, and only a slight to moderate positive impact on housework and childcare, the latter not being statistically significant in the case of the multiple birth IV.

Table 3.5: Wald estimates

	Same sex					
	0		1			
	Mean	s.e.	Mean	s.e.	Wald	s.e.
Mother's hours per week of paid work	23.212	0.048	22.799	0.048	-5.680 ***	0.060
Mother's hours per week of childcare	36.949	0.053	37.425	0.053	6.548 ***	0.066
Mother's hours per week of housework	27.394	0.046	27.729	0.046	4.604 ***	0.058
Father's hours per week of paid work	41.215	0.048	41.129	0.048	-1.180 ***	0.060
Father's hours per week of childcare	22.111	0.049	22.325	0.049	2.952 ***	0.061
Father's hours per week of housework	13.923	0.033	13.995	0.033	0.993 ***	0.041
Average number of children	2.335		2.408			
N	164,636		165,633			
	Multiple birth					
	0		1			
	Mean	s.e.	Mean	s.e.	Wald	s.e.
Mother's hours per week of paid work	23.057	0.034	19.820	0.266	-2.858 ***	0.236
Mother's hours per week of childcare	37.122	0.038	41.149	0.288	3.555 ***	0.257
Mother's hours per week of housework	27.497	0.033	31.599	0.270	3.622 ***	0.240
Father's hours per week of paid work	41.165	0.034	41.653	0.278	0.431	0.247
Father's hours per week of childcare	22.189	0.035	23.993	0.280	1.593 **	0.249
Father's hours per week of housework	13.941	0.024	15.058	0.199	0.986 **	0.177
Average number of children	2.354		3.486			
N	325,090		5,179			

Notes: Statistical significance for the Wald estimate is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Although the estimates in Table 3.5 are based on exogenous sources of variation, no IV is perfect. There may be residual differences in characteristics that should be taken into account. To demonstrate this, I show differences in observable characteristics by the IV values in Tables 3.6 and 3.7 below. Beginning with Table 3.6, which is broken down by value of the same sex IV, it is evident that there are some small, but statistically significant differences in maternal and paternal education. Since education is an important determinant of labour supply, it is important to account for these differences in the econometric models that follow.

Table 3.6: Means of explanatory variables by sex composition of first two children

	Same sex = 0 Mean	Same sex = 1 Mean	Δ		s.e.
Mother's age	37.445	37.443	-0.002		0.021
Father's age	40.085	40.081	-0.004		0.024
Mother has less than a high school diploma	0.101	0.102	0.001		0.001
Mother has a high school diploma	0.234	0.237	0.003	**	0.001
Mother has a college certificate	0.396	0.396	0.000		0.002
Mother has a bachelor's degree	0.216	0.211	-0.004	***	0.001
Mother has a professional degree	0.041	0.042	0.001		0.001
Mother has a master's degree	0.008	0.007	-0.001	***	0.000
Mother has an earned doctorate	0.005	0.005	0.000		0.000
Father has less than a high school diploma	0.126	0.125	-0.001		0.001
Father has a high school diploma	0.212	0.215	0.003	*	0.001
Father has a college certificate	0.400	0.401	0.001		0.002
Father has a bachelor's degree	0.185	0.182	-0.003	**	0.001
Father has a professional degree	0.055	0.054	-0.001		0.001
Father has a master's degree	0.010	0.011	0.001	*	0.000
Father has an earned doctorate	0.012	0.013	0.000		0.000
Mother is white	0.779	0.779	0.000		0.001
Mother is black	0.019	0.019	0.000		0.000
Mother is Asian	0.137	0.136	-0.001		0.001
Mother is Arab	0.013	0.013	0.000		0.000
Mother is Latino	0.012	0.012	0.000		0.000
Mother is Aboriginal	0.035	0.035	0.001		0.001
Mother is other non-white	0.006	0.006	0.000		0.000
Father is white	0.782	0.782	0.000		0.001
Father is black	0.022	0.022	0.000		0.001
Father is Asian	0.132	0.131	-0.001		0.001
Father is Arab	0.014	0.014	0.001		0.000
Father is Latino	0.011	0.011	0.000		0.000
Father is Aboriginal	0.033	0.033	0.000		0.001
Father is other non-white	0.006	0.006	0.000		0.000
Local unemployment rate (women, 25 to 54)	0.055	0.055	0.000		0.000
Local unemployment rate (men, 25 to 54)	0.051	0.051	0.000		0.000
N	164,636	165,633			

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

The exercise is repeated in Table 3.7, except along the multiple birth IV dimension this time. In this case, there are some significant differences in parental education, but also some differences in parental ethnicity. As noted by Cáceras-Delpiano (2006), the incidence of monozygotic twins (identical twins, who share the same, but divided embryo) is equal in all races, age groups, and countries. However, the incidence of dizygotic twins (two separate fertilized embryos) depends on various factors, including ethnicity. In Table 3.7, the incidence of a multiple birth is more likely among blacks and whites, and less likely among Asians. Again, if these factors are independent determinants of labour supply preferences, it is important to account for the differences in the models to follow.

Table 3.7: Means of explanatory variables by presence of a multiple birth on the second or later birth

	Mutiple birth = 0	Multiple birth = 1			
	Mean	Mean	Δ		s.e.
Mother's age	37.443	37.528	0.085		0.081
Father's age	40.084	40.048	-0.035		0.093
Mother has less than a high school diploma	0.101	0.099	-0.002		0.004
Mother has a high school diploma	0.235	0.237	0.001		0.006
Mother has a college certificate	0.396	0.385	-0.011		0.007
Mother has a bachelor's degree	0.213	0.223	0.010	*	0.006
Mother has a professional degree	0.041	0.041	0.000		0.003
Mother has a master's degree	0.008	0.008	0.000		0.001
Mother has an earned doctorate	0.005	0.006	0.001		0.001
Father has less than a high school diploma	0.126	0.131	0.006		0.005
Father has a high school diploma	0.213	0.211	-0.002		0.006
Father has a college certificate	0.400	0.398	-0.002		0.007
Father has a bachelor's degree	0.183	0.180	-0.003		0.005
Father has a professional degree	0.055	0.058	0.003		0.003
Father has a master's degree	0.010	0.012	0.002		0.002
Father has an earned doctorate	0.012	0.009	-0.003	***	0.001
Mother is white	0.779	0.809	0.031	***	0.006
Mother is black	0.019	0.023	0.004	*	0.002
Mother is Asian	0.137	0.097	-0.040	***	0.004
Mother is Arab	0.013	0.015	0.003		0.002
Mother is Latino	0.012	0.012	0.000		0.002
Mother is Aboriginal	0.035	0.038	0.003		0.003
Mother is other non-white	0.006	0.006	0.000		0.001
Father is white	0.782	0.806	0.024	***	0.006
Father is black	0.022	0.023	0.001		0.002
Father is Asian	0.132	0.095	-0.036	***	0.004
Father is Arab	0.014	0.016	0.002		0.002
Father is Latino	0.011	0.014	0.003		0.002
Father is Aboriginal	0.033	0.039	0.006	**	0.003
Father is other non-white	0.006	0.005	-0.001		0.001
Local unemployment rate (women, 25 to 54)	0.055	0.054	-0.001		0.001
Local unemployment rate (men, 25 to 54)	0.051	0.051	0.000		0.001
N	325,090	5,179			

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

3.5 Econometric results

OLS approach

I begin the econometric section as I did the descriptive section, by presenting non-causal evidence. In Tables 3.8 and 3.9, I show OLS regression results, where the dependent variables are the hours per week spent in various activities. The key independent variable is the number of children (not drawn from an exogenous source of variation). The other covariates are the ones described above: parental age, highest level of education, ethnicity, and local unemployment rates.

In Table 3.8, the results for the mother are shown. The number of children has the expected impact on work patterns: negative with respect to paid work (-3.118 hours per week), positive with respect to childcare (3.332 hours per week) and housework (4.241 hours per week).

Table 3.8: OLS regressions of maternal work hours on the number of children and other controls

	Hours per week of paid work			Hours per week of childcare			Hours per week of housework		
	b		s.e.	b		s.e.	b		s.e.
Number of children	-3.118	***	0.056	3.332	***	0.059	4.241	***	0.057
Mother's age	2.345	***	0.063	-0.500	***	0.071	-0.825	***	0.063
Mother's age^2	-0.025	***	0.001	-0.004	***	0.001	0.009	***	0.001
Father's age	0.633	***	0.042	-1.099	***	0.048	-0.333	***	0.042
Father's age^2	-0.006	***	0.000	0.009	***	0.001	0.003	***	0.000
Mother has a high school diploma	3.313	***	0.156	0.897	***	0.166	-0.656	***	0.155
Mother has a college certificate	5.865	***	0.150	0.970	***	0.159	-2.171	***	0.149
Mother has a bachelor's degree	6.940	***	0.169	2.182	***	0.179	-3.707	***	0.166
Mother has a professional degree	8.586	***	0.244	1.520	***	0.255	-5.256	***	0.230
Mother has a master's degree	14.140	***	0.491	-1.292	***	0.484	-8.148	***	0.435
Mother has an earned doctorate	13.174	***	0.588	-0.037		0.576	-8.676	***	0.471
Father has a high school diploma	0.070		0.145	0.611	***	0.154	-0.631	***	0.142
Father has a college certificate	-1.314	***	0.134	1.157	***	0.142	0.175		0.132
Father has a bachelor's degree	-4.644	***	0.159	1.280	***	0.169	0.207		0.156
Father has a professional degree	-6.761	***	0.213	1.078	***	0.226	1.211	***	0.207
Father has a master's degree	-8.332	***	0.365	4.019	***	0.422	3.708	***	0.391
Father has an earned doctorate	-7.823	***	0.375	2.020	***	0.396	2.458	***	0.363
Mother is black	-1.287	***	0.448	-4.504	***	0.473	-1.379	***	0.438
Mother is Asian	-1.255	***	0.272	-3.314	***	0.276	-0.213		0.255
Mother is Arab	-3.843	***	0.728	-5.198	***	0.749	-0.709		0.690
Mother is Latino	-4.120	***	0.505	-3.488	***	0.533	0.303		0.499
Mother is Aboriginal	0.240		0.251	1.014	***	0.263	0.686	***	0.251
Mother is other non-white	0.211		0.653	-3.019	***	0.670	0.273		0.632
Father is black	1.424	***	0.417	-1.161	***	0.429	-0.998	**	0.406
Father is Asian	-1.107	***	0.275	-3.558	***	0.281	-0.346		0.260
Father is Arab	-3.949	***	0.693	0.740		0.710	0.791		0.656
Father is Latino	0.410		0.522	-2.966	***	0.545	-2.086	***	0.510
Father is Aboriginal	0.436	*	0.251	0.762	***	0.267	0.461	*	0.250
Father is other non-white	-0.055		0.636	-2.229	***	0.679	0.103		0.641
Local unemployment rate (women, 25 to 54)	-26.135	***	1.542	16.069	***	1.629	16.505	***	1.542
Local unemployment rate (men, 25 to 54)	4.382	***	1.160	-11.631	***	1.237	-8.244	***	1.167
Intercept	-37.669	***	1.026	81.449	***	1.175	45.089	***	1.072
Adjusted R^2	0.079			0.129			0.041		
N	330,269			330,269			330,269		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

In terms of the other covariates, older mothers are more likely to work outside of the home. Also, the mothers' education is positively linked with her paid work hours and negatively linked to her unpaid housework; however, the link with childcare is less clear, although slightly positive if anything. So, for a given number of children, mothers with more education choose more paid work at the expense of housework, not childcare. The relationship is much less clear between the mother's work patterns and her husband's education. The link between the mother's paid work and the father's education is negative for most of the education spectrum, but not unilaterally so. Most groups of non-whites spend less time doing paid work (e.g. blacks, Asians, Arabs, and Latinos), but this might relate to the difficulties they face in finding employment in the labour market. Finally, the effect of the local unemployment rate faced by mothers on paud hours is negative, as expected.

In Table 3.9, the exercise is repeated for the father's work patterns. In this case, work hours in all three activities increase in response to additional children. However, the magnitude of the effect is quite small: always less than one additional hour per week for every additional child. The effect was much larger for the mother in Table 3.8. In terms of the other covariate effects, the relationship between the father's education and his paid work hours is positive, albeit smaller than the one for mothers. In terms of ethnicity, all non-white groups work fewer paid hours than whites. Finally, the unemployment rate faced by fathers has a negative effect on paid work hours, as it did in the case of mothers, except that the effect is now about twice as large.

Table 3.9: OLS regressions of paternal work hours on the number of children and other controls

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Number of children	0.439 ***	0.063	0.655 ***	0.059	0.953 ***	0.045
Mother's age	0.953 ***	0.070	0.061	0.067	-0.052	0.047
Mother's age^2	-0.012 ***	0.001	-0.006 ***	0.001	0.001	0.001
Father's age	0.385 ***	0.055	-0.463 ***	0.045	0.036	0.031
Father's age^2	-0.007 ***	0.001	0.004 ***	0.001	0.000	0.000
Mother has a high school diploma	2.024 ***	0.172	0.565 ***	0.160	-0.032	0.114
Mother has a college certificate	1.989 ***	0.166	1.878 ***	0.154	0.455 ***	0.110
Mother has a bachelor's degree	1.657 ***	0.181	3.599 ***	0.172	0.678 ***	0.121
Mother has a professional degree	1.020 ***	0.242	4.257 ***	0.238	1.333 ***	0.165
Mother has a master's degree	-1.344 ***	0.486	6.255 ***	0.454	2.964 ***	0.331
Mother has an earned doctorate	-0.851	0.529	6.636 ***	0.529	2.149 ***	0.359
Father has a high school diploma	2.462 ***	0.163	0.987 ***	0.152	-0.029	0.108
Father has a college certificate	2.437 ***	0.153	0.614 ***	0.141	0.006	0.100
Father has a bachelor's degree	2.263 ***	0.170	-0.198	0.162	-1.371 ***	0.113
Father has a professional degree	2.637 ***	0.214	-1.925 ***	0.204	-2.139 ***	0.142
Father has a master's degree	8.757 ***	0.418	-3.761 ***	0.355	-4.215 ***	0.233
Father has an earned doctorate	3.902 ***	0.362	-2.354 ***	0.331	-2.717 ***	0.224
Mother is black	-2.482 ***	0.448	-2.346 ***	0.465	-0.251	0.320
Mother is Asian	-2.738 ***	0.266	-1.386 ***	0.263	0.815 ***	0.188
Mother is Arab	-5.340 ***	0.765	-3.049 ***	0.712	-0.287	0.440
Mother is Latino	-1.925 ***	0.491	-3.328 ***	0.486	-0.978 ***	0.346
Mother is Aboriginal	-1.636 ***	0.285	3.249 ***	0.279	2.989 ***	0.203
Mother is other non-white	-0.913	0.595	-2.137 ***	0.635	0.446	0.471
Father is black	-3.924 ***	0.420	-0.013	0.435	-0.250	0.296
Father is Asian	-1.731 ***	0.268	-4.075 ***	0.267	-0.915 ***	0.191
Father is Arab	-3.123 ***	0.728	-2.899 ***	0.686	-2.706 ***	0.407
Father is Latino	-4.344 ***	0.530	-1.467 ***	0.508	-0.498	0.364
Father is Aboriginal	-3.819 ***	0.293	4.256 ***	0.285	2.072 ***	0.199
Father is other non-white	-2.814 ***	0.586	-0.974	0.649	-0.159	0.470
Local unemployment rate (women, 25 to 54)	-4.470 **	1.984	3.597 **	1.661	2.517 **	1.206
Local unemployment rate (men, 25 to 54)	-55.782 ***	1.445	12.161 ***	1.260	13.809 ***	0.952
Intercept	16.840 ***	1.170	37.026 ***	1.166	10.386 ***	0.798
Adjusted R^2	0.049		0.051		0.016	
N	330,269		330,269		330,269	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

IV approach

We now turn to the causal portion of the econometric results, namely the IV regression results. In Table 3.10, I show results from the first-stage regressions of the number of children on the instruments, plus the other covariates. The coefficients on the IVs confirm the descriptive findings from Table 3.4. Specifically, the same sex IV is associated with 0.072 additional children, while the multiple birth IV is associated with 1.124 additional children. Both coefficients are significant at 1% and pass all thresholds for a strong IV, suggested by the F-statistic (squared value of the t-statistic), as noted in Stock and Yogo (2005). In most instances, an F-statistic of 16 is sufficient. The F-statistics reported in Table 3.10 are much larger: 717 and 7,323.

Table 3.10: First-stage regression of the number of children on the instrumental variables and other controls

	Same sex instrument			Multiple birth instrument		
	b		s.e.	b		s.e.
Same sex/Multiple birth	0.072	***	0.003	1.124	***	0.013
Mother's age	0.069	***	0.002	0.067	***	0.002
Mother's age^2	-0.001	***	0.000	-0.001	***	0.000
Father's age	0.015	***	0.002	0.015	***	0.002
Father's age^2	0.000	***	0.000	0.000	***	0.000
Mother has a high school diploma	-0.151	***	0.006	-0.151	***	0.006
Mother has a college certificate	-0.209	***	0.006	-0.208	***	0.006
Mother has a bachelor's degree	-0.237	***	0.007	-0.238	***	0.007
Mother has a professional degree	-0.274	***	0.009	-0.274	***	0.008
Mother has a master's degree	-0.212	***	0.017	-0.216	***	0.017
Mother has an earned doctorate	-0.310	***	0.018	-0.315	***	0.016
Father has a high school diploma	-0.047	***	0.005	-0.045	***	0.005
Father has a college certificate	-0.052	***	0.005	-0.051	***	0.005
Father has a bachelor's degree	-0.021	***	0.006	-0.019	***	0.006
Father has a professional degree	0.005		0.008	0.005		0.008
Father has a master's degree	0.110	***	0.016	0.111	***	0.015
Father has an earned doctorate	0.000		0.013	0.007		0.013
Mother is black	0.177	***	0.018	0.171	***	0.018
Mother is Asian	-0.045	***	0.008	-0.040	***	0.008
Mother is Arab	0.135	***	0.026	0.129	***	0.026
Mother is Latino	-0.027		0.017	-0.021		0.017
Mother is Aboriginal	0.220	***	0.010	0.221	***	0.010
Mother is other non-white	-0.006		0.023	-0.005		0.022
Father is black	0.144	***	0.016	0.147	***	0.015
Father is Asian	0.007		0.009	0.008		0.008
Father is Arab	0.141	***	0.024	0.144	***	0.024
Father is Latino	0.091	***	0.019	0.083	***	0.018
Father is Aboriginal	0.236	***	0.010	0.233	***	0.010
Father is other non-white	0.058	**	0.024	0.060	**	0.023
Local unemployment rate (women, 25 to 54)	-0.168	***	0.056	-0.159	***	0.055
Local unemployment rate (men, 25 to 54)	0.093	**	0.042	0.093	**	0.041
Intercept	0.975	***	0.037	1.028	***	0.036
F-statistic	717.404			7,322.557		
Adjusted R^2	0.040			0.077		
N	330,269			330,269		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

In Tables 3.11 to 3.14, I show the coefficients from the second stage of the IV regressions. These are considered the preferred results since they are based on somewhat exogenous sources of variation and they take into account differences in observable characteristics that remain. Given the large volume of coefficients from various tables, I summarize the key results in Table 3.15, which shows only the coefficients related to the number of children variable.

Table 3.11: IV regressions of maternal work hours on the number of children and other controls - same sex IV

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Number of children	-5.397 ***	1.044	6.456 ***	1.119	4.317 ***	1.015
Mother's age	2.503 ***	0.096	-0.717 ***	0.105	-0.831 ***	0.094
Mother's age^2	-0.028 ***	0.001	-0.001	0.001	0.009 ***	0.001
Father's age	0.668 ***	0.045	-1.146 ***	0.052	-0.334 ***	0.044
Father's age^2	-0.006 ***	0.000	0.009 ***	0.001	0.003 ***	0.000
Mother has a high school diploma	2.969 ***	0.221	1.369 ***	0.237	-0.645 ***	0.217
Mother has a college certificate	5.389 ***	0.264	1.623 ***	0.282	-2.155 ***	0.258
Mother has a bachelor's degree	6.399 ***	0.300	2.924 ***	0.319	-3.689 ***	0.291
Mother has a professional degree	7.963 ***	0.377	2.375 ***	0.398	-5.236 ***	0.360
Mother has a master's degree	13.650 ***	0.542	-0.619	0.542	-8.131 ***	0.486
Mother has an earned doctorate	12.469 ***	0.672	0.930	0.672	-8.652 ***	0.566
Father has a high school diploma	-0.035	0.154	0.755 ***	0.164	-0.628 ***	0.150
Father has a college certificate	-1.433 ***	0.145	1.320 ***	0.155	0.179	0.143
Father has a bachelor's degree	-4.691 ***	0.161	1.343 ***	0.172	0.208	0.157
Father has a professional degree	-6.750 ***	0.214	1.063 ***	0.228	1.210 ***	0.207
Father has a master's degree	-8.076 ***	0.387	3.668 ***	0.444	3.700 ***	0.407
Father has an earned doctorate	-7.821 ***	0.377	2.016 ***	0.398	2.458 ***	0.363
Mother is black	-0.884 *	0.485	-5.056 ***	0.517	-1.392 ***	0.474
Mother is Asian	-1.358 ***	0.277	-3.173 ***	0.283	-0.210	0.259
Mother is Arab	-3.537 ***	0.736	-5.618 ***	0.767	-0.719	0.704
Mother is Latino	-4.182 ***	0.507	-3.403 ***	0.536	0.305	0.500
Mother is Aboriginal	0.742 **	0.343	0.325	0.362	0.669 **	0.336
Mother is other non-white	0.199	0.659	-3.002 ***	0.674	0.273	0.632
Father is black	1.753 ***	0.444	-1.612 ***	0.463	-1.009 **	0.431
Father is Asian	-1.091 ***	0.277	-3.579 ***	0.284	-0.347	0.260
Father is Arab	-3.624 ***	0.702	0.295	0.728	0.780	0.671
Father is Latino	0.618	0.532	-3.251 ***	0.557	-2.093 ***	0.518
Father is Aboriginal	0.974 ***	0.353	0.024	0.378	0.443	0.346
Father is other non-white	0.077	0.643	-2.410 ***	0.688	0.099	0.644
Local unemployment rate (women, 25 to 54)	-26.520 ***	1.557	16.596 ***	1.654	16.517 ***	1.552
Local unemployment rate (men, 25 to 54)	4.595 ***	1.168	-11.923 ***	1.256	-8.251 ***	1.171
Intercept	-35.362 ***	1.476	78.286 ***	1.619	45.012 ***	1.486
F-statistic	26.711		33.280		18.077	
Adjusted R^2	0.073		0.119		0.041	
N	330,269		330,269		330,269	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Table 3.12: IV regressions of paternal work hours on the number of children and other controls - same sex IV

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Number of children	-1.154	1.053	3.008 ***	1.066	0.984	0.734
Mother's age	1.063 ***	0.101	-0.102	0.099	-0.054	0.069
Mother's age^2	-0.013 ***	0.001	-0.003 **	0.001	0.001	0.001
Father's age	0.409 ***	0.058	-0.498 ***	0.048	0.035	0.033
Father's age^2	-0.007 ***	0.001	0.004 ***	0.001	0.000	0.000
Mother has a high school diploma	1.784 ***	0.232	0.920 ***	0.227	-0.027	0.160
Mother has a college certificate	1.657 ***	0.274	2.370 ***	0.271	0.461 **	0.189
Mother has a bachelor's degree	1.279 ***	0.307	4.157 ***	0.306	0.685 ***	0.212
Mother has a professional degree	0.584	0.375	4.900 ***	0.376	1.341 ***	0.261
Mother has a master's degree	-1.687 ***	0.536	6.761 ***	0.509	2.971 ***	0.366
Mother has an earned doctorate	-1.343 **	0.621	7.364 ***	0.625	2.159 ***	0.426
Father has a high school diploma	2.388 ***	0.171	1.096 ***	0.160	-0.028	0.113
Father has a college certificate	2.355 ***	0.163	0.736 ***	0.152	0.007	0.107
Father has a bachelor's degree	2.230 ***	0.172	-0.150	0.164	-1.370 ***	0.114
Father has a professional degree	2.645 ***	0.214	-1.936 ***	0.205	-2.140 ***	0.142
Father has a master's degree	8.936 ***	0.434	-4.025 ***	0.377	-4.219 ***	0.246
Father has an earned doctorate	3.904 ***	0.363	-2.356 ***	0.331	-2.717 ***	0.224
Mother is black	-2.201 ***	0.484	-2.762 ***	0.504	-0.257	0.345
Mother is Asian	-2.810 ***	0.270	-1.280 ***	0.268	0.816 ***	0.191
Mother is Arab	-5.126 ***	0.774	-3.365 ***	0.727	-0.291	0.451
Mother is Latino	-1.968 ***	0.492	-3.263 ***	0.488	-0.977 ***	0.346
Mother is Aboriginal	-1.285 ***	0.369	2.730 ***	0.365	2.982 ***	0.261
Mother is other non-white	-0.921	0.593	-2.124 ***	0.635	0.446	0.471
Father is black	-3.694 ***	0.447	-0.353	0.465	-0.255	0.314
Father is Asian	-1.719 ***	0.269	-4.091 ***	0.268	-0.916 ***	0.191
Father is Arab	-2.896 ***	0.740	-3.234 ***	0.701	-2.710 ***	0.420
Father is Latino	-4.199 ***	0.537	-1.682 ***	0.517	-0.501	0.370
Father is Aboriginal	-3.443 ***	0.385	3.700 ***	0.382	2.064 ***	0.263
Father is other non-white	-2.722 ***	0.585	-1.111 *	0.651	-0.161	0.471
Local unemployment rate (women, 25 to 54)	-4.739 **	1.996	3.994 **	1.674	2.522 **	1.212
Local unemployment rate (men, 25 to 54)	-55.633 ***	1.450	11.941 ***	1.267	13.806 ***	0.954
Intercept	18.452 ***	1.574	34.646 ***	1.584	10.355 ***	1.090
F-statistic	1.200		7.957		1.799	
Adjusted R^2	0.046		0.045		0.016	
N	330,269		330,269		330,269	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Table 3.13: IV regressions of maternal work hours on the number of children and other controls - multiple birth IV

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Number of children	-3.099 ***	0.266	3.402 ***	0.291	3.682 ***	0.278
Mother's age	2.344 ***	0.065	-0.505 ***	0.073	-0.786 ***	0.065
Mother's age^2	-0.025 ***	0.001	-0.004 ***	0.001	0.009 ***	0.001
Father's age	0.633 ***	0.043	-1.100 ***	0.048	-0.324 ***	0.042
Father's age^2	-0.006 ***	0.000	0.009 ***	0.001	0.003 ***	0.000
Mother has a high school diploma	3.316 ***	0.161	0.908 ***	0.171	-0.741 ***	0.161
Mother has a college certificate	5.869 ***	0.159	0.985 ***	0.170	-2.288 ***	0.159
Mother has a bachelor's degree	6.945 ***	0.181	2.199 ***	0.192	-3.840 ***	0.179
Mother has a professional degree	8.591 ***	0.255	1.539 ***	0.267	-5.409 ***	0.242
Mother has a master's degree	14.144 ***	0.494	-1.277 ***	0.488	-8.268 ***	0.439
Mother has an earned doctorate	13.180 ***	0.594	-0.015	0.583	-8.849 ***	0.479
Father has a high school diploma	0.071	0.145	0.614 ***	0.155	-0.657 ***	0.143
Father has a college certificate	-1.313 ***	0.135	1.161 ***	0.143	0.146	0.133
Father has a bachelor's degree	-4.644 ***	0.159	1.281 ***	0.169	0.195	0.156
Father has a professional degree	-6.761 ***	0.213	1.078 ***	0.226	1.213 ***	0.207
Father has a master's degree	-8.335 ***	0.366	4.011 ***	0.423	3.771 ***	0.392
Father has an earned doctorate	-7.823 ***	0.375	2.019 ***	0.396	2.458 ***	0.363
Mother is black	-1.290 ***	0.450	-4.516 ***	0.476	-1.280 ***	0.441
Mother is Asian	-1.254 ***	0.272	-3.311 ***	0.276	-0.238	0.256
Mother is Arab	-3.846 ***	0.728	-5.208 ***	0.750	-0.634	0.692
Mother is Latino	-4.120 ***	0.505	-3.486 ***	0.533	0.288	0.499
Mother is Aboriginal	0.236	0.257	0.998 ***	0.270	0.809 ***	0.258
Mother is other non-white	0.212	0.653	-3.018 ***	0.670	0.270	0.631
Father is black	1.422 ***	0.419	-1.171 ***	0.431	-0.917 **	0.408
Father is Asian	-1.107 ***	0.275	-3.558 ***	0.281	-0.342	0.260
Father is Arab	-3.951 ***	0.694	0.730	0.711	0.871	0.658
Father is Latino	0.409	0.522	-2.973 ***	0.546	-2.035 ***	0.510
Father is Aboriginal	0.431 *	0.258	0.745 ***	0.275	0.593 **	0.259
Father is other non-white	-0.056	0.636	-2.233 ***	0.679	0.136	0.641
Local unemployment rate (women, 25 to 54)	-26.132 ***	1.543	16.080 ***	1.630	16.410 ***	1.542
Local unemployment rate (men, 25 to 54)	4.380 ***	1.160	-11.637 ***	1.238	-8.192 ***	1.166
Intercept	-37.688 ***	1.060	81.377 ***	1.213	45.655 ***	1.106
F-statistic	135.512		137.159		175.644	
Adjusted R^2	0.079		0.129		0.041	
N	330,269		330,269		330,269	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Table 3.14: IV regressions of paternal work hours on the number of children and other controls - multiple birth IV

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Number of children	0.292	0.288	1.403 ***	0.292	0.975 ***	0.207
Mother's age	0.963 ***	0.073	0.009	0.070	-0.054	0.049
Mother's age^2	-0.012 ***	0.001	-0.005 ***	0.001	0.001	0.001
Father's age	0.387 ***	0.055	-0.474 ***	0.045	0.035	0.031
Father's age^2	-0.007 ***	0.001	0.004 ***	0.001	0.000	0.000
Mother has a high school diploma	2.002 ***	0.177	0.678 ***	0.166	-0.029	0.118
Mother has a college certificate	1.959 ***	0.175	2.034 ***	0.166	0.459 ***	0.118
Mother has a bachelor's degree	1.622 ***	0.192	3.777 ***	0.185	0.683 ***	0.130
Mother has a professional degree	0.980 ***	0.254	4.461 ***	0.250	1.339 ***	0.174
Mother has a master's degree	-1.376 ***	0.489	6.416 ***	0.458	2.969 ***	0.334
Mother has an earned doctorate	-0.896 *	0.536	6.868 ***	0.536	2.156 ***	0.365
Father has a high school diploma	2.455 ***	0.164	1.022 ***	0.153	-0.028	0.108
Father has a college certificate	2.430 ***	0.154	0.653 ***	0.142	0.007	0.101
Father has a bachelor's degree	2.260 ***	0.170	-0.183	0.162	-1.371 ***	0.113
Father has a professional degree	2.638 ***	0.214	-1.928 ***	0.204	-2.140 ***	0.142
Father has a master's degree	8.774 ***	0.419	-3.845 ***	0.356	-4.218 ***	0.234
Father has an earned doctorate	3.902 ***	0.362	-2.355 ***	0.331	-2.717 ***	0.224
Mother is black	-2.456 ***	0.450	-2.478 ***	0.468	-0.255	0.323
Mother is Asian	-2.745 ***	0.266	-1.352 ***	0.264	0.815 ***	0.188
Mother is Arab	-5.320 ***	0.765	-3.149 ***	0.713	-0.290	0.441
Mother is Latino	-1.929 ***	0.491	-3.307 ***	0.486	-0.977 ***	0.346
Mother is Aboriginal	-1.604 ***	0.292	3.084 ***	0.286	2.984 ***	0.208
Mother is other non-white	-0.914	0.595	-2.133 ***	0.635	0.446	0.471
Father is black	-3.903 ***	0.422	-0.121	0.438	-0.253	0.297
Father is Asian	-1.730 ***	0.268	-4.080 ***	0.267	-0.916 ***	0.191
Father is Arab	-3.102 ***	0.730	-3.005 ***	0.686	-2.709 ***	0.408
Father is Latino	-4.331 ***	0.531	-1.535 ***	0.508	-0.500	0.365
Father is Aboriginal	-3.785 ***	0.301	4.080 ***	0.294	2.067 ***	0.205
Father is other non-white	-2.806 ***	0.586	-1.017	0.648	-0.160	0.470
Local unemployment rate (women, 25 to 54)	-4.495 **	1.985	3.723 **	1.662	2.521 **	1.207
Local unemployment rate (men, 25 to 54)	-55.768 ***	1.445	12.091 ***	1.261	13.807 ***	0.952
Intercept	16.989 ***	1.203	36.270 ***	1.198	10.365 ***	0.822
F-statistic	1.029		23.137		22.246	
Adjusted R^2	0.049		0.050		0.016	
N	330,269		330,269		330,269	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton.
Source: Census of Population, 2006.

Table 3.15: Summary of IV regression results of the effect of the number of children on parental work hours

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework		Total hours per week of paid work, childcare, and
	b	s.e.	b	s.e.	b	s.e.	
Same sex IV							
Mother	-5.397 ***	1.044	6.456 ***	1.119	4.317 ***	1.015	5.376
Father	-1.154	1.053	3.008 ***	1.066	0.984	0.734	2.838
Total	-6.551		9.464		5.301		
Multiple birth IV							
Mother	-3.099 ***	0.266	3.402 ***	0.291	3.682 ***	0.278	3.985
Father	0.292	0.288	1.403 ***	0.292	0.975 ***	0.207	2.669
Total	-2.807		4.805		4.656		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with at least two births, and the first is a singleton. Included in the regressions are controls for each parent's age, education, ethnicity, and the gender specific local unemployment rate they face.
Source: Census of Population, 2006.

The results are entirely in line with Becker's theory of specialization, combined with Lundberg and Rose's theory of home intensity. In response to an additional child, mothers spend less time in paid work (-5.397 for the same sex IV; -3.099 for the multiple birth IV), but more time doing unpaid childcare (6.456; 3.402) and housework (4.317; 3.682). All of these results are statistically significant at 1%.

For the father, the responses are far more moderate. In response to an additional child, fathers spend about the same amount of time in paid work. In fact, the coefficients for either IV strategy are not significant. However, fathers spend more time doing unpaid childcare (3.008 for the same sex IV; 1.403 for the multiple birth IV), which are both significant at 1%. Regarding housework, there is no consistent significant effect.

On balance, mothers respond to an additional child by increasing their total workload by an additional 5.376 (same sex IV) or 3.985 (multiple birth IV) hours per week. The corresponding numbers are smaller for fathers: 2.838 and 2.669.

It is important to compare the size of the IV estimates to those obtained from OLS. The multiple birth IV estimates are very close in magnitude to OLS, while the same sex IV estimates are larger in absolute value. Whether the OLS estimates were biased to begin with is unclear, depending on which set of IV estimates are more credible. Thus, at best, the IV estimates simply confirm the direction of the OLS effects.

3.6 Assessing the validity of the instruments

Validity implies that the instrument is not correlated with the error term in a regression of work on fertility. The sex composition of the first two children is almost certainly random, and thus not correlated with anything (including the error term in a regression of work on fertility). However, there are reasons why this condition may not hold in the case of multiple births. For example, multiple births are more common among older parents and blacks (Cáceras-Delpiano, 2006). Both of these groups may have particular time use preferences. Nevertheless, both groups can be identified in the Census. More problematic is the fact that multiple births are far more common among women taking fertility drugs or among couples undergoing fertility procedures, such as in-vitro fertilization (IVF). Although it is not clear why fertility problems and preferences for paid and unpaid work are related, it is still possible that the decision to undergo fertility treatments is related to work patterns, especially in light of the high cost of certain treatments.

The same sex IV is also not immune to validity concerns. As I noted earlier, twins necessarily come in pairs. The same cannot be said for additional children generated from the sex composition instrument. When the second child is born, even if it is of the same sex as the first, parents still have to decide if they will pursue having another child. It is at this point where the process may become selective.

To address these concerns for both IVs, I use the quasi-longitudinal nature of the Census to try to predict the IV values with work patterns in the previous year. If paid work patterns predict future IV values (i.e. if the sign on the previous work patterns coefficient is significantly different from zero), then the validity of the IV is put into question.[14] It is important to note that, at best, this exercise may suggest validity, but cannot prove it. Also, a similar exercise is not possible for unpaid work since this is not available for the previous year.

In Tables 3.16 and 3.17, I show the relevant OLS regression results. Beginning with Table 3.16, the sample consists of married or common-law couples, where the mother is less than 40 years old (i.e. of usual child-bearing age), and the couple has two births, the second of which occurred in 2006 (the outcome variable) and the first prior to 2004. Also, the first birth is a singleton. I restrict the first birth to have occurred prior to 2004 since births in 2004 or 2005 are likely to affect labour supply in 2005 (the

[14] Levitt (1996) applies a similar approach. His study is focused on estimating the causal impact of incarceration rates on crime rates using state-level data. As an instrument for incarceration rates, he uses prison overcrowding lawsuits, which are negatively correlated with incarceration rates (i.e. it is a strong instrument). To support the validity assumption, Levitt demonstrates that lawsuits cannot be predicted from prior information on crime rates.

independent variable of interest). I only select mother's below the age of 40 since fertility declines substantially afterwards.

The first point of interest in the table is that fact that the adjusted R^2 value is very low, indicating that it is very difficult to predict either IV. The more detailed results suggest no significant relationship between the multiple birth IV and previous patterns of paid work. Although most lagged work pattern variables also fail to predict the same sex IV, the coefficient corresponding to the mother having previously worked on a full-time basis is significant at 5%. This finding is important, given that Angrist and Evans argue that the same sex IV is valid based on its randomness.

Table 3.16: OLS regressions of instrumental variables on previous patterns of paid work and other controls

	Same sex			Multiple birth		
	b		s.e.	b		s.e.
Mother's weeks worked last year	0.000		0.001	0.000		0.000
Mother mainly worked full-time last year	-0.045	**	0.020	0.000		0.005
Father's weeks worked last year	0.001		0.001	0.000		0.000
Father mainly worked full-time last year	0.028		0.037	0.003		0.007
Mother's age	-0.043		0.022	0.001		0.004
Mother's age^2	0.001	*	0.000	0.000		0.000
Father's age	-0.009		0.006	-0.001		0.001
Father's age^2	0.000		0.000	0.000		0.000
Mother has a high school diploma	0.005		0.034	0.002		0.005
Mother has a college certificate	-0.016		0.033	0.003		0.006
Mother has a bachelor's degree	-0.023		0.037	0.011		0.008
Mother has a professional degree	0.070		0.048	0.009		0.011
Mother has a master's degree	0.041		0.096	-0.006		0.006
Mother has an earned doctorate	0.154		0.123	0.016		0.019
Father has a high school diploma	0.016		0.030	-0.003		0.005
Father has a college certificate	0.044		0.028	-0.001		0.005
Father has a bachelor's degree	0.041		0.033	0.000		0.008
Father has a professional degree	0.070		0.045	-0.007		0.009
Father has a master's degree	-0.104		0.089	-0.016	**	0.006
Father has an earned doctorate	-0.057		0.079	-0.016	**	0.008
Mother is black	-0.005		0.075	0.013		0.027
Mother is Asian	0.083	*	0.044	-0.001		0.008
Mother is Arab	0.060		0.114	0.011		0.013
Mother is Latino	0.206	**	0.101	-0.005		0.004
Mother is Aboriginal	-0.041		0.048	-0.001		0.007
Mother is other non-white	0.059		0.117	-0.005		0.006
Father is black	0.003		0.071	-0.019		0.020
Father is Asian	-0.061		0.046	-0.007		0.008
Father is Arab	-0.023		0.107	-0.008		0.006
Father is Latino	-0.043		0.092	-0.011	***	0.004
Father is Aboriginal	0.062		0.051	0.013		0.010
Father is other non-white	-0.099		0.106	-0.017	***	0.005
Intercept	1.259	***	0.332	-0.008		0.063
Adjusted R^2	0.006			-0.001		
N	5,320			5,320		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples, where the mother is less than 40 years old, and the couple has two births, the second of which occurred in 2006 and the first prior to 2004. Also, the first birth is a singleton.
Source: Census of Population, 2006.

As I alluded to earlier, the real window of opportunity for selectivity with regards to the same sex IV lies in the decision to have a third child or not, conditional on having same sex children on the first two. In Table 3.17, I focus on a sample of married or common-law couples, where the mother is less than 40 years old, and the couple has two or three births, the first two of which occurred prior to 2004, and the third (if present) occurred in 2006. Also, the first two births were singletons of the same sex. The dependent variable in this case is the occurrence of a third child. Note that the sample is much larger in this case since it is far less likely to exclude couples who had two or more children, which is common among couples who choose not to remain childless. The coefficient of -0.0002 in this linear probability model suggests that an additional week of maternal work in the previous year is associated with a 0.02 percentage point reduction in the probability of having a third child, conditional on having two (significant at 1%). Thus, although the coefficient is statistically significant, it is not large by any means, suggesting once again that selection effects are likely to be quite small.

Table 3.17: OLS regressions of the incidence of a third child on previous patterns of paid work and other controls

	b		s.e.
Mother's weeks worked last year	-0.0002	***	0.0000
Mother mainly worked full-time last year	-0.0023		0.0019
Father's weeks worked last year	0.0001		0.0001
Father mainly worked full-time last year	-0.0030		0.0042
Mother's age	-0.0105	***	0.0038
Mother's age^2	0.0001	*	0.0001
Father's age	-0.0032	***	0.0009
Father's age^2	0.0000	***	0.0000
Mother has a high school diploma	-0.0040		0.0032
Mother has a college certificate	-0.0008		0.0031
Mother has a bachelor's degree	0.0028		0.0036
Mother has a professional degree	0.0007		0.0054
Mother has a master's degree	-0.0120	*	0.0071
Mother has an earned doctorate	-0.0188	***	0.0045
Father has a high school diploma	0.0007		0.0027
Father has a college certificate	0.0020		0.0024
Father has a bachelor's degree	0.0058	*	0.0032
Father has a professional degree	0.0156	***	0.0056
Father has a master's degree	0.0126		0.0117
Father has an earned doctorate	0.0129		0.0102
Mother is black	0.0255	**	0.0128
Mother is Asian	0.0015		0.0061
Mother is Arab	0.0137		0.0239
Mother is Latino	-0.0092		0.0107
Mother is Aboriginal	0.0051		0.0045
Mother is other non-white	-0.0125		0.0110
Father is black	0.0059		0.0103
Father is Asian	-0.0002		0.0061
Father is Arab	0.0259		0.0241
Father is Latino	0.0187		0.0125
Father is Aboriginal	0.0056		0.0047
Father is other non-white	0.0186		0.0156
Intercept	0.3404	***	0.0663
Adjusted R^2		0.018	
N		45,621	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples, where the mother is less than 40 years old, and the couple has two or three births, the first two of which occurred prior to 2004, and the third (if present) occurred in 2006. Also, the first two births were singletons of the same sex.
Source: Census of Population, 2006.

What can we conclude from this? First, the multiple birth IV fares quite well in terms of validity. In contrast, some doubt is cast on the validity of the same sex IV. This is not only true for the decision to have a third child conditional on having two of the same sex, but also with regards to having two of the same sex in the first place. This second point seems odd, given that the gender of the child is largely random. To verify if the model specification might be the cause of this result, I ran a similar regression on the same sample, but only included the dummy variable indicating full-time status (last year) for the mother. The coefficient was largely unchanged at -0.039 (and again significant at 5%). Although it is not impossible that this result is caused by sampling variability, the sample size is not small by any means (5,320). In any event, what this exercise highlights is the importance of exploiting as many IVs for fertility as possible to ensure robust results.

3.7 Concluding remarks

In this Chapter, I use Canadian Census data to assess the impact of fertility on the allocation of paid and unpaid work among couples. To account for the possible endogeneity of family size and preferences for time use, I instrument fertility with the sex composition of the first two children and the presence of a multiple birth on the second or later birth.

The results suggest that larger families are associated with substantial changes in the allocation of parental time. The results are consistent with Becker's theory of specialization in the sexual division of labour (Becker, 1985) and Lundberg and Rose's theory of home intensity (Lundberg and Rose, 1999). Specifically, additional children lead to a reduction in paid work and to an even larger increase in unpaid work among mothers. In contrast, additional children are not related to paternal paid work, although there is evidence of a small increase in unpaid childcare. In the end, total work hours increase, especially for the mother, but also for the father.

In terms of specific contributions of this chapter to the literature, several points are worth mentioning. First, to the best of my knowledge, this is the first study anywhere to provide quasi-causal evidence of the impact of fertility on unpaid parental work patterns. This is important since the theories that consider fertility and labour supply are based on the reallocation of home and market work, yet to date home work patterns have been garnered residually from market work patterns. Moreover, unpaid work patterns may help reconcile the fact that larger families are associated with declines in parental investments in children, but not always with a decline in the academic performance of children (as suggested in Chapter 2). Becker's Quantity-Quality theory implies that any increase in family size will generate less parental investment per child. However, Becker's theory of specialization, combined with Lundberg and Rose's theory of home intensity suggest that mothers will spend more time at home in response to additional children while fathers may or may not spend more time at home. If parents do spend more time at home in the aggregate, then this can be seen as a form of unintended parental investments (i.e. time) resulting from additional children. It is unintended because it results in part from the relative productivity of wives and husbands in performing market and housework, as opposed to a conscientious effort to invest in child quality. In any event, the increased parental contact with the child may counterbalance the reduced investment per child, yielding no decline in measured child quality.

Second, the study is also one of the first to look at the relationship between family size and paternal labour supply. This is important to monitor as today's households may choose to allocate labour differently than households in the past. However, the results suggest that paternal labour supply is largely impervious to fertility.

Third, the chapter also contributes to the assessment of the IVs used in the literature by proposing a test of validity based on the predictive power of previous patterns of paid work.

Fourth, this is the first comprehensive study of the labour supply consequences of fertility using Canadian data. Most of the literature focuses on the US, which is largely a function of the nationality of the researchers who have studied the topic.

The findings have several important implications aside from informing the literature. First, increased fertility is one potential way of alleviating the looming retirement crunch. This chapter finds that a strategy of replacing older workers through increased fertility may have the opposite effect in the short to medium run. In terms of paid work hours in the economy, the cost of adding one potential labour market participant (i.e. the child) is simply the reduction in maternal paid work (about 3 to 5 fewer hours per week on average over the first 18 years of the child's life). The benefit in paid work hours is simply the expected work hours of the child over their lifetime.

Although the benefit may be larger than the cost in raw numbers, the benefit only materializes later.[15]

Of course, there are other potential costs and benefits associated with increased fertility. For example, substantial costs are needed to incite fertility, as shown by Milligan (2002). Focusing on a financial incentive program introduced in Québec in 1988 (and subsequently cancelled in 1997), this study estimates the cost per additional child born as a result of the program. To estimate the number of additional children that resulted from the program, Milligan assumed that the gap in the fertility rate between Québec and the rest of Canada that existed prior to the introduction of the program would have remained constant throughout the program period had the program not been introduced. The study concludes that although the program was successful in achieving its goal of raising the fertility rate, it did so at a high cost: more than $15,000 (Canadian) per additional child.

Another potential implication of the findings relates to the allocation of labour within the household. Faced with additional children, the mother typically takes on an additional four to six hours of total work per week. In contrast, the father takes on an additional three hours per week. Moreover, the mother accumulates less human capital over her offspring's childhood given that she spends less time in the paid

[15] Note that intertemporal substitution of labour supply is ignored here. For example, the mother may increase her paid work hours before having children or after she is done caring for her children to compensate for the reduction in paid hours during her child caring years. Testing this hypothesis is not possible with the available data.

labour market. This may have implications for her future wage growth, which can be important in the event of marital separation.

The physical and mental health of the mother may also be affected by children given that the mother's overall workload increases substantially with additional children. This is especially true if childcare is relatively more labour intensive, as suggested by Becker (1960). Other potential costs and benefits may also be present.

Of course, fertility rates have actually been declining in industrialized nations over the last several decades. Given the findings in this chapter, the declining fertility rates may *in part* explain some well-documented long-term macro-trends in the developed world.[16] On the parental labour supply front, it is well documented that female paid labour supply has increased. This may reflect, at least in part, the declining fertility rate. In actual fact, it may very well be the case that women made their labour supply and fertility decisions simultaneously, but the reduction in fertility may have further freed up some of their time available to spend in the labour market. Given that women now spend more time on the paid labour market, the discounted lifetime returns to higher education may now be higher for them. This may explain why women in particular have increased their investments in postsecondary schooling in recent decades.

[16] The OECD produces several statistics related to the trends listed below in their publications 'Education at a Glance' and 'Employment Outlook'. These publications are available at www.oecd.org.

Chapter 4: The Impact of Schooling on Academic Performance

4.1 Introduction

Although it is well-established that more education is causally linked to higher earnings (Card, 2001; Lemieux and Card, 2001), the precise mechanism is not so well understood. Education may act as a signal in the labour market, allowing potential employers to screen in ‘good’ candidates based on how well they have performed in a formal school setting. Whether they have learned anything that is useful for the job refers to the human capital aspect of education. In general, empirical findings can be better explained by signalling models than by human capital theory, although the literature finds evidence that both factors play important roles in wage determination (Weiss, 1995).

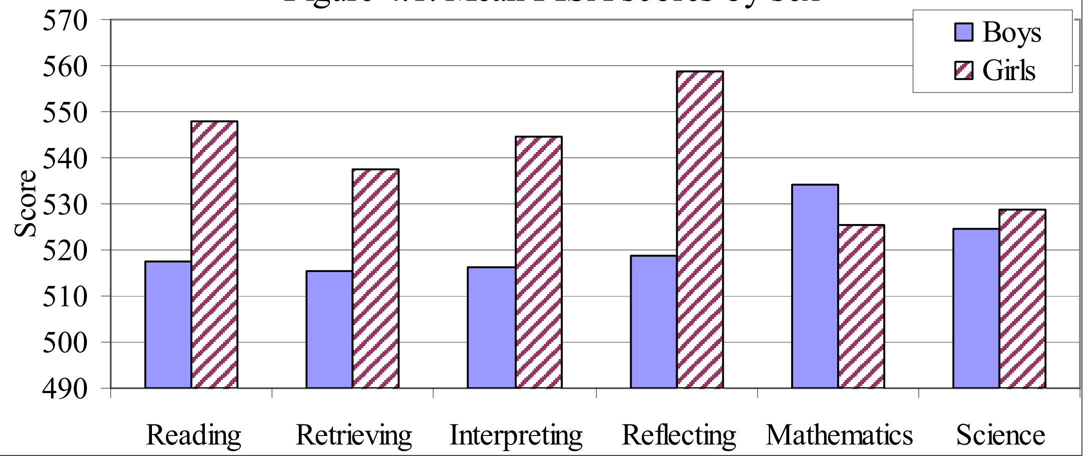
This chapter contributes to our knowledge in this area by assessing the impact of schooling on one particular dimension of human capital: academic performance. I do so with a survey of Canadian youth that is linked to academic test score data. Identifying the impact of schooling can be problematic since individuals who choose more schooling may do so because they have higher abilities. Thus, an exogenous source of variation in schooling is required for identification. The approach used in this chapter takes advantage of a setting whereby large samples of students of roughly similar age wrote the same standardized tests, but were in different school grades because of school entry laws. In some cases, students who were one day apart in age were in adjacent school grades, but wrote the same tests. In other words, one additional year of schooling is associated with as little as one additional day of life in general in this setting.

More specifically, students in the survey were all born in the same calendar year. In most provinces, this means that they were assigned the same school grade (grade 10 by the time they wrote the tests). This is not the case in Québec and Nova Scotia. In these two provinces, students born prior to October are assigned grade 10, while those born later in the year are assigned grade 9. Since they wrote the same standardized tests, it is possible to estimate the impact of an additional school year on academic performance. I do by instrumenting the actual school grade with the initially assigned school grade, all the while controlling for differences in age (which are small in any case).

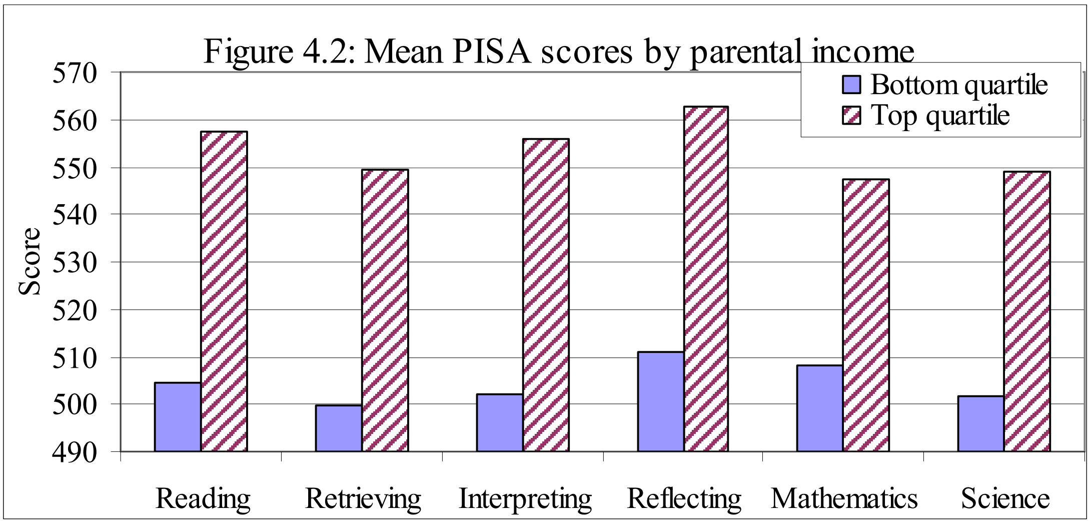
The specific objectives of the chapter are twofold. First, I will quantify the extent to which reading, mathematics, and science performance improves with an additional year of schooling. Second, I will assess the degree of heterogeneity in the results. Specifically, how do the results vary across the conditional distribution of academic performance? Do girls and boys benefit equally from more schooling? What about youth from higher and lower income families?

The benefit that schooling confers onto different groups of students is a contentious issue. In Canada, virtually all schools are public, and as such, they may be seen as a conduit for equalizing opportunities. If the gap between the highly able and the less highly able widens as students progress in the school system, then opportunities have clearly not been equalized. Of course, abilities tend to be concentrated among particular groups. This is the case according to the Canadian portion of the Programme for International Student Assessment (PISA), which was administered to 15 year old students in 2000. Based on mean scores, girls outperform boys in reading by a large margin, while boys outperform girls in mathematics by a smaller margin (Figure 4.1). In science there is a smaller advantage held by females. When the data are broken down by parental income, the story is clearer: youth in the top quartile of the distribution outperform those in the bottom quartile by a sizeable margin in all test areas (Figure 4.2).

Figure 4.1: Mean PISA scores by sex



Source: Youth in Transition Survey, Cohort A.



Source: Youth in Transition Survey, Cohort A.

These patterns have important implications for human capital development since recent work has established that gaps in academic performance go a long way in helping us understand why boys are less likely to go on to university than girls (Frenette and Zeman, 2009) and why lower income youth are less likely to go on to university than higher income youth (Frenette, 2009).

The findings in this chapter suggest that one additional year of schooling (grade 10 in most cases) is associated with significant improvements in reading, mathematics, and science performance. More importantly, schooling confers the same benefits in each academic area to students across three important dimensions: the conditional distribution of academic performance, sex, and parental income. These findings suggest that factors outside of the secondary school system may be the driving force behind heterogeneous academic performance.

The chapter proceeds as follows. In the next section (Section 4.2), I provide an overview of the Canadian educational system, with special focus on the elementary and secondary systems. In Section 4.3, I review the previous literature related to the impact of schooling on academic performance and describe how the current chapter fits into this literature. The empirical portion of the chapter is presented in Section 4.4 (Methodology), Section 4.5 (Descriptive results), and Section 4.6 (Econometric results). I examine the robustness of the results in Section 4.7. In Section 4.8, I investigate heterogeneity in the results across three dimensions: the conditional distribution of academic performance, sex, and parental income. Finally, the chapter concludes in Section 4.9.

4.2 An overview of the Canadian elementary and secondary education systems

In most of Canada's ten provinces, formal school entry (i.e. into kindergarten) begins in the year that the student becomes five years old. In Québec and Nova Scotia, school entry begins if the student was five years old on September 30 and October 1, respectively. To simplify the discussion and analysis, I will use September 30 as the cut-off date for both provinces. This had no discernable effect on the results since there are far more students from Québec than in Nova Scotia in the population. In the end, only a very small handful of Nova Scotia students were affected by collapsing the two cut-off points. In Prince-Edward-Island, the cut-off date is January 31, while in Alberta the cut-off date varies by school board. Compulsory kindergarten normally lasts for one year, which is followed by elementary schooling.

When students begin school, they enter a system that falls under provincial jurisdiction. Moreover, the vast majority of schools in Canada are public (93.86%, according to the YITS data, which are used in this chapter). Schooling is generally compulsory until the age of 16 in most provinces. Ontario and New Brunswick are exceptions in this regard. Since 1999 (in New Brunswick) and 2006 (in Ontario), compulsory schooling laws remain in effect until the age of 18. All along, however, parents may opt to educate their children at home rather than through the formal school system.

Once in high school, which begins in grade 9 in most provinces, students may choose their courses from a wide range of levels (e.g. remedial, standard, gifted, etc.) However, there is no hard streaming per se as in the German system, except for a few rare exceptions (e.g. technical high schools geared towards the trades). In other words, students may tailor their course selection to suit their future intentions regarding higher education or the job market, without being fully committed to following a specific pathway.

In most provinces, students obtain a high school diploma after 12 completed years of elementary and secondary schooling. The province of Québec stands out in this regard. Students in that province normally graduate with a high school diploma after 11 completed years of schooling. In the past, the system was also different in Ontario. For students who began high school prior to 1999, university attendance required a regular high school diploma (12 years) plus several courses at the OAC (Ontario Academic Credit) level. Although it was possible to complete the OAC requirements by the end of grade 12, very few students achieved this. In the vast majority of cases, one additional year of high school was required. The Ontario system has since been reformed. For students beginning high school in 1999 or later, the university bound curriculum has been compressed from five years to four, meaning that students normally become eligible for university entry after grade 12, although many students still need an additional year to obtain the advanced credits that are necessary for university admission (King, 2004).

4.3 Literature review

Overview

Is intelligence inherited or can it be influenced by environmental factors, such as parents, friends, or school? This question has been debated by social scientists countless times over the last several decades. In the review that follows, I will highlight the main studies in the theoretical and empirical portions of the literature. As we shall see, the theoretical side of the literature clearly suggests that cognitive ability can be shaped by environmental factors, including schooling. The main focus of the debate has thus centered around confirming the causal flow going from schooling to cognitive ability, as well as measuring the strength of the relationship.

Theoretical literature

The theory concerning intelligence has been the domain of psychologists from the first. Child psychologists have been particularly involved in this literature since it is believed that intelligence is a developmental concept, generally improving from infancy to maturity. There is a consensus in the literature on this point (e.g. Binet and Simon, 1916; Jensen, 1980; Wohlwill, 1980; Reynolds, 1982; Sternberg and Powell, 1983). Glaser (1984) goes a step further and suggests that current learning activities in

American scholastic curricula are geared towards the formation of cognitive strategies that are necessary to perform well on aptitude tests.

The main question of interest in the literature has thus been on the size of the effect of schooling on cognitive ability (or aptitude), as opposed to whether or not schooling affects scholastic learning (e.g. learning curricula). This is the point I now turn to in the next section. Note that my review will reflect the fact that considerable attention has been paid in the literature on identifying the causal relationship between schooling and academic performance.

Empirical literature

The early empirical studies were, once again, largely the domain of psychologists. Ceci (1991) reviews this literature and concludes that additional schooling has a sizeable effect on academic performance. These studies are grouped into eight classes, depending on the methodological approach. I re-organize these eight classes into three meta-classes, based on their general approach: correlational, indirect, and causal. I also limit my critique of these studies to points that were not mentioned by Ceci (1991), unless otherwise stated.

In the correlational meta-class, three approaches have been used. The first considers the statistical correlation between Intelligence Quotient (IQ) and years in school. For example, Bouchard (1984) examines this correlation among twins reared apart. However, such twins may have been exposed to very different family environments, which may have a direct effect on IQ. Nevertheless, other studies find that the schooling-IQ correlation persists even after controlling for socio-economic status and other social variables (Kemp, 1955; Wiseman, 1966). Of course, unobservable factors may lie beneath the differences in observed schooling choices.

The second approach examines early termination of school and subsequent IQ scores. Harnqvist (1968) examines Swedish males who were administered IQ tests at age 13 and 18. Among boys who had similar IQ tests and other characteristics at age 13, every additional year of schooling was associated with an additional 1.8 IQ points on the test administered at age 18. As noted by Ceci (1991), one criticism is that students who chose to dropout earlier may have done so because they were not performing well in school. Ceci doesn't push this point hard and even argues that there is no evidence that this was the case. However, he does not point to any evidence suggesting that this was *not* the case.

The third approach used in the correlational meta-class is based on the correlation between intermittent school attendance and IQ. A study by Hugh Gordon in 1923 (reported in Freeman, 1934) reveals that children in London who rarely attended school had very low IQs. The reason for intermittent school attendance was usually a physical disability or being the offspring of transient parents (e.g. gypsies). In contrast, Gordon noted that children who regularly attended school and had very low IQs were retarded in the traditional sense. In other words, he argued that having very low IQs could only result from mental retardation or a lack of schooling. Ceci (1991) lists other studies that have exploited variation in schooling for specific reasons, such as living in mountainous regions in the United States (Sherman and Key, 1932; Tyler, 1965; Wheeler, 1942). Although this approach is somewhat more compelling than simply calculating correlations, there is still room for unobserved heterogeneity among students with different degrees of school attendance. For example, students with a physical disability may be limited in their academic work because of physical limitations (e.g. reading a book without assistance may be difficult for some). Students living in mountainous regions are there because of choices made by their parents, which may be correlated with the natural abilities of the youth themselves. The paper by Sherman and Key (1932) is an exception in this regard since they study variation in geography based on ethnicity. Of course, ethnicity may itself be related to cognitive ability.

A second meta-class of studies actually consists of only one approach. It is the indirect evidence approach. The idea begins with the notion that schooling is expected to have a positive influence on achievement test scores that do not have an aptitude component. If this is the case, then observing a strong correlation between schooling and aptitude (relative to the correlation between schooling and achievement test scores) provides indirect evidence of an effect of schooling on aptitude. Schmidt (1967) reports that schooling is at least as strongly correlated with IQ than with achievement test scores. Other studies have come to similar conclusions (e.g. Coleman, 1968 and Jencks et al., 1972). Of course, this all depends on the original assumption that schooling exerts a positive influence on achievement. There could be an extraneous factor driving the correlation between schooling and the types of test scores. For example, as students progress through the school system, they also age (i.e. mature), they are exposed to their family environment or friends, their neighbours, etc. While a relatively strong correlation between schooling and aptitude is suggestive of a causal relationship, it is by no means proof of such a relationship.

A third meta-class offers more promise along the causality lines. Four approaches have been adopted. The first approach argues that historical changes in schooling are generated by exogenous forces (e.g. changes in policy, social norms, etc.), such that changes in IQ scores over these periods can be causally linked to changes in schooling. For example, Tuddenham (1948) compared test scores of World War II draftees with those of World War I draftees, and found that the former outperformed the latter by nearly one full standard deviation. Tuddenham notes that education accounts for about one half of this increase in performance. Although he lists other possibilities that could explain the remaining half, there are some factors that could explain the contribution of education. For example, the quality of education may have improved between the wars. Teaching methods were in their infancy at this time, and there could very well have been plenty of room for improvement. There could also have been substantial demographic changes resulting from immigration during the intra-World Wars period.

The second of the causal approaches involves variation in IQ before and after the summer months. Several studies find that IQ scores decline over the summer months, likely due to the absence of schooling (Jencks et al., 1972; Heyns, 1978; Hayes and Grether, 1982). This is especially the case among low-income youth. This is highly suggestive of a positive effect of schooling on IQ; however, two points of caution are worth pointing out. The first concerns symmetry. The variation in schooling exploited by the authors in this literature is based on a *reduction* in schooling equivalent to about two summer months. Would *adding* two months to the school year have the same size effect with the opposite sign? The answer is not known from these studies.

Another point of caution concerns the ability of these studies to credibly estimate the magnitude of the effect. During the summer months, schooling is removed from the equation, but parents may be added to the picture (especially when one parent does not work outside the home). This could serve to dampen the effect of the reduction in schooling.

A more recent study that provides somewhat more insight into this question is Alexander, Entwistle, and Olson (2001). They tracked the achievement of 650 students in the Baltimore public school system on the California Achievement Test, which measures math and reading abilities. Students were tested before and after the summer holidays, as well as in different months of the school year. Their findings over the summer months confirm those of the earlier studies; however, their results over the school year stand in stark contrast to the summer results: student test scores improve substantially. What is even more interesting is that children from low and high income families see similar improvements in their test scores over the school year, but not during the summer months. However, this study is limited by its low sample size (650) and its narrow focus (the Baltimore area).

The third causal approach focuses on the delayed onset of schooling. This approach looks at children who delayed their school entry for reasons that are more or less exogenous to their abilities. It is similar to the intermittent schooling approach, except that children may attend schooling regularly once they enter the system. These studies have focused on delayed schooling for entire communities due to the Nazi siege during World War II (DeGroot, 1951) or the unavailability of teachers (Ramphal, 1962). While the DeGroot study can be criticized on the basis of selective school closures resulting from the Nazi Siege, the study by Ramphal is somewhat stronger from an identification point of view. Ramphal examines children of Indian Ancestry in South African villages. Among groups of children with similar genetic background, those who did not have teachers available experienced a decline in IQ equivalent to 5 points per year.

The final approach in the causal meta-class of studies examines variation in schooling based on small differences in chronological age. The idea is that children born just before a school entry cut-off date are no different than children born just after the cut-off date, except in one respect: they will have one additional year of schooling. In the rare instance when these students wrote the same test, it is relatively simple to identify the effect of the additional school grade on performance. The approach is regression discontinuity (RD), which is described in Appendix A4.1. Briefly, this approach consists of regressing the test score on some function of chronological age, but allow for a discontinuity around the cut-off date. If the regression shows a significant jump at the cut-off date, then that is evidence of a schooling effect. One challenge is that students in different school grades almost always write tests that are designed for their grade.[17]

[17] There is a separate, but related literature on the impact of relative age within school grades on outcomes. This literature compares school children within a given school grade, but who were born at different times in the year. The idea behind this research is that students who begin school at an older age are more mature than others, and thus, tend to outperform younger students. See Bedard and Dhuey (2006), McEwan and Shapiro (2008), and Elder and Lubotsky (2009) for examples of such studies.

There are three studies in the literature that exploit situations where students in different school grades wrote the same test. The first is Baltes and Reinert (1969), who examine German school children between the ages of 8 and 10 years old. The authors find a strong correlation between schooling and test scores. However, the authors did not adopt an RD approach. They simply compared test scores of students born before and after the school entry cut-off date. With a sufficient sample of school children born just before and just after the cut-off date, this approach may very well identify the effect of schooling on test scores. However, the authors only have data on hundreds of school children and do not have precise date of birth information (they have season of birth information).

A second study more closely follows an RD approach. Cahan and Davis (1987) use data on grade 1 and 2 Israeli school children. Their data offer two advantages over the data used by Baltes and Reinert (1969). First, the sample size is larger (they use over 2,000 observations for each grade). Second, they have information on month of birth. Cahan and Davis also better distinguish between school and age effects, calling for the use of RD. They also point out two potential problems concerning the selection of school children into school grades. First, birthdays may not be randomly distributed around the school entry cut-off date. This may result from a deliberate attempt by the parents to manipulate the school entry date and/or relative age (within grade) of their children. No attempts were made to address this point. Second, students born in the month before (after) the cut-off date are more likely to be one grade below (above) the usual grade for their age because of relative age effects. This sort of selection (termed a 'fuzzy discontinuity') can have a biasing effect on RD estimates, and is normally dealt with by instrumental variables, as described in Appendix A4.1. Their solution to the problem is to drop all students who were born within one month of the cut-off date in either direction. This largely removes students who are not in their usual grade for their age, but it also introduces larger age differences around the discontinuity (a minimum of two months). In general, omitting certain students violates the 'intention-to-treat' principle. That is, the intention was to treat all youth of a given age with the treatment (i.e. the additional year of schooling). Removing some of those intended recipients based on the observed school grade may lead to biased results. They discuss and attempt to address this issue by showing test score data for the omitted students in order to get a sense for the extent of the bias. In the end, their preferred estimates (the ones where some students are dropped from the sample) suggests that one additional year of schooling (grade 2) leads to a 19 percentage point improvement in math achievement and to a 17 percentage point improvement in reading achievement.

A similar study by Cahan and Cohen (1989) was conducted on older Israeli school children (grades 4 to 6). These data offer two advantages over the data used by Cahan and Davis (1987). First, the sample size is considerably larger (over 10,000 students in the three grades). Second, the exact date of birth (i.e. year, month, and day) is known from school administrative records. However, their approach is similar to Cahan and Davis in that they exclude students born near the cut-off date; therefore, they do not fully utilize the more precise information on the date of birth. Specifically, they exclude students born within two months before the cut-off date since those months contain the highest proportion of students who are not in their appropriate grade for their age. They also explicitly exclude any student not in the appropriate grade. Finally, they normalize their dependent variables (the test scores) to a mean of

0 and a standard deviation of 1. This yields regression coefficients that are interpreted in standard deviation terms.

What Cahan and Cohen find is that one additional year of schooling generates an increase in test scores ranging from 0.11 to 0.50 standard deviations. Verbal tests scores improve the most, while numerical and figural test scores less so. They also show that the school effect is about twice as large as the age effect when both are estimated in the same metric (years).

The consensus at this point in the literature was clear: more schooling leads to superior academic performance. This view was challenged by Herrnstein and Murray (1994) in their influential book *The Bell Curve*. In it, they argue that schooling only has a marginal effect on academic performance, and that abilities are largely inherited. Herrnstein and Murray suggest that schooling is randomly assigned conditional on a pretest administered at a younger age. In other words, the value of the pre-test will determine how much schooling a child will eventually obtain. Schooling thus confers a 'value-added' in terms of academic performance. In their view, the 'value-added' can be captured by test results from the Armed Forces Qualifying Test (AFQT), which is applied to respondents in the National Longitudinal Survey of Youth (NLSY), conditional on the results from the pretest administered earlier for certain NLSY respondents. Their results further support their view that schooling confers very little benefit in terms of academic performance.

The controversy generated by *The Bell Curve* has led many researchers to challenge the new findings. For example, Winship and Korenman (1997) re-examine Herrnstein and Murray's analysis by addressing various technical issues and model specifications. A key element in their assessment involves the measure of education. Herrnstein and Murray, use educational attainment to proxy years of schooling rather than exact years of schooling. Since certain students may skip or fail a grade (perhaps based on ability), using educational attainment may bias the estimates of the impact of schooling on academic performance. Another important addition was to include parental socioeconomic status as a control variable in the educational production function (Herrnstein and Murray do not). In the end, Winship and Korenman estimate that schooling confers about twice the effect on academic performance found by Herrnstein and Murray.

The approach of conditioning on a pretest used by Herrnstein and Murray and by Winship and Korenman has also been criticized since the pretest is not a perfect proxy for ability and is not comparable to the AFQT (Hansen, Heckman, and Mullen, 2004; Todd and Wolpin, 2003). Winship and Korenman actually question whether or not the pretest should be included as a control variable. They argue that there may be a spurious correlation between the pretest and the later test. Alternatively, Neal and Johnson (1996) and Hansen, Heckman, and Mullen (2004) use quarter of birth as an instrument for schooling. Quarter of birth is highly correlated with cut-off dates from school entry laws, but is purported to not belong in the education production function. These authors also find effects that are about twice as large as those found by Herrnstein and Murray.

Cascio and Lewis (2006) critique the approach of Neal and Johnson and of Hansen et al. since earlier studies have found that quarter of birth is related to several outcomes in jurisdictions not constrained by school entry laws. Cascio and Lewis take a different route in their study. In fact, their approach is similar to the regression discontinuity studies in the psychological development literature (e.g. Cahan and Davis, 1987; Cahan and Cohen, 1989), except that Cascio and Lewis tackle the issue of grade selection in a more direct fashion than previous authors. The older studies noted that students born near the school entry cut-off dates were more likely to not be in the grade that they were initially assigned. To account for this, those studies simply dropped students born near the cut-offs from the analysis. In a sense, they were treated as a nuisance. The issue of course is that this leaves students in the sample who are not exactly close in age, which was the original strength of the data made available to the authors.

Cascio and Lewis also look at students born before and after school entry cut-off dates. They do so with US data on standardized test scores and knowledge of school entry laws in various states. Specifically, they use the NLSY data, which contains the AFQT test scores. Rather than drop students born near the cut-off dates, they include them in the analysis, but instrument the actual school grade with the initially assigned school grade based on the date of birth. Their model also includes parametric controls for the date of birth. In other words, their approach is to treat the school entry cut-off dates as a fuzzy discontinuity, which is the appropriate strategy.

They also provide estimates in standard deviation units, albeit only by ethnicity and for general performance. Nevertheless, they generally find that an additional year of schooling boosts academic performance by 0.3 to 0.4 standard deviations.

Contributions of the present chapter to the literature

This chapter contributes to the literature in several important ways. First, results are generated across three important dimensions: the conditional distribution of academic performance, sex, and parental income. Heterogeneity in the results is useful to document for policy purposes since it indicates for *whom* the schools are working. These are particularly important dimensions. Academi performance is perhaps obvious since schools might be concerned with trying to help those who are having the most difficulty. Sex and parental income are also very important dimensions since it is well-document that there exist important differences in academic performance along these measures. To date, only Cascio and Lewis (2006) look at ethnicity and Alexander et al. (2001) examine parental income.

The second contribution concerns the range of academic areas examined. Among the most credible studies in the literature, the focus has either been on mathematics- and language-related scores (e.g. Cahan and Davis, 1987; Cahan and Cohen, 1989) or on a broad test score (Cascio and Lewis, 2006). In this Chapter, I consider three broad areas: reading, mathematics, and science. In addition, I show results for three sub-components of the reading test: retrieving, interpreting, and reflecting.

Finally, it is the only study to provide Canadian evidence on the impact of schooling on academic performance. As with the previous two chapters, this helps establish the robustness of the findings in the literature.

4.4 Methodology

The identification strategy is based on comparing results from identical standardized tests that were administered to students in different school grades. As we shall see in the next section, students in the data were born in the same calendar year. In most Canadian provinces, children begin school based on their age on December 31. In contrast, children in Québec and Nova Scotia begin school based on their age on September 30 and October 1, respectively.[18] Recall that I collapse the dates to September 30 for both provinces (for ease of discussion and analysis), which only affected a very small handful of students in Nova Scotia. The school entry laws in Québec and Nova Scotia provide fertile grounds upon which to examine the impact of an additional school grade on academic performance. One way of doing so is to apply a regression discontinuity (RD) estimator to compare academic test scores of students born before and after September 30 for students in Nova Scotia and Québec (see Appendix A4.1 for a description of RD). This involves estimating the following baseline education production function using ordinary least squares:

$$(4.1) STDSCORE_i = \alpha_0 + \alpha_1 GRADEASSIGNED_i + \alpha_2 F(AGE_i) + \alpha_3 X_i + \varepsilon_i$$

[18] Two other provinces stand out in terms of school entry legislation. In Prince-Edward-Island, the cut-off date is January 31 of the following calendar year. This means that PISA students who were born prior to the cut-off date should be in grade 11. Since there were too few of these cases, this province could not be used in the identification strategy. In Alberta, the cut-off date depends on the school board. In many cases, the cut-off is February 28 of the following calendar year. Students born before this date should also be in grade 11 at the time of the test. Unfortunately, even if specific Alberta school boards were identified in the data, the resulting sample of grade 11 students would be very small. For this reason, Alberta also did not figure in the identification strategy.

This involves regressing standardized test scores (*STDSCORE*), on some function (*F*) of age (*AGE*).[19] As is commonly done in the literature on test scores, the scores are standardized to a mean of 0 and a standard deviation of 1 by subtracting the mean and dividing by the standard deviation (as described in Appendix A2.6). Coefficients are thus interpreted as the effects in standard deviation units. By policy design, Nova Scotia and Québec students born in September or earlier are normally in grade 10, while those born later are normally in grade 9. To capture this discontinuity, the regression includes a variable (*GRADEASSIGNED*) equal to 9 or 10, based on school entry laws and the age of the youth.[20,21] The vector *X* contains other variables belonging in the education production function.

[19] Since the exact date of the test is not known, I use the exact age (in days) as of December 31, 1999. This is a reasonable proxy for age at the test since students wrote the test shortly thereafter (in either April or May). Furthermore, there is no systematic student-level bias based on age since the date of the test was the same for all students within a school.

[20] One potentially confounding factor is that some high schools begin in grade 10. In other words, the movement from grade 9 to grade 10 may not only pick up a 'grade' effect, but also the effect of going from the oldest grade to the youngest grade in school. However, high school begins in grade 7 in Québec (Secondaire I), while in Nova Scotia, it usually begins in grade 9 (depending on the school board). Based on YITS data, 84.9% of grade 9 students in Nova Scotia and Québec are in a high school. Furthermore, Lipps (2005) finds little systematic evidence of a relationship between moving from middle school to high school and academic performance. Finally, I re-estimated the models by focusing only on high schools, and obtained similar results. These results are available in Appendix 4.2, and they are comparable to the results in Tables 4.9a and 4.9b, which will be presented later in this chapter.

[21] Another possibly confounding factor is that we only know the province of school attendance at age 15, which may or may not correspond to the province of school attendance at age of entry. According to Statistics Canada's 2001 Census, only 13.8% of 15 year old youth living in Nova Scotia in 2001 were born in a different province. The figure for Québec is even smaller (10.6%), and the rates were

The problem with this approach is one of compliance. In an ideal setting, all youth born before the cut-off date would be in grade 10, and otherwise in grade 9. This would constitute a ‘sharp’ discontinuity (i.e. the treatment status is a deterministic function of age). In reality, the discontinuity is more likely to be a ‘fuzzy’ one, meaning that the expected value of the school grade is a function of age with a break at the cut-off.

There are many possible reasons why the treatment is not necessarily a deterministic function of age. One way is for parents to selectively choose the date of birth of their child (perhaps based on their expectations for the child, likely proxied by their own abilities). Nonetheless, even if this were possible, Lee (2008) concludes that the localized random assignment into the treatment will still occur as long as agents (parents in this case) do not have the ability to sort precisely around the threshold (i.e. near the threshold, individual characteristics are independent of the treatment status, and the threshold status follows some continuous probability distribution, and thus, is based on luck).

This is likely the case since most women don’t know when they ovulate, so that the due date is typically calculated by counting 280 days (40 weeks) from the first day of the last menstrual period (Bennett, 2004). As a result, only 5% deliver on the due date,

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similar in other provinces. Furthermore, it appears that among this birth cohort, most inter-provincial moves occurred prior to attending school. According to the 1991 Census 11.5% of 5 year old children living in Nova Scotia in 1991 were born in a different province (7.2% for Québec).

although most deliver within two weeks of the due date. An ultrasound may help narrow the date further, but this does not apply in the pre-conception stage.

What do the data suggest? Figure 4.3 shows the distribution of birthdates among youth born in 1984 from Statistics Canada's Census of Population, 2001 (a 20% random sample of the population). For the most part, the relative frequencies are very similar in Nova Scotia and Québec compared to the rest of the country around the school entry cut-off dates. Specifically, there is no evidence that parents in Nova Scotia and Québec tried to speed up school entry (to reduce the total time sending the child to daycare or staying at home to rear the child) or delay it (to make their child relatively older in their grade).

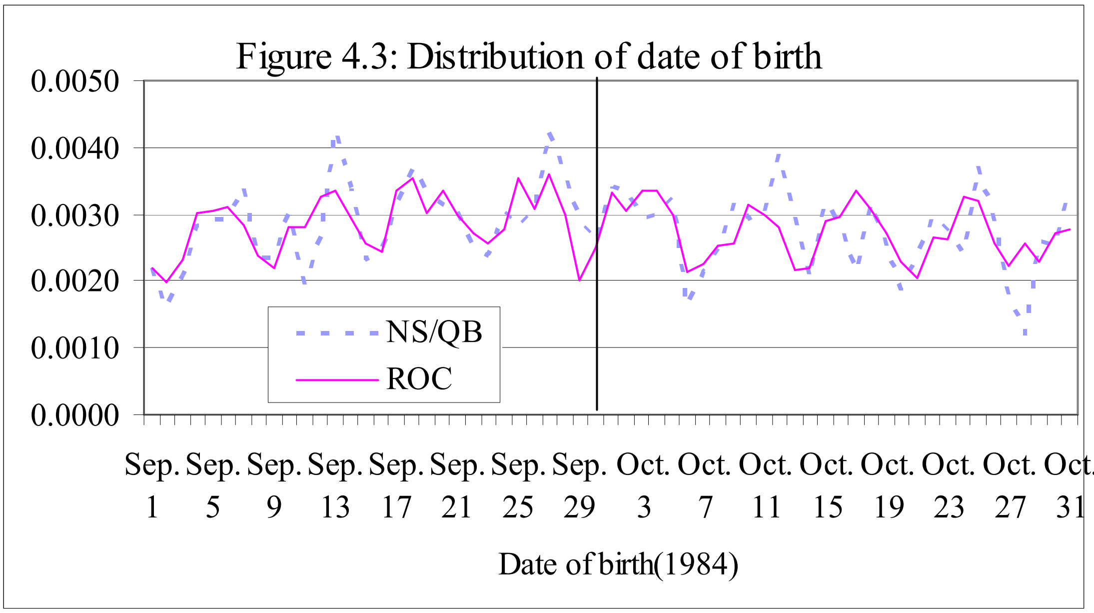

Figure 4.3: Distribution of date of birth

Note: The sample consists of all children born in September or October, 1984.
Source: Census of Population, 2001.

Although there is no evidence that parents manipulate the treatment (i.e. the actual school grade) through timing of birth, it is still possible that students, parents, or schools may manipulate the treatment by holding children back or requesting that they skip ahead. Over time, we expect this problem to become worse as opportunities for grade retention or acceleration accumulate. This is in fact the case. Although very few youth are in a grade above the usual one for their age (2.71% in the Nova Scotia and Québec sample), 19.45% of youth are in a grade below their expected grade in the same sample (of these, more than 80% of parents noted, when asked, that their child was held back by the school system, as opposed to starting school later).

The appropriate estimation approach given this fuzzy discontinuity is instrumental variable (IV) regression. Equations 4.2 and 4.3 show the two stages of this IV approach:

$$(4.2) First-stage: GRADE_i = \delta_0 + \delta_1 GRADEASSIGNED_i + \delta_2 F(AGE_i) + \delta_3 X_i + \eta_i$$

$$(4.3) Second-stage: STDSCORE_i = \phi_0 + \phi_1 \hat{GRADE}_i + \phi_2 F(AGE_i) + \phi_3 X_i + \gamma_i$$

Note that $\hat{GRADE}$ is the predicted value of from the first stage. Given the very real possibility that the discontinuity is fuzzy, the main estimation strategy will be IV.

The data for the chapter are drawn from the Statistics Canada's Youth in Transition Survey (YITS), Cohort A matched to data from the OECD's Programme for International Student Assessment (PISA). Since these data were described in Chapter 2, I only point out the key features that are relevant to the current chapter. Note that standard errors are calculated in the same way as in Chapter 2 (i.e. using the 100 bootstrap weights provided by Statistics Canada). Bootstrapping generates consistent estimates of the standard errors. Thus, it will account for stratification and multi-stage sampling of the YITS. It will also correct for heteroscedasticity if it is present. See Appendix A2.1 for more information on bootstrapping standard errors.

Recall that the target population consisted of students enrolled in an educational institution on December 31, 1999 who were 15 years old on that day (i.e. they were born in 1984). The assessment took place in April or May, 2000, depending on the sampled school.

The main analytical sample consists of students who were born in Canada, were within one school grade of the usual grade for their age, and lived in Québec or Nova Scotia at the time of the survey. The first two restrictions are an attempt to eliminate students who followed unusual paths in the school system for reasons other than their abilities. This may include, for example, foreign students who had their schooling delayed due to war or domestic students who were temporarily removed from school for health reasons. Given their loss in school years, they would show up as outliers in the data (e.g. students who are two years behind, yet they may perform relatively well). The third restriction is based on the identification strategy discussed above (i.e. the existence of particular school entry laws in these two provinces).

What if some youth dropped out of school prior to the PISA assessment? In 2000, compulsory school laws required students in all provinces to remain in school until the age of 16, except in New Brunswick, where a minimum age of 18 was in place. Since the assessment was administered in April or May, some youth born in 1984 were 16 years old when the tests were administered; specifically, those born in the earlier part of the year. This leaves open the possibility that some students had dropped out of school prior to being assessed, which could introduce a selection bias in the results. Nonetheless, some of the results to follow will show differences in test scores around the school entry cut-off date, which consists exclusively of 15 year olds.

The outcome variables in this chapter are the PISA scores in reading, mathematics, and science. Note that the raw PISA scores have already been standardized to a mean of 500 and a standard deviation of 100 for all participating countries combined (i.e. the 'global' mean is set to 500 and the 'global' standard deviation is set to 100 for each score). As in Chapter 2, most of the analysis here is based on transformed versions of the scores, where the mean is set to 0 and the standard deviation is set to 1.

In 2000, the PISA assessment focused primarily on reading. All students wrote the reading exam, while about half wrote the mathematics exam, and the other half wrote the science exam (through random assignment). The reading portion accounted for about two-thirds of the total testing time. The assessment was administered in the language of instruction of the school, which was either English or French. The reading test consisted of having students perform a range of tasks with different kinds of text, including: retrieving specific information, interpreting text, and reflecting on the content and features of the text. The texts included standard prose passages and various types of documents such as lists, forms, graphs, and diagrams. An overall reading score is available, as are scores related to the retrieving, interpreting, and reflecting components of the test. The mathematics and science tests were more general than the reading test.

Since PISA is administered to students in several countries (i.e. several educational jurisdictions), it is non-curriculum based. This does not imply that schooling cannot possibly have an impact on the tests scores since learning the curriculum may still be useful for performing tasks that are not necessarily covered in the curriculum. For example, students may learn grammar and sentence structure in standard prose text. However, the grammar and sentence structure they learn may help them perform tasks with different kinds of text, or even to better understand the questions on the mathematics and science tests. Similarly, learning algebra or trigonometry may help develop logical thought, which could be useful in understanding diagrams or graphs. More details of the tests, including sample questions, appear in Appendix A2.5.

The key explanatory variables include the observed and initially assigned grades of the student, as well as their age on December 31, 1999 (expressed in years, based on the exact date of birth). The age variable will control for two effects: chronological age and relative age within grade. The two cannot be separately identified in the current framework (i.e. students in the same grade and of the same chronological age will be of the same relative age).[22]

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[22] Controlling for relative age is particularly important since it may cause a permanent shift in the education production function, or it may affect the trend. For example, early starters may perform better than later starters in the early years (since early starters have one additional year of schooling), but this difference may narrow over time if the learning curve is shallower for early starters (e.g. if, within their own school grade, teachers pay more attention to older children). In this instance, the timing of the tests becomes important. In particular, testing at age 15 would understate the true schooling effect if we fail to properly control for relative age effects. As we shall see, however, the size of the effects found in this chapter lie well within the normal range of the estimates generated by

Several other variables belonging in the education production function are also included. For example, a series of birth order dummy variables are included. This represents the birth order of the siblings in their current family (i.e. relative to their current siblings, including step, adopted, and foster siblings). For some, the birth order in their original family will be different. Unfortunately, there is no information in the data on birth order within original families. Nevertheless, it is not clear which birth order is more relevant.

In the literature on birth order and academic achievement, an important variable to take into account is the age of the mother. Kantarevic and Mechoulan (2006) find that first-born children complete more years of schooling than later born children only after they account for the fact that first-borns were raised by younger mothers than later-borns. Since the youth in this study were all born in 1984, using the current age of the person most knowledgeable is tantamount to using their age at the birth of the child.

Socio-economic background characteristics are also taken into account in the models, including the highest level of education of either parent (for the purposes of this chapter: no postsecondary certificate, a non-university postsecondary certificate, an undergraduate degree, or a graduate or professional degree), total pre-tax income of the parents and its squared value[23], and the presence of parents in the home (for the

other studies in the literature, most of which focus on earlier school years. In other words, the timing of the test does not seem to affect the results in this literature.

[23] Equivalent income is used to construct a 'per capita' measure of income that accounts for economies of scale in households of different sizes. The specific method used here consists of dividing income

purposes of this chapter: one parent present, two parents present but fewer than two are birth parents, or two birth parents present).

Important differences in academic performance have also been documented by sex. To account for this, a female dummy variable is included in the models.

One reason for differences in academic performance by years of schooling might be the subjects that the students are taking currently in school. To account for this, I include a dummy variable indicating whether or not the student is taking a subject related to the test in question.

Finally, province fixed effects are also included in each model. This is effectively a dummy for Québec. This is an important variable since education falls under provincial jurisdiction in Canada, so that it may pick up the quality differences in educational systems. The province dummy may also pick up unobserved abilities of students in the sample.

In Table 4.1, I show means and standard errors of the variables used in the analysis by sample selection criteria. The reading sample is used here, and thus, only the reading score is shown. The goal here is simply to investigate the impact of sample selection on the data. The first sample selection criteria—dropping youth born outside Canada—has a moderate impact on the sample size and virtually no impact on the

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by the square root of the number of members in the household. This approach essentially combines the effects of parental income and family size into one measure (separating these effects is not necessary here, as it was in Chapter 2).

mean characteristics. The second criteria consists of dropping youth who are more than one grade ahead or behind the usual grade for their age. This measure has little impact on the sample (both in terms of size and characteristics). The final sample selection criterion, applied for identification purposes, consists of dropping youth living outside of Québec and Nova Scotia. The sample size obviously declines substantially (from 23,425 to 5,507), but the characteristics are also somewhat different. Compared to the rest of the country, youth in the final sample are higher achieving, have a lower birth order, and have slightly lower parental income. Not surprisingly, the average school grade of students in Québec and Nova Scotia is lower because of the school entry laws in those provinces.

Table 4.1: Means and standard errors of variables used in the analysis by sample selection criteria

	Initial sample of youth		Drop if born outside Canada		Drop if more than one grade ahead/behind		Drop if not living in Québec/Nova Scotia	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Reading score	534.506	1.299	536.117	1.291	538.054	1.255	549.048	2.234
School grade	9.822	0.008	9.818	0.007	9.856	0.005	9.631	0.015
School grade initially assigned	9.755	0.004	9.756	0.004	9.755	0.004	9.756	0.010
Age of the youth	15.494	0.002	15.494	0.003	15.495	0.003	15.497	0.005
Birth order	1.537	0.007	1.533	0.007	1.534	0.007	1.486	0.014
Age of parent most knowledgeable of youth	43.642	0.069	43.621	0.068	43.637	0.068	43.800	0.113
Parent with no postsecondary certificate	0.366	0.006	0.377	0.006	0.372	0.006	0.389	0.012
Parent with a non-university PS certificate	0.356	0.005	0.366	0.005	0.367	0.005	0.369	0.008
Parent with a bachelor's degree	0.180	0.005	0.171	0.005	0.174	0.005	0.167	0.007
Parent with a graduate or professional degree	0.097	0.005	0.086	0.005	0.087	0.005	0.076	0.008
Equivalent total parental income	34,290	462	34,688	449	34,915	454	32,197	627
One parent present	0.161	0.003	0.163	0.003	0.161	0.003	0.180	0.008
Two parents present, at least one not from birth	0.132	0.004	0.136	0.004	0.135	0.004	0.120	0.007
Two birth parents present	0.708	0.005	0.702	0.005	0.704	0.005	0.700	0.009
Female	0.499	0.005	0.497	0.005	0.500	0.005	0.497	0.012
Related course	0.970	0.002	0.969	0.002	0.970	0.002	0.983	0.002
Québec	0.214	0.004	0.223	0.005	0.214	0.005	0.866	0.004
N	25,064		23,715		23,425		5,507	

Source: Youth in Transition Survey, Cohort A.

Given the very specific group of students examined in this chapter, it is important to keep in mind that the results are only relevant for this group, namely students from

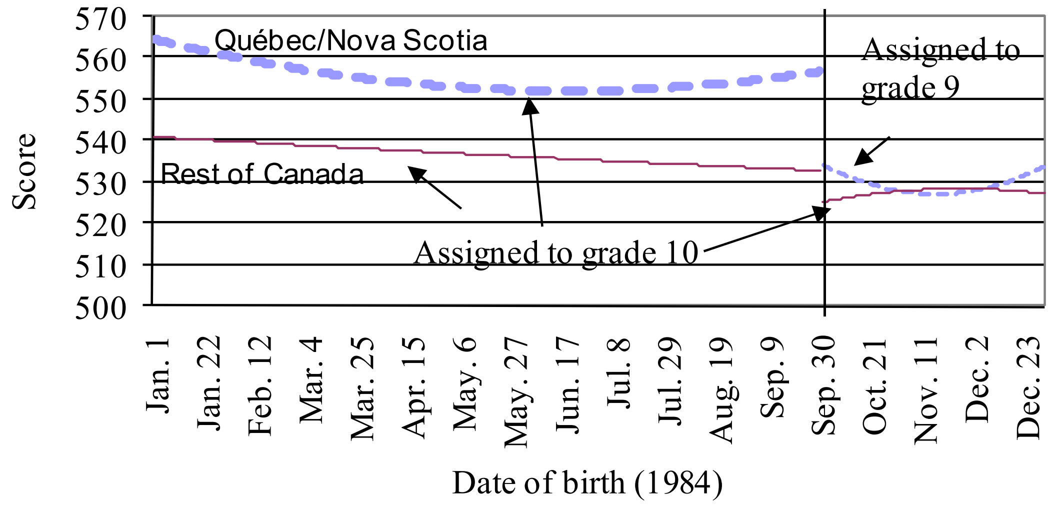
Québec and Nova Scotia. Their school system might also be very different than those in other jurisdictions. One difference evident from Table 4.1 is the higher test scores among this sample of students. Further analysis suggests this is entirely related to Québec students. Why students from Québec have above average test scores is not clear. Using the same data, Willms (2004) notes that scores in Québec were above average despite the fact that socio-economic characteristics are generally weaker in that province. This may suggest that the education system is more effective in Québec than in the rest of the country. However, on thing to keep in mind is that most Quebec students wrote the tests in French, as opposed to English in the rest of the country. Unfortunately, there is no way to decipher whether this had an impact on test scores.

In any event, the key point from the above discussion is that the results to follow are specific to the sample studied here and no inferences should be made on the broader population of students. This does not invalidate the results (i.e. they are still relevant for the sample at hand); it simply means that different results might be obtained with youth from other jurisdictions.

4.5 Descriptive results

I begin the results portion of the chapter with descriptive evidence of the impact of schooling on academic performance. First, I look at academic performance around the point of discontinuity. Figure 4.4 depicts the overall reading score by exact date of birth for students attending school in Nova Scotia and Québec (denoted by the dashed line) and those attending school in the rest of Canada (denoted by the solid line). Separate OLS regression quadratic trend lines are estimated for each region before and after the school entry cut-off date (September 30). Students born in Nova Scotia and Québec after September 30 are usually in grade 9, while those born prior to October 1 are usually in grade 10. In other provinces, they are usually in grade 10 regardless of their date of birth.

Figure 4.4: Reading scores by date of birth



Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.

Prior to October, there is a slight downward trend in Nova Scotia and Québec, as well as in the rest of Canada. Starting in October, there is a clear dip in reading scores in Nova Scotia and Québec. Do reading scores fall suddenly among students born in October or later in other provinces (where students are usually in grade 10)? According to Figure 4.4, there is little evidence of this. A small dip is noted, but it pales in comparison to the dip registered in Nova Scotia and Québec. This suggests that the dip that occurs between September and October birthdays in Nova Scotia and Québec is likely not related to nature. Results for the other tests appear in Figures A4.3.1 to A.4.3.5 in Appendix A4.3. Similar results are noted in interpreting and reflecting scores. Smaller effects are evident in mathematics, while in retrieving and science, there is little or no effect. Also in Appendix A4.3, I show the data without smoothing, as means by date of birth (Figures A4.3.6 for Québec and Nova Scotia and Figure A4.3.7 for the rest of Canada). While a noticeable dip appears between September and October for the Québec/Nova Scotia sample, the rest of Canada sample displays a flat trend.

The problem with the regression discontinuity approach is one of compliance. Not all students initially assigned to a grade will be in that grade. As a result, the 'dip' in test scores we observed in Figure 4.4 is not necessarily associated with exactly one less school grade.

To begin addressing this point, I show mean standardized academic scores by observed school grade in Table 4.2. As the observed grade rises, so too does the mean test score. This is true in a monotonic sense (i.e. scores rise for every additional school grade), and it holds true for each of the six test scores.

Table 4.2: Means of outcome variables by school grade

	School grade			
Standardized test score	8	9	10	11
Reading	-1.315	-0.445	0.269	0.854
Retrieving	-1.116	-0.375	0.229	0.593
Interpreting	-1.135	-0.407	0.242	0.856
Reflecting	-1.221	-0.352	0.222	0.636
Mathematics	-1.098	-0.441	0.253	0.642
Science	-1.217	-0.291	0.196	0.406
N - reading sample	142	1,842	3,488	35
N - mathematics sample	74	1,036	1,943	21
N - science sample	77	1,022	1,908	18

Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Although one could easily derive interpretable estimates of the impact of schooling on academic performance from Table 4.2, those estimates would likely suffer from ‘selection into the treatment bias’ (i.e. the observed school grade may be allocated based on performance). This section addresses this point in the tables to follow. Another point concerns the separability of school and age effects. The econometric section will deal with this point by introducing age controls.

Rather than focus on observed grade, I now turn to the school grade initially assigned (Table 4.3). The differences shown below are likely to be estimated correctly since the school grade initially assigned is more likely to be random than the observed school grade. However, as with the regression discontinuity analysis in Figure 4.4, the interpretation is not clear. Nevertheless, the finding is qualitatively the same: test scores improve in all six areas.

Table 4.3: Means of outcome variables by school grade initially assigned

	School grade initially assigned		
Standardized test score	9	10	Δ
Reading	-0.243	0.078	0.321
Retrieving	-0.206	0.066	0.273
Interpreting	-0.222	0.071	0.293
Reflecting	-0.189	0.061	0.250
Mathematics	-0.233	0.075	0.308
Science	-0.178	0.056	0.234
N - reading sample	1,461	4,046	
N - mathematics sample	826	2,248	
N - science sample	792	2,233	

Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

In Table 4.4, I show the mean differences in observed school grade by the school grade initially assigned for the three samples (reading, mathematics, and science). These differences can be used to adjust the estimates in Table 4.3 to obtain estimates in the unit of the treatment variable (i.e. the observed school grade). Note that, on average, one additional assigned school grade is associated with almost one additional observed school grade (about 0.86 to 0.87).

Table 4.4: Mean school grade by the school grade initially assigned

School grade	School grade initially assigned 9	10	Δ
Reading sample	8.976	9.843	0.867
Mathematics sample	8.990	9.848	0.858
Science sample	8.969	9.841	0.872
N - reading sample	1,461	4,046	
N - mathematics sample	826	2,248	
N - science sample	792	2,233	

Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Combining all of this information, we can derive Wald estimates (Table 4.5). The results suggest that one additional school grade is associated with an additional 0.370 standard deviations (henceforth, 'SD') in reading, 0.359 SD in mathematics, and 0.268 SD in science. Results for reading and mathematics are statistically significant at 1%, while those for science are only significant at 10%.

Table 4.5: Wald estimates

	School grade initially assigned					
	9		10			
Standardized test score	Mean	s.e.	Mean	s.e.	Wald	s.e.
Reading	-0.243	0.027	0.078	0.015	0.370 ***	0.045
Retrieving	-0.206	0.027	0.066	0.015	0.315 **	0.048
Interpreting	-0.222	0.027	0.071	0.015	0.338 ***	0.047
Reflecting	-0.189	0.027	0.061	0.015	0.289 **	0.045
Mathematics	-0.233	0.001	0.075	0.000	0.359 ***	0.045
Science	-0.178	0.001	0.056	0.000	0.268 *	0.066
Average grade - reading sample	8.976		9.843			
Average grade - mathematics sample	8.990		9.848			
Average grade - science sample	8.969		9.841			
N - reading sample	1,461		4,046			
N - mathematics sample	826		2,248			
N - science sample	792		2,233			

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

The conclusions drawn from these findings must be interpreted with some degree of caution. Many factors enter into the education production function, none of which were taken into account in the descriptive analysis (except for broad age group). In Table 4.6, I show the means of student characteristics used in the analysis by school grade initially assigned for the reading sample.

Table 4.6: Means of explanatory variables by school grade initially assigned

	School grade initially assigned			
	9	10	Δ	s.e.
Age of the youth	15.127	15.616	0.488 ***	0.004
Birth order	1.492	1.485	-0.007	0.026
Age of parent most knowledgeable of youth	43.504	43.896	0.392 **	0.178
Parent with no postsecondary certificate	0.404	0.384	-0.021	0.018
Parent with a non-university postsecondary certificate	0.363	0.371	0.008	0.017
Parent with a bachelor's degree	0.158	0.170	0.011	0.015
Parent with a graduate or professional degree	0.074	0.076	0.002	0.009
Equivalent total parental income	33,071	31,916	-1,154	1,342
One parent present	0.200	0.173	-0.027	0.016
Two parents present, at least one not from birth	0.119	0.121	0.002	0.014
Two birth parents present	0.681	0.706	0.025	0.019
Female	0.475	0.504	0.028	0.019
Related course	0.974	0.986	0.012 *	0.007
Québec	0.848	0.872	0.025 *	0.013
N	1,461	4,046		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

It is not clear why there would be any difference in characteristics by birthday. However, with small surveys, sampling variation may result in some differences. Although most differences are quite small, some are statistically significant. For obvious reasons, the mean age is higher among students initially assigned to grade 10. Likewise, the mean age of the parent most knowledgeable of the child is higher among students initially assigned to grade 10. Some smaller, significant differences exist as well. For example, students assigned to grade 10 are less likely to have only one parent present in the home, and more likely to have two birth parents present. They are also slightly more likely to be female, to be taking a course related to reading, and to reside in Québec. Since these differences may matter in determining academic performance, they are taken into account in the econometric analysis to follow.

4.6 Econometric results

OLS approach

I begin the econometric section with results from OLS. In Tables 4.7a and 4.7b, the estimated association between one year of schooling and the test scores is close to one full standard deviation in some cases. This is very large in comparison to the Wald estimates presented in the previous section. The reason is that the observed school grade is very likely to be endogenously chosen by students, parents, or schools.

In terms of the control variables, the results are also worth mentioning. The age of the student is negatively related to performance, although this might be due to a high correlation with the school grade variable. The effect of the latter is not properly identified at this point. In the IV results to follow, the student age effects are no longer statistically significant.

The test scores generally decline more or less monotonically with the order of birth. The age of the parent most knowledgeable is not linked to the academic performance of the youth. The socio-economic background of the child matters. Those with higher educated parents and those from more well-to-do families (proxied by parental income) generally perform better. In terms of parental presence, youth from reconstituted families (two parents, at least one not from birth) generally perform worse than other groups of youth, although results are not always statistically significant.

Girls perform better than boys in all areas of reading; however, they perform worse than boys in mathematics, although the gap is smaller than the one registered in reading. In science, the gap is small and not statistically significant. Not surprisingly, students who are currently taking a course related to the test subject generally perform better. Finally, students in Québec outperform those in Nova Scotia, in general.

Table 4.7a: OLS regressions of standardized test scores on the school grade

	Reading		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.869 ***	0.034	0.823 ***	0.042	0.636 ***	0.055
Age of the youth	-44.278 ***	6.077	-40.076 ***	7.060	-42.110 ***	10.054
Age of the youth^2	1.410 ***	0.196	1.278 ***	0.228	1.348 ***	0.324
Second born	-0.128 ***	0.038	-0.063	0.045	-0.106 **	0.050
Third born	-0.214 ***	0.059	-0.068	0.087	-0.226 ***	0.076
Fourth born	-0.134	0.115	-0.087	0.158	-0.371 ***	0.126
Fifth born	-0.394	0.427	0.794 **	0.389	-0.689	0.795
Sixth born	-0.508	1.029	-1.227 **	0.614	0.574 **	0.293
Age of parent most knowledgeable of youth	-0.006	0.033	0.023	0.044	-0.008	0.036
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.149 ***	0.027	0.186 ***	0.047	0.164 ***	0.048
Parent with a bachelor's degree	0.342 ***	0.042	0.238 ***	0.071	0.262 ***	0.067
Parent with a graduate or professional degree	0.447 ***	0.052	0.417 ***	0.116	0.292 ***	0.098
Equivalent total parental income	0.037 ***	0.010	0.033	0.022	0.055 **	0.022
Equivalent total parental income^2	-0.001 *	0.000	-0.001	0.001	-0.001	0.001
Two parents present, at least one not from birth	-0.127 **	0.056	-0.073	0.064	-0.115	0.104
Two birth parents present	-0.058	0.037	0.017	0.048	-0.127 *	0.069
Female	0.276 ***	0.027	-0.212 ***	0.036	-0.064	0.045
Related course	0.492 ***	0.128	0.420 ***	0.147	0.500 ***	0.108
Québec	0.389 ***	0.035	0.655 ***	0.049	0.429 ***	0.042
Intercept	337.824 ***	46.987	304.495 ***	54.397	321.712 ***	77.916
Adjusted R^2	0.269		0.246		0.173	
N	5,507		3,074		3,025	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.7b: OLS regressions of standardized test scores on the school grade - Reading sub-components

	Retrieving		Interpreting		Reflecting	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.732 ***	0.035	0.796 ***	0.034	0.720 ***	0.034
Age of the youth	-36.646 ***	6.988	-36.615 ***	5.803	-38.573 ***	6.426
Age of the youth^2	1.168 ***	0.225	1.163 ***	0.187	1.230 ***	0.207
Second born	-0.122 ***	0.041	-0.111 ***	0.037	-0.087 **	0.039
Third born	-0.163 ***	0.059	-0.176 ***	0.065	-0.204 ***	0.067
Fourth born	-0.012	0.109	-0.170	0.125	-0.092	0.104
Fifth born	-0.269	0.524	-0.087	0.334	-1.107	0.796
Sixth born	-0.541	0.864	-0.540	0.631	-0.430	1.183
Age of parent most knowledgeable of youth	0.009	0.026	-0.022	0.035	-0.019	0.041
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.122 ***	0.034	0.137 ***	0.026	0.108 ***	0.031
Parent with a bachelor's degree	0.246 ***	0.046	0.324 ***	0.040	0.261 ***	0.040
Parent with a graduate or professional degree	0.426 ***	0.068	0.461 ***	0.055	0.259 ***	0.051
Equivalent total parental income	0.027 **	0.013	0.035 ***	0.011	0.030 ***	0.011
Equivalent total parental income^2	-0.001	0.000	-0.001 **	0.000	0.000	0.000
Two parents present, at least one not from birth	-0.096	0.066	-0.102 *	0.058	-0.165 ***	0.049
Two birth parents present	-0.035	0.039	-0.080 **	0.038	-0.028	0.041
Female	0.099 ***	0.030	0.226 ***	0.028	0.359 ***	0.027
Related course	0.410 ***	0.135	0.459 ***	0.121	0.387 ***	0.117
Québec	0.330 ***	0.038	0.414 ***	0.032	0.207 ***	0.034
Intercept	279.079 ***	54.073	279.682 ***	44.981	294.769 ***	49.719
Adjusted R^2	0.177		0.226		0.196	
N	5,507		5,507		5,507	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

IV approach

To account for the endogenous selection of the school grade, I adopt an IV approach. Specifically, I instrument the observed school grade with the initially assigned school grade, based on the school entry laws in Québec and Nova Scotia and the exact date of birth.

In Table 4.8, I show the first-stage regression results. The findings suggest a very strong association between the initially assigned school grade and the actual school grade. The coefficients are above 0.7 for each sample. The F-statistic is very high in each case: 185 is the lowest value (in the mathematics sample).

Table 4.8: First-stage regression of the school grade on the school grade initially assigned and other controls

	Reading sample			Mathematics sample			Science sample		
	b		s.e.	b		s.e.	b		s.e.
School grade initially assigned	0.747	**	0.043	0.713	**	0.052	0.795	**	0.053
Age of the youth	2.340		4.037	4.221		5.781	-0.342		5.022
Age of the youth^2	-0.069		0.129	-0.128		0.185	0.015		0.161
Second born	0.007		0.014	0.004		0.019	0.015		0.019
Third born	-0.037		0.034	-0.019		0.039	-0.048		0.046
Fourth born	0.032		0.052	0.015		0.065	0.028		0.081
Fifth born	-0.493		0.354	0.024		0.025	-0.566		0.387
Sixth born	0.084		0.079	0.193	*	0.101	-0.032		0.038
Age of parent most knowledgeable of youth	0.018		0.015	0.002		0.019	0.033		0.020
Age of parent most knowledgeable of youth^2	0.000		0.000	0.000		0.000	0.000		0.000
Parent with a non-university PS certificate	0.075	**	0.016	0.076	**	0.023	0.108	**	0.022
Parent with a bachelor's degree	0.121	**	0.023	0.104	**	0.033	0.139	**	0.027
Parent with a graduate or professional degree	0.174	**	0.026	0.188	**	0.028	0.196	**	0.036
Equivalent total parental income	0.026	**	0.006	0.030	**	0.009	0.015	**	0.007
Equivalent total parental income^2	-0.001	**	0.000	-0.001		0.001	0.000		0.000
Two parents present, at least one not from birth	-0.094	**	0.031	-0.094	**	0.042	-0.101	**	0.042
Two birth parents present	0.006		0.021	0.007		0.032	0.016		0.028
Female	0.070	**	0.014	0.078	**	0.018	0.063	**	0.017
Related course	0.099		0.068	0.102		0.082	0.276	**	0.071
Québec	-0.062	**	0.015	-0.057	**	0.017	-0.051	**	0.020
Intercept	-18.094		31.175	-32.311		44.634	2.299		38.858
F-statistic	300.938			185.230			224.310		
Adjusted R^2	0.478			0.477			0.491		
N	5,507			3,074			3,025		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

The second stage IV results appear below in Tables 4.9a and 4.9b. These are considered the preferred estimates. In terms of reading, one additional year of schooling is associated with an increase of 0.419 SD (significant at 1%). Among the sub-components of reading, the effect of schooling is largest in interpreting (0.480 SD, significant at 1%) and smallest in reflecting (0.249 SD, significant at 5%). Mathematics scores also improve with an additional year of schooling (by 0.298 SD, significant at 5%), as do science scores (by 0.265 SD, significant at 10%). Note that the significance levels falls from 1% for reading, to 5% for mathematics, to 10% for science. Thus, at best, the evidence for science performance is weak

Table 4.9a: IV regressions of standardized test scores on the school grade

	Reading		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.419 ***	0.119	0.298 **	0.133	0.265 *	0.151
Age of the youth	-14.060	9.906	-5.863	12.141	-16.737	13.748
Age of the youth^2	0.451	0.316	0.192	0.388	0.541	0.440
Second born	-0.127 ***	0.039	-0.060	0.046	-0.102 **	0.051
Third born	-0.218 ***	0.061	-0.077	0.089	-0.236 ***	0.080
Fourth born	-0.101	0.115	-0.053	0.172	-0.363 ***	0.131
Fifth born	-0.585	0.423	0.772 **	0.380	-0.869	0.720
Sixth born	-0.455	0.985	-1.088 **	0.544	0.561 *	0.287
Age of parent most knowledgeable of youth	0.006	0.033	0.030	0.046	0.006	0.036
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.001	0.000	0.000
Parent with a non-university PS certificate	0.184 ***	0.028	0.224 ***	0.051	0.206 ***	0.048
Parent with a bachelor's degree	0.402 ***	0.045	0.298 ***	0.074	0.318 ***	0.074
Parent with a graduate or professional degree	0.523 ***	0.051	0.510 ***	0.120	0.362 ***	0.104
Equivalent total parental income	0.048 ***	0.010	0.049 **	0.024	0.059 **	0.024
Equivalent total parental income^2	-0.001 **	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.165 ***	0.059	-0.121	0.074	-0.149	0.106
Two birth parents present	-0.053	0.037	0.020	0.053	-0.116 *	0.069
Female	0.309 ***	0.028	-0.166 ***	0.039	-0.038	0.047
Related course	0.536 ***	0.139	0.457 ***	0.157	0.606 ***	0.127
Québec	0.362 ***	0.038	0.628 ***	0.053	0.412 ***	0.044
Intercept	104.058	76.670	40.001	93.623	125.323	106.617
Adjusted R^2	0.232		0.197		0.147	
N	5,507		3,074		3,025	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.9b: IV regressions of standardized test scores on the school grade - Reading sub-components

	Retrieving		Interpreting		Reflecting	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.292 **	0.117	0.480 ***	0.129	0.249 **	0.108
Age of the youth	-7.115	9.760	-15.392	10.810	-6.964	9.452
Age of the youth^2	0.230	0.312	0.489	0.345	0.226	0.302
Second born	-0.121 ***	0.040	-0.111 ***	0.038	-0.086 **	0.041
Third born	-0.167 ***	0.060	-0.179 ***	0.067	-0.209 ***	0.069
Fourth born	0.021	0.116	-0.146	0.121	-0.057	0.105
Fifth born	-0.456	0.503	-0.222	0.358	-1.307 *	0.672
Sixth born	-0.490	0.821	-0.504	0.598	-0.375	1.139
Age of parent most knowledgeable of youth	0.020	0.027	-0.014	0.036	-0.006	0.040
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.156 ***	0.036	0.161 ***	0.026	0.145 ***	0.030
Parent with a bachelor's degree	0.304 ***	0.051	0.366 ***	0.043	0.323 ***	0.043
Parent with a graduate or professional degree	0.500 ***	0.067	0.514 ***	0.055	0.338 ***	0.057
Equivalent total parental income	0.039 ***	0.013	0.043 ***	0.010	0.043 ***	0.011
Equivalent total parental income^2	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000
Two parents present, at least one not from birth	-0.134 *	0.070	-0.129 **	0.057	-0.206 ***	0.053
Two birth parents present	-0.031	0.040	-0.077 **	0.038	-0.023	0.040
Female	0.131 ***	0.033	0.248 ***	0.028	0.393 ***	0.028
Related course	0.453 ***	0.141	0.489 ***	0.130	0.433 ***	0.127
Québec	0.303 ***	0.041	0.395 ***	0.034	0.178 ***	0.037
Intercept	50.626	75.486	115.506	83.740	50.246	73.177
Adjusted R^2	0.141		0.207		0.154	
N	5,507		5,507		5,507	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Cascio and Lewis (2006) also provide estimates in standard deviation units, albeit only by ethnicity and for general performance. Nevertheless, they generally find that an additional year of schooling boosts academic performance by 0.3 to 0.4 standard deviations. These estimates are generally within close range of those provided above in Tables 4.9a and 4.9b.

4.7 Robustness tests

In this section, I subject the preferred results shown in Tables 4.9a and 4.9b to three robustness tests that are commonly applied in the regression discontinuity literature (e.g. Lemieux and Milligan, 2008). First, several age specifications are applied (i.e. no age controls, linear, quadratic, cubic, and quartic). Second, I re-estimate the models without parametric age controls, but on narrower windows around the cut-off date (i.e. +/- three months, +/- two months, and +/- one month). Third, the reduced-form models were estimated in Québec and Nova Scotia, as well as in the rest of Canada (where the cut-off dates hold no special significance). The main coefficients from these models appear below in Table 4.10. The full set of regressions results appear in Tables A4.4.1 to A4.4.10 in Appendix A4.4.

Table 4.10: Robustness tests on the IV results

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Alternating the age specification												
No age controls	0.325 ***	0.045	0.279 ***	0.049	0.298 ***	0.047	0.253 ***	0.045	0.327 ***	0.047	0.238 ***	0.062
Linear	0.309 ***	0.074	0.236 ***	0.086	0.360 ***	0.073	0.194 ***	0.070	0.249 ***	0.082	0.141	0.104
Quadratic	0.419 ***	0.119	0.292 **	0.117	0.480 ***	0.129	0.249 **	0.108	0.298 **	0.133	0.265 *	0.151
Cubic	0.422 ***	0.120	0.294 **	0.119	0.488 ***	0.130	0.251 **	0.108	0.311 **	0.133	0.294 *	0.157
Quartic	0.422 ***	0.119	0.295 **	0.118	0.488 ***	0.130	0.253 **	0.109	0.310 **	0.134	0.294 *	0.159
Narrowing the window												
+/-Three months	0.322 ***	0.057	0.255 ***	0.065	0.332 ***	0.058	0.243 ***	0.053	0.257 ***	0.058	0.206 ***	0.078
+/-Two months	0.377 ***	0.078	0.293 ***	0.081	0.395 ***	0.084	0.255 ***	0.066	0.282 ***	0.081	0.195 *	0.106
+/- One month	0.407 ***	0.088	0.265 ***	0.089	0.493 ***	0.106	0.244 ***	0.080	0.332 ***	0.112	0.212 *	0.128
Falsification tests (reduced form impact of cut-off date)												
Québec/Nova Scotia	0.314 ***	0.096	0.219 **	0.092	0.359 ***	0.104	0.186 **	0.083	0.213 **	0.100	0.211 *	0.125
Rest of Canada	0.028	0.048	0.072	0.050	0.010	0.050	0.024	0.054	0.020	0.069	0.080	0.066

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

With regards to the first two robustness tests, we observe that schooling is still generally associated with significant improvements in tests scores. However, results for science are not always significant. For the third robustness test, note that being born prior to the Québec/Nova Scotia cut-off date is generally associated with a large improvement in tests scores in those provinces, but it has virtually no impact in the rest of Canada. This suggests that the cut-off date is not picking up some sort of naturally occurring discontinuity.

4.8 Heterogeneity in the results

For whom does academic performance improve the most with additional schooling? I examine this question along three important dimensions: the conditional distribution of academic performance, sex, and parental income. Examining results along the conditional distribution of academic performance is important since it suggests the extent to which the (largely public) school system works towards reducing variability in performance across students, and thus, variability in life opportunities. Why examine results by sex and parental income? One reason is that it is already well-documented that girls perform better than boys on standardized reading tests (e.g. Frenette and Zeman, 2009) and that reading, mathematics, and science performance improve with parental income (e.g. Frenette, 2009a). However, it is not so well understood why these gaps exist in the first place. Is it because girls and high income youth benefit more from the schooling system? Alternatively, is it the case that girls and high income youth have access to better parental resources? This section will help shed some light on the observed gaps by examining the role of additional schooling on reading, mathematics, and science performance along the sex and parental income dimensions.

<u>Results across the conditional distribution of academic performance</u>

This section looks at results across the conditional distribution of academic performance. To do so, I estimate quantile regressions in an IV framework (as described in Appendix A4.5). Briefly, OLS regression estimates the impact of a variable on the conditional mean of the outcome (i.e. it shows the relationship between the explanatory variables and the mean value of the outcome, conditional on the control variables). If one suspects that the impact is not the same for everyone, then estimating a quantile regression may be useful. The quantile regression simply estimates the relationship between the explanatory variables and the value of the outcome at a particular quantile of the distribution, conditional on the control variables.

In the present context, I use quantile IV regression to estimate the impact that schooling has on shaping the distribution of academic performance. I do so by estimating quantile regressions at every 10^{th} percentile, less the extremes (i.e. 0.1, 0.2, …, 0.9). The approach I use (Quantile Treatment Effects, or QTE, for IV) was developed by Abadie, Angrist, and Imbens (2002), which is appropriate for binary assignment and treatment variables. Until now, I have used continuous assignment and treatment variables (i.e. assigned grade and actual grade), but these can be easily dichotomized by setting a cut-off between grades 9 and 10 (i.e. the assignment binary variable is set to 1 if grade 10 is assigned, while the treatment binary variable is set to 1 if the actual grade is 10 or above). Since this changes the metric slightly (i.e. we are now estimating the impact of being in grade 10 or above, relative to being in grade 9 or below), I re-run the two-stage least squares IV using this approach to facilitate comparisons with the quantile estimates. The results of this exercise appear in Tables 4.11a and 4.11b.

Table 4.11a: Quantile Treatment Effects (QTE) for IV regression of standardized test scores on being in grade 10 or above

	Reading			Mathematics			Science		
	b		s.e.	b		s.e.	b		s.e.
IV	0.612	***	0.048	0.476	***	0.061	0.421	***	0.076
QTE for IV									
10th	0.658	***	0.066	0.482	***	0.069	0.591	***	0.078
20th	0.617	***	0.049	0.544	***	0.067	0.611	***	0.054
30th	0.626	***	0.049	0.520	***	0.055	0.597	***	0.040
40th	0.650	***	0.048	0.538	***	0.049	0.621	***	0.051
50th	0.618	***	0.057	0.495	***	0.044	0.629	***	0.055
60th	0.548	***	0.055	0.510	***	0.060	0.608	***	0.057
70th	0.599	***	0.055	0.519	***	0.066	0.645	***	0.067
80th	0.590	***	0.078	0.451	***	0.077	0.658	***	0.067
90th	0.587	***	0.135	0.434	***	0.108	0.762	***	0.117

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.11b: Quantile Treatment Effects (QTE) for IV regression of standardized test scores on being in grade 10 or above - Reading sub-components

	Retrieving			Interpreting			Reflecting		
	b		s.e.	b		s.e.	b		s.e.
IV	0.459	***	0.046	0.652	***	0.051	0.413	***	0.051
QTE for IV									
10th	0.739	***	0.067	0.576	***	0.074	0.708	***	0.074
20th	0.680	***	0.051	0.612	***	0.061	0.633	***	0.054
30th	0.642	***	0.047	0.593	***	0.053	0.582	***	0.045
40th	0.628	***	0.052	0.583	***	0.049	0.619	***	0.052
50th	0.623	***	0.064	0.582	***	0.051	0.634	***	0.054
60th	0.579	***	0.052	0.617	***	0.057	0.638	***	0.057
70th	0.646	***	0.060	0.644	***	0.069	0.682	***	0.070
80th	0.608	***	0.095	0.562	***	0.092	0.749	***	0.081
90th	0.663	***	0.135	0.543	***	0.101	0.849	***	0.116

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

First, note that the regular IV effects are somewhat larger than what was found earlier. This is expected as we are now estimating the impact of being in grade 10 or above, relative to being in grade 9 or below. Earlier, we estimated the impact of one additional school grade. More importantly, the QTE for IV results suggest that there is little evidence of substantial heterogeneity in the effects. The point estimates are not very different across the conditional distribution of academic performance for all test scores. There are some exceptions (e.g. at the 10^{th} and 90^{th} percentiles), but in general, the estimates are similar across most of the distribution. In other words, there is little evidence that additional schooling benefits youth of certain performance levels more so than others.

<u>Results by sex</u>

We now examine results by sex. Here, we go back to the two-stage least squares (IV) approach. In Tables 4.12a and 4.12b, results are shown for males, while in Tables 4.13a and 4.13b, results for females are shown. The results suggest that males benefit from additional schooling in all areas, except in retrieving and in science (at least not in a statistical sense). Females benefit in reading only—mathematics and science results are not statistically significant.

Table 4.12a: IV regressions of standardized test scores on the school grade - Males

	Reading			Mathematics			Science		
	b		s.e.	b		s.e.	b		s.e.
School grade	0.327	***	0.117	0.365	**	0.157	0.299		0.194
Age of the youth	-2.844		10.710	-9.864		13.815	-20.867		20.737
Age of the youth^2	0.091		0.343	0.323		0.442	0.674		0.664
Second born	-0.112	**	0.056	-0.044		0.063	-0.106	*	0.064
Third born	-0.236	***	0.079	-0.135		0.136	-0.329	***	0.107
Fourth born	-0.193		0.177	-0.113		0.276	-0.411	*	0.226
Fifth born	-0.443		0.336	--		--	-0.632		0.965
Sixth born	-0.393		0.980	-1.124	**	0.567	0.674	*	0.350
Age of parent most knowledgeable of youth	-0.013		0.042	-0.001		0.070	-0.002		0.055
Age of parent most knowledgeable of youth^2	0.000		0.000	0.000		0.001	0.000		0.001
Parent with a non-university PS certificate	0.158	***	0.046	0.272	***	0.076	0.200	***	0.072
Parent with a bachelor's degree	0.374	***	0.067	0.298	***	0.098	0.206	**	0.101
Parent with a graduate or professional degree	0.492	***	0.078	0.519	***	0.162	0.300	*	0.153
Equivalent total parental income	0.057	**	0.026	0.041		0.042	0.083	***	0.028
Equivalent total parental income^2	-0.001		0.002	-0.001		0.003	-0.002		0.002
Two parents present, at least one not from birth	-0.302	***	0.079	-0.199	*	0.115	-0.157		0.146
Two birth parents present	-0.105	**	0.049	0.037		0.083	-0.149		0.108
Related course	0.652	***	0.215	0.380	*	0.200	0.619	***	0.156
Québec	0.388	***	0.049	0.647	***	0.072	0.418	***	0.059
Intercept	17.824		82.924	70.645		106.337	157.506		161.052
Adjusted R^2	0.199			0.212			0.145		
N	2,773			1,555			1,541		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of males born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.12b: IV regressions of standardized test scores on the school grade - Males, reading sub-components

	Retrieving		Interpreting		Reflecting	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.228	0.148	0.344 ***	0.133	0.251 *	0.141
Age of the youth	5.812	11.996	-3.004	12.183	-4.982	11.915
Age of the youth^2	-0.186	0.384	0.093	0.390	0.164	0.381
Second born	-0.090	0.058	-0.095 *	0.056	-0.098 *	0.057
Third born	-0.117	0.081	-0.216 **	0.087	-0.253 ***	0.087
Fourth born	-0.123	0.183	-0.156	0.198	-0.077	0.219
Fifth born	-0.262	0.474	-0.077	0.156	-1.485	1.057
Sixth born	-0.415	0.832	-0.459	0.587	-0.337	1.124
Age of parent most knowledgeable of youth	0.031	0.043	-0.041	0.046	-0.039	0.052
Age of parent most knowledgeable of youth^2	0.000	0.000	0.001	0.000	0.000	0.001
Parent with a non-university PS certificate	0.134 **	0.055	0.183 ***	0.045	0.067	0.051
Parent with a bachelor's degree	0.292 ***	0.069	0.348 ***	0.067	0.276 ***	0.070
Parent with a graduate or professional degree	0.476 ***	0.099	0.516 ***	0.078	0.267 ***	0.087
Equivalent total parental income	0.045 **	0.019	0.057 **	0.027	0.044	0.027
Equivalent total parental income^2	-0.001	0.001	-0.001	0.002	-0.001	0.002
Two parents present, at least one not from birth	-0.224 **	0.096	-0.268 ***	0.081	-0.333 ***	0.089
Two birth parents present	-0.082	0.054	-0.116 **	0.051	-0.057	0.065
Related course	0.614 ***	0.213	0.608 ***	0.200	0.391 *	0.200
Québec	0.355 ***	0.054	0.417 ***	0.046	0.191 ***	0.049
Intercept	-49.513	92.819	20.438	94.525	35.339	92.417
Adjusted R^2	0.134		0.182		0.120	
N	2,773		2,773		2,773	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of males born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.13a: IV regressions of standardized test scores on the school grade - Females

	Reading		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.
School grade initially assigned	0.493 ***	0.172	0.227	0.188	0.224	0.204
Age of the youth	-23.940	15.543	-2.955	17.294	-11.656	17.838
Age of the youth^2	0.768	0.497	0.096	0.554	0.378	0.572
Second born	-0.148 ***	0.046	-0.060	0.057	-0.096	0.072
Third born	-0.208 **	0.085	-0.024	0.122	-0.086	0.130
Fourth born	-0.068	0.155	-0.012	0.192	-0.392 **	0.165
Fifth born	-0.843	0.761	0.855 **	0.422	-1.332 *	0.700
Sixth born	--	--	--	--	--	--
Age of parent most knowledgeable of youth	0.028	0.042	0.050	0.046	0.034	0.050
Age of parent most knowledgeable of youth^2	0.000	0.000	-0.001	0.000	0.000	0.001
Parent with a non-university PS certificate	0.215 ***	0.042	0.185 ***	0.065	0.209 ***	0.071
Parent with a bachelor's degree	0.438 ***	0.061	0.316 ***	0.094	0.443 ***	0.098
Parent with a graduate or professional degree	0.559 ***	0.085	0.501 ***	0.146	0.426 ***	0.152
Equivalent total parental income	0.041 ***	0.014	0.048	0.032	0.032	0.039
Equivalent total parental income^2	-0.001 *	0.000	-0.001	0.002	-0.001	0.003
Two parents present, at least one not from birth	-0.044	0.075	-0.042	0.111	-0.121	0.114
Two birth parents present	-0.008	0.053	0.007	0.074	-0.074	0.079
Related course	0.371 *	0.198	0.581 **	0.267	0.560 ***	0.174
Québec	0.334 ***	0.050	0.613 ***	0.066	0.404 ***	0.061
Intercept	180.213	119.856	17.976	133.264	85.437	138.007
Adjusted R^2	0.215		0.163		0.149	
N	2,734		1,519		1,484	

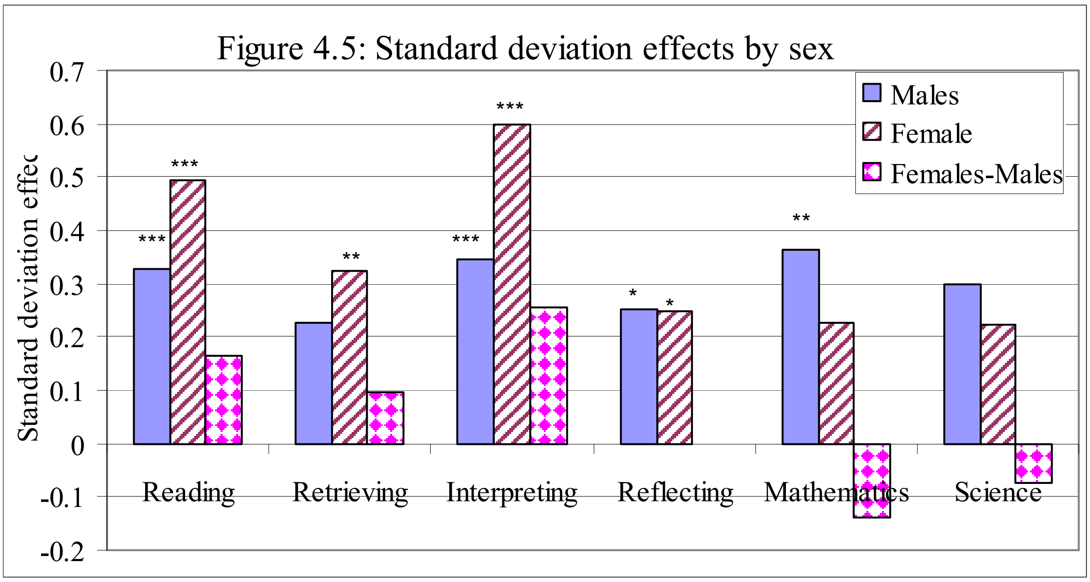
Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of females born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.13b: IV regressions of standardized test scores on the school grade - Females, reading sub-components

	Retrieving			Interpreting			Reflecting		
	b		s.e.	b		s.e.	b		s.e.
School grade initially assigned	0.325	**	0.165	0.599	***	0.181	0.250	*	0.141
Age of the youth	-17.261		15.223	-26.639	*	15.278	-10.042		14.151
Age of the youth^2	0.558		0.487	0.849	*	0.489	0.323		0.453
Second born	-0.161	***	0.051	-0.126	***	0.044	-0.076		0.046
Third born	-0.241	***	0.081	-0.142		0.093	-0.165	*	0.091
Fourth born	0.080		0.167	-0.171		0.142	-0.038		0.147
Fifth born	-0.823		0.843	-0.393		0.667	-1.094	**	0.516
Sixth born	--		--	--		--	--		--
Age of parent most knowledgeable of youth	0.006		0.030	0.020		0.045	0.033		0.043
Age of parent most knowledgeable of youth^2	0.000		0.000	0.000		0.000	0.000		0.000
Parent with a non-university PS certificate	0.184	***	0.051	0.144	***	0.039	0.227	***	0.046
Parent with a bachelor's degree	0.330	***	0.071	0.394	***	0.058	0.373	***	0.065
Parent with a graduate or professional degree	0.539	***	0.093	0.516	***	0.096	0.406	***	0.088
Equivalent total parental income	0.033	*	0.019	0.033	**	0.014	0.039	**	0.017
Equivalent total parental income^2	-0.001		0.001	-0.001	*	0.000	-0.001		0.001
Two parents present, at least one not from birth	-0.048		0.086	-0.016		0.081	-0.083		0.070
Two birth parents present	0.022		0.059	-0.047		0.056	0.002		0.052
Related course	0.196		0.210	0.316	*	0.182	0.521	**	0.203
Québec	0.253	***	0.052	0.369	***	0.047	0.169	***	0.051
Intercept	129.519		117.588	201.860	*	117.776	73.885		109.219
Adjusted R^2	0.133			0.194			0.120		
N	2,734			2,734			2,734		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of females born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

The fact that mathematics scores improve with additional schooling for males, but not necessarily for females is interesting. However, as Figure 4.5 suggests, this difference is not statistically significant. In fact, no differences are significant.



Notes: ***=1% significance; **=5% significance; *=10% significance. The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

If schooling (at the secondary level) is not contributing towards the gender divide in reading, then what is? One candidate explanation is that gender differences are shaped earlier in the school system. One possible reason for this is that in elementary school, 83% of teachers are female (Statistics Canada's Census, 2001), and being taught by a teacher of the same sex has been shown to benefit students (e.g. Dee, 2007). In high school, only 54% of teachers are female (Statistics Canada's Census, 2001), which may explain why girls don't benefit more from grade 10 in reading. Other possible reasons why girls outperform boys in reading include different experiences in the home (e.g. differential treatment of boys and girls by the parents), or differences that are present at birth. Frenette and Zeman (2009) list several physical, developmental, and behavioural fronts upon which boys face challenges relative to girls in early childhood. For example, relative to girls, boys face higher infant mortality and hospitalization rates, fare more poorly on copying and symbol use tests, display less independence in dressing, and have weaker attention spans and more aggressive behaviour.

Returning to the gender composition of teachers in high school, we might expect that high school would tend to improve mathematics scores for boys more than for girls. This is especially so if most high school mathematics teachers are men. However, this is not the case. In French Québec, 59% of mathematics teachers of 16 year olds are female, while in English Nova Scotia, the number stands at 46% (Council of Ministers of Education, Canada, 2001). Note that almost all of Québec is French speaking, while almost all of Nova Scotia is English speaking.

<u>Results by parental income</u>

The other dimension I examine is parental income. In this case, I have selected youth in the top and bottom quartiles of the income distribution. In Tables 4.14a and 4.14b, I show results for the bottom quartile, while in Tables 4.15a and 4.15b, results appear for the top quartile. Note that sample sizes become smaller since I drop 50% of the population (i.e. those in the middle) in order to focus on the most and least privileged youth.

The results generally show that both high and low income youth benefit from the school system, although results are not always significant given the sample sizes. In fact, statistical significance is only achieved for low-income youth. Furthermore, the differences in the estimated effects are never statistically significant (Figure 4.6). Of importance, there is no evidence that higher income youth benefit more from additional schooling than lower income youth, which is in line with Alexander et al. (2001).

Table 4.14a: IV regressions of standardized test scores on the school grade - Bottom income quartile

	Reading			Mathematics			Science		
	b		s.e.	b		s.e.	b		s.e.
School grade	0.480	***	0.169	0.112		0.236	0.396	*	0.209
Age of the youth	-30.343	**	13.340	0.729		19.881	-39.429	**	18.938
Age of the youth^2	0.977	**	0.426	-0.017		0.635	1.275	**	0.606
Second born	-0.168	**	0.079	0.000		0.083	-0.039		0.097
Third born	-0.170	*	0.099	0.036		0.157	0.093		0.145
Fourth born	-0.138		0.213	-0.122		0.178	-0.187		0.235
Fifth born	-1.042	***	0.399	--		--	-1.492	**	0.632
Sixth born	-1.543	**	0.768	-0.913	**	0.464	--		--
Age of parent most knowledgeable of youth	-0.036		0.037	0.016		0.049	-0.025		0.042
Age of parent most knowledgeable of youth^2	0.001		0.000	0.000		0.001	0.000		0.000
Parent with a non-university PS certificate	0.108	*	0.059	0.215	**	0.090	0.149		0.091
Parent with a bachelor's degree	0.395	***	0.093	0.158		0.149	0.399	***	0.136
Parent with a graduate or professional degree	0.756	***	0.196	0.718	***	0.200	0.296		0.297
Equivalent total parental income	-0.096		0.232	-0.176		0.440	0.036		0.274
Equivalent total parental income^2	0.102		0.096	0.096		0.175	0.087		0.113
Two parents present, at least one not from birth	-0.153		0.095	-0.031		0.160	-0.181		0.152
Two birth parents present	-0.071		0.060	-0.017		0.092	-0.210	*	0.108
Female	0.298	***	0.056	-0.117		0.080	0.028		0.083
Related course	0.619	**	0.253	0.569	**	0.255	0.502	***	0.157
Québec	0.377	***	0.056	0.645	***	0.080	0.391	***	0.072
Intercept	230.118	**	103.256	-10.077		153.332	300.079	**	146.704
Adjusted R^2	0.259			0.134			0.172		
N	1,678			965			900		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth in the bottom income quartile who born in Canada, who were within one grade of the usual one for their age, and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.14b: IV regressions of standardized test scores on the school grade - Bottom income quartile, reading sub-components

	Retrieving			Interpreting			Reflecting		
	b		s.e.	b		s.e.	b		s.e.
School grade	0.475	***	0.177	0.630	***	0.163	0.083		0.178
Age of the youth	-44.093	***	13.937	-35.433	***	13.316	0.309		16.702
Age of the youth^2	1.421	***	0.445	1.133	***	0.426	-0.002		0.535
Second born	-0.138	*	0.073	-0.147	**	0.071	-0.132	*	0.079
Third born	-0.194	**	0.095	-0.129		0.095	-0.120		0.118
Fourth born	-0.026		0.239	-0.174		0.218	-0.093		0.171
Fifth born	-1.068	***	0.387	-0.536	**	0.249	-1.970	**	0.864
Sixth born	-1.357	**	0.674	-1.103	**	0.551	-1.683	**	0.838
Age of parent most knowledgeable of youth	-0.039		0.042	-0.031		0.033	-0.053		0.047
Age of parent most knowledgeable of youth^2	0.001		0.000	0.000		0.000	0.001		0.001
Parent with a non-university PS certificate	0.087		0.063	0.070		0.053	0.103		0.065
Parent with a bachelor's degree	0.351	***	0.105	0.341	***	0.101	0.299	***	0.097
Parent with a graduate or professional degree	0.563	***	0.161	0.568	**	0.261	0.802	***	0.198
Equivalent total parental income	0.079		0.242	-0.179		0.238	-0.166		0.235
Equivalent total parental income^2	0.037		0.097	0.115		0.096	0.118		0.095
Two parents present, at least one not from birth	-0.189	**	0.096	-0.023		0.095	-0.271	***	0.105
Two birth parents present	-0.045		0.063	-0.100	*	0.056	-0.027		0.074
Female	0.109	**	0.046	0.238	***	0.059	0.389	***	0.066
Related course	0.531	*	0.291	0.453	**	0.209	0.632	***	0.209
Québec	0.387	***	0.059	0.427	***	0.054	0.096	*	0.051
Intercept	336.714	***	107.819	270.408	***	102.894	-5.082		129.337
Adjusted R^2	0.211			0.244			0.114		
N	1,678			1,678			1,678		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth in the bottom income quartile who born in Canada, who were within one grade of the usual one for their age, and lived in Nova Scotia or Québec. Source: Youth in Transition Survey, Cohort A.

Table 4.15a: IV regressions of standardized test scores on the school grade - Top income quartile

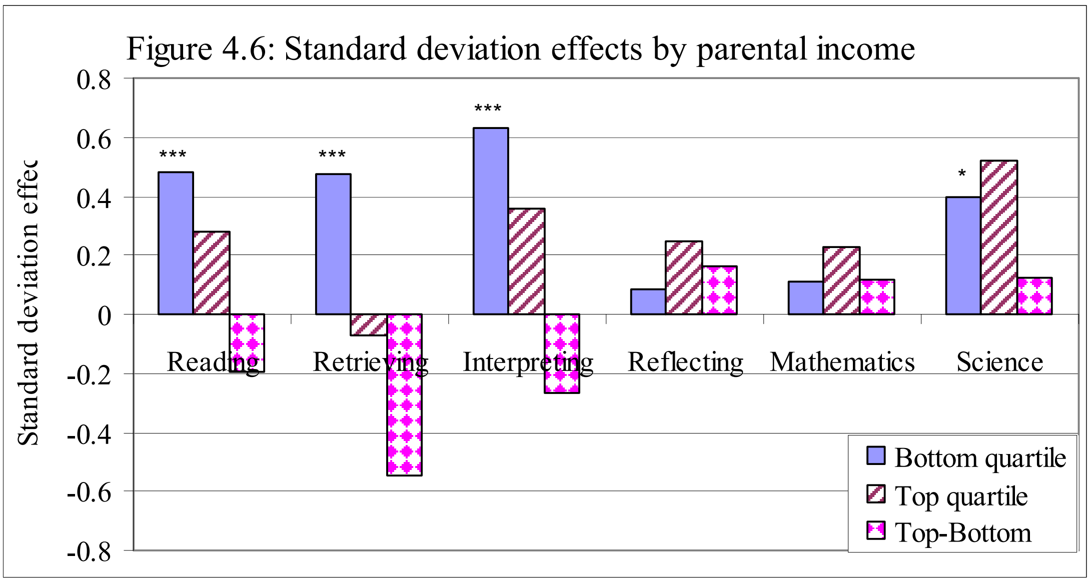
	Reading		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.
School grade	0.283	0.297	0.227	0.348	0.521	0.405
Age of the youth	-5.787	24.991	17.721	30.427	-65.995 **	33.435
Age of the youth^2	0.180	0.799	-0.570	0.974	2.117 **	1.070
Second born	-0.056	0.068	-0.094	0.095	-0.110	0.110
Third born	0.008	0.162	-0.015	0.192	-0.423 **	0.167
Fourth born	-0.374	0.250	-0.880 **	0.384	-0.600	0.535
Fifth born	--	--	--	--	--	--
Sixth born	--	--	--	--	--	--
Age of parent most knowledgeable of youth	0.076	0.077	0.108	0.111	0.120	0.104
Age of parent most knowledgeable of youth^2	-0.001	0.001	-0.001	0.001	-0.001	0.001
Parent with a non-university PS certificate	0.110	0.113	0.262 *	0.158	-0.103	0.151
Parent with a bachelor's degree	0.405 ***	0.102	0.403 **	0.164	0.085	0.137
Parent with a graduate or professional degree	0.538 ***	0.102	0.684 ***	0.181	0.178	0.152
Equivalent total parental income	0.020	0.018	0.042	0.048	-0.019	0.040
Equivalent total parental income^2	0.000	0.000	-0.001	0.002	0.000	0.002
Two parents present, at least one not from birth	-0.165	0.127	-0.149	0.176	-0.138	0.225
Two birth parents present	0.012	0.143	0.121	0.147	0.146	0.177
Female	0.348 ***	0.059	-0.133	0.091	-0.075	0.098
Related course	0.221	0.365	0.030	0.416	1.204 ***	0.455
Québec	0.180 **	0.088	0.490 ***	0.124	0.445 ***	0.113
Intercept	41.249	193.554	-143.091	234.510	505.187 *	258.799
Adjusted R^2	0.149		0.134		0.119	
N	1,067		602		572	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth in the top income quartile who born in Canada, who were within one grade of the usual one for their age, and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

Table 4.15b: IV regressions of standardized test scores on the school grade - Top income quartile, reading sub-components

	Retrieving		Interpreting		Reflecting	
	b	s.e.	b	s.e.	b	s.e.
School grade	-0.071	0.320	0.360	0.276	0.249	0.312
Age of the youth	23.081	25.909	-7.980	22.180	-4.272	26.219
Age of the youth^2	-0.742	0.828	0.248	0.708	0.133	0.838
Second born	-0.044	0.078	-0.091	0.081	-0.004	0.062
Third born	0.040	0.164	-0.013	0.179	0.002	0.139
Fourth born	-0.469	0.391	-0.316	0.309	-0.086	0.351
Fifth born	--	--	--	--	--	--
Sixth born	--	--	--	--	--	--
Age of parent most knowledgeable of youth	0.152 *	0.082	0.020	0.090	0.053	0.072
Age of parent most knowledgeable of youth^2	-0.002 *	0.001	0.000	0.001	0.000	0.001
Parent with a non-university PS certificate	0.170	0.118	0.045	0.110	0.078	0.143
Parent with a bachelor's degree	0.348 ***	0.105	0.356 ***	0.106	0.282 **	0.112
Parent with a graduate or professional degree	0.581 ***	0.118	0.512 ***	0.111	0.306 ***	0.116
Equivalent total parental income	0.041	0.027	0.015	0.016	-0.004	0.021
Equivalent total parental income^2	-0.001	0.001	0.000	0.000	0.000	0.000
Two parents present, at least one not from birth	-0.142	0.166	-0.083	0.147	-0.288 **	0.136
Two birth parents present	-0.089	0.165	0.114	0.170	-0.060	0.136
Female	0.144 *	0.076	0.265 ***	0.057	0.439 ***	0.065
Related course	0.684 **	0.269	0.285	0.389	-0.116	0.504
Québec	0.147	0.091	0.219 **	0.088	0.072	0.080
Intercept	-183.185	200.437	59.412	171.972	30.383	203.288
Adjusted R^2	0.040		0.132		0.124	
N	1,067		1,067		1,067	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth in the top income quartile who born in Canada, who were within one grade of the usual one for their age, and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.



Notes: ***=1% significance; **=5% significance; *=10% significance. The sample consists of youth born in Canada who were within one grade of the usual one for their age and lived in Nova Scotia or Québec.
Source: Youth in Transition Survey, Cohort A.

If secondary schooling does not explain why higher income youth outperform lower income youth, then what does? It may be that lower income youth face considerable challenges outside of the school system, and that schooling may act as an equalizer. Alternatively, it may be that there is a ceiling effect in place (i.e. it is more difficult for higher income youth to improve their performance in school since it is so high to begin with). Whatever the reason may be, the results strongly suggests that understanding the income gap in academic performance may require looking at other factors, such as earlier years of schooling, parental influences, or factors present at birth (as was the case for the gender gap in reading and mathematics performance).

4.9 Concluding remarks

In this chapter, I estimate the effect of schooling on academic performance, with a particular aim of understanding how schooling impacts students along various dimensions (ability, sex, and parental income). To do so, I take advantage of a setting whereby large samples of students of similar age wrote the same standardized tests, but were in different school grades simply because of age of school entry legislation. In some cases, students who were one day apart in age were in adjacent school grades, but wrote the same tests.

The findings suggest that one additional year of schooling (grade 10 in most cases) is associated with significant improvements in reading, mathematics, and science performance. More importantly, schooling confers the same benefits in each academic area across three important dimensions: the conditional distribution of academic performance, sex, and parental income. These findings suggest that factors outside of the secondary school system may be the driving force behind heterogeneous academic performance.

The chapter contributes to the literature in three important ways. First, it places more emphasis on heterogeneity in the impact of schooling on academic performance. Second, a wider range of test scores is considered here. Third, it is the first Canadian study on the topic.

So what is behind the gender gap in reading and mathematics performance and the broader income gap in academic performance? The findings suggest that high school factors fail to provide much insight. Candidate explanations that cannot be ruled out are those related to earlier school experiences, influences in the home, or even factors present at birth. As a result, more work is needed in this area. For example, it would be useful to investigate the role of earlier school years in developing learning, especially in view of understanding gender differences in academic performance. More detailed data on classroom strategies might be useful in this case. Also, the role of the teacher's gender may be important at this stage, as suggested by a recent American study (Dee, 2007). It may also be useful to estimate the role of parental resources in shaping the income gap in academic performance, especially in the early years.

Chapter 5: The Impact of Prospective Debt on Postsecondary Attendance

5.1 Introduction

Previous research from Canada and the US suggests that student financial aid generally helps reduce liquidity constraints. However, rising student debt load is a concern in both countries and in many others. Student debt may have an impact on post-graduate outcomes (e.g. job quality, life outcomes), while prospective student debt may impact the decision to enroll in postsecondary education (PSE) in the first place.

This chapter is devoted to analyzing the latter of these two hypotheses by studying the introduction of two large non-refundable grants made available to low-income youth in Canada. An interesting aspect of these grants is that they help reduce debt, but they have no impact on liquidity constraints since they are simply clawed back from loans. Furthermore, there is a sharp discontinuity in the eligibility criteria, based on parental income. These two features, the clawback of the grants from loans and the sharp discontinuity in eligibility, provide the ideal conditions to study the impact of prospective debt load on PSE attendance (while holding liquidity constraints constant). To date, no study in the world has looked at prospective debt load and attendance under these circumstances.

Using a large longitudinal administrative data set that is linked at the family level, I find evidence that the grants helped raise enrolment in university among a group of students who face low net returns to attending university: males who were raised far from a university. These students must bear additional direct transportation costs and opportunity costs associated with their travel time. Moreover, they face lower labour market returns to university than females, and particularly so if they plan on working in their hometown (where opportunities for university graduates are relatively rare).[24] As a result, these students may view university as a bad investment given the added cost of attending in absence of the grants. I find that reducing prospective debt by up to $6,000 led to a 7 percentage point increase in university attendance rates for males raised beyond 40 km of a university. For youth in general, there is no statistical evidence that the grants helped raise enrolment in PSE in general nor in university in particular.

In the next section (Section 5.2), I provide an overview of the postsecondary education system in Canada, including its fee structure and the financial aid system available to Canadian postsecondary students. In Section 5.3, I provide some background for the analysis presented in this chapter by discussing the roles of the student financial aid system. Following this, I begin examining student debt and postsecondary attendance by reviewing the relevant literature (Section 5.4). I then present a very simple theoretical model to better conceptualize the relationship between debt and attendance (Section 5.5). The remainder of the chapter is devoted to the empirical analysis. To this end, I begin by discussing the identification strategy,

[24] The returns to a university degree are higher for females, largely because they earn less than males when both have a high school diploma (Christofides, Hoy, and Yang, 2006).

the data, some critiques of the identification strategy (manipulation effects and program awareness), and the methods used in the chapter in Section 5.6 to Section 5.9, in that order. In Sections 5.10 and 5.11, I present the results from differences-in-differences estimators and regression discontinuity estimators, respectively. In Section 5.12, I apply robustness tests on the main results. In Section 5.13, I generate results across different dimensions. Finally, the chapter is summarized and the findings put into perspective in Section 5.14.

5.2 An overview of the Canadian postsecondary education system

Postsecondary schooling generally includes three types of institutions in Canada: university, college, and trade school. However, trade school doesn't necessarily require a high school diploma for entry. University and college generally require a high school diploma, although some students may be eligible to begin postsecondary studies without a high school diploma if they are deemed to be 'mature students' (i.e. usually 21 years old or above). A typical university undergraduate degree takes four years to complete, which may be followed by a graduate degree (a Master's or a PhD) or a professional degree (Medicine, Dentistry, Law, etc.) A college diploma can normally be obtained after two or three years of study, while a trade school diploma is even shorter in duration.

The system in the province of Québec is quite different. For students wishing to pursue university, they must first complete a two-year college program at CEGEP (Collège d'enseignement général et professionnel, meaning 'College of General and Vocational Education'). Following this two year program, Québec students normally only require three years to complete a university undergraduate degree. For those wishing to obtain a terminal college diploma, students must complete a three year CEGEP program.

With the exception of the small number of private career colleges and some elite professional university programs, postsecondary institutions are heavily regulated by government. Provincial governments usually set a price ceiling on tuition fees, although they often allow for some variability in tuition fees to reflect differences in costs. To ensure that the price ceiling does not reduce enrolment too much, governments provide supply side subsidies to universities for every student enrolled. Fees are not always regulated, although *de facto* price ceilings still exist since subsidies are reduced when tuition increases.

Average tuition fees are about $4,000 at Canadian universities. Fees range from about $2,000 in Québec for in-province students, to more than $6,000 in Nova Scotia. Within provinces, fees are fairly similar across programs, with the exception of some recently deregulated elite professional programs (particularly in Ontario). Although Statistics Canada no longer maintains data on college tuition fees, they are generally about half that of university fees. College tuition fees are remarkably similar across programs and most provinces. The one exception is in Québec, where in-province CEGEP students pay only nominal registration fees.

How do Canadian students finance the costs associated with a college or university education? In Canada, governments provide direct funding for postsecondary education through non-merit based aid in the form of loans and grants (including loan remissions). The bulk of this aid is in the form of student loans. When students apply for loans, they may also qualify for special grants that are generally targeted at low income youth. This process is automatic with the loan application. The formula for determining the amount of student aid (*AID*) is simply:

$$(5.1)\, Aid = Needs - Resources\ ,$$

where *Needs* correspond to the costs associated with attending the program (tuition, books, moving expenses, living expenses, etc.), and *Resources* correspond to parental income, as well as other student resources (e.g. savings). The calculated amount of aid is disbursed by the federal and provincial governments. Although there is a limit on the total amount of aid available per student, this is non-binding in the vast majority of cases. In other words, if youth want to enroll in a postsecondary program and are in need of funds, the money is generally available, albeit at the cost of becoming indebted.

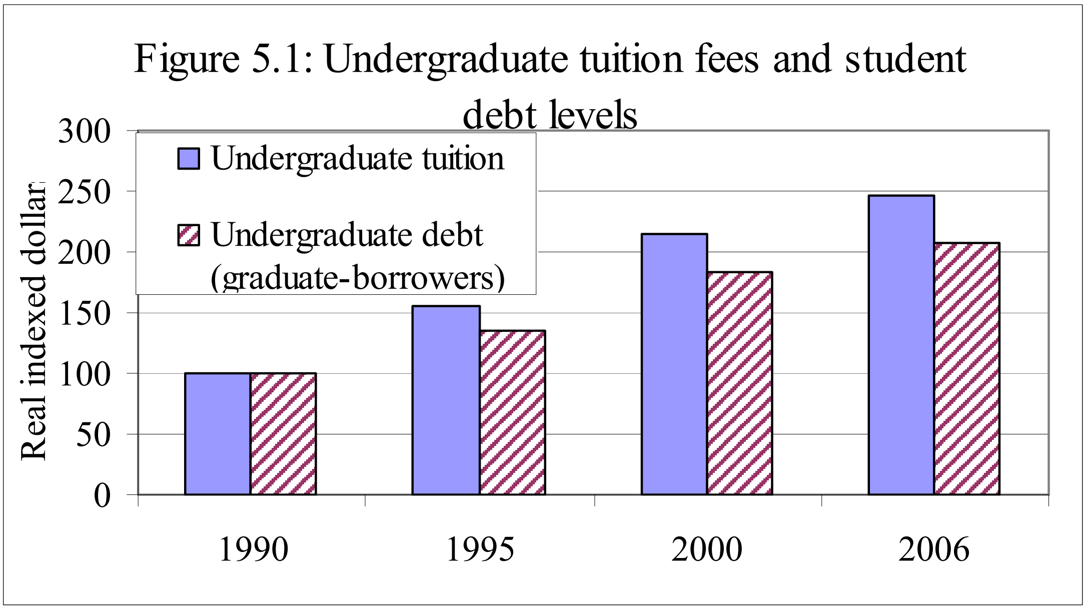
Of course, many other factors come into play in the decision to attend postsecondary, including high school marks, parental and peer influences, returns to schooling, discount rates, etc. As a result, there remain considerable inequities in postsecondary attendance in Canada, especially at the university level. Of particular relevance for this chapter, research has shown that three groups of students face low odds of attendance: low-income youth (Frenette, 2009a), males (Frenette and Zeman, 2009), and youth who grew up far from a university (Frenette, 2004; 2006; 2009b).

5.3 The roles of a student financial aid system

The main purpose of student financial aid is to reduce liquidity constraints for students contemplating attending postsecondary schooling. The Canadian student financial aid system generally covers all or most of the cost of attending PSE in the form of grants and loans. Frenette (2009a) provides some empirical evidence that supports this claim. The study shows that only 10% of high school graduates from Canada claimed to not have attended university (despite wanting to do so) due to their financial situation (including a lack of credit). Furthermore, this figure may be overstated since the majority of these students registered high school grades that were well below the usual minimum grades required for university admission. In other words, many students who reported a financial barrier to attending university may not have been able to attend in any event. Of course, their financial situation may have influenced the level of effort invested in school in order to achieve their goals.

Studies in the US also come to the same general conclusion using different methods. For example, Carneiro and Heckman (2002) found that, at most, 8% of youth are credit constrained in terms of PSE access. They identified credit constraints by using a residual approach: they suggest that the unexplained portion of the gap in attendance rates between high- and low-income youth is due to credit constraints, under the assumption that high-income youth (those in the top quartile) are not credit constrained. However, Belley and Lochner (2007) update this work and find that the proportion doubled in recent years (to about 17%).

Perhaps a larger concern regarding student financial aid is the debt load that students carry with them upon graduation. This is especially so given that tuition fees have been increasing substantially over the last two decades in Canada. As Figure 5.1 below suggests, debt load upon graduation (from a regular undergraduate degree) has increased with tuition fees. Between 1990 and 2006, real tuition fees have increased by 147%, while real debt load upon graduation has increased by 107%.



Note: 1990 dollars = 100.
Source for tuition data: Tuition and Living Accomodation Costs (TLAC) survey.
Sources for debt data: National Graduate Survey (NGS), 1990-2000; Canadian Undergraduate Survey Consortium (CUSC), 2006.

Does debt matter, given that students generally have enough money to attend university or college? Surprisingly very little work has been done in this area. In the US, some very recent studies have concluded that higher debt loads are associated with poorer post-graduation job quality from a 'public interest' point of view (Rothstein and Rouse, 2007) and lower odds of marriage and homeownership (Chiteji, 2007). In line with the general theme of this thesis (human capital acquisition), this chapter is concerned with another aspect of student debt: whether or not prospective debt affects enrolment decisions. I begin this inquiry in the next section by reviewing the relevant literature.

5.4 Literature Review

Overview

As noted in the previous section, the two primary roles of a well functioning student financial aid system are to reduce liquidity constraints for those facing them, as well as to ensure that borrowers are not saddled with large debts following graduation. Both of these aspects of aid—liquidity constraints and total expected debt upon graduation—may impact on decisions to enrol in postsecondary education in the first place. Liquidity constraints do so in a mechanical fashion by affecting students' ability to pay for the education, while debt reduction through a non-refundable grant does so by affecting the net returns to PSE (i.e. the wage premium less the loan repayment).

This chapter is concerned with the latter of the two (debt reduction), but as we shall see, there are very few studies relating prospective debt to enrolment decisions. Thus, the vast majority of the available evidence on the relationship between student aid and enrolment comes from liquidity constraints studies. For this reason, this section begins by reviewing this literature before moving on to the literature on debt and enrolment.

Literature on liquidity constraints and postsecondary attendance

In terms of theory, liquidity constraints affect enrolment in a very straightforward manner. Students facing a liquidity constraint cannot attend, while those facing no constraint may attend as long as they apply and get accepted. Thus, programs aimed at reducing liquidity constraints will have an impact on enrolment if certain conditions are met:

- There are some students who face liquidity constraints.
- The additional aid erases the liquidity constraints for certain students.
- Some students who saw their liquidity constraints disappear applied and were accepted to PSE.

We know that some students face liquidity constraints (e.g. Carneiro and Heckman, 2002; Belley and Lochner, 2007; Frenette, 2009a), but whether or not an increase in student aid will actually raise enrolment is an empirical question. Thus, this section will focus on the empirical work in the literature.

The early studies were reviewed by Leslie and Brinkman (1988). The consensus finding from these studies is that a $1,000 decrease in the net price of college (fees less non-refundable aid) is associated with an increase in college enrolment of 3 to 5 percentage points in the US. As a point of reference, the National Center for Education Statistics, or NCES (http://nces.ed.gov/) reports that on average, tuition, fees, and room and board cost $2,373 ($5,470) in public (private) four-year colleges and universities in 1980-81 in the US.

The limitation of many of these early studies is that they are largely based on observed correlations. However, students must choose to apply for and accept aid. Student aid eligibility is often based on observable characteristics such as parental income, savings, student work patterns, etc. There is no guarantee that in the absence of aid, students who qualified for aid based on these characteristics would have a similar probability of attending as those who did not qualify. The purpose of the aid is, after all, to reduce inequities in enrolment. Hence, estimating the impact of aid on enrolment by simple differences in enrolment by borrowing status is, by design, flawed since enrolment rates are likely to be different under the counterfactual (no aid).

Later studies focused on temporal variation in student aid derived from natural experiments. Changes in student aid policies provide such variation, and the US is not short on this front. The majority of aid provided to American students comes from the Pell Grants and the Stafford Loans. The Pell Grants were initially offered in 1974, when they were named the Basic Educational Opportunity Grants. Pell Grants are needs-based, and form the majority of federal grants for students in the US. Aside from grants, US students could also secure federally-sponsored loans. In 1965, the Guaranteed Student Loan Program was created, which was later renamed the Stafford Loan Program in 1987. According to McPherson and Shapiro (1991), federal grants accounted for \$3.5 billion in aid in 1980, compared to \$5.5 billion in federal loans (both expressed in 1982 US dollars).

Kane (1995) noted that Pell Grants had no impact on attendance when they were introduced in the 1970s, a period when real tuition was relatively stable. The resulting supply constraints may have prevented enrolment from rising despite the increased aid. This view was supported by McPherson and Shapiro (1991), who then extended the analysis into the 1980s—a period when tuition fees rose—and found that a $1,000 increase in the Pell Grant was associated with a 6.8 percentage point increase in the enrolment of low-income students.

Dynarski and Scott-Clayton (2008) later argued that the complexity in the system may have discouraged students to apply. They contrast the Pell Grant system with the relatively simpler Georgia Hope Scholarship and similar programs, noting that research has consistently pointed to significant effects in the latter, but not the former.

Arguably, the studies related to the Pell Grant system were not able to implement a compelling identification strategy. This is because the system was introduced in 1974 and was targeted at low-income youth. National level changes in enrolment rates pre- and post-treatment by income class is hardly a desirable research design.

In contrast, the aforementioned Georgia Hope Scholarship (GHS) and similar programs did offer more promising avenues of research. Dynarski (2000) examined the GHS, which was a merit-based aid package offered to college students in the US state of Georgia beginning in 1993. Students who obtained a B average in high school were eligible for the grant. Specifically, eligible students who are residents of Georgia could attend any of Georgia's state colleges for free.

Dynarski (2000) finds that a $1,000 increase in student aid is associated with a 3.7 to 4.2 percentage point increase in enrolment compared to nearby 'control' states.

However, since merit is based on grades, and grades tend to rise with parental affluence, the gap in enrolment between high- and low-income students rose following the GHS.

In Dynarski (2003), the same author adopts a very different identification strategy. Social Security is a monthly benefit available to elderly Americans. Prior to 1965, benefits were also allocated to children of deceased, disabled, or retired Social Security beneficiaries as long as they were in school full-time and less than 18 years old. Between 1965 and 1982, the benefits to children were extended to college or university age children. Specifically, 18 to 22 year-old children of deceased, disabled, or retired Social Security beneficiaries received monthly payments if they were enrolled in school full-time (most students were enrolled in postsecondary schooling at that age). The average annual payment in 1980 was $6,700 (in 2000 US dollars). In 1982, the extension beyond age 18 was terminated.

Using a differences-in-differences approach with the National Longitudinal Survey of Youth (NLSY), and a proxy for Social Security beneficiaries (a deceased father), Dynarski (2003) finds that the elimination of the extended benefits led to a decline in postsecondary attendance. Specifically, a $1,000 decrease in benefits (a form of aid since it is tied to education) led to a 3.6 percentage point decline in enrolment.

Around the same time, van der Klaauw (2002) exploited discontinuities in financial aid rules at one US East Coast college. Using administrative data on students who applied to the college, he finds that aid increases enrolment. While the identification approach in this study—a regression discontinuity design—is very strong, it does not address the relationship between aid and enrolment in general; rather, it looks at aid in the form of helping a specific college compete for students.

Some recent reforms in Europe provide the groundwork for compelling research in the area. Baumgartner and Steiner (2006) use the German Socio-Economic Panel (GSOEP) to examine a German reform in student aid in 2001. Using a differences-in-differences approach (pre-/post-reform for low-/high- income students), the authors find no statistically significant relationship between aid and enrolment. However, unlike the US system, the German postsecondary system was well-funded to begin with: loans and non-refundable grants covering all costs were available to students in need.

A similar reform in Denmark in 1988 was studied by Nielsen, Sørensen, and Taber (2008). Using a longitudinal register of high school graduates from the classes of 1985 to 1990, they find that a \$1,000 increase in aid is associated with a 1.35 percentage point increase in college enrolment. Although the effect is significant (in a statistical sense), it is somewhat smaller than the US findings. Once again, this could be due to the funding in place in Denmark prior to the 1988 reform. In fact, tuition was already free in that country.

<u>Literature on prospective debt and postsecondary attendance</u>

Linsenmeier, Rosen, and Rouse (2006) derive a simple theoretical model relating the decision to enroll to the anticipated debt load. Their model is applied to the case where students decide between competing institutions. In the next section, I show that this model can be easily adapted to study the decision to enroll in postsecondary schooling in general. For now, note that their model predicts that demand will increase following a reduction in loan repayment, holding liquidity constraints fixed (in fact, assuming no liquidity constraints). I discuss why this result does not necessarily hold in the case examined here. Furthermore, Linsenmeier, Rosen, and Rouse (2006) do not (need to) consider the supply side in their scenario. In contrast, the supply side is critical to the analysis of the market for postsecondary education in Canada. My version of the model leads me to conclude that a reduction in student loan repayment may or may not lead to an increase in demand. In the end, enrolment among the target group may increase, or it may remain fixed. In other words, there is no guarantee that a reduction in loan repayment will improve access among targeted students.

For the moment, I consider the empirical literature on the topic. Surprisingly, there are only three studies that are relevant. Note that in the previous section, I only reviewed a small handful of the existing studies on total aid and PSE enrolment.

The three studies have all surfaced in recent years. The first is from Germany (Baumgartner and Steiner, 2004), where a substantial reform to the loan repayment schedule happened in 1990. Prior to that year, student aid was in the form of loans, which had to be repaid in full. Following the reform, only half of the aid had to be repaid. This represented a significant reduction in debt for eligible students. The authors report that a fully supported student saw their debt load reduced by 23,500 EUR.

Using the German Socio-Economic Panel (GSOEP), the authors estimate a differences-in-differences model, the results of which suggest that the aid reform was ineffective in raising enrolment rates. Although this contrasts with most of the studies on total aid and enrolment, recall that the same authors looked at a reform in the total amount of aid available in Germany in 2001 (Baumgartner and Steiner, 2006), and also found no impact of aid. It is possible that there is something specific about Germany, perhaps about their system, their labour market, or about students themselves, that works towards dampening the effect of aid or loan repayment on enrolment decisions.

As an alternative, consider the US evidence. Recall that US studies have found that total aid tends to boost enrolment, but what about loan repayment schemes? Linsenmeier et al. (2006) examine a significant program change at a major northeastern US university (ANON U). Prior to 1998, the university's financial aid package available to freshmen from low-income families consisted of grants, loans, and jobs. Beginning with the 1998 freshmen class, the loan component of the aid package was converted to non-refundable grants.

Using admissions and financial aid data from the university, the authors used a differences-in-differences approach and found that the loan reduction program had no statistically significant impact on the probability of enrolment at ANON U. However, for low-income minority students, loan reduction was associated with an increase in the probability of enrolment (significant at 10% only).

There are several limitations regarding this study. First, the amount of loans converted to grants was small relative to the tuition fees at the institution. The authors report that tuition fees were $34,171 in 2000. However, only about $4,000 in loans was converted to grants.

Second, competing institutions may have altered their funding scheme in order to attract students. While the authors show that seven competing institutions in the northeast did not alter their funding substantially, they also admit that this is only suggestive. Although not discussed, it can be argued that a major university would compete for students at the national level.[25]

Third, total aid relative to costs did not remain fixed over the period, although the variation was small. This highlights one of the weaknesses of a differences-in-differences design: there is no guarantee that all else remains constant.

One additional study in this area is worth noting, this time based on a social experiment. Field (2009) examines enrolment rates of New York University (NYU) law students in various areas of law. The experiment was set up to test the hypothesis that debt matters to students. Students were randomly assigned to two groups. The control group received a loan that would be forgiven for up to 10 years following graduation if they pursued a career in 'public interest law' (i.e. legal fields with a public good aspect to it, which often is lower-paying than other forms of law). The

[25] Although the anonymity of the university was maintained throughout the study, it is worth noting that all three authors list their affiliation as Princeton University, which is a major northeastern US university.

treatment group received a non-refundable grant if they pursued a public interest law career. In both cases, the amount of aid covered two-thirds of tuition fees. The results suggest that the treatment group was twice as likely to enroll in a public interest field of law, and substantially more likely to hold a first job in public interest law.

Three issues stand out here. First, the experiment only involved 140 test subjects, including the control and treatment groups. The low sample size (and the resulting potential for sampling error) limits the effectiveness of random assignment. Second, the results pertain to a very specific group of people: law school students at NYU. Tuition fees are very high at NYU law: about $40,000. As a result, a large loan reduction program such as the one implemented above is likely to have an effect. Third, the outcome was the choice of specialization, as opposed to the decision to enroll or not in university.

Contributions of the present chapter to the literature

The present chapter adds to the literature in three important ways. First, it is the only study in the world that examines the impact of prospective debt on postsecondary enrolment decisions in a situation where the policy change led to a sharp discontinuity in prospective debt load based on parental income. Other studies have had to rely on differences-in-differences estimators, which may be susceptible to confounding factors (i.e. other policies may have changed at the same time, as part of a broad reform).

Second, the chapter examines results across several dimensions. The motivation for adopting this approach lies in the possibility that certain groups of students may be more or less sensitive to prospective debt load. For example, males and females may have different tolerance levels for debt, especially if their expected returns to PSE are different. Moreover, students who must displace themselves geographically in order to attend may be more sensitive to debt than others. The only other study in this literature to examine results by sub-group is Linsenmeier et al. (2006), who examine low-income youth from visible minority groups.

Finally, this is the only Canadian study on the topic. As discussed in the background section, the issue is of importance in Canada given that tuition fees have risen considerably in recent years, leading to rapidly rising student debt load. Furthermore, the literature review describes how there is only a scant number of studies in this area and they come to very different conclusions. This may be the result of the very different policy environments already in place when the debt reduction programs were introduced in the various countries/settings. It may also be due to the varying size of the debt reduction programs. Other explanations are possible. For these reasons, adding more evidence from the Canadian context will help inform this relatively nascent literature.

5.5 Theory

What is the anticipated impact of prospective student debt load on postsecondary enrolment? The answer depends on both the demand and supply associated with postsecondary education. This section begins with the demand side, as is so often the case in the literature. The supply side, as well as the expected market outcome will follow.

Demand side

Linsenmeier et al. (2006) derive a simple theoretical model relating the decision to enroll in one institution over another to the prospective debt load. I modify their model to fit the case of a student deciding between enrolling in PSE or not.

First, I begin with the model assumptions:

- There are two periods.
- In period 1, the agent decides between enrolling in postsecondary school (S) or not (N).
- Agents are able to gain entry into PSE (i.e. they face no liquidity or academic constraints).
- PSE attendees will graduate within one period.
- Students fund their education with loans; the balance (C dollars) is paid by the student in period 1.
- In period 2, a postsecondary graduate must repay L dollars back from their student loans.
- There are only two types of jobs, based solely on wages: a good job, paying G dollars, and a bad job, paying B dollars ($G > B$).
- The discount rate, r, is positive.

- Postsecondary graduates will receive a good job with probability p and a bad job with probability $(1-p)$.
- Non-postsecondary graduates will receive a good job with probability q and a bad job with probability $(1-q)$.
- The probability of obtaining a good job is higher for PSE graduates ($p > q$).
- If an agent is in school, they cannot hold a job. However, they must hold a job if not in school.
- Agents maximize expected lifetime utility, where 'lifetime' is defined as the two periods.
- Utility depends solely on net income (NI), defined as income from a job (G or B) less the loan repayment (L). There are no psychic costs or benefits associated with attending school or working.
- Utility increases with net income [$U'(NI) > 0$].

Based on these assumptions, the expected lifetime utility of an agent who chooses to attend PSE (S) is:

$$(5.2) E(U_S) = pU\left(\frac{G-L}{1+r}\right) + (1-p)U\left(\frac{B-L}{1+r}\right) - U(C)$$

For an agent who chooses to work in period 1 instead (N), it is:

$$(5.3) E(U_N) = [qU(G) + (1-q)U(B)] + qU\left(\frac{G}{1+r}\right) + (1-q)U\left(\frac{B}{1+r}\right)$$

Agents attend PSE if the net benefit (in utility terms) is greater than the alternative:

$$(5.4)\theta = E(U_S) - E(U_N) > 0\text{, or:}$$

$$(5.5)\theta = pU\left(\frac{G-L}{1+r}\right) + (1-p)U\left(\frac{B-L}{1+r}\right) - U(C) - qU(G) - (1-q)U(B) - qU\left(\frac{G}{1+r}\right) - (1-q)U\left(\frac{B}{1+r}\right)$$

How does a loan repayment (L) affect the net benefit function (θ)? The answer lies in the first derivative. Applying the chain rule, we get:

$$(5.6)\partial\theta / \partial L = -\left(\frac{1}{1+r}\right)pU'\left(\frac{G-L}{1+r}\right) - \left(\frac{1}{1+r}\right)(1-p)U'\left(\frac{B-L}{1+r}\right)$$

By rearranging the terms, we obtain:

$$(5.7)\partial\theta / \partial L = -\left(\frac{1}{1+r}\right)\left[(1-p)U'\left(\frac{B-L}{1+r}\right) + pU'\left(\frac{G-L}{1+r}\right)\right]$$

Since $U'(NI) > 0$, Equation 5.7 implies that $\partial\theta / \partial L < 0$. In words, the net benefit of attending PSE increases as loan repayment obligations decline.

However, whether a decline in loan repayment obligations will actually lead to an increase in demand is another issue. Suppose we have two types of students: type A (who value PSE above the alternative) and type B (who value PSE below the alternative). Although the net benefit is expected to rise for all students, demand will not increase among type A students since they would attend in any event. Only among type B students will demand stand a chance of rising (as long as the increase in net returns transforms PSE into a better investment than the alternative). Of course, if net returns are too far below the threshold, then 'crossing over' may be a challenge.[26]

What factors will determine the student type? From Equation 5.5, these include the relative probabilities of obtaining good and bad jobs under each scenario, the relative net incomes arising from these jobs, the discount rate, and the self-financed costs. The number of capitalization periods also matter. In this simple two-period model, agents who choose to pursue a postsecondary education only have one period to capitalize on their investment. In reality, PSE graduates have 30 years or more to capitalize.

It is interesting to go back to the empirical literature at this point. The discussion above suggests that lowering loan repayment obligations may only increase demand among type B students. This result may explain the findings from the three studies on prospective debt and attendance. In Baumgartner and Steiner (2004), no effects were found, but this may simply be the result of the low costs of attending a German PSE institution back in 1990. In other words, perhaps many students were of type A. In Linsenmeier et al. (2006), the major US university they examined may have in fact been a good investment for most students even prior to the loan repayment reform (i.e. many students may have been of type A, explaining why the authors found no impact). Finally, the experiment conducted by Field (2009) considered public interest law (relative to private interest law) as the outcome. Since public interest law careers pay

[26] This is in contrast to the expected impact of liquidity constraints. In that case, enrolment critically depends on obtaining liquidity. Assuming that some (otherwise qualified) students face liquidity constraints, then a reduction in these constraints will lead to an unambiguous increase in the demand for PSE. This may explain why relatively more liquidity constraints studies find that aid matters compared to the debt studies.

less than private interest law, it is quite likely that most students would have been classified as type B in this instance. Again, this is consistent with the author's finding that lower debt has a positive impact on choosing public law.

Supply side and expected market outcome

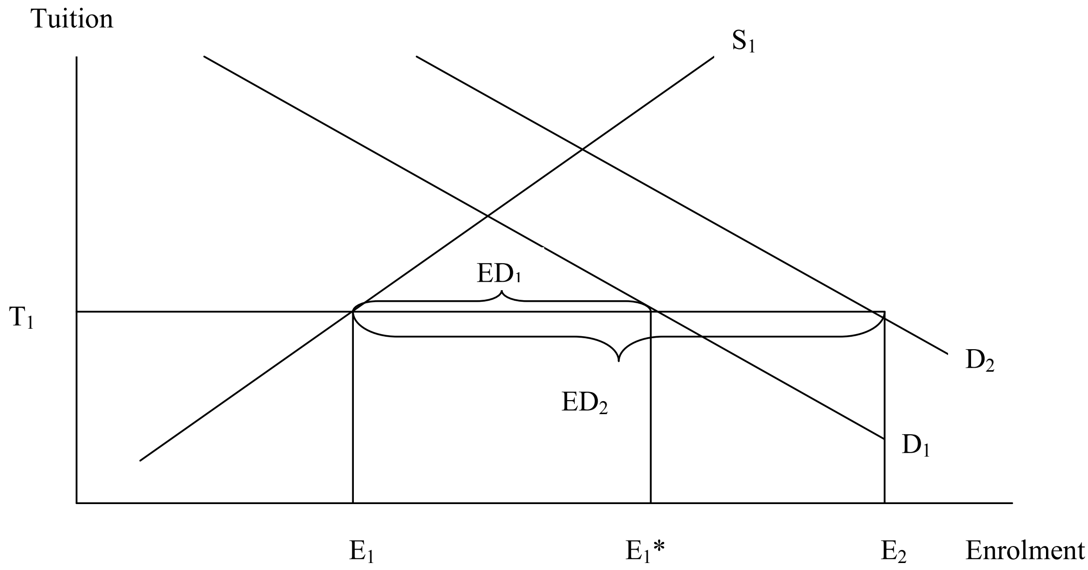
The supply side of the market consists of postsecondary institutions. They are indifferent to the amount of loans students must repay since it is the government who provides these loans. Thus, a change in the loan repayment schedule should have no impact on supply.

However, supply does come into play as a result of a market intervention in Canada.[27] Specifically, tuition fees are often regulated through a price cap. Even when no tuition freeze is imposed, fees tend to be stable since universities lose subsidies from the government when they raise fees, resulting in a *de facto* price cap.

Figure 5.2 below depicts the anticipated impact of a reduction in student debt given the Canadian context. Prior to the decrease in debt, the equilibrium point is (E_1, T_1) since we are in a supply constrained environment. Excess demand is ED_1.

[27] Again, to be fair to Linsenmeier et al. (2006), this discussion may not apply in their case since they (almost certainly) looked at the unregulated private postsecondary education market in the US.

Figure 5.2: The market for higher education in Canada



Let's suppose that the debt reduction program is not associated with a change in liquidity. This would be the case if the government offers non-refundable grants to students that are clawed back from loans. As a result of this new program, demand may not respond, as described in the demand side model above. In this case, nothing would change, and the program would have no impact on enrolment.

Now, suppose that the program does lead to an increase in demand (from D_1 to D_2), which is also consistent with the demand side model above. Since tuition fees are still regulated (either explicitly or implicitly), enrolment remains fixed at E_1 even when demand increases. What *does* change is the level of excess demand (from ED_1 to ED_2). In other words, university applications would increase. This may result in a change in the mix of students attending. How does the mix change? The answer is not clear. Since student financial aid is normally targeted to low-income youth, we might expect that they are the ones driving the shift in demand. However, these low-income youth are still required to achieve a certain minimum grade point average to gain entry into PSE. Empirical evidence suggests that a strong positive relationship exists between parental income and high school grades (Frenette, 2009a).

The end result of this simple conceptualization is that, while a reduction in prospective student debt load should reduce enrolment among targeted youth, it may not increase it either. Essentially, enrolment among this group may increase (if demand increases and targeted students are able to displace students who would otherwise attend), or it may remain fixed (if demand does not increase or if targeted students are not able to displace others). Critical in this discussion is the movement of the demand curve. If some students have a negative valuation of PSE as an investment relative to the alternative (no PSE), then we may see demand increase for that group following the introduction of a non-refundable grant.

5.6 Identification strategy

To identify the impact of prospective student debt load on PSE attendance, an important ingredient would be an exogenous increase in expected debt, but with no change in total student financial aid provided. The implementation of the Canada Access Grant for Low-Income youth (CAG-LI) and the Millenium Access Bursaries (MAB) provides such a setting. Note that in both cases, the main objective was to increase enrolment in postsecondary schools (as their names imply). I discuss both in turn.

The CAG-LI consists of a non-refundable grant whereby loans are clawed back by the amount of the grant. In other words, CAG-LI does not provide more aid to students. Rather, it changes the amount of aid that must be repaid.

Another convenient aspect of the grant is that students are eligible for the full grant if their parental income is below a certain threshold. If parental income is above the threshold (even by $0.01), students are not eligible for the grant. Thus, there is a sharp discontinuity in the amount of the non-refundable grant available (and therefore, debt) around the threshold. The threshold thus acts as a random assignment of debt since students with parents with very similar incomes are likely to have been quite similar in their PSE choices in absence of the CAG-LI.

These two features, the clawback of the grant from loans and the sharp discontinuity in eligibility, provide the ideal conditions to study the impact of prospective debt load on PSE attendance (while holding liquidity constraints constant). To date, no study in the world has looked at debt load and attendance under these circumstances.

The CAG-LI was introduced in 2005, and became available to students in the 2005-06 academic year. The grant applies to first-year, full-time PSE students only. The amount of the CAG-LI is one half of first year tuition, up to a limit of $3,000. University tuition fees average about $4,000 in Canada, but range from about $2,000 in Quebec to just over $6,000 in Nova Scotia; college tuition fees are normally close to $2,000.

Eligibility is based on the net income of the parent(s), as per line 236 of their income tax return in the previous year. Net income consists of the sum of employment income, other market income (e.g. investment income, rental income, etc.), transfer income (including Social Assistance, Employment Insurance, Old Age Security, etc., but excluding the Child Tax Benefit and the National Child Benefit Supplement, and the Goods and Services and Harmonized Sales Tax Credit), minus certain deductions such as Registered Pension Plan contributions, union dues, etc.[28] The threshold for CAG-LI eligibility is the same threshold used for the National Child Benefit Supplement (NCBS), which is around $35,000, depending on family size and year.[29]

The CAG-LI coincided with the introduction of a similar grant: The Millenium Access Bursary (MAB). In four provinces, the MAB worked in a very similar way as CAG-LI in that eligibility for both programs were based on the NCBS threshold. In Ontario (beginning in 2005) and Manitoba (beginning in 2006), the MAB was also similar to CAG-LI in terms of the amount of the grant (i.e. one half of tuition, up to a limit of $3,000). In New Brunswick (beginning in 2006), the grant was larger ($4,000), but was spread out over three years. In a fourth province, Prince-Edward-Island, the MAB was also similar to CAG-LI, but for reasons discussed in the

[28] Of these income components, perhaps the easiest to manipulate (in order to qualify for the grants) is the contributions to a Registered Pension Plan. I will investigate later whether or not net income was manipulated.

[29] The NCBS income itself does not create a discontinuity of its own since it does not jump suddenly at the threshold. Rather, it goes from zero when net income is above the threshold, to a positive but gradually increasing amount as net income falls below the threshold and becomes smaller. Just below the threshold, NCBS income is very close to zero. Details are available at http://www.nationalchildbenefit.ca/eng/o4/chap2.shtml.

methods section, this province cannot be included in the analysis. In other provinces, different versions of the MAB were available, but in all of those cases, no clear discontinuities could be identified based on program parameters. As a result, analysis will be restricted to New Brunswick, Ontario, and Manitoba. The combination of CAG-LI and MAB provided up to $6,000 ($7,000 in New Brunswick) in debt reduction for qualified students in these provinces. Again, the actual amount of the grants depended on tuition fees.

In both cases, students need only apply for student loans to receive the grants. No additional application is necessary. The CAG-LI and MAB take-up rate for eligible PSE students is 100%.[30]

5.7 Data

The data required to conduct this study should contain information on PSE attendance of youth, their parental income, the province of residence, and a sufficiently large sample to allow one to look very closely around the point of discontinuity.

The Canadian Longitudinal Administrative Databank (LAD), developed by Statistics Canada, satisfies all of these requirements. The LAD is built from personal income tax records (the T1s). The T1 data are combined into families to form the T1 Family

[30] This is among students who were enrolled in the first-year of full-time studies at a post-secondary institution. This is not entirely surprising, as the grants represent free money to students. Thanks to Malgorzata Winizewska from the Canada Student Loans Program at Human Resources and Skills Development Canada and to Anne Motte from the Canadian Millenium Scholarship Foundation for confirming that no eligible PSE student had turned down the grants.

File (T1FF). The T1FF contains not only records for tax filers, but also for their non-filing dependents.[31] The LAD is a 20% simple random sample of T1FF, with the records linked longitudinally (until they leave the sample through death, out-migration, or if everyone in their family stops filing taxes).[32] Currently, data are available from 1982 to 2006.

Given the fact that LAD is a simple random sample of an administrative data base, stratification and multi-stage sample are non-issues in this chapter. However, heteroscedasticity is still a potential issue. To correct for heteroscedasticity in this chapter, I calculate robust standard errors using the standard Huber-White sandwich estimator.

Since CAG-LI and MAB apply to first year students, it is necessary to identify the year in which youth become eligible for first year enrolment in PSE. In six of the 10 Canadian provinces (Newfoundland and Labrador, New Brunswick, Ontario, Manitoba, Saskatchewan, and British Columbia), this is simply the year in which the youth turned 18. This is because age of entry in those provinces is determined based on one's age as of December 31. In the LAD, we know the year of birth for all

[31] Dependents are imputed through information provided by tax filers on their returns. This includes spouses and children. The population coverage in T1FF is about 97% compared to census data.

[32] Since 1993, virtually all families with children (even ones with low incomes) have had an incentive to file taxes in Canada. This is largely because of the introduction of the Child Tax Benefit, which is available to about 90% of families with children below the age of 18.

children[33], allowing one to identify the year when youth first become eligible for PSE attendance. Of the six provinces, CAG-LI and MAB were quite similar in New Brunswick, Ontario and Manitoba. For these reasons, analysis is limited to those three provinces.[34] A final point worth noting is that in Ontario prior to 2003, students could normally only begin university at age 19 (they could begin college at age 18). Since 2003, both college and university normally begin at age 18. For this reason, analysis is limited to the 2003-2006 period.

It is of course possible that students take a 'gap-year' (i.e. they begin postsecondary studies after taking a year-long break following high school). This can pose a problem if we only focus on 18 year olds and there is a systematic bias in the propensity to take a gap-year by parental income level. According to Finnie and Johnson (2010), 32% of post-secondary students from Ontario took a gap-year following high school based on the same YITS data used in Chapters 2 and 4. However, their econometric evidence suggests that there is no statistical relationship between taking a gap-year and parental income, both for college and university students.

The specific variables used in the analysis are as follows:

Dependent variable

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[33] Unless they are tax filers themselves, in which case we know the exact date of birth. However, many children do not file taxes, so a certain degree of selection bias might be introduced by selecting children with detailed birth date information.

[34] CAG-LI and MAB were also quite similar in Prince-Edward-Island, but their school entry laws are based on age as of January 31.

- Full-time PSE attendance in year t (age 18)
    - This is derived from full-time tuition credits and full-time education deductions. If either of these is greater than zero, then the indicator is set to 1.
    - These credits/deductions can be transferred to a higher income family member (specifically, a parent); since the late 1990s, we can identify which family member actually attended PSE.

Independent variables[35]

- Net parental income in year (t-1)
    - This variable will be used to identify eligibility for CAG-LI and MAB by mapping the relevant NCBS threshold to each family.
- Province in year (t-1)
- Lone-parent family dummy in year (t-1)
- Number of children in family in year (t-1)
- Sex of the youth

The means of the variables used in the analysis and sample sizes appear below in Table 5.1. Note that for confidentiality reasons, all reported dollar estimates from

[35] Many of these variables are captured in year (t-1), at age 17, since in year t, many youth may move from the parental home in order to attend PSE. As such, their 'family' on the tax files may simply consist of themselves. All variables derived from this family will thus omit information on their parents, their parental home, their siblings, etc. Note also that even if youth tried to strategically move out of their home at age 17 (to lower their income in hopes of qualifying for the grants), this would have no bearing on grant eligibility since *parental* income is used in determining eligibility.

LAD must be rounded to the nearest 100, while all sample sizes must be rounded to the nearest 5. Note that the actual micro-data I use in the calculations are not rounded. Slightly fewer than half of 18 year olds have attended PSE. There is some provincial variability in this figure, which is not surprising given that each province has its own postsecondary education system. Parental income also varies by province (highest in Ontario, lowest in New Brunswick, among the three affected provinces). Note that parental income among this sample is relatively high since only families with at least one child of age 17 are included here (i.e. they are relatively older families). About one in five youth live in families with income that is sufficiently low to qualify them for the NCBS (and thus, the CAG-LI and MAB grants in certain years). The other variables—lone-parent status, the number of children in the family, and sex—are included as control variables. Of interest is the fact that slightly less than 50% of the sample consists of females. This is because 17 year-old males are more likely to remain in their parental home than 17 year-old females. A final point worth mentioning is that Ontario is far more populous than the other provinces, and thus, its sample size is much larger. Hence, the analysis to follow will focus somewhat more on Ontario.

Table 5.1: Sample means of variables used in analysis

	New Brunswick	Ontario	Manitoba	Rest of Canada
Full-time PSE attendance	0.482	0.426	0.376	0.453
Net parental income	65,600	99,600	77,900	84,800
Below NCBS threshold	0.259	0.178	0.210	0.214
Lone-parent family	0.139	0.134	0.133	0.142
Number of children in family	2.5	2.8	2.8	2.7
Female	0.464	0.490	0.476	0.477
N	3,705	56,735	5,530	75,795

Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

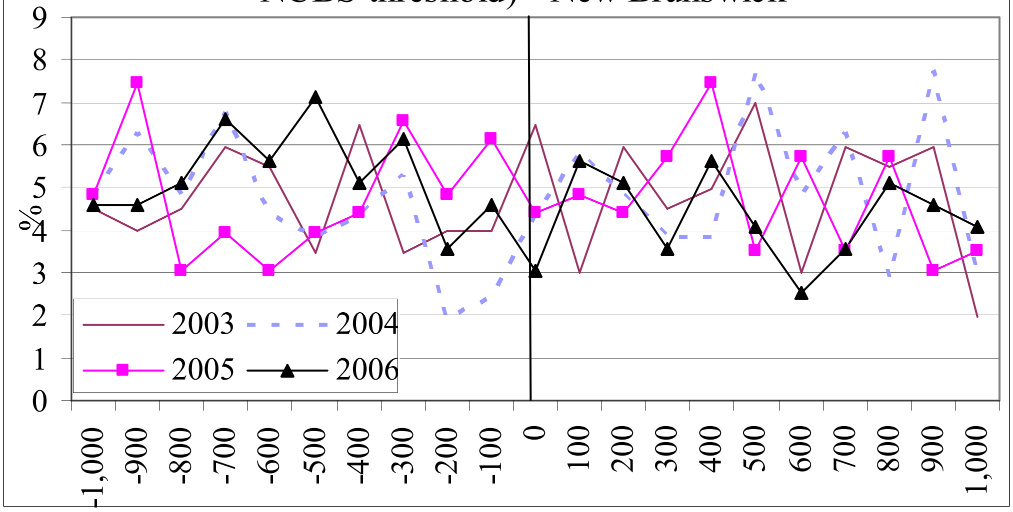
5.8 Addressing manipulation effects and program awareness

Although CAG-LI and MAB provide a nice framework to study the causal impact of prospective debt on PSE access, there are still reasons to believe that this is not necessarily so. First, as with any discontinuity, there is always the possibility of manipulation effects. Parents would have a very high incentive to hide their income on aid applications in order to help their children qualify for the grant. However, parental income has to match line 236 of their income tax returns. In some provinces, tax documents have to be included with the student loan application. In other provinces, random checks are applied.

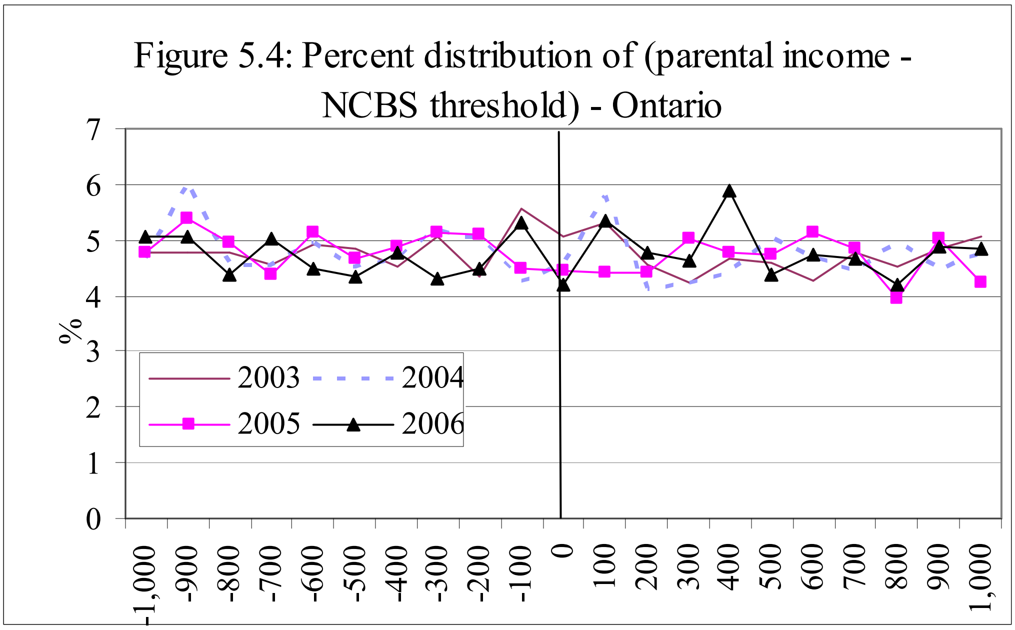
Alternatively, parents could manipulate the income reported on their tax files through legitimate or illegitimate means. To test this, I used the LAD data to generate the distribution of the gap between net parental income and the CAG-LI/MAB threshold among parents in the sample (described in the previous section) for each of the three affected provinces, as well as the rest of Canada, for the years 2003 to 2006, inclusive.

If manipulation effects are present, we would expect to see a change in this distribution following the implementation of the policies within a narrow window around the threshold in the three affected provinces, relative to the rest of Canada. In particular, we would expect to see a jump (dip) in the frequency to the left (right) of zero following the introduction of the programs in the affected provinces. However, the results in Figures 5.3 to 5.6 suggest no such jump or dip, especially when one compares Ontario (Figure 5.4)—where sample sizes are largest—with the rest of Canada (Figure 5.6).

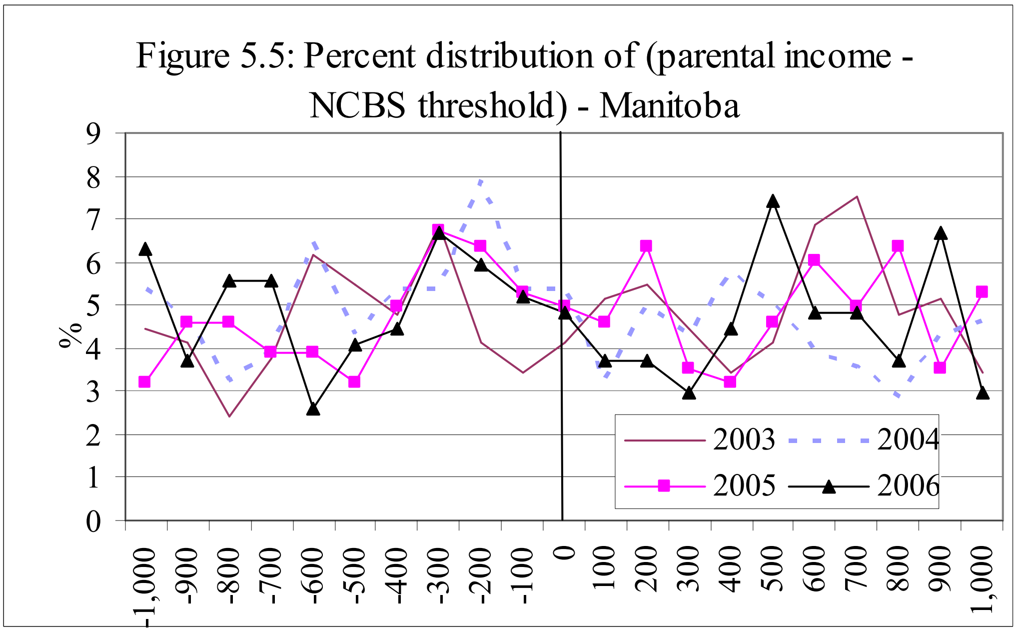
Figure 5.3: Percent distribution of (parental income - NCBS threshold) - New Brunswick



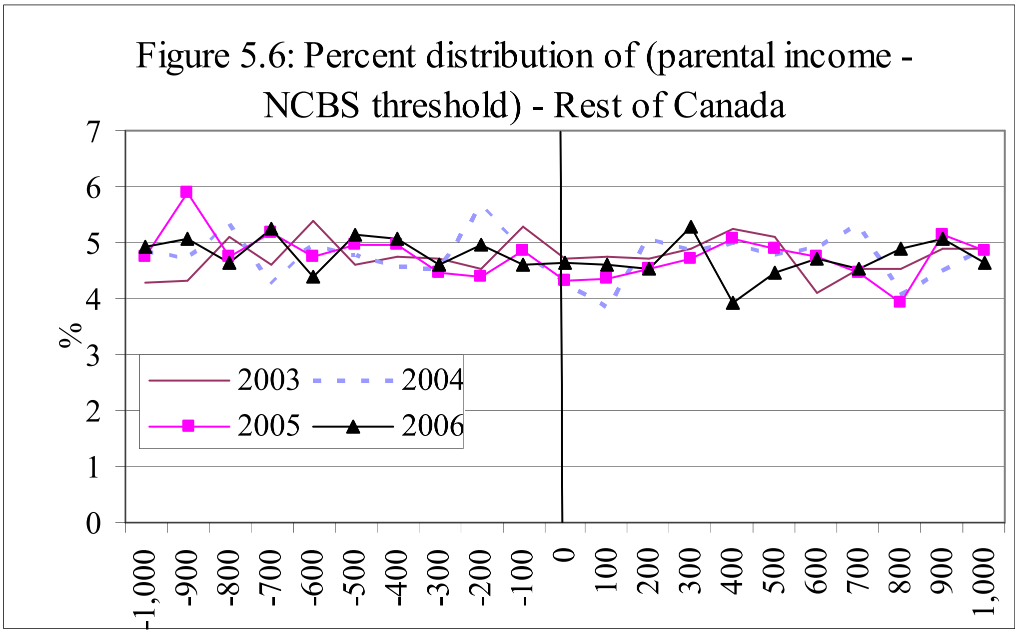
Notes: The sample consists of 18 year-old youth. All variables are captured at age 17.
Source: Longitudinal Administrative Databank (LAD).



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17.
Source: Longitudinal Administrative Databank (LAD).



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17.
Source: Longitudinal Administrative Databank (LAD).



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17.
Source: Longitudinal Administrative Databank (LAD).

To be sure, I tested whether or not there was a statistically significant increase in the proportion of cases below the threshold as we move from the pre-grant period (2003 and 2004) to the post-grant period (2005 and 2006). The results are shown below in Table 5.2. For all three provinces, there is no evidence of any change for any combination of pre- and post-grant years.

Table 5.2: Proportion with net family income below NCBS threshold (within a $1,000 band of the threshold)

	New Brunswick		Ontario		Manitoba	
Year	Proportion	s.e.	Proportion	s.e.	Proportion	s.e.
2003	0.478 ***	0.035	0.458 ***	0.011	0.429 ***	0.032
2004	0.498 ***	0.035	0.481 ***	0.011	0.466 ***	0.033
2005	0.440 ***	0.035	0.475 ***	0.012	0.498 ***	0.034
2006	0.480 ***	0.036	0.471 ***	0.012	0.473 ***	0.032
2005-2004	-0.058	0.049	-0.005	0.016	0.032	0.047
2006-2004	-0.018	0.050	-0.010	0.016	0.006	0.046
2005-2003	-0.038	0.049	0.017	0.016	0.069	0.047
2006-2003	0.002	0.050	0.013	0.016	0.044	0.046

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17.
Source: Longitudinal Administrative Databank (LAD).

Second, program awareness is always an issue. If students do not know that a program exists, there is no reason to believe that they will modify their behaviour because of it. However, all students were assessed for CAG-LI and MAB eligibility once they applied for student aid, and take up was 100%. Of course, students may not have applied for student aid if they were not aware of the new grants since they may not have planned on attending PSE. To help make students aware of financial aid opportunities (including loans and grants), the Canadian government provides a convenient on-line loan calculator.[36] Still, there are no guarantees that students were made aware of these programs. The closest direct form of evidence on this issue comes from the Canadian Survey of Youth in 2008. Published data indicates that among 17 to 30 year olds, 59% were aware of study grant opportunities. Of course, it

[36] The calculator is available at http://tools.canlearn.ca/cslgs-scpse/cln-cln/40/sfae-eafe/sfae-eafe-0-eng.do.

is not clear why a typical 30 year old would need to be aware of study grant opportunities, so the rate may be higher among younger individuals.

5.9 Methods

Two econometric approaches will be used in this study. The first exploits the fact that the CAG-LI/MAB programs were introduced at different times in different provinces, and were targeted at low-income youth (those below the NCBS threshold). Thus, a differences-in-differences (DD) approach will be used (essentially, how does the gap in PSE access between low- and high-income youth evolve over time across provinces?) [37] An issue with DD estimators is that other programs or events may have occurred at the same time in the same provinces that may interfere with our estimate of the impact of the CAG-LI/MAB programs. For example, the student loan limits rose at the same time that CAG-LI and MAB were introduced. This may have also contributed to a rise in attendance among youth from low-income families.

The second approach exploits the discontinuity of the grant eligibility by applying a regression discontinuity (RD) estimator (see Appendix A4.1). In short, this consists of regressing a binary PSE attendance variable on some flexible function of parental income, as well as a dummy variable indicating eligibility for the NCBS. In the years when the grants were offered, the coefficient on the NCBS dummy will provide an estimate of the impact of the grant eligibility on enrolment.

[37] The differences-in-differences estimator is described in more detail in Appendix A5.1.

This is perhaps the stronger of the two approaches, given the design of the programs. The idea here is that students near the threshold should otherwise be quite similar in their PSE choice behaviour (in absence of the grants). In other words, they are randomly assigned to the treatment/control groups around the point of discontinuity, thus mimicking an experimental design (Lee, 2008).

After providing baseline results from the RD estimator, I then apply three robustness tests that are commonly used in the literature.[38] The first consists of 'narrowing the window' of the analysis around the NCBS threshold. This is also termed 'imposing a caliper'. In an ideal world, the researcher would have access to thousands of observations straddling the point of discontinuity (i.e. one dollar more or less than the threshold). In that world, youth with different amounts of grants offered to them would come from families with very similar incomes. To attempt to mimic these ideal conditions, I gradually narrow the window to the extent possible with the data. Specifically, I apply windows of +/- $10,000 and $5,000 around the threshold.

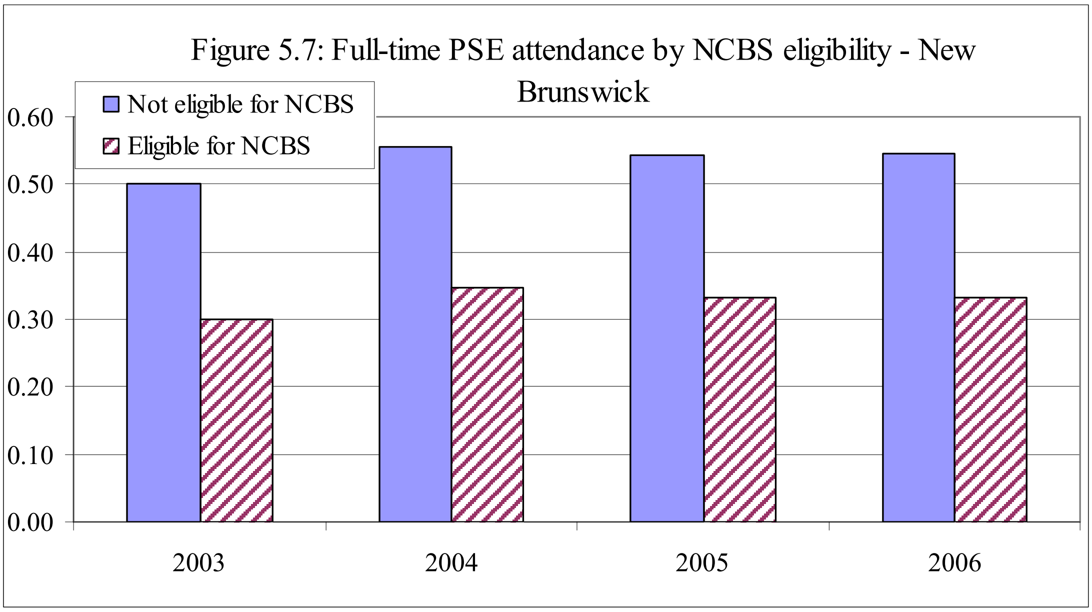
For the second robustness test, I change the specification of the functional form of income. The baseline specification for income is a quartic function. However, the danger in estimating a very flexible function is that the function may absorb the effect of the discontinuity. To be sure, I simplify the functional form by estimating cubic, quadratic, linear, and constant functions.

[38] See Lemieux and Milligan (2008) for an example of this approach.

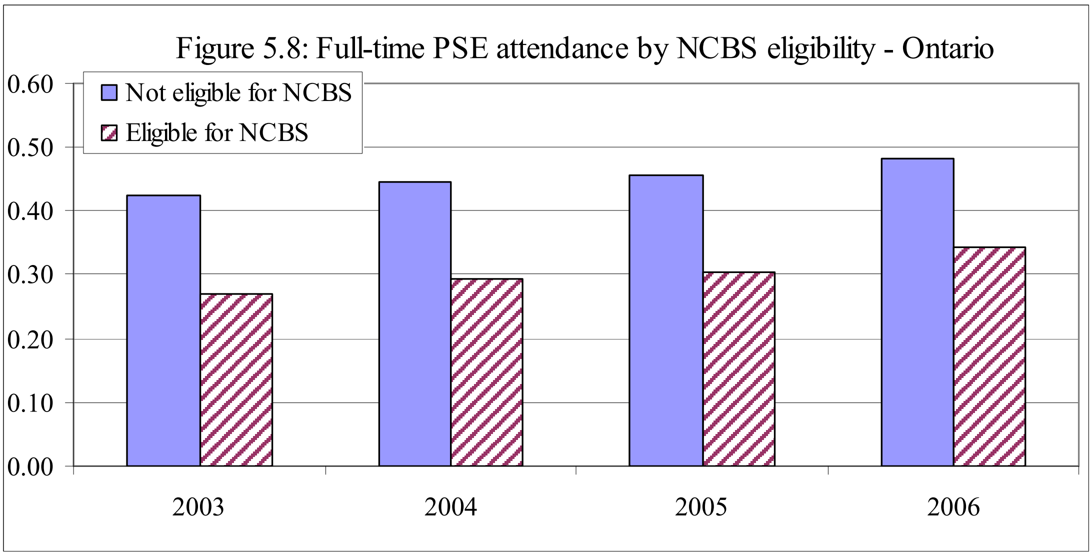
All of the discussion so far assumes that the NCBS threshold will actually capture the effect of the grants when they are offered. But what if there is a naturally occurring discontinuity at the NCBS threshold? As noted earlier, the NCBS income does not pose a problem since it rises very gradually from zero dollars at the threshold. However, it is difficult to rule out other possibilities. To be sure, the third robustness test consists of examining the trend around the discontinuity in a time when the discontinuity was less (or not) relevant (i.e. New Brunswick and Manitoba prior to 2006 and Ontario prior to 2005, respectively). This is termed a 'falsification test'.

5.10 Differences-in-differences results

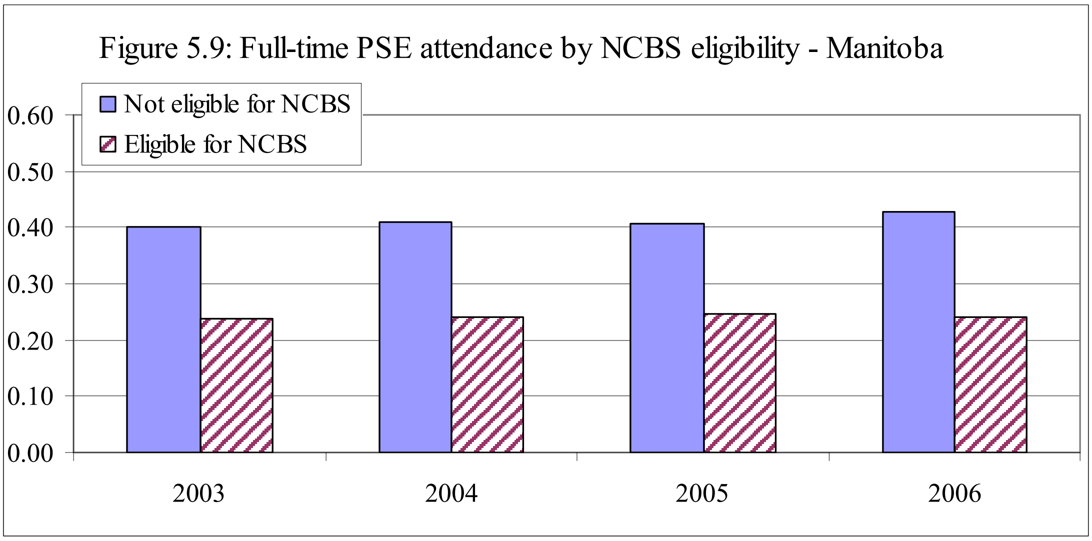
The first portion of the empirical analysis leans on a differences-in-differences (DD) approach. In Figures 5.7 to 5.9 below, I plot full-time PSE attendance rates among first-year age eligible youth by year and income category in New Brunswick, Ontario, and Manitoba. Although CAG-LI and MAB were in full effect from 2006 in New Brunswick, 2005 in Ontario, and 2006 in Manitoba, full-time, first-year PSE attendance rates did not increase at a faster rate among low-income youth (i.e. those eligible for NCBS) in the relevant years.



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Although the results above suggest no association between prospective debt reduction and PSE attendance, no other factors were taken into account. The sample sizes and means of the variables used in the analysis are broken down by province, year, and NCBS eligibility below in Tables 5.3 to 5.5. As can be seen from these tables, there are considerable differences in the socio-characteristics of youth in families whose income qualifies them (or not) for the NCBS. For example, those who qualify for the NCBS are far less likely to attend PSE. The gap is about 15 to 20 percentage points. This is likely because of the substantial difference in net parental income. Those who qualify for the NCBS genrally have net parental incomes in the $20,000 to $25,000. In contrast, net parental income is generally above $80,000 among youth who do not qualify for the NCBS. Not surprisingly, this group is also less likely to be raised in a lone-parent family (only about 5% to 8% of them are in lone-parent families, compared to about 40% for youth in families who qualify for the NCBS). If parental income and presence matter for attending university, then it is obviously important to account for these factors in the analysis.

Table 5.3: Sample means of variables used in analysis by NCBS eligibility - New Brunswick

	2003		2004		2005		2006	
	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS
Full-time PSE attendance	0.500	0.300	0.556	0.346	0.542	0.333	0.546	0.333
Net parental income	81,800	23,800	79,300	23,700	78,700	23,800	81,600	22,600
Lone-parent family	0.049	0.340	0.059	0.385	0.056	0.422	0.054	0.400
Number of children in family	2.7	2.5	2.6	2.5	2.6	2.5	2.5	2.2
Female	0.458	0.480	0.467	0.481	0.465	0.489	0.454	0.444
Sample size	710	250	675	260	710	225	650	225

Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.4: Sample means of variables used in analysis by NCBS eligibility - Ontario

	2003		2004		2005		2006	
	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS
Full-time PSE attendance	0.425	0.270	0.447	0.294	0.457	0.304	0.482	0.343
Net parental income	112,000	22,700	114,800	22,700	117,500	22,200	120,800	22,500
Lone-parent family	0.071	0.401	0.079	0.407	0.075	0.398	0.082	0.398
Number of children in family	2.8	2.8	2.8	2.9	2.8	2.8	2.8	2.8
Female	0.492	0.474	0.488	0.478	0.492	0.490	0.490	0.496
Sample size	12,030	2,480	11,690	2,520	11,595	2,550	11,335	2,540

Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.5: Sample means of variables used in analysis by NCBS eligibility - Manitoba

	2003		2004		2005		2006	
	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS	Not eligible for NCBS	Eligible for NCBS
Full-time PSE attendance	0.402	0.237	0.409	0.242	0.407	0.246	0.427	0.241
Net parental income	89,000	24,100	90,000	23,000	93,800	23,800	97,000	24,400
Lone-parent family	0.058	0.390	0.068	0.339	0.067	0.421	0.068	0.370
Number of children in family	2.8	3.1	2.8	3	2.7	2.9	2.7	2.9
Female	0.482	0.475	0.473	0.468	0.478	0.456	0.491	0.463
Sample size	1,120	295	1,100	310	1,045	285	1,100	270

Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

We now turn to the regression portion of the DD analysis. In Table 5.6, results for models estimated on the three provinces are shown. The models consist of regressing a dummy indicating PSE attendance on interactions between the grant eligibility indicator and the year t dummy variables, as well as the control variables described earlier. Whether the grants had an impact is difficult to ascertain directly from this table. In Table 5.7, I show the results from various F-tests (i.e. differences in coefficients from Table 5.6). The idea here is to test whether the gap in PSE attendance between those eligible and not eligible for the NCBS changed once the grants were introduced.

Based on the p-values in Table 5.7, the answer is a definite ‘no’. However, the interaction terms in Table 5.6 suggest that the gap in attendance by income appears to close somewhat following policy changes, and especially so between 2005 and 2006 (albeit not in a statistically significant way). This may suggest that, over time, more potential PSE students are learning about the new grants, and this may be contributing towards closing the attendance gap. However, this impact, if it exists at all, is not large enough as of yet to be detected statistically.

Table 5.6: Results from differences-in-differences estimation of full-time PSE attendance

	New Brunswick			Ontario			Manitoba		
	b		s.e.	b		s.e.	b		s.e.
Above NCBS threshold*2004	0.065	**	0.027	0.023	***	0.006	0.012		0.021
Above NCBS threshold*2005	0.052	**	0.026	0.032	***	0.006	0.011		0.021
Above NCBS threshold*2006	0.054	**	0.027	0.058	***	0.006	0.029		0.021
Below NCBS threshold*2003	-0.165	***	0.035	-0.119	***	0.010	-0.131	***	0.029
Below NCBS threshold*2004	-0.132	***	0.036	-0.095	***	0.010	-0.123	***	0.030
Below NCBS threshold*2005	-0.142	***	0.037	-0.087	***	0.010	-0.113	***	0.031
Below NCBS threshold*2006	-0.114	***	0.037	-0.050	***	0.011	-0.121	***	0.031
Lone-parent family	-0.053	**	0.025	-0.085	***	0.006	-0.082	***	0.020
Number of children in family	0.099	***	0.028	0.063	***	0.007	0.021		0.022
$(\text{Number of children in family})^2$	-0.013	***	0.005	-0.009	***	0.001	-0.003		0.004
Female	0.171	***	0.016	0.182	***	0.004	0.162	***	0.013
Intercept	0.264	***	0.042	0.251	***	0.011	0.296	***	0.035
Adjusted R^2	0.068			0.054			0.048		
N	3,710			56,790			5,530		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.7: F-test results of differences-in-differences coefficients

Gap in full-time PSE attendance	p-values		
between those eligible and not eligible	New Brunswick	Ontario	Manitoba
2005=2003	0.5571	0.9771	0.8567
2005=2004	0.9503	0.9853	0.7958
2006=2003	0.9464	0.4724	0.6552
2006=2004	0.5641	0.4688	0.7180
2006=2005	0.6114	0.4597	0.5428

Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

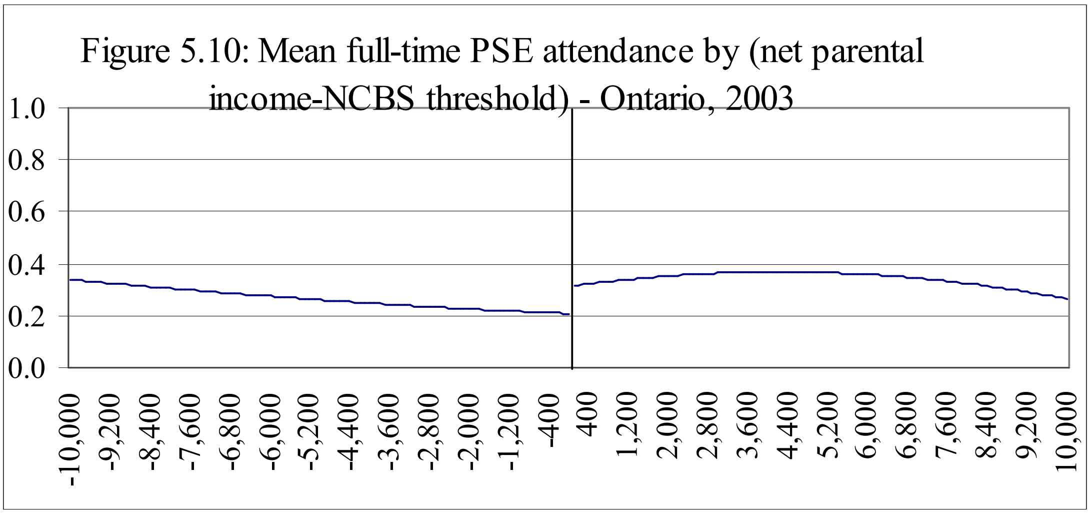
The other coefficients in Table 5.6 are also worth noting. Youth from lone-parent families are less likely to attended PSE. Sibling size is positively related to PSE attendance in New Brunswick and Ontario (albeit at a decreasing rate), as is being female in all three provinces.

5.11 Regression discontinuity results

The differences-in-differences approach used in the previous section may suffer from omitted factors that may bias the results. Since no significant effects were found, it may still be the case that confounding factors may have worked in the opposite direction, thus 'masking' a true effect. This may be the case when policies are 'bundled' together, which is often the rule rather than the exception. Rather than attempt to identify all possible confounding factors, an alternative strategy is to adopt an approach that is not susceptible to this problem. This is the spirit of this section, as I turn to a regression discontinuity (RD) approach.

I begin the RD analysis with pictures. This is appropriate since an RD estimator is nothing more than a very close look at the dependent variable (PSE attendance) around some critical threshold. In Figures 5.10 to 5.13, I show quadratic trends in full-time PSE attendance rates by the gap between net parental income and the NCBS threshold in Ontario for each year from 2003 to 2006. Separate quadratic trend functions are estimated above and below the NCBS cut-off (denoted by the vertical bars). Note that I focus primarily on Ontario from this point since sample sizes in other provinces are often too small to support the regression discontinuity analysis.[39]

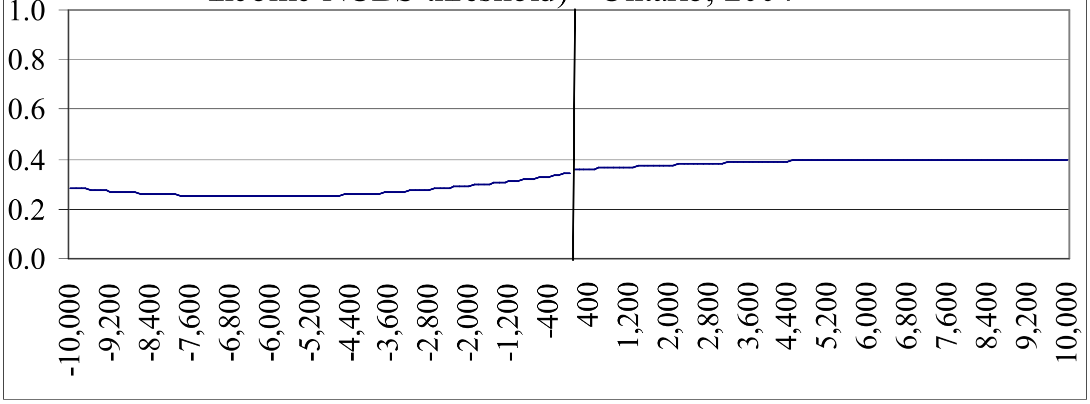
If the prospective debt reduction programs worked, we should expect to see a higher PSE rate when the gap is slightly negative compared to when it is slightly positive in 2005 and 2006 (the years when the grants were offered), relative to earlier years when the grant was not offered. However, there is no evidence of this in the figures. In all years, the trends are essentially flat, or they display a slight dip as we move from the positive to the negative.



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

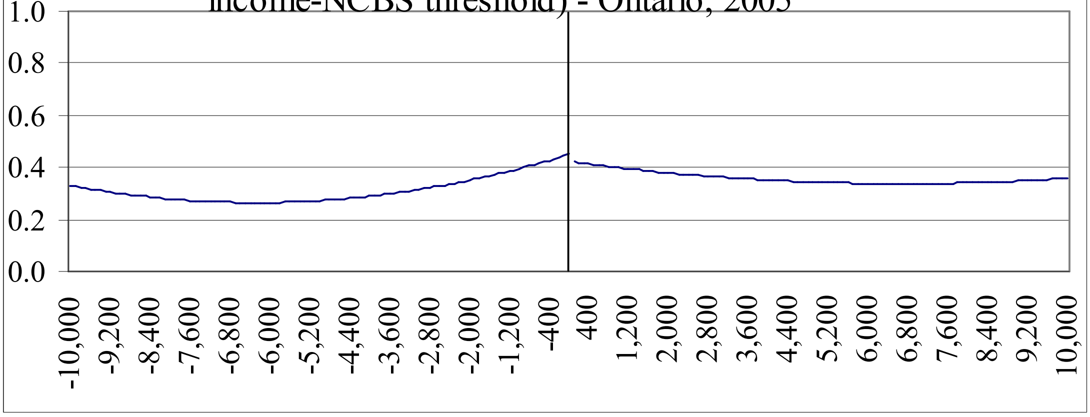
[39] Recall that in Chapter 4, I also showed the raw data (in slightly aggregated form). This was very effective since those data (standardized test scores) were continuous. In the current case, the data consist of rates, which in small samples are more often than not equal to zero. As a result, the underlying discontinuity (or lack thereof) is very difficult to detect visually with the raw data, and some degree of parametrization becomes necessary (as in Figures 5.10 to 5.13).

Figure 5.11: Mean full-time PSE attendance by (net parental income-NCBS threshold) - Ontario, 2004



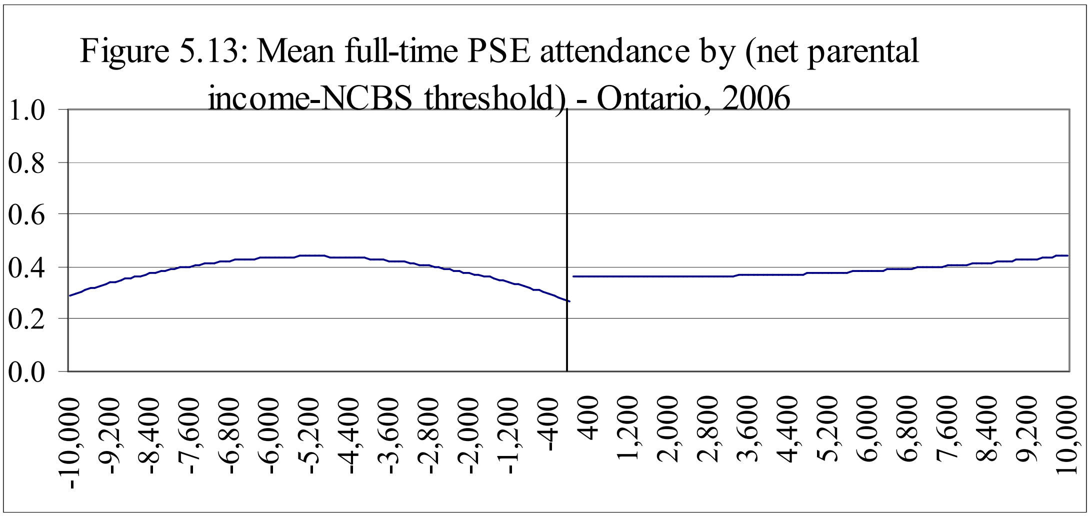
Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Figure 5.12: Mean full-time PSE attendance by (net parental income-NCBS threshold) - Ontario, 2005



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Figure 5.13: Mean full-time PSE attendance by (net parental income-NCBS threshold) - Ontario, 2006



Notes: The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

In Table 5.8, I estimate a regression discontinuity model separately for the three provinces in the years when the grants were offered. The idea here is to regress the PSE attendance dummy on a flexible set of variables capturing net parental income (a quartic in this case), and a dummy indicating eligibility for the NCBS, as well as other control variables. The coefficient on the NCBS dummy will provide an estimate of the impact of the grants since income is more or less held fixed.

Table 5.8: Results from regression discontinuity estimation of full-time PSE attendance

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.021	0.070	-0.020	0.013	-0.027 **	0.013	-0.010	0.046
Net parental income	4.E-06	3.E-06	1.E-06 ***	9.E-08	1.E-06 ***	9.E-08	4.E-06 ***	1.E-06
Net parental income^2	7.E-12	2.E-11	-1.E-12 ***	1.E-13	-8.E-13 ***	1.E-13	-1.E-11 ***	4.E-12
Net parental income^3	-7.E-17	7.E-17	2.E-19 ***	2.E-20	2.E-19 ***	3.E-20	1.E-17 ***	5.E-18
Net parental income^4	8.E-23	5.E-23	-9.E-27 ***	1.E-27	-1.E-26 ***	2.E-27	-4.E-24 ***	2.E-24
Lone-parent family	0.012	0.054	-0.062 ***	0.013	-0.053 ***	0.013	-0.005	0.042
Number of children in family	0.066	0.062	0.067 ***	0.014	0.062 ***	0.014	0.017	0.044
(Number of children in family)^2	-0.009	0.011	-0.010 ***	0.002	-0.010 ***	0.002	-0.003	0.007
Female	0.222 ***	0.032	0.176 ***	0.008	0.187 ***	0.008	0.165 ***	0.026
Intercept	0.039	0.138	0.146 ***	0.022	0.192 ***	0.022	0.081	0.081
Adjusted R^2	0.093		0.074		0.070		0.070	
N	885		14,150		13,870		1,360	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

The coefficients in the first row ('Eligible for NCBS') are never statistically significant except for Ontario, 2006; however, in that case, it is negative (this result disappears following robustness tests below). If the grants improved access to PSE, we would have expected to see a positive sign. In terms of other coefficients in the model, they are generally quite similar to their counterparts from the differences-in-differences models (Table 5.6).

In the next two sections, I use the results from Table 5.8 as the starting point for further analysis. In Section 5.12, I test the robustness of these results by using three common approaches in the RD literature: narrowing the window (i.e. looking more closely around the point of discontinuity), implementing specification tests (i.e. changing the functional form of the income controls), and applying falsification tests (i.e. examining the trend around the discontinuity at a time when the grants were not offered).

In Section 5.13, I examine heterogeneity in the results along several dimensions: sex, type of PSE institution, and presence of a local university. This exercise is useful since sensitivity to prospective debt load may vary along these dimensions, which means that important effects may still be present even though the general results to date suggest no effect in the aggregate.

5.12 Robustness tests

Narrowing the window

Although the functional forms described so far are quite flexible, the best way to control for income differences is by looking very closely around the point of discontinuity (as we did in Figures 5.10 to 5.13). In Table 5.9, I select a +/- $10,000 window around the NCBS threshold, and find no statistically significant coefficients on the NCBS dummy. In Table 5.10, I repeat the exercise with a +/- $5,000 window, and obtain the same result.

Table 5.9: Results from regression discontinuity estimation of full-time PSE attendance - $10,000 window

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.014	0.172	0.001	0.046	-0.023	0.045	-0.103	0.136
Net parental income	3.E-03	6.E-03	-8.E-05	8.E-04	2.E-04	8.E-04	4.E-03 *	2.E-03
Net parental income^2	-1.E-07	2.E-07	5.E-09	3.E-08	-1.E-08	3.E-08	-1.E-07 *	8.E-08
Net parental income^3	2.E-12	4.E-12	-1.E-13	5.E-13	2.E-13	5.E-13	2.E-12 *	1.E-12
Net parental income^4	-1.E-17	3.E-17	1.E-18	3.E-18	-1.E-18	3.E-18	-1.E-17 *	8.E-18
Lone-parent family	0.110	0.095	-0.094 ***	0.024	-0.055 **	0.025	-0.070	0.072
Number of children in family	0.032	0.158	0.043	0.040	0.071 *	0.040	0.061	0.107
(Number of children in family)	-0.002	0.032	-0.009	0.007	-0.006	0.008	-0.006	0.020
Female	0.192 ***	0.073	0.171 ***	0.022	0.185 ***	0.022	0.134 **	0.062
Intercept	-22.723	53.227	0.493	7.295	-1.390	7.513	-34.428 *	20.656
Adjusted R^2	0.011		0.039		0.042		0.006	
N	195		1,845		1,860		235	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.10: Results from regression discontinuity estimation of full-time PSE attendance - $5,000 window

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.065	0.242	0.020	0.059	-0.063	0.055	-0.120	0.178
Net parental income	1.E-02	3.E-02	4.E-03	5.E-03	4.E-03	4.E-03	9.E-03	2.E-02
Net parental income^2	-6.E-07	1.E-06	-1.E-07	2.E-07	-2.E-07	2.E-07	-3.E-07	8.E-07
Net parental income^3	1.E-11	2.E-11	2.E-12	3.E-12	3.E-12	3.E-12	6.E-12	1.E-11
Net parental income^4	-6.E-17	1.E-16	-9.E-18	2.E-17	-2.E-17	2.E-17	-4.E-17	8.E-17
Lone-parent family	0.127	0.146	-0.082 **	0.034	-0.066 **	0.033	-0.120	0.103
Number of children in family	0.236	0.268	0.024	0.069	0.028	0.067	0.085	0.180
(Number of children in family)	-0.052	0.058	-0.007	0.014	0.002	0.014	-0.007	0.038
Female	0.247 **	0.110	0.175 ***	0.031	0.212 ***	0.031	0.074	0.091
Intercept	-130.374	269.901	-42.258	45.940	-35.630	45.006	-82.364	211.460
Adjusted R^2	-0.017		0.040		0.053		-0.046	
N	95		940		975		115	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Specification tests

One issue with narrowing the window and having income controls in the main model at the same time is that a real effect may exist, but the associated jump (or dip) may be absorbed by the flexible income function, rather than by the NCBS dummy. This is especially problematic with a quartic income function, which allows for three inflexion points. One way to deal with this is to alter the specification of income by gradually making it more restrictive (i.e. fewer inflexion points).

In Table 5.11 to 5.13, I re-estimate the model using a cubic, quadratic, and linear specification, in that order. In each case, I find no significant impact of the grants on PSE enrolment. In Table 5.14, I drop the income control from the model, and hinge my identification completely on the size of the window around the threshold (still +/- $5,000). Again, I find no significant effect.

Table 5.11: Results from regression discontinuity estimation of full-time PSE attendance - $5,000 window, cubic specification

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.117	0.224	0.026	0.058	-0.054	0.055	-0.109	0.173
Net parental income	-2.E-03	2.E-03	2.E-03 ***	5.E-04	-7.E-04	5.E-04	-1.E-03	2.E-03
Net parental income^2	5.E-08	6.E-08	-4.E-08 ***	1.E-08	2.E-08	1.E-08	3.E-08	4.E-08
Net parental income^3	-3.E-13	5.E-13	3.E-13 ***	1.E-13	-1.E-13	1.E-13	-2.E-13	3.E-13
Lone-parent family	0.134	0.145	-0.082 **	0.034	-0.066 **	0.033	-0.114	0.100
Number of children in family	0.270	0.265	0.025	0.069	0.026	0.067	0.085	0.178
(Number of children in family)^2	-0.060	0.058	-0.007	0.014	0.002	0.014	-0.006	0.037
Female	0.244 **	0.109	0.176 ***	0.031	0.212 ***	0.031	0.065	0.090
Intercept	25.980	31.610	-20.081 ***	6.714	10.136	6.886	16.906	22.546
Adjusted R^2	-0.009		0.041		0.053		-0.039	
N	95		940		975		115	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.12: Results from regression discontinuity estimation of full-time PSE attendance - $5,000 window, quadratic specification

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.109	0.223	0.039	0.058	-0.048	0.055	-0.107	0.172
Net parental income	-3.E-04	2.E-04	3.E-05	6.E-05	3.E-06	6.E-05	-4.E-05	2.E-04
Net parental income^2	4.E-09	3.E-09	-3.E-10	8.E-10	-1.E-10	8.E-10	3.E-10	2.E-09
Lone-parent family	0.131	0.145	-0.079 **	0.034	-0.067 **	0.033	-0.122	0.099
Number of children in family	0.302	0.262	0.015	0.070	0.034	0.067	0.083	0.177
(Number of children in family)^2	-0.066	0.057	-0.007	0.015	0.001	0.014	-0.005	0.037
Female	0.248 **	0.107	0.174 ***	0.031	0.213 ***	0.031	0.070	0.090
Intercept	4.762	4.253	-0.621	1.074	0.279	1.098	1.260	3.455
Adjusted R^2	-0.003		0.033		0.052		-0.033	
N	95		940		975		115	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.13: Results from regression discontinuity estimation of full-time PSE attendance - $5,000 window, linear specification

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.069	0.225	0.043	0.057	-0.047	0.055	-0.106	0.171
Net parental income	1.E-05	4.E-05	1.E-05	1.E-05	-6.E-06	9.E-06	-2.E-05	3.E-05
Lone-parent family	0.103	0.144	-0.078 **	0.034	-0.067 **	0.033	-0.123	0.098
Number of children in family	0.120	0.232	0.028	0.061	0.039	0.060	0.076	0.175
(Number of children in family)^2	-0.022	0.050	-0.009	0.012	0.000	0.012	-0.004	0.036
Female	0.214 **	0.106	0.174 ***	0.031	0.213 ***	0.031	0.070	0.090
Intercept	-0.300	1.594	-0.253	0.398	0.439	0.396	0.831	1.141
Adjusted R^2	-0.012		0.034		0.053		-0.024	
N	95		940		975		115	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.14: Results from regression discontinuity estimation of full-time PSE attendance - $5,000 window, no income controls

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.002	0.106	-0.024	0.031	-0.017	0.030	-0.015	0.090
Lone-parent family	0.103	0.144	-0.081 **	0.034	-0.066 **	0.033	-0.117	0.097
Number of children in family	0.066	0.171	-0.018	0.052	0.062	0.049	0.132	0.145
(Number of children in family)^2	-0.008	0.029	0.003	0.009	-0.006	0.008	-0.020	0.024
Female	0.216 **	0.106	0.170 ***	0.031	0.213 ***	0.031	0.067	0.090
Intercept	0.215	0.246	0.314 ***	0.075	0.182 ***	0.070	0.136	0.212
Adjusted R^2	-0.002		0.033		0.054		-0.018	
N	95		940		975		115	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Falsification tests

So far, there is no evidence that the grants improved access to PSE for low-income youth. This is ascertained by observing (using various techniques) that there is no sudden change in enrolment patterns around the critical threshold for grant eligibility during the period when the grants were offered. However, what if there is a naturally occurring discontinuity around this threshold and the introduction of the grants simply counterbalanced this natural effect? Although it is not clear why a natural discontinuity would exist[40], a safe approach is to test for this possibility. The results of such tests are shown below in Tables 5.15 to 5.17. More precisely, the same model as in Table 5.8 is estimated, but for earlier years (prior to the introduction of the grant).

The results suggest that the coefficients were about the same before and after the introduction of the grant in each of the three provinces. This is true in the empirical

[40] One possibility, the fact that the NCBS kicks in at the same point as the grant eligibility, was dismissed earlier since NCBS amounts rise very gradually from zero dollars at the threshold.

and statistical sense. Thus, the possibility of a natural discontinuity is more or less ruled out.

Table 5.15: Results from regression discontinuity estimation of full-time PSE attendance - Falsification tests, New Brunswick

	2003		2004		2005		2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	-0.039	0.060	0.007	0.064	0.023	0.065	0.021	0.070
Net parental income	2.E-06	2.E-06	6.E-06 *	3.E-06	9.E-06 ***	3.E-06	4.E-06	3.E-06
Net parental income^2	7.E-12	2.E-11	-2.E-11	2.E-11	-4.E-11	3.E-11	7.E-12	2.E-11
Net parental income^3	-3.E-17	4.E-17	2.E-17	6.E-17	9.E-17	8.E-17	-7.E-17	7.E-17
Net parental income^4	3.E-23	3.E-23	-7.E-24	5.E-23	-6.E-23	8.E-23	8.E-23	5.E-23
Lone-parent family	0.054	0.052	-0.095 *	0.050	0.013	0.052	0.012	0.054
Number of children in family	0.119 **	0.055	0.061	0.054	0.113 **	0.055	0.066	0.062
(Number of children in family)^2	-0.020 **	0.010	-0.007	0.009	-0.018 *	0.010	-0.009	0.011
Female	0.178 ***	0.031	0.135 ***	0.032	0.171 ***	0.032	0.222 ***	0.032
Intercept	0.036	0.122	0.084	0.128	-0.099	0.134	0.039	0.138
Adjusted R^2	0.093		0.083		0.089		0.110	
N	965		935		930		885	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.16: Results from regression discontinuity estimation of full-time PSE attendance - Falsification tests, Ontario

	2003		2004		2005		2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	-0.019	0.013	-0.021 *	0.012	-0.020	0.013	-0.027 **	0.013
Net parental income	2.E-06 ***	1.E-07	1.E-06 ***	9.E-08	1.E-06 ***	9.E-08	1.E-06 ***	9.E-08
Net parental income^2	-1.E-12 ***	1.E-13	-9.E-13 ***	1.E-13	-1.E-12 ***	1.E-13	-8.E-13 ***	1.E-13
Net parental income^3	4.E-19 ***	5.E-20	2.E-19 ***	3.E-20	2.E-19 ***	2.E-20	2.E-19 ***	3.E-20
Net parental income^4	-3.E-26 ***	4.E-27	-1.E-26 ***	2.E-27	-9.E-27 ***	1.E-27	-1.E-26 ***	2.E-27
Lone-parent family	-0.052 ***	0.013	-0.062 ***	0.012	-0.062 ***	0.013	-0.053 ***	0.013
Number of children in family	0.034 **	0.014	0.056 ***	0.014	0.067 ***	0.014	0.062 ***	0.014
(Number of children in family)^2	-0.006 ***	0.002	-0.009 ***	0.002	-0.010 ***	0.002	-0.010 ***	0.002
Female	0.182 ***	0.008	0.180 ***	0.008	0.176 ***	0.008	0.187 ***	0.008
Intercept	0.150 ***	0.022	0.150 ***	0.022	0.146 ***	0.022	0.192 ***	0.022
Adjusted R^2	0.072		0.077		0.074		0.070	
N	14,520		14,250		14,150		13,870	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

Table 5.17: Results from regression discontinuity estimation of full-time PSE attendance - Falsification tests, Manitoba

	2003		2004		2005		2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.030	0.043	0.020	0.052	0.058	0.044	-0.010	0.046
Net parental income/1000	4.E-06 ***	9.E-07	3.E-06 *	2.E-06	5.E-06 ***	7.E-07	4.E-06 ***	1.E-06
(Net parental income/1000)^2	-9.E-12 **	4.E-12	-6.E-12	1.E-11	-1.E-11 ***	2.E-12	-1.E-11 ***	4.E-12
(Net parental income/1000)^3	8.E-18 *	4.E-18	3.E-19	3.E-17	9.E-18 ***	2.E-18	1.E-17 ***	5.E-18
(Net parental income/1000)^4	-2.E-24 *	1.E-24	2.E-24	1.E-23	-2.E-24 ***	4.E-25	-4.E-24 ***	2.E-24
Lone-parent family	-0.080 **	0.038	-0.076 **	0.039	-0.009	0.041	-0.005	0.042
Number of children in family	-0.030	0.045	-0.040	0.042	0.111 ***	0.042	0.017	0.044
(Number of children in family)^2	0.004	0.007	0.006	0.007	-0.018 ***	0.007	-0.003	0.007
Female	0.188 ***	0.025	0.143 ***	0.025	0.139 ***	0.026	0.165 ***	0.026
Intercept	0.111	0.083	0.166 *	0.101	-0.103	0.073	0.081	0.081
Adjusted R^2	0.084		0.065		0.023		0.070	
N	1,420		1,420		1,330		1,360	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

The main finding arising from both the DD and RD main results, as well as their robustness tests, is that there is no evidence that the grants had an impact on postsecondary enrolment among youth. This finding must be qualified, however, as the analysis so far has focused on the average youth. More to the point, some youth may have benefited from the grants if they are more sensitive to debt. I turn to this possibility in the next section.

5.13 Heterogeneity in the results

Perhaps there are certain groups of youth who are sensitive enough to prospective debt, and thus, may have altered their behaviour following the introduction of the CAG-LI/MAB grants. Males and females may be different in this respect, especially since returns to schooling vary by sex. Returns are higher for females, largely because they earn less than males when both have a high school diploma (Christofides, Hoy, and Yang, 2006).

Also, students who are raised far from a university may also be more sensitive to prospective debt.[41] Previous studies have suggested that these students are less likely to attend university, particularly if they are from a lower income family (Frenette, 2004, 2006, 2009b). One possible reason is the higher cost of attending when students leave the home to attend (Barr-Telford et al., 2003). If students face a long commuting distance, then they likely also face direct transportation costs, as well as opportunity costs associated with their travel time. It may also be the case that the labour market returns to higher education are lower in rural areas, where many distant students may plan to live. This too will work towards lowering net returns.

In Table 5.18 and 5.19, I re-run the base model (from Table 5.8) on males and females, respectively. The results are more or less the same. Importantly, there is no evidence that enrolment was higher as a result of the new grants (i.e. the coefficient on the NCBS dummy is never positive and statistically significant).

Table 5.18: Results from regression discontinuity estimation of full-time PSE attendance - Males

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	-0.013	0.097	0.017	0.016	-0.001	0.018	-0.036	0.059
Net parental income	4.E-06	4.E-06	2.E-06 ***	1.E-07	2.E-06 ***	2.E-07	3.E-06 ***	1.E-06
Net parental income^2	4.E-12	4.E-11	-1.E-12 ***	1.E-13	-2.E-12 ***	3.E-13	-6.E-12	4.E-12
Net parental income^3	-5.E-17	1.E-16	2.E-19 ***	3.E-20	5.E-19 ***	1.E-19	6.E-18	5.E-18
Net parental income^4	6.E-23	1.E-22	-9.E-27 ***	1.E-27	-5.E-26 ***	1.E-26	-2.E-24	2.E-24
Lone-parent family	-0.014	0.075	-0.069 ***	0.016	-0.059 ***	0.017	0.052	0.054
Number of children in family	0.075	0.084	0.055 ***	0.019	0.054 ***	0.019	0.026	0.059
(Number of children in family)	-0.014	0.015	-0.008 ***	0.003	-0.009 ***	0.003	-0.003	0.010
Intercept	0.084	0.199	0.139 ***	0.029	0.168 ***	0.031	0.068	0.102
Adjusted R^2	0.065		0.052		0.043		0.056	
N	490		7,185		7,060		700	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

[41] Distance to college is less of an issue as the vast majority of Canadian youth have local access to a college (Frenette, 2004).

Table 5.19: Results from regression discontinuity estimation of full-time PSE attendance - Females

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.074	0.112	-0.022	0.020	-0.033 *	0.019	0.024	0.081
Net parental income	6.E-06	7.E-06	2.E-06 ***	2.E-07	1.E-06 ***	1.E-07	5.E-06 *	3.E-06
Net parental income^2	-2.E-11	8.E-11	-3.E-12 ***	4.E-13	-7.E-13 ***	1.E-13	-2.E-11	2.E-11
Net parental income^3	5.E-17	3.E-16	1.E-18 ***	2.E-19	1.E-19 ***	3.E-20	2.E-17	3.E-17
Net parental income^4	-8.E-23	4.E-22	-2.E-25 ***	3.E-26	-9.E-27 ***	2.E-27	-9.E-24	2.E-23
Lone-parent family	0.042	0.081	-0.045 **	0.019	-0.042 **	0.019	-0.068	0.065
Number of children in family	0.059	0.091	0.080 ***	0.021	0.069 ***	0.021	0.010	0.066
(Number of children in family)	-0.005	0.016	-0.013 ***	0.004	-0.011 ***	0.003	-0.004	0.011
Intercept	0.161	0.239	0.273 ***	0.034	0.375 ***	0.032	0.254 *	0.147
Adjusted R^2	0.058		0.041		0.030		0.029	
N	395		6,965		6,810		660	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). All variables are captured at age 17, except full-time PSE attendance (captured at age 18).
Source: Longitudinal Administrative Databank (LAD).

I now turn to results by distance to school. Since this is only an issue for university attendance, I begin by re-estimating the base model with a dependent variable indicating university attendance (as opposed to any PSE). In the tax files, we only know PSE attendance with certainty since there is no distinction between college and university tuition credits and education deductions. However, based on the amount of the tuition credits claimed, as well as known tuition fees in Canadian provinces (which are somewhat constant across institutions), a series of proxies for university attendance can be created. I create two such variables.[42] In the first, I set university attendance equal to 1 if tuition credits are at least 80% of mean tuition fees in the province and year in question (for one semester only since students normally begin school in September, and the tax year ends in December—coinciding with the end of the first semester). In the second, I take a reverse approach: I code anyone claiming tuition credits that are 150% or more of average college tuition fees as having

[42] I thank Alex Usher, Ross Finnie, and Theresa Qiu for providing me with university and college tuition fees, as well as for sharing their imputation approach (which I adapted for my own purposes).

attended university. In the end, the same result is generated from both specifications in each of the relevant jurisdictions and periods: university attendance did not rise as a result of the debt reduction program (Tables 5.20 and 5.21).

Table 5.20: Results from regression discontinuity estimation of full-time university attendance - Method 1

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.085	0.059	0.019	0.012	0.009	0.010	0.018	0.039
Net parental income	3.E-06	3.E-06	2.E-06 ***	9.E-08	9.E-07 ***	8.E-08	3.E-06 ***	9.E-07
Net parental income^2	3.E-12	2.E-11	-1.E-12 ***	1.E-13	-6.E-13 ***	9.E-14	-9.E-12 **	4.E-12
Net parental income^3	-4.E-17	7.E-17	2.E-19 ***	2.E-20	1.E-19 ***	2.E-20	9.E-18 **	5.E-18
Net parental income^4	5.E-23	6.E-23	-1.E-26 ***	1.E-27	-8.E-27 ***	2.E-27	-3.E-24 *	2.E-24
Lone-parent family	0.038	0.047	-0.048 ***	0.011	-0.022 **	0.010	0.023	0.037
Number of children in family	0.005	0.055	0.051 ***	0.013	0.031 ***	0.011	0.024	0.037
(Number of children in family)^2	0.001	0.010	-0.008 ***	0.002	-0.005 ***	0.002	-0.005	0.006
Female	0.118 ***	0.029	0.150 ***	0.008	0.053 ***	0.007	0.104 ***	0.023
Intercept	-0.065	0.120	0.044 **	0.020	0.053 ***	0.018	-0.033	0.069
Adjusted R^2	0.054		0.075		0.031		0.048	
N	885		14,150		13,870		1,360	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). In Method 1, the student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Table 5.21: Results from regression discontinuity estimation of full-time university attendance - Method 2

	New Brunswick - 2006		Ontario - 2005		Ontario - 2006		Manitoba - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.092	0.066	0.008	0.012	0.014	0.012	-0.001	0.044
Net parental income	6.E-06 **	3.E-06	2.E-06 ***	9.E-08	1.E-06 ***	1.E-07	4.E-06 ***	9.E-07
Net parental income^2	-1.E-11	3.E-11	-1.E-12 ***	1.E-13	-9.E-13 ***	1.E-13	-1.E-11 ***	4.E-12
Net parental income^3	-2.E-17	7.E-17	2.E-19 ***	2.E-20	2.E-19 ***	3.E-20	1.E-17 ***	5.E-18
Net parental income^4	4.E-23	6.E-23	-1.E-26 ***	1.E-27	-1.E-26 ***	2.E-27	-5.E-24 ***	2.E-24
Lone-parent family	0.017	0.052	-0.062 ***	0.012	-0.040 ***	0.012	0.014	0.041
Number of children in family	0.035	0.061	0.064 ***	0.013	0.064 ***	0.013	0.014	0.042
(Number of children in family)^2	-0.004	0.011	-0.010 ***	0.002	-0.011 ***	0.002	-0.003	0.007
Female	0.233 ***	0.032	0.158 ***	0.008	0.165 ***	0.008	0.145 ***	0.025
Intercept	-0.140	0.132	0.063 ***	0.021	0.061 ***	0.021	0.028	0.078
Adjusted R^2	0.114		0.076		0.074		0.069	
N	885		14,150		13,870		1,360	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). In Method 1, the student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

I now replicate the results using the first method (in Table 5.20) by distance to school. Using an approach described in Appendix A5.2, I calculate the straight-line distance in kilometres (km) between the student's residence and the nearest university. In Table 5.22, I show the results for youth who are within 40 km of a university and others.[43] The results are shown for Ontario only since sample sizes are very small in New Brunswick and Manitoba when we focus on distant youth, and RD estimators require fairly large samples for estimation. Note that 24% of youth grew up in a home that is at least 40 km from a university.

[43] The goal of the exercise in the current section is to identify a group of students who may be particularly sensitive to prospective debt, based on the costs they face. This is particularly useful for policy purposes since it may facilitate better targeting of the grants. Appendix A5.3 shows and discusses results for different distance thresholds. The results indicate that distance does seem to matter in general, although this is not the case for very long thresholds, either because the samples become too small for reliable analysis or because the costs of displacement are too high for grants to matter at those distances. What is clear from the exercise, however, is that students beyond 40 km (as a whole) are particularly sensitive to prospective debt. Also, 40 km has been used in the literature on distance to school and university attendance (e.g. Frenette, 2006). For these reasons, I use 40 km as a threshold in the chapter.

Table 5.22: Results from regression discontinuity estimation of full-time university attendance by distance to university

	Local youth (< 40 km)				Distant youth (≥ 40 km)			
	Ontario - 2005		Ontario - 2006		Ontario - 2005		Ontario - 2006	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.013	0.014	0.002	0.012	0.055 **	0.027	0.059 ***	0.020
Net parental income	1.E-06 ***	1.E-07	9.E-07 ***	9.E-08	3.E-06 ***	6.E-07	2.E-06 ***	4.E-07
Net parental income^2	-1.E-12 ***	1.E-13	-5.E-13 ***	1.E-13	-4.E-12	2.E-12	-3.E-12 **	1.E-12
Net parental income^3	2.E-19 ***	2.E-20	1.E-19 ***	2.E-20	2.E-18	3.E-18	2.E-18	1.E-18
Net parental income^4	-9.E-27 ***	1.E-27	-7.E-27 ***	2.E-27	-3.E-25	1.E-24	-2.E-25	3.E-25
Lone-parent family	-0.062 ***	0.014	-0.039 ***	0.012	-0.005	0.022	0.010	0.017
Number of children in family	0.050 ***	0.016	0.023	0.014	0.025	0.024	0.023	0.019
(Number of children in family)^2	-0.009 ***	0.003	-0.004 *	0.002	-0.002	0.004	-0.003	0.003
Female	0.152 ***	0.009	0.053 ***	0.008	0.147 ***	0.014	0.058 ***	0.012
Intercept	0.087 ***	0.025	0.097 ***	0.023	-0.085 *	0.046	-0.066 **	0.033
Adjusted R^2	0.071		0.029		0.074		0.026	
N	10,180		9,935		3,250		3,205	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Since most youth are near a university, those results are similar to our previous ones (i.e. no statistically significant coefficients). However, there are positive, statistically significant effects among distant students. This marks a first in this chapter, and indicates that perhaps the grants helped raise enrolment in university among youth who grew up out-of-commuting distance or facing a long commute to university. This may be because these students face higher costs of attending, and thus, lower net returns. In other words, they are likely type B students.

As noted earlier, males face lower labour market returns to higher education than females. This had no implications for the results when I examined PSE attendance. However, when combined with facing higher costs to attending (i.e. being out-of-commuting distance or facing a long commute to university), university attendance rates for males increase substantially when debt is reduced, and results are statistically significant in each case (Table 5.23). Specifically, reducing prospective debt by up to $6,000 (depending on the tuition fees) led to a 7 percentage point increase in university attendance rates for males raised far from a university. For females, no effect is discerned.

Table 5.23: Results from regression discontinuity estimation of full-time university attendance by sex (≥ 40 km)

	Males								Females							
	Ontario - 2005				Ontario - 2006				Ontario - 2005				Ontario - 2006			
	b		s.e.		b		s.e.		b		s.e.		b		s.e.	
Eligible for NCBS	0.074	**	0.032		0.070	***	0.026		-0.002		0.044		0.024		0.037	
Net parental income	2.E-06	***	7.E-07		2.E-06	***	6.E-07		1.E-06		1.E-06		-2.E-08		1.E-06	
Net parental income^2	-2.E-12		3.E-12		-6.E-12	***	2.E-12		9.E-12		6.E-12		6.E-12		7.E-12	
Net parental income^3	2.E-18		4.E-18		4.E-18	*	2.E-18		-2.E-17	***	9.E-18		-1.E-17		1.E-17	
Net parental income^4	-6.E-25		1.E-24		-8.E-25		6.E-25		1.E-23	***	4.E-24		5.E-24		7.E-24	
Lone-parent family	-0.027		0.025		0.029		0.021		0.012		0.034		-0.014		0.025	
Number of children in family	0.064	**	0.028		0.037		0.023		-0.017		0.039		0.008		0.032	
(Number of children in family)^2	-0.011	**	0.005		-0.006		0.004		0.006		0.006		0.001		0.005	
Intercept	-0.078		0.054		-0.121	***	0.042		0.142	*	0.080		0.092		0.069	
Adjusted R^2	0.043				0.032				0.056				0.010			
N	1,635				1,590				1,615				1,615			

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

There is another potential reason why positive results are found for distant students. The quality of the universities that are geographically available to them may be lower than those available to youth raised in large cities. This is obviously very difficult to evaluate, but it remains a possibility. However, note that this follows the same line of reasoning: if university quality is lower in outlying areas, then perhaps youth in those areas face lower net returns to attending in absence of the grants. The grants may have, once again, pushed them over the break-even point. Since this possibility is difficult to defend (compared to returns by sex and distance related costs), I leave it as a possibility.

5.14 Concluding remarks

In this chapter, I estimate the impact of prospective debt load on the probability of PSE attendance among youth. To identify this effect, I exploit a setting whereby non-refundable grants were offered to students, but were clawed back from their calculated loan amount. This feature ensured that liquidity constraints remained constant since students were offered the same amount of total aid (loans and grants). The only variable factor was the amount of aid that had to be repaid. For identification purposes, the interesting (and unique) feature of the program related to eligibility: students with parental income below a critical threshold were eligible to receive the full grant, while those above the threshold could not receive the grant. This created a sharp discontinuity in eligibility.

Using a large longitudinal administrative data set that is linked at the family level, I find evidence that the grants helped raise enrolment in university among a group of students who face low net returns to attending university: males who were raised far from a university. Specifically, reducing prospective debt by up to $6,000 led to a 7 percentage point increase in university attendance rates for males raised beyond 40 km of a university. For youth in general, there is no statistical evidence that the grants helped raise enrolment in PSE in general nor in university in particular.

The magnitude of the impact of prospective debt on university attendance for men who grew up beyond 40 km from a university is quite large in relative terms. The raw enrolment rate among this group was 15.37% in 2005 and 10.12% in 2006.[44] Thus, a

[44] These results are for Ontario youth since it corresponds to the sample used in the analysis by distance to school and sex (due to sample size limitations in other provinces).

reduction in debt of up to $6,000 led to an increase in enrolment equivalent to 48% and 70% relative to the baseline rate.

The chapter adds to the literature in three important ways. First, the sharp regression discontinuity design is likely a more convincing identification strategy than what is available in most previous studies. Second, results are generated across several dimensions, which is an important feature given that certain students may face different net returns to PSE in absence of the grants, and thus, may differ in their propensity to change their decisions regarding attendance. The only other study in this literature to examine results by sub-group is Linsenmeier et al. (2006), who examine low-income youth from visible minority groups. Finally, this is the only Canadian study on the topic.

It is worth placing the findings of the study in the context of the simple theoretical model presented in this chapter. This model suggests that offering a non-refundable grant that is clawed back from loans raises the net present value of lifetime earnings associated with attending PSE. However, demand for PSE may not rise if students already valued the net discounted returns to PSE more than the alternative (no PSE) before the introduction of the grants. However, if they estimate net returns to PSE to be smaller than no PSE, then there is an opportunity for the grants to make a difference in this calculation.

The empirical evidence in this chapter suggests that most students may have viewed PSE as a good investment in the first place (and thus, the grants simply generated economic rents for them). For males who faced a geographic barrier or challenge, they may have viewed PSE as a bad investment given that they faced higher costs of attending (related to long commutes or displacement from the parental home) and given that the labour market returns to higher education are lower for males (and perhaps particularly so if they plan on returning to their hometown). However, many of them may have viewed PSE as a good investment once the grants were factored in.

Could there be other reasons why the loan reduction program had no impact on PSE attendance for most students? I ruled out manipulation effects earlier. However, I also noted the possibility that students simply were not aware of the grant opportunities, despite the fact that they were assessed for the grants with their loan application, and the Canadian government has made available an online loan calculator, which includes information on grant eligibility. This is unlikely, however, given that certain students appear to have benefited from the grant program, namely males facing a geographic barrier or challenge. It is not clear why they would have obtained more information about the grants.

Given the strength of the identification approach, future work using a similar framework could focus on other possible outcomes of student debt. These include persisting in PSE (including completing the program), pursuing further studies after graduation, and life outcomes following graduation (i.e. marriage, childbearing, homeownership, retirement savings, etc.)

Chapter 6: Conclusion

6.1 Summary of the thesis

The objective of this thesis has been to estimate the role of various factors in determining human capital acquisition among Canadian youth. In the current context, human capital has been measured from an educational perspective, including academic performance and progression to higher education. An important focus throughout has been to pay careful attention in attempting to identify causal relationships, as opposed to simple correlations.

In Chapter 2, I examined the relationship between family size (i.e. the number of children) and child quality. According to Becker's Quantity-Quality model (Becker, 1960), there exists a trade-off between the number of children in the household and the investments that parents make in their children.

Using Cohort A of the Canadian Youth in Transition Survey (YITS), I estimated the impact of family size on parental investments in children. After instrumenting family size with the incidence of a multiple birth on the second or later birth, I found that family size was indeed negatively related to all available measures of parental investments in children, including enrolment in private school, the number of computers per child, and saving for higher education.

However, despite the fact that parental investments in children decline as families grow, the academic performance of the child does not suffer. In fact, I found weak evidence suggesting that it improves.

Several candidate explanations were discussed. The first was the possibility that the parental investments are not causally linked to the child's academic performance. In fact, the best evidence in the literature suggests that there is no link between parental investments and the child's academic performance. Another candidate—the existence of economies of scale in rearing larger families and/or in selecting effective sibling interactions—explains some, but not all of the puzzle. Specifically, I demonstrated that test scores did not fall with family size even among youth who had no siblings born within two years of them, and thus, were unlikely to be affected by economies of scale. A third possibility is that larger families draw mothers away from the paid labour force and into the home to take care of their children. Maternal contact has been shown to be positively correlated with the cognitive development of children. Since decisions regarding household allocation of labour supply require a different framework than the one in place in Chapter 2, I explored this issue in Chapter 3.

According to Becker's theory of specialization (Becker, 1985), combined with Lundberg and Rose's theory of home intensity (Lundberg and Rose, 1999), larger families will induce mothers to spend less time in market work and more time performing housework and childcare. For fathers, the theoretical prediction is ambiguous.

I tested the models in Chapter 3 by using Canadian Census data, which contains detailed information on paid and unpaid work hours of individuals. To identify the impact of family size on work hours, I used two strategies. The first is similar to the one used in Chapter 2, which involved instrumenting family size with the incidence of a multiple birth on a second or later birth. The second IV was the sex composition of the first two children. Both approaches generated qualitatively similar findings. Specifically, mothers respond to larger families by spending more time in the home performing housework and childcare and less time performing paid work. In contrast, the labour supply response of fathers is close to nil, although a small positive impact on unpaid childcare was found.

In Chapter 4, I set out to estimate the impact of schooling on academic performance. To identify the impact of schooling, I explored a setting whereby students of close age wrote the same standardized tests (PISA), but were in different school grades simply because of school entry laws. Most students were in secondary school in this setting.

Using the same YITS data as in Chapter 2, I implemented an IV approach (under a fuzzy regression discontinuity design) whereby the actual school grade is instrumented with the initially assigned school grade based on age and the entry laws. I found that schooling confers significant benefits to students in the area of reading, mathematics, and science. Moreover, I found that schooling provides more or less the same benefits to students along several important dimensions, including the conditional distribution of academic performance, sex, and parental income.

The focus of the thesis shifted somewhat in Chapter 5. At this point, I moved from academic performance as a measure of human capital, to postsecondary attendance. More specifically, I looked at the impact of prospective student debt on PSE attendance. Using a very simple theoretical model, I demonstrated that following a reduction in prospective debt, the demand for PSE can only rise among youth who initially had a negative valuation of PSE relative to the alternative of no PSE. Furthermore, a rise in demand will not necessarily lead to a rise in enrolment since supply side factors (i.e. capacity constraints, tuition freezes, etc.) may limit entry into PSE. It may, however, lead to a re-allocation of students receiving offers from PSE institutions.

Using the Canadian Longitudinal Administrative Databank (LAD), which is a 20% file of personal tax records and family members linked over time, I explored a unique policy change regarding prospective debt. Specifically, non-refundable grants were offered to entering PSE students if they came from a low-income family. For identification purposes, the grants had two interesting features. First, they did not increase the amount of total aid received since they were simply clawed-back from student loans. In other words, liquidity constraints were held fixed. Second, the full grant was offered if parental income was below a certain threshold. If income was just above the threshold, no grant was available. I exploited this feature by adopting a sharp regression discontinuity design.

The findings suggested that in general, the grants did not raise enrolment in PSE. However, positive effects were found for one group of students who may otherwise face negative returns to university education: males who were raised far from a university. Specifically, reducing prospective debt by up to $6,000 led to a 7 percentage point increase in university attendance rates for males raised beyond 40 km of a university. This effect represented between 48% and 70% of the baseline attendance rate among this group.

6.2 Contributions to the literature

This thesis has contributed to several strands of the literature. In each chapter, one of the important contributions was to provide Canadian evidence. In fact, each of the chapters constituted a Canadian first in the literature. However, for the remainder of this section, I will highlight contributions to the international literature.

The work in Chapter 2 was only the second to provide quasi-causal estimates of the link between family size and academic performance. Examining the impact of fertility on parental investments in children provided an important test to Becker's Quantity-Quality model of household production. For more than four decades, no solid evidence was available to support this theory. To date, only the study by Cáceras-Delpiano (2006) provides empirical evidence on the topic. Chapter 2 added to this body of knowledge by confirming Cáceras-Delpiano's finding of a negative relationship between fertility and private school enrolment. It also lent more credibility to Becker's model by finding a negative relationship between fertility and other forms of parental investments, namely the number of computers per child and savings for the child's higher education. These investments have not been previously examined. Finally, the chapter offered three possible explanations as to why increased family size is linked to reduced parental investments in children, yet does not necessarily reduce child academic performance (in fact, evidence suggests it bolsters it). The candidates examined included: the absence of hard evidence in the literature linking parental investments to child outcomes, economies of scale in rearing more children or in selecting effective sibling interactions, and increased parental time at home.

In Chapter 3, studying the relationship between fertility and labour supply contributed to the literature in three important ways. First, it is the only study to provide quasi-causal estimates of the impact of fertility on unpaid work. This provided a possible reason behind the finding that increased fertility leads to less parental investments in children, but not necessarily to a decline in child quality. To date, two studies using credible identification strategies have come to this conclusion (Cáceras-Delpiano, 2006; Chapter 2). According to Cáceras-Delpiano, one possible reason is that mothers of larger families spend more time taking care of children. However, the data available to him only contained information on the paid labour force. In Chapter 3, I confirmed that mothers spend considerably more time in the home performing unpaid childcare when there are more children. This finding is also important since the theories regarding fertility and labour supply critically depends on the allocation of labour between the husband and the wife in both paid an unpaid work (Becker, 1985; Lundberg and Rose, 1999). The findings in Chapter 3 confirmed the unified theories of Becker and Lundberg/ Rose. Second, I also examined the relationship between fertility and paid work in Chapter 3. Although this is not new, the analysis of paternal work patterns in this chapter stands among a small handful of studies on this topic. Finally, the chapter assessed the IVs used in this literature by proposing a test of validity based on the predictive power of previous patterns of paid work.

Chapter 4 also contributed to the literature by exploring heterogeneity in the impact of schooling on academic performance to a much greater extent than before. Specifically, results were generated across three important dimensions: the conditional distribution of academic performance, sex, and parental income. This is important since it indicates for *whom* the schools are working. Differences by performance level are perhaps obvious since schools might be concerned with trying to help those who are having the most difficulty. Sex and parental income are also very important dimensions since it is well-documented that there exist important differences in academic performance along these measures. To date, only Cascio and Lewis (2006) look at ethnicity and Alexander et al. (2001) examine parental income.

The second contribution Chapter 4 made to the literature concerned the range of academic areas examined. Among the most credible studies in the literature, the focus has either been on mathematics- and language-related scores (e.g. Cahan and Davis, 1987; Cahan and Cohen, 1989) or on a broad test score (Cascio and Lewis, 2006). In Chapter 4, I considered three broad areas: reading, mathematics, and science. In addition, I showed results for three sub-components of the reading test: retrieving, interpreting, and reflecting. Identifying the areas in which students are benefiting the most from additional schooling is critical for effectively allocating resources.

Two important advances were made in Chapter 5 regarding the literature on prospective debt and postsecondary attendance. The first advance concerns the identification strategy used in the chapter. Two of the three previous studies on this topic all exploited a differences-in-differences approach. While this is a popular and useful approach for identification purposes, the possibility that education reforms are 'bundled' and the inherent difficulties in falsifying this critique cast some doubt on the findings. A third study (Field, 2009) implemented a social experiment with random assignment, but with a very small sample. As an alternative, I adopted a 'sharp' regression discontinuity approach, which was possible given the policy change I examined. This design is similar to random assignment as long as the sample is large enough around the discontinuity and manipulation effects are not present (two conditions that were met in the design in Chapter 5). In other words, this approach may be as good as the one adopted by Field, if not better (given her small sample).

Second, I developed a framework for understanding the conditions when debt reduction may help raise PSE attendance. I adapted a simple model by Linsenmeier et al. (2006) to show that the discounted net returns to PSE will rise when less debt needs to be repaid, all else constant. I then argued that this is no guarantee that the *demand* for PSE will rise since students may have already viewed PSE as a good investment. Moreover, supply constraints in the system may further limit enrolment increases and may lead to a re-allocation of students receiving offers from PSE institutions. I then provided empirical evidence supporting the framework above. Specifically, overall enrolment in PSE did not rise among youth targeted by a debt reduction program. However, *university* enrolment rose among youth who faced higher costs and lower labour market returns (thus, lower net returns).

6.3 Policy implications

There are several policy implications that arise from the findings in this thesis. Taken at face value, the finding that family size does not necessarily negatively affect the academic performance of children (Chapter 2) may suggest that offering financial incentives to influence fertility has no negative implications for children. However, this may simply be the case because mothers tend to spend more time at home as their family grows (Chapter 3). As suggested by Alexander et al. (2001), the home environment may actually be detrimental to children in low-income families in particular. That is, parents of low-income children have fewer resources to devote to learning activities (e.g. sending their children to camp). Thus, the counterbalancing maternal contact effect may simply not be present for low-income children. Does this imply that rising fertility is detrimental to children in low-income families? There is no definitive answer, as data limitations (number of multiple births) prevented this sort of analysis. What this argument does suggest, however, is that targeting financial incentives to higher income families might be optimal in terms of child outcomes (albeit perhaps less effective at inducing fertility). Tying the incentives to labour force attachment might be particularly effective in this case (e.g. tax deductions for the lower earning spouse).

Another policy implication regarding Chapter 3 relates to a different objective of fertility policies: replenishing the labour force. This is important because of the aging population in developed countries. A common strategy in this regard is to take in more skilled immigrants, but research has shown that many new entrants face integration issues in Canada and in many industrialized nations. An alternative approach is to create financial incentives for families to have more children. Such incentives are already in place throughout most of the developed world since the tax and transfer systems of 28 out of 30 countries in the OECD contain special provisions for families with children (OECD, 2002a). In the Canadian case, many programs that have been developed in recent years may arguably contain such incentives, either by design or by coincidence. For example, the maternity/parental leave benefits available through the employment insurance program were extended from six months to one year in 2001. More recently, the Universal Child Care Benefit (UCCB) was introduced in 2006, and consists of a $100 monthly cheque that is mailed to parents for each child below the age of six. All parents qualify to receive the benefit regardless of income, although the benefit is taxable.

However, the fertility strategy is a long-term one, as children can only begin work in their teenage years. In the short to medium term, the strategy may actually be counterproductive since maternal labour supply declines considerably as family size grows. To compensate for the reduction in paid work hours, the mother may increase her paid work hours in advance of having children or once she has stopped caring for her children; however, data limitations preclude further investigation into this area.

The research in Chapter 4 regarding the impact of schooling on academic performance has obvious implications for education policy. Specifically, the methodology provides an alternative framework for evaluating the benefits that schooling confers to students. Education departments in Canada and around the world spend considerable time and financial resources in administering standardized tests. In the current framework, students in different school grades are administered different tests. Thus, there is no way to evaluate student progress throughout the school system. To mimic the PISA test conditions in Québec and Nova Scotia, education departments could administer the same test to students in adjacent school grades on a bi-annual basis (so that most students do not write the same test twice).

The findings in Chapter 4 also made important contributions to policy. Specifically, educational policymakers can use the results to better target spending. Significant effects were found in all areas, but the evidence was weak for science. Should more resources be spent on promoting the sciences? If so, then perhaps a useful starting point might be before students attend university given the findings in Chapter 4.

On a more positive note, the results in Chapter 4 suggest that students from various backgrounds benefit equally from schooling, at least at the secondary level. Specifically, schooling confers the same benefits to high and low performing students, to boys and to girls, and to students from well-to-do and less favourable socioeconomic backgrounds. This signals to policymakers that other arenas may be better targets for attempting to equalize learning opportunities. For example, economically disadvantaged youth may struggle in school not because of factors present in them, but because of conditions in their home life. This was suggested by Alexander et al. (2001) who saw tests scores decline in the summer months for these youth, but not during the school months relative to richer children. Of course, policies designed to influence learning in the home might be difficult to implement. A solution might be to extend the school year, or perhaps more feasibly, kindergarten. Recent quasi-experimental work from the Netherlands supports the strategy of expanding learning opportunities in the early years (Leuven, Lindahl, Oosterbeek, and Webbink, 2010). Their findings suggest that extending kindergarten for 'disadvantaged' four year-olds has large beneficial effects on cognitive ability at age 6. To match the Dutch funding scheme for primary schools, the authors define ‘disadvantaged’ as any child whose parents have at most a degree from a low level technical school. An alternative option is to improve the *quality* of early learning opportunities. Many programs in the US have been targeted to disadvantaged youth, such Head Start, the Perry School project, and others. Currie (2001) and Garces, Thomas, and Currie (2002) report the existence of substantial short and long-term benefits of such programs in several areas (e.g. cognitive ability, educational attainment, criminal activity, spillovers to younger siblings, etc.)

For the gender gap, the home is not likely a useful target since socio-economic conditions are usually the same for boys and girls. Factors in elementary school might be more appropriate; for example, teacher gender might matter (Dee, 2007). If so, then wage incentives to attract male elementary school teachers could be adopted.

The results in Chapter 5 provide a clear framework for policy. Specifically, the fact that overall PSE attendance rates do not improve among students targeted by the non-refundable grants suggest that most grant recipients are receiving economic rents. In other words, the grants represent a transfer from taxpayers to students who would have attended PSE in any event. Perhaps having less debt to repay will help these students establish themselves following graduation, but that is not clear at this point.

The findings do suggest, however, that the grants could be better targeted. For the moment, they are geared towards youth from low-income families. Since university attendance rates improved among males who face a geographic barrier or challenge with regards to attending, perhaps the eligibility criteria for the grants could be modified to incorporate the location of the parental home relative to universities. Adding the gender of the student may prove to be a slightly more difficult challenge from a political point of view.[45] If better targeting is not possible, one alternative might be to subsidise the additional costs associated with leaving the parental home for students who must do so, although this would not address the gender dimension.

6.4 Directions for future research

Although the thesis has helped shed light on several important topics, there are many directions that future related work could take. For example, the broad finding in Chapter 2 that fertility does not negatively affect the academic performance of children may need to be qualified. This finding may critically depend on the counterbalancing effect of increased maternal contact. As suggested by Alexander et al. (2001), this counterbalancing effect is not present for low-income youth. However, this is an empirical question, and a useful avenue of future research.

Another possible reason why increased fertility does not necessarily negatively affect academic performance is because reduced parental investments in children may simply not matter. The research on parental investments and children's academic performance is not very well established and could benefit substantially from studies that pay more attention to causal relationships.

[45] The reverse has been implemented. Canada has offered scholarships to encourage women to take on doctoral studies.

There are other potential implications of fertility aside from those examined in Chapters 2 and 3 (i.e. academic performance, parental investments, and labour supply). For example, research could focus on the well-being of the mother given her additional hours of unpaid work in response to increased fertility. A research design similar to the one employed in Chapter 3 could be implemented in a study of fertility and maternal health (both physical and emotional). If fertility does affect maternal health, this could cause strain in the couple's relationship. Thus, examining the impact of fertility on divorce or separation may be another useful avenue of research.

In Chapter 4, I suggested that the evidence regarding the effect of schooling on science performance is weak. Whether policymakers should be concerned about this critically depends on the marginal benefit of raising knowledge in science. Coulombe and Tremblay (2006) use national level data over time to demonstrate that literacy scores (averaged over several areas) are positively associated with GDP per capita. A similar study comparing the effects of different types of tests scores on GDP per capita would be very informative.

The findings in Chapter 4 also suggest that the key to understanding differences in academic performance may lie in factors outside of secondary school. For example, earlier school factors, the home environment, or genetic factors. Future work could then focus on studying factors within these domains as possible determinants of achievement for different groups of students.

Finally, the work in Chapter 5 could be enhanced by examining other potential consequences of prospective student debt. For example, one could look at the impact of prospective debt on persistence in PSE or completion (graduation). Another usual avenue would be the 'life outcomes' of graduates. Rothstein and Rouse (2007) look at the impact of student debt on job quality (from a public interest point of view), while Chiteji (2007) looks at homeownership and marriage as outcomes. Other outcomes would be of interest, such as childbearing, saving for the child's education, and saving for one's retirement.

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Appendix A2.1: Boostrapped standard errors

In Chapters 2 and 4, I use complex survey data. When data are generated from a simple random sample of the population, standard variance formulae apply. However, when complex survey designs are introduced (e.g. multi-stage or stratified sampling), the formulae for variances or standard errors of estimates become more complex. Bootstrapping is one way to estimate the standard errors of the point estimate (see Chernick, 2008).

In an ideal world, the standard error of a point estimate (e.g. a mean or regression coefficient) could be obtained from several samples taken from the population. The point estimate would be calculated for each sample, thus providing a sample distribution of the point estimate. In reality, we usually only have one sample to work with. However, we can still generate an estimate of the distribution of point estimates by re-sampling with replacement from the original sample. This is the method of non-parametric bootstrapping for independent and identically distributed observations, which is used in this thesis.

For convenience, survey methodologists often produce bootstrap weights, which are designed to replicate the re-sampling with replacement process (when different sets of bootstrap weights are applied). This makes standard error estimation under a complex survey design relatively straightforward: researchers begin by producing the point estimate with the standard set of weights. To calculate the standard error, the point estimate is re-generated once for each set of bootstrap weights, producing a sample distribution of point estimates. The estimate of the standard error is then calculated by producing the standard error of the point estimates. Note that bootstrapping provides a consistent estimate of the standard errors, and as such, will also correct for potential heteroscedasticity (i.e. non-constant variance of error terms across observations).

Appendix A2.2: Wald estimate

The goal of the empirical analysis in Chapters 2 and 3 is to estimate the impact of fertility (the number of children) on child quality measures and parental labour supply, respectively. In Chapter 4, the goal is to estimate the impact of schooling on academic performance. To meet these objectives, two estimation approaches are adopted. The first approach is the Wald estimate (Angrist, 1990). The second approach will be described in Appendix A2.3.

The idea behind the Wald estimate is that some exogenous force influences some outcome through some mediating factor. Three exogenous forces are examined in the thesis: the incidence of a multiple birth on the second or later birth (Chapters 2 and 3), the incidence of two same sex children on the first two (Chapter 3), and the school grade initially assigned based on the exact date of birth and school entry laws (Chapter 4). These are described in more detail in the chapters.

More formally, the Wald estimate is a measure of the impact of a variable N on Y, where N draws its variation from some instrumental variable Z, which is exogenous to Y. In the language of experimental design, the outcome (Y) is influenced by the treatment (N), which draws its variation from some assignment variable (Z). A crude way to estimate this impact would be to calculate the difference in the average values of Y between families with the different values of the instrumental variable. However, this would give us the impact of the instrument on the outcome. If one wants to estimate the impact of N on Y, it is necessary to rescale this difference by dividing by the difference in the average value of N for different values of the instrument. This yields an estimate of the impact of N on Y, where N draws its variation from Z, but all is expressed in the units of N.

For example, the Wald estimate can be expressed as the ratio of the difference in average parental labour supply ($\overline{Y}$) between families with (1) and without (0) same sex children on the first two, to the difference in the average number of children ($\overline{N}$) generated by the incidence of same sex children, as shown below.

$$(A2.1.1)\; Wald = \frac{\left(\overline{Y}1 - \overline{Y}0\right)}{\left(\overline{N}1 - \overline{N}0\right)}$$

The standard error of the Wald estimate is (Angrist, 1990):

$$(A2.1.2)\; \text{s.e.}(Wald) = \frac{\sqrt{\left(\sigma^2_{\overline{Y}1} \big/ n_1\right) + \left(\sigma^2_{\overline{Y}0} \big/ n_0\right)}}{\left(\overline{N}1 - \overline{N}0\right)},$$

where n refers to the sample size. For significance testing, note that the Wald estimate follows $\chi^2(1)$.

If the instrument is truly exogenous, then the Wald estimate has a causal interpretation, and there is no need to provide econometric evidence. In reality, however, few instruments are perfect. For that reason, it is good practice to extend the Wald estimate to a multivariate platform, where differences in covariates can be taken into account. Such an approach is described in Appendix A2.3.

Appendix A2.3: Instrumental variable (two-stage least squares) regression

The instrumental variable (two-stage least squares) approach is the regression analogue to the Wald estimate. I use it in Chapters 2 and 3 to estimate the impact of fertility on child quality and parental labour supply, respectively. I also use it in Chapter 4 to estimate the impact of schooling on academic performance. The idea behind this approach is simple, and it is perhaps best illustrated by first discussing the second stage. Here, the outcome variable (e.g. parental labour supply, *Y*) is regressed on fertility (*N*) and other covariates (*X*). However, the value of the fertility variable is the predicted number of children generated from a first-stage regression of the actual number of children on the instrumental variable (e.g. the incidence of same sex children on the first two, *Z*) and the same covariates used in the second stage, as shown below.

$$(A2.2.1)\ First-stage: N_i = \alpha_0 Z_i + \alpha_1 X_i + \varepsilon_i$$

$$(A2.2.2)\ Second-stage: Y_i = \beta_0 \hat{N}_i + \beta_1 X_i + \mu_i$$

By using the predicted value of fertility ($\hat{N}$), we are effectively focusing on additional children that are generated by the event denoted by the instrumental variable. Furthermore, the estimate of interest in stage 2 (β_0) is already expressed on a per capita (per child) basis. Both of these features were encountered in the Wald estimate.

The only difference is that the Wald estimate does not take into account differences in covariates, while IV regression does.

Appendix A2.4: An important limitation of IV estimation

One limitation of using a binary IV (whether in a descriptive or econometric framework) concerns the interpretation, which is that of a Local Average Treatment Effect, or LATE (Imbens and Angrist, 1994). Put differently, the estimated effect applies only to the compliers (i.e. those whose treatment status changed as a result of the assignment). For others, we cannot estimate an effect since their treatment status did not change. In the case of the multiple birth IV, the compliers are families who were induced to have another child as a result of having experienced a multiple birth, as well as those who were not induced to have another child as a result of not experiencing a multiple birth. Unfortunately, it is impossible to identify the compliers in this case since we do not know anything about family size in the counterfactual case. The same applies to the other instruments used in this thesis (i.e. sex composition of the first two children in Chapter 2 and being born before or after a cut-off date in Chapter 4). In the latter case, I expressed the variable *GRADEASSIGNED* in a continuous manner, but in reality, there are only two possible values (9 or 10). In effect, this is equivalent to expressing the variable in binary form (i.e. the results are exactly the same when a binary version of the IV is used). Thus, the results are also LATE.

Appendix A2.5: A description of the PISA tests and sample questions

The Programme for International Student Assessment (PISA) is run by the OECD.[46] PISA differs from other assessment programmes in that it is not primarily curriculum-based. Although PISA recognizes the importance of curriculum-based knowledge, it tests for this mainly in terms of acquisition of broad concepts and skills that allow that knowledge to be applied to real world problems.

In 2000, there were three PISA tests: reading, mathematics, and science. The concept of literacy in each of these three domains is defined below:

- Reading literacy: "The capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society."

- Mathematical literacy: "The capacity to identify, to understand, and to engage in mathematics and make well-founded judgements about the role that mathematics plays, as needed for an individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned, and reflective citizen."

[46] The information in this appendix is taken directly from OECD (2002b).

- Scientific literacy: "The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity."

Sample questions appear below for each domain. The 'Lake Chad' text is followed by three questions, each testing a separate domain of reading literacy (retrieving, interpreting, and reflecting). The 'Speed of a racing car' text is followed by a question testing students' mathematical literacy. Finally, the 'Ozone' text is followed by a scientific literacy question.

Lake Chad

Figure A shows changing levels of Lake Chad, in Saharan North Africa. Lake Chad disappeared completely in about 20000 BC, during the last Ice Age. In about 11000 BC it reappeared. Today, its level is about the same as it was in AD 1000.

Figure A

Lake Chad: changing levels

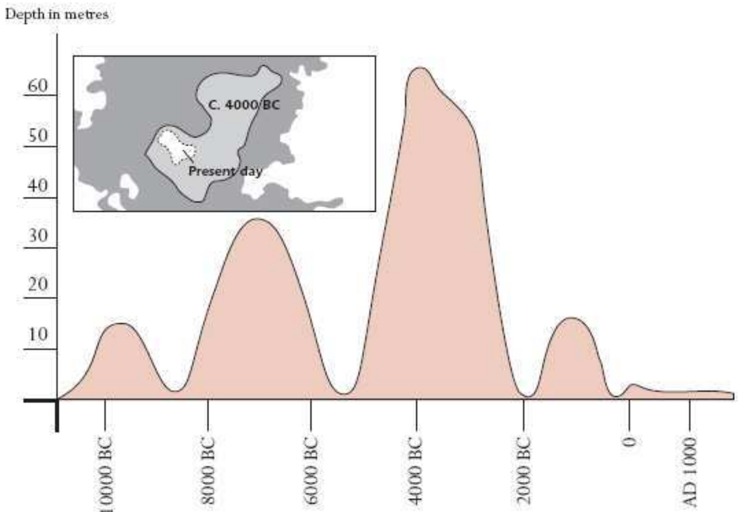
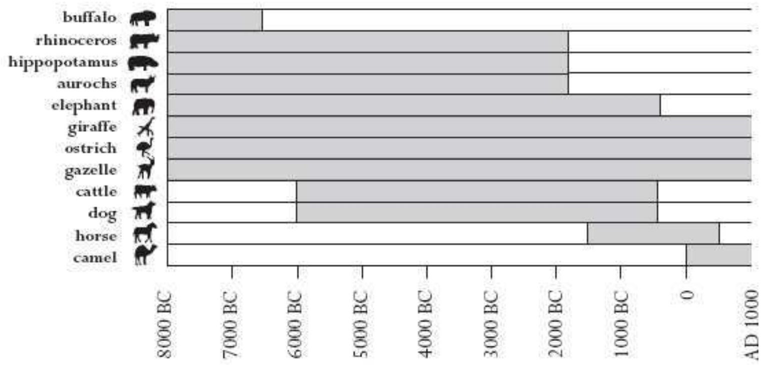


Figure B shows Saharan rock art (ancient drawings or paintings found on the walls of caves) and changing patterns of wildlife.

Figure B

Saharan rock art and changing patterns of wildlife



Question 1: LAKE CHAD (R040Q02)

Reading task: *Retrieving information*
Text format: *Non-continuous*
Situation: *Public*

What is the depth of Lake Chad today?

(A) About two metres.

B About fifteen metres.

C About fifty metres.

D It has disappeared completely.

E The information is not provided.

Question 4: LAKE CHAD (R040Q04)

Reading task: *Interpreting texts*
Text format: *Non-continuous*
Situation: *Public*

Figure B is based on the assumption that

(A) the animals in the rock art were present in the area at the time they were drawn.

B the artists who drew the animals were highly skilled.

C the artists who drew the animals were able to travel widely.

D there was no attempt to domesticate the animals which were depicted in the rock art.

Question 3: LAKE CHAD (R040Q03B)

Reading task: *Reflection and evaluation*
Text format: *Non-continuous*
Situation: *Public*

Why has the author chosen to start the graph at this point?

Scoring – Question 3

Score 1: Answers which refer to the reappearance of the lake. Note: an answer may receive score 1 even if the previous answer is incorrect. For example:

- Lake Chad reappeared in 11000 BC after disappearing completely around 20000 BC.
- The lake disappeared during the Ice Age and then came back at about this time.
- It reappeared then.
- About 11000 BC it came back.
- Then the lake reappeared after being gone for 9000 years.

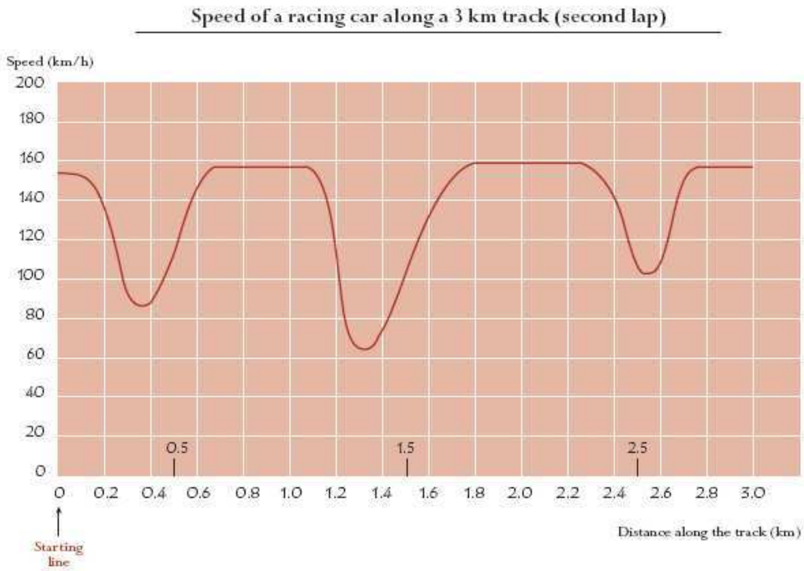
Score 0: Other answers. For example:

- This is when animals started to appear.
- 11000 BC is when humans began to do rock art.
- 11000 BC was when the lake (first) appeared.
- Because at that time Lake Chad was completely dried up.
- Because that was the first movement on the graph.

MATHEMATICS UNIT 3

Speed of a racing car

This graph shows how the speed of a racing car varies along a flat 3 kilometre track during its second lap.



Source: In memory of Claude Janvier, who died in June 1998. Modified task after his ideas in Janvier, C. (1978): The interpretation of complex graphs – studies and teaching experiments. Accompanying brochure to the Dissertation. Univrsity of Nottingham, Shell Centre for Mathematical Education, Item C-2.

The pictures of the tracks are taken from Fischer, R & Malle, G. (1985): *Mensch und Mathematik*. Bibliographisches Institut: Mannheim-Wien-Zurich, 234-238.

Question 5: SPEED OF RACING CAR (M159Q01)

Process: *Competency class 2 (Connections and integration for problem solving)*
Content: *Change and relationships*
Situation: *Scientific*

What is the approximate distance from the starting line to the beginning of the longest straight section of the track?

A 0.5 km.
(B) 1.5 km.
C 2.3 km.
D 2.6 km.

SCIENCE UNIT 2

Ozone

Read the following section of an article about the ozone layer.

> The atmosphere is an ocean of air and a precious natural resource for sustaining life on the Earth. Unfortunately, human activities based on national/personal interests are causing harm to this common resource, notably by depleting the fragile ozone layer, which acts as a protective shield for life on the Earth.
>
> Ozone molecules consist of three oxygen atoms, as opposed to oxygen molecules which consist of two oxygen atoms. Ozone molecules are exceedingly rare: fewer than ten in every million molecules of air. However, for nearly a billion years, their presence in the atmosphere has played a vital role in safeguarding life on Earth. Depending on where it is located, ozone can either protect or harm life on Earth. The ozone in the troposphere (up to 10 kilometres above the Earth's surface) is "bad" ozone which can damage lung tissues and plants. But about 90 percent of ozone found in the stratosphere (between 10 and 40 kilometres above the Earth's surface) is "good" ozone which plays a beneficial role by absorbing dangerous ultraviolet (UV-B) radiation from the Sun.
>
> Without this beneficial ozone layer, humans would be more susceptible to certain diseases due to the increased incidence of ultra-violet rays from the Sun. In the last decades the amount of ozone has decreased. In 1974 it was hypothesised that chlorofluorocarbons (CFCs) could be a cause for this. Until 1987, scientific assessment of the cause-effect relationship was not convincing enough to implicate CFCs. However, in September 1987, diplomats from around the world met in Montreal (Canada) and agreed to set sharp limits to the use of CFCs.
>
> *Source:* Connect, UNESCO International Science, Technology & Environmental Education Newsletter, section from an article entitled "The Chemistry of Atmospheric policy", Vol., XXII No. 2, 1997 (spelling adapted).

Question 6: OZONE (S253Q02)

Process: *Critically evaluating scientific evidence/data*
Concept: *Science in Earth and environment (Earth/Space)*
Situation: *Global*

Ozone is also formed during thunderstorms. It causes the typical smell after such a storm. In lines 10–12 the author of the text distinguishes between ""bad ozone" and "good ozone".

In terms of the article, is the ozone that is formed during thunderstorms "bad ozone" or "good ozone"?

Choose the answer and the explanation that is supported by the text.

	Bad ozone or good ozone?	Explanation
A	Bad	It is formed during bad weather.
(B)	Bad	It is formed in the troposphere.
C	Good	It is formed in the stratosphere.
D	Good	It smells good.

Appendix A2.6: Standardizing test scores

It is common practice in the literature to standardize test scores when they are treated as outcome variables. Standardizing involves transforming the test score (*T*) to a generic unit of measurement. The most common way to do this is by subtracting the mean score from the actual score, and dividing this difference by the standard deviation (σ), as shown below.

$$(2.5.1)\ Z_i = (T_i - \overline{T}) / \sigma$$

The new variable, *Z*, is distributed with mean of 0 and a standard deviation of 1, or $Z \sim (0, 1)$. Some authors refer to *Z* as a normalized variable (i.e. if *T* is normally distributed, then *Z* will follow the standard normal distribution).

Note that *Z* is expressed in standard deviations. In other words, a one unit increase in the standardized score signals a one standard deviation in the raw score. Similarly, a regression coefficient in a model where the standardized score appears as the dependent variable should be interpreted in standard deviation units. The benefit of standardizing is that results from one study can be compared to results from another with the same metric. The approach is not perfect, however, since the dispersions of different underlying distributions may themselves be different. Nevertheless, this approach has become so commonplace that it would be difficult to justify adopting a different one.

There is one potential pitfall associated with standardizing the test score in practice. When various sample selection criteria are applied in an analysis, it is important to realize that the point at which one standardizes the test score will matter. For example, if the test score is standardized at the very beginning (i.e. prior to any sample selection criteria), then the standardized score in the final selection criteria may not have a mean of 0 and a standard deviation of 1. This is because the first and second moments of the raw test score likely depend on the sample selection criteria.

Appendix A2.7: Assessing the measurement accuracy of multiple birth siblings in the child quality analysis

In the child quality analysis in Chapter 2, which uses YITS data, I identify multiple birth siblings by assuming that all siblings born to the same mother during the same calendar year are multiple birth siblings. However, it is still possible that two siblings who report the same age in discrete years are not twins, even if they share the same biological mother. This would require the mother to give birth in January, February, or March, promptly get pregnant again, and have another delivery near the end of the year. The first delivery could not be later than March assuming that the following pregnancy has a nine month term.

As unlikely as this seems, it is still worthwhile investigating. One way to do so is to turn to an extraneous data set that contains information on the exact date of birth of siblings. Statistics Canada's Survey of Labour and Income Dynamics (SLID) is a household panel survey data with information on the exact date of birth of each member of the household, as well as the relationship between each member (including the biological relationship between parent and child). Using the 1999 version of SLID, I find that among the 62 pairs of second and third born siblings who were born in the same year and shared the same biological mother, 54 of them shared the same birthday. Of the 8 who didn't share the same birthday, one pair were 1 day apart, suggesting they may have been born around midnight. Another 6 pairs were less than 9 months apart (in fact, they were all less than 5 months apart), suggesting that the date of birth may have been miscoded. For example, the year may have been misreported; however, this is highly unlikely for the sampled youth in the YITS data since all students were born in 1984 based on school administrative records. For siblings of YITS respondents who aren't part of the YITS sample, it is also unlikely since the parent is prompted to list household members in descending order of age, and then report each member's age in discrete years. In the end, only 1 of the 62 pairs were more than 9 months apart, and it is possible for them to have been born in the same year to the same mother, without actually being twins. In other words, the strategy for identifying twins with the YITS data is likely to correctly identify twins in about 98% of the cases.

Appendix A2.8: Assessing the impact of fertility on lone motherhood

Table A2.8.1: IV regressions of lone motherhood on the number of children and other controls

	b	s.e.
Number of children	0.015	0.034
Child's birth order	-0.012	0.018
Child's age (months/12)	-0.021	0.015
Child is a female	0.014 **	0.007
Child is an immigrant	0.023 *	0.014
Mother's age (years in integers)	-0.055 ***	0.013
Mother's age^2 (years in integers)	0.001 ***	0.000
Mother has a high school diploma	-0.028 **	0.014
Mother has a college certificate	-0.003	0.014
Mother has a bachelor's degree	-0.036 **	0.018
Mother has a professional degree	-0.054	0.039
Mother has a master's degree	-0.040 *	0.022
Mother has an earned doctorate	-0.028	0.048
Mother is an immigrant	-0.050 ***	0.011
Prince-Edward-Island	-0.003	0.018
Nova Scotia	0.009	0.014
New Brunswick	-0.005	0.013
Québec	0.028 **	0.014
Ontario	0.027 *	0.014
Manitoba	0.014	0.015
Saskatchewan	-0.005	0.015
Alberta	0.007	0.015
British Columbia	0.025 *	0.015
Intercept	1.581 ***	0.387
Adjusted R^2	0.005	
N	17,961	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with a biological mother in the home, who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

Appendix A2.9: Adding parental income to the child

Table A2.9.1a: IV regressions of standardized reading score on the number of children and other controls - parental income added

	b		s.e.
Number of children	0.155	*	0.093
Child's birth order	-0.226	***	0.045
Child's age (months/12)	0.181	***	0.035
Child is a female	0.344	***	0.024
Child is an immigrant	-0.269	***	0.059
Mother's age (years in integers)	0.139	***	0.045
Mother's age^2 (years in integers)	-0.001	***	0.000
Father's age (years in integers)	0.019		0.027
Father's age^2 (years in integers)	0.000		0.000
Mother has a high school diploma	0.248	***	0.039
Mother has a college certificate	0.327	***	0.045
Mother has a bachelor's degree	0.497	***	0.058
Mother has a professional degree	0.395	***	0.135
Mother has a master's degree	0.723	***	0.085
Mother has an earned doctorate	0.699	***	0.160
Father has a high school diploma	0.236	***	0.039
Father has a college certificate	0.308	***	0.038
Father has a bachelor's degree	0.447	***	0.046
Father has a professional degree	0.580	***	0.080
Father has a master's degree	0.481	***	0.074
Father has an earned doctorate	0.715	***	0.114
Parental income (thousands)	0.002	***	0.000
Parental income (thousands)^2	0.000	***	0.000
One parent is an immigrant	0.036		0.043
Both parents are immigrants	-0.017		0.040
Prince-Edward-Island	-0.130	**	0.063
Nova Scotia	-0.093	*	0.048
New Brunswick	-0.250	***	0.045
Québec	0.121	**	0.051
Ontario	-0.034		0.051
Manitoba	0.029		0.055
Saskatchewan	0.077		0.061
Alberta	0.197	***	0.056
British Columbia	0.074		0.055
Intercept	-7.787	***	1.105
Adjusted R^2		0.166	
N		15,555	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

Table A2.9.1b: IV regressions of parental investments on the number of children and other controls - parental income added

	Attends a private school			Attends a private, non-sectarian school			Computers per child			Parents have saved money for PSE		
	b		s.e.	b		s.e.	b		s.e.	b		s.e.
Number of children	-0.041	***	0.012	-0.010	**	0.005	-0.144	***	0.028	-0.111	**	0.049
Child's birth order	0.015	**	0.007	0.005	*	0.003	-0.004		0.016	-0.028		0.027
Child's age (months/12)	-0.003		0.008	0.007	*	0.004	0.011		0.013	-0.034		0.024
Child is a female	-0.013	**	0.006	-0.005		0.003	-0.032	***	0.007	0.014		0.010
Child is an immigrant	-0.016		0.016	0.000		0.007	-0.027		0.021	-0.097	***	0.026
Mother's age (years in integers)	-0.008		0.009	-0.001		0.005	0.007		0.013	0.037	*	0.020
Mother's age^2 (years in integers)	0.000		0.000	0.000		0.000	0.000		0.000	0.000	*	0.000
Father's age (years in integers)	-0.008		0.009	-0.013	**	0.007	0.017	**	0.007	-0.003		0.014
Father's age^2 (years in integers)	0.000		0.000	0.000	**	0.000	0.000	**	0.000	0.000		0.000
Mother has a high school diploma	0.030	***	0.010	0.009	*	0.006	0.044	***	0.014	0.115	***	0.024
Mother has a college certificate	0.036	***	0.013	0.013	*	0.008	0.050	***	0.014	0.161	***	0.023
Mother has a bachelor's degree	0.052	***	0.015	0.014	*	0.007	0.085	***	0.017	0.167	***	0.027
Mother has a professional degree	0.042	*	0.022	0.020	*	0.012	0.104	**	0.048	0.277	***	0.057
Mother has a master's degree	0.059	**	0.027	0.014		0.011	0.099	***	0.029	0.198	***	0.037
Mother has an earned doctorate	0.200	***	0.073	0.021		0.028	0.142	*	0.080	0.186	**	0.080
Father has a high school diploma	0.016	***	0.006	0.002		0.003	0.067	***	0.011	0.053	***	0.020
Father has a college certificate	0.024	***	0.007	0.001		0.003	0.109	***	0.013	0.075	***	0.022
Father has a bachelor's degree	0.048	***	0.012	0.003		0.006	0.162	***	0.014	0.104	***	0.026
Father has a professional degree	0.088	***	0.029	0.016		0.011	0.171	***	0.032	0.144	***	0.038
Father has a master's degree	0.093	***	0.024	0.014	*	0.008	0.217	***	0.025	0.126	***	0.031
Father has an earned doctorate	0.122	***	0.045	0.018		0.012	0.207	***	0.040	0.095		0.059
Parental income (thousands)	0.000	***	0.000	0.000		0.000	0.001	***	0.000	0.002	***	0.000
Parental income (thousands)^2	0.000	**	0.000	0.000		0.000	0.000	***	0.000	0.000	***	0.000
One parent is an immigrant	0.034	***	0.011	0.010		0.006	0.060	***	0.014	0.014		0.020
Both parents are immigrants	0.042	**	0.017	0.028	*	0.015	0.064	***	0.013	0.030		0.019
Prince-Edward-Island	0.019	***	0.005	0.001		0.002	0.040	***	0.015	0.022		0.029
Nova Scotia	-0.006		0.004	0.002		0.001	0.072	***	0.013	0.023		0.022
New Brunswick	-0.005		0.003	-0.001		0.001	0.029	**	0.013	0.011		0.021
Québec	0.168	***	0.036	0.048	**	0.020	0.046	***	0.012	-0.129	***	0.023
Ontario	-0.005		0.012	-0.011	**	0.005	0.148	***	0.013	0.097	***	0.023
Manitoba	0.067	***	0.021	0.016		0.013	0.081	***	0.015	0.102	***	0.025
Saskatchewan	0.029	***	0.011	0.007		0.007	0.098	***	0.015	0.110	***	0.025
Alberta	0.002		0.015	-0.005	*	0.003	0.110	***	0.013	0.086	***	0.026
British Columbia	0.060	**	0.028	0.005		0.013	0.130	***	0.016	0.049	*	0.025
Intercept	0.379	*	0.224	0.219	*	0.132	-0.219		0.364	0.371		0.610
Adjusted R^2	0.089			0.043			0.225			0.100		
N	15,555			15,555			15,555			15,555		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of youth with two opposite sex parents in the home (mother is biological), who are not part of a multiple birth, and the family has had at least two births (the first being a singleton).
Source: Youth in Transition Survey, Cohort A.

Appendix A3.1: Assessing the imputation approach of unpaid childcare and housework in the parental labour supply analysis

In the census data used for the parental labour supply analysis in Chapter 3, the number of hours spent on childcare and housework is categorical: none, less than 5 hours, 5 to 14 hours, 15 to 29 hours, 30 to 59 hours, and 60 hours or more. In order to facilitate comparisons with the paid work results, I imputed continuous values for the measures of unpaid work.

For bounded categories, I simply assumed a symmetric distribution and took the midpoint. For the (unbounded) upper category, I simply coded all values to 60 hours since few people spend more than 60 hours per week in any activity. Since this imputation approach is somewhat arbitrary, I verified its impact with Statistics Canada's 2005 General Social Survey (GSS), Cycle 16, which focused on the time use of Canadians. This survey contains continuous variables measuring the number of minutes per day spent on childcare and housework (among other activities). To match the working sample in this study as closely as possible, I selected male-female married or common-law couples with at least two children. I then replicated the imputation approach described above. The patterns of actual and imputed hours per week in each activity by the number of children are quite similar, indicating that the imputation error is minimal. For women, average actual and imputed hours per week of childcare were 15.6 and 15.8, respectively. In terms of housework, average actual and imputed hours per week were 27.5 and 27.9, respectively. For men, average actual and imputed hours per week of childcare were 7.3 and 7.5, respectively. For housework, the corresponding numbers were both 14.4.

Appendix A3.2: Does the sex composition of the first two children influence parental labour supply?

The same sex IV is used in the parental labour supply analysis in Chapter 3, but not in the child quality analysis in Chapter 2. The reason is that the sex composition of children may influence child quality in a direct manner, according to several previous studies. One could make the same argument with parental labour supply since parents may have a preference to spend time withsame or opposite sex children. To investigate this hypothesis, I examined parental work patterns among couples by the sex composition of the first two. Since the sex composition is related to the number of children, which may in turn influence labour supply (Angrist and Evans, 1998), it is important to take this into consideration in this exercise. The approach I adopt is to examine couples with two singleton children, but had the second child not too long before the Census reference week (so that the couple likely wouldn't have enough time to conceive a third child), but long enough for the mother to return to market work if that path is chosen. In Canada, maternity and parental benefits expire after one year. As a result, I consider couples whose second child was born in 2005 (the year prior to the Census), but at least one full year prior to the Census reference week (i.e. between January 2005 and May 2005).

The results are shown below in Table A3.2.1 for mothers and in Table A3.2.2 for fathers. In all cases, the same sex coefficient is not statistically significant. In fact, the t-ratio is always well below 1 in absolute value. This is consistent with the notion that the same sex IV does not exert an independent influence on parental work patterns.

Table A3.2.1: OLS regressions of maternal work hours on the same sex and other controls

	Hours per week of paid work			Hours per week of childcare			Hours per week of housework		
	b		s.e.	b		s.e.	b		s.e.
Same sex	-0.260		0.455	-0.134		0.423	0.275		0.478
Mother's age	2.110	***	0.468	-0.258		0.442	-0.614		0.498
Mother's age^2	-0.029	***	0.007	0.001		0.007	0.012		0.008
Father's age	0.140		0.218	-0.122		0.199	-0.203		0.216
Father's age^2	-0.003		0.003	0.001		0.002	0.001		0.003
Mother has a high school diploma	2.800	***	0.976	1.527		0.956	-1.224		1.083
Mother has a college certificate	7.003	***	0.958	0.452		0.930	-2.960	***	1.045
Mother has a bachelor's degree	8.959	***	1.076	0.046		1.024	-3.973	***	1.151
Mother has a professional degree	11.472	***	1.384	-1.844		1.347	-6.178	***	1.458
Mother has a master's degree	20.467	***	2.763	-5.323	*	2.805	-10.782	***	2.529
Mother has an earned doctorate	14.496	***	2.648	-3.506		2.973	-11.306	***	2.561
Father has a high school diploma	0.638		0.911	1.126		0.825	-0.896		0.981
Father has a college certificate	-0.366		0.863	0.092		0.785	-1.559	*	0.921
Father has a bachelor's degree	-3.422	***	1.008	1.138		0.898	-1.682		1.054
Father has a professional degree	-7.264	***	1.214	1.443		1.172	0.394		1.326
Father has a master's degree	-7.962	***	2.649	3.695		2.531	5.660	*	2.953
Father has an earned doctorate	-6.253	***	1.887	0.057		2.178	0.378		2.358
Mother is black	-4.102	*	2.275	-4.859	*	2.597	1.041		2.385
Mother is Asian	-4.641	***	1.345	-3.834	***	1.332	1.497		1.467
Mother is Arab	-1.486		4.312	1.007		3.251	6.195	*	3.416
Mother is Latino	-4.965	**	2.373	1.367		2.198	1.828		2.871
Mother is Aboriginal	-0.201		1.505	0.270		1.201	1.023		1.490
Mother is other non-white	-9.548	***	3.199	-1.420		3.088	2.712		3.491
Father is black	4.504	**	2.136	-2.810		2.337	-1.454		2.311
Father is Asian	0.599		1.359	-4.200	***	1.356	-1.676		1.490
Father is Arab	-8.404	**	4.071	-4.405		3.264	-3.953		3.420
Father is Latino	-0.921		2.686	-7.990	***	2.883	0.491		3.249
Father is Aboriginal	0.587		1.471	1.089		1.218	3.549	**	1.498
Father is other non-white	0.296		3.879	1.208		3.010	1.561		3.282
Local unemployment rate (women, 25 to 54)	-12.103		10.653	15.431		9.177	12.959		9.953
Local unemployment rate (men, 25 to 54)	-3.146		7.230	-21.568		7.132	-23.752		7.951
Intercept	-22.162	***	7.263	57.690	***	6.947	45.478	***	8.040
Adjusted R^2	0.052			0.037			0.011		
N	8,729			8,729			8,729		

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with two singleton children, the second of which was born between January 2005 and May 2005.
Source: Census of Population, 2006.

Table A3.2.2: OLS regressions of paternal work hours on the same sex IV and other controls

	Hours per week of paid work		Hours per week of childcare		Hours per week of housework	
	b	s.e.	b	s.e.	b	s.e.
Same sex	0.275	0.478	-0.075	0.455	-0.109	0.473
Mother's age	-0.614	0.498	0.582	0.463	0.421	0.492
Mother's age^2	0.012	0.008	-0.008	0.007	-0.007	0.007
Father's age	-0.203	0.216	-0.412 *	0.221	0.084	0.217
Father's age^2	0.001	0.003	0.003	0.003	-0.003	0.003
Mother has a high school diploma	-1.224	1.083	0.778	1.110	0.864	1.048
Mother has a college certificate	-2.960 ***	1.045	1.828 *	1.047	1.018	1.019
Mother has a bachelor's degree	-3.973 ***	1.151	0.300	1.116	3.433 ***	1.118
Mother has a professional degree	-6.178 ***	1.458	1.468	1.312	3.005 **	1.431
Mother has a master's degree	-10.782 ***	2.529	-4.041	2.544	8.320 ***	2.795
Mother has an earned doctorate	-11.306 ***	2.561	-0.425	2.269	5.073 *	2.736
Father has a high school diploma	-0.896	0.981	3.580 ***	0.945	-0.049	0.981
Father has a college certificate	-1.559 *	0.921	3.735 ***	0.912	-0.620	0.923
Father has a bachelor's degree	-1.682	1.054	3.583 ***	0.963	-0.574	1.048
Father has a professional degree	0.394	1.326	3.417 ***	1.183	-2.610 **	1.246
Father has a master's degree	5.660 *	2.953	13.608 ***	2.060	-7.987 ***	2.380
Father has an earned doctorate	0.378	2.358	5.173 **	2.046	-2.126	1.950
Mother is black	1.041	2.385	0.845	2.201	-4.332 *	2.457
Mother is Asian	1.497	1.467	-1.593	1.492	-2.537 *	1.415
Mother is Arab	6.195 *	3.416	-3.711	3.044	1.543	3.757
Mother is Latino	1.828	2.871	1.641	2.281	-0.192	2.504
Mother is Aboriginal	1.023	1.490	-2.727	1.669	2.829 *	1.651
Mother is other non-white	2.712	3.491	-3.248	3.893	-5.089	3.653
Father is black	-1.454	2.311	-5.798 **	2.393	3.230	2.321
Father is Asian	-1.676	1.490	-3.485 **	1.512	-5.186 ***	1.413
Father is Arab	-3.953	3.420	-3.344	2.924	-8.015 **	3.614
Father is Latino	0.491	3.249	-5.201 *	2.657	-6.575 **	2.585
Father is Aboriginal	3.549 **	1.498	-5.485 ***	1.779	5.911 ***	1.686
Father is other non-white	1.561	3.282	-2.400	2.652	-0.503	4.077
Local unemployment rate (women, 25 to 54)	12.959	9.953	17.286	11.468	4.660	10.711
Local unemployment rate (men, 25 to 54)	-23.752	7.951	-71.767	9.503	6.647	7.930
Intercept	45.478 ***	8.040	40.848 ***	7.613	20.042 ***	7.711
Adjusted R^2	0.052		0.033		0.012	
N	8,729		8,729		8,729	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of married or common-law couples with two singleton children, the second of which was born between January 2005 and May 2005.
Source: Census of Population, 2006.

Appendix A4.1: Regression discontinuity estimators

For decades, regression discontinuity (RD) estimators were the domain of psychologists (e.g. Thistlethwaite and Campbell, 1960). Only recently have they garnered attention in the economics literature. Relatively more attention has been paid by labour economists, who generally demonstrate a keen interest in estimating causal relationships. This appendix summarizes the major features of RD estimators. Imbens and Lemieux (2008) provide a more detailed description.

The idea behind an RD estimator is that the treatment status is influenced in some way by the value of some assignment variable. In particular, the influence of the assignment variable on the treatment status must change very suddenly at a fixed cut-off point. The argument supporting the causal nature of the treatment effect relates to the fact that, around the discontinuity and in absence of the treatment, subjects are very similar.

If the treatment value is a deterministic function of the assignment variable, we have a 'sharp' discontinuity in the treatment status. A more succinct way of describing a sharp discontinuity is as follows:

$$(A4.1.1) TREAT_i = \begin{cases} 1 \; if \; a_i \geq a_0 \\ 0 \; if \; a_i \prec a_0 \end{cases},$$

where a is the assignment variable, a_0 is the cut-off, and *TREAT* is the treatment. Note that *TREAT* is a binary variable here, but it can also take on other values.

In reality, discontinuities are often ‘fuzzy’, meaning that the probability or expected value of the treatment is a function of some variable with a break at the cut-off, or:

$$(A4.1.2)\, E\left(TREAT_i \mid a_i\right) = \begin{cases} f_1\left(a_i\right) \text{ if } a_i \geq a_0 \\ f_0\left(a_0\right) \text{ if } a_i \prec a_0 \end{cases},$$

where $f_1(a_0) \neq f_0(a_0)$.

A potential source of bias in RD estimation is manipulation effects. This refers to subjects changing their characteristics slightly in order to qualify for a program. The presence of manipulation effects can usually be tested by comparing the distributions around the threshold when the program is in effect compared to when it is not in effect. Even with manipulation effects, it is still possible to infer causality from RD. Under very weak assumptions, Lee (2008) concludes that the localized random assignment into the treatment can still occur as long as agents do not have the ability to sort precisely around the threshold (i.e. near the threshold, individual characteristics are independent of the treatment status, and the threshold status follows some continuous probability distribution, and thus, it is based on luck).

Discontinuities usually result from policy. However, they are rare events. The reason is that they make for policies that may be less than ideal from a public perception point of view. For example, consider a child benefit that is geared towards low-income families. Suppose that benefits fall from a substantial amount to zero when family income crosses a specific threshold. Is it also the case that the needs of families are very different around that threshold? If the answer is no, then policy makers may prefer to gradually 'phase-out' the benefit as income rises.

In certain situations, however, discontinuities may occur naturally. Take, for example, the literature on union wage premiums. Since employees in workplaces that choose to be unionized may be quite different than those that choose otherwise, results from OLS are likely to be biased due to unobserved heterogeneity. One way to estimate the causal relationship is to examine union certification voting patterns. If a critical threshold is applied (say 50% + 1 vote), then an RD design may be possible (as long as there are enough cases near the discontinuity).

An issue arises when a policy-induced discontinuity is studied, but a naturally occurring discontinuity would happen in the absence of the program. A robustness test that addresses this concern is to re-estimate the RD in a period or jurisdiction when or where the program was not in effect. If we obtain the same results, this is evidence of a naturally occurring discontinuity. This approach is termed a 'falsification test'.

In Chapter 4, I use RD (in an IV framework) to study the impact of an additional school grade on academic performance, where the school grade is instrumented with a binary variable indicating birth before or after a school entry cut-off date.

I also apply RD in Chapter 5, where I examine the introduction of a program consisting of replacing government sponsored student loans with non-repayable grants, based on parental income and a specific threshold for eligibility.

The nature of the discontinuity is not the same in each chapter. In Chapter 4, students are assigned to a school grade based on their age. Evidence is shown to suggest that parents do not manipulate birthdays to alter the treatment status; however, the discontinuity is still fuzzy since the assigned grade need not match the actual grade. In Chapter 5, the treatment is grant eligibility, which is determined by parental income. Thus, the discontinuity is sharp in this case. Note the difference in the treatments: in Chapter 4, it is actual grade (not grade eligibility, or assigned grade), while in Chapter 5, it is eligibility for a grant, as opposed to obtaining a grant. The treatment is based on eligibility in Chapter 5 because of the research question, which asks "What is the impact of introducing a grant on PSE attendance?" By design, we cannot ask "What is the impact of obtaining a grant on PSE attendance?" since all grant recipients have necessarily attended PSE.

For estimation purposes, RD is quite straightforward. In the case of a sharp discontinuity, the idea is to estimate the impact of the treatment variable (*TREAT*) on some outcome Y, while accounting for some function of the assignment variable, $\delta(a)$, as shown below:

$$(A4.1.3)\ Y_{ia} = \beta_0 TREAT_{ai} + \beta_1 X_{ai} + \delta(a) + \mu_{ia},$$

where $TREAT$=1 if a is above or below a certain threshold, and 0 otherwise. The form of $\delta(a)$ is obviously very important. Data permitting, this should be estimated with as much flexibility as possible.

In the case of a fuzzy discontinuity, the treatment variable is not determined perfectly by a discontinuity. Thus, we must instrument the treatment with a variable indicating the discontinuity (i.e. above or below a threshold).

Appendix A4.2: IV results when only high schools are included

Table A4.2.1a: IV regressions of standardized test scores on the school grade - High schools only

	Reading		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.
School grade initially assigned	0.396 ***	0.119	0.259 *	0.149	0.255	0.174
Age of the youth	-15.948	9.906	-5.483	12.935	-23.070	14.281
Age of the youth^2	0.512	0.316	0.180	0.414	0.745	0.457
Second born	-0.135 ***	0.039	-0.077 *	0.045	-0.105 *	0.056
Third born	-0.207 ***	0.061	-0.055	0.093	-0.260 ***	0.084
Fourth born	-0.093	0.115	-0.077	0.182	-0.370 ***	0.135
Fifth born	-0.307	0.423	0.727 **	0.357	-0.707	0.911
Sixth born	-0.480	0.985	-1.131 **	0.565	0.518 *	0.269
Age of parent most knowledgeable of youth	-0.002	0.033	0.033	0.049	0.004	0.037
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.001	0.000	0.000
Parent with a non-university PS certificate	0.181 ***	0.028	0.231 ***	0.051	0.207 ***	0.051
Parent with a bachelor's degree	0.397 ***	0.045	0.314 ***	0.071	0.337 ***	0.073
Parent with a graduate or professional degree	0.520 ***	0.051	0.533 ***	0.118	0.364 ***	0.109
Equivalent total parental income	0.046 ***	0.010	0.044 *	0.024	0.054 **	0.024
Equivalent total parental income^2	-0.001 **	0.000	-0.001	0.001	-0.001	0.001
Two parents present, at least one not from birth	-0.139 **	0.059	-0.112	0.080	-0.141	0.111
Two birth parents present	-0.054	0.037	0.046	0.057	-0.108	0.072
Female	0.307 ***	0.028	-0.162 ***	0.039	-0.045	0.049
Related course	0.536 ***	0.139	0.462 ***	0.165	0.602 ***	0.138
Québec	0.336 ***	0.038	0.596 ***	0.059	0.371 ***	0.048
Intercept	119.078	76.670	37.320	99.624	174.774	110.605
Adjusted R^2	0.208		0.169		0.128	
N	4,857		2,713		2,668	

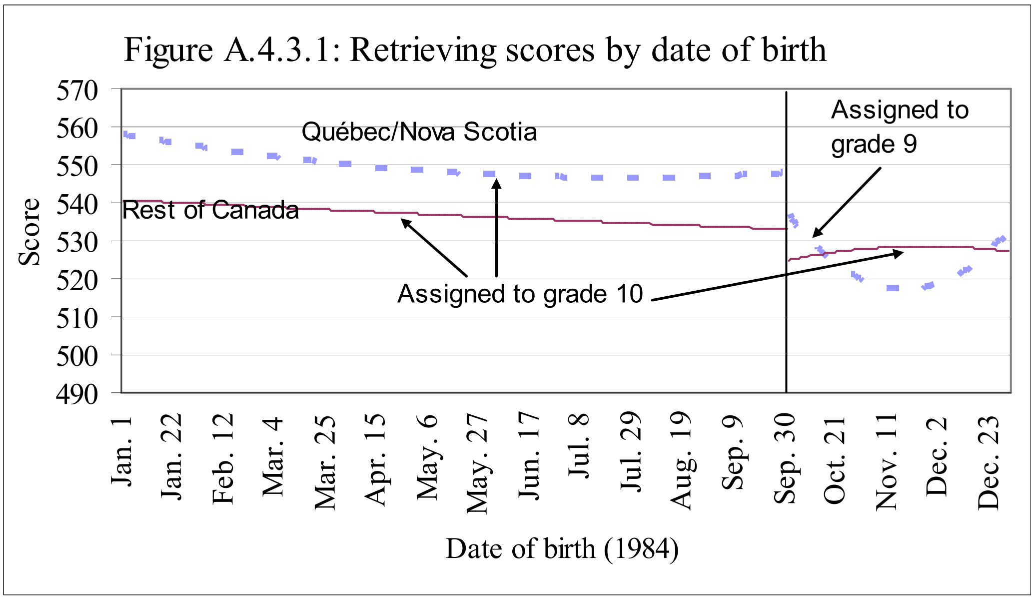
Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.2.1b: IV regressions of standardized test scores on the school grade - High school only, reading sub-components

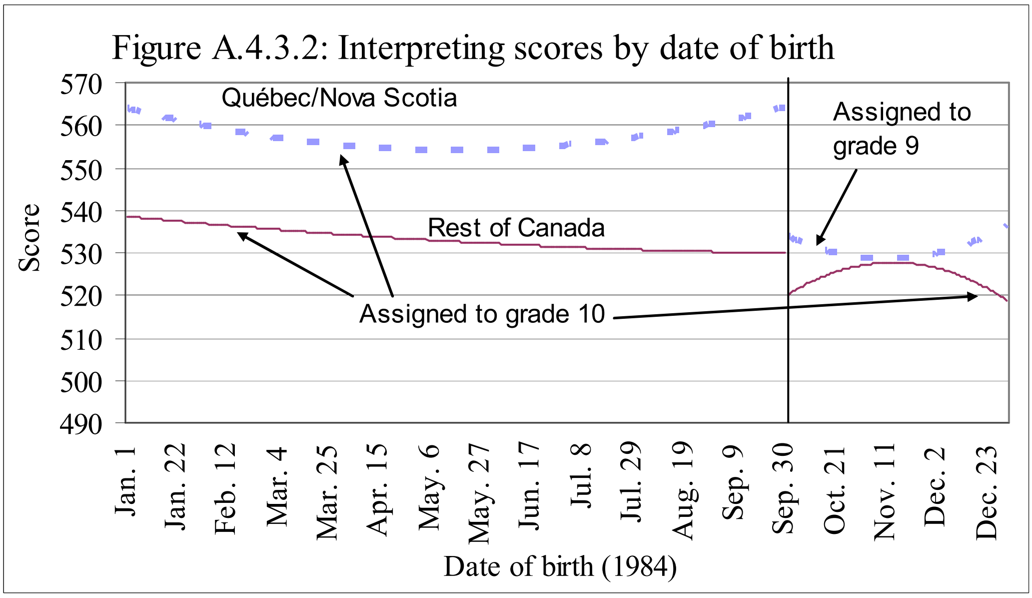
	Retrieving		Interpreting		Reflecting	
	b	s.e.	b	s.e.	b	s.e.
School grade initially assigned	0.252 *	0.132	0.480 ***	0.144	0.216 *	0.117
Age of the youth	-7.777	10.157	-18.596 *	11.187	-8.497	9.728
Age of the youth^2	0.252	0.325	0.592 *	0.358	0.276	0.311
Second born	-0.126 ***	0.040	-0.127 ***	0.037	-0.078 *	0.043
Third born	-0.157 **	0.064	-0.177 **	0.071	-0.196 ***	0.073
Fourth born	0.046	0.124	-0.176	0.122	-0.003	0.109
Fifth born	-0.143	0.502	0.041	0.314	-1.330	0.883
Sixth born	-0.522	0.817	-0.538	0.594	-0.366	1.137
Age of parent most knowledgeable of youth	0.014	0.027	-0.022	0.037	-0.015	0.041
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.149 ***	0.038	0.165 ***	0.027	0.137 ***	0.032
Parent with a bachelor's degree	0.300 ***	0.054	0.364 ***	0.046	0.320 ***	0.045
Parent with a graduate or professional degree	0.499 ***	0.069	0.523 ***	0.058	0.323 ***	0.060
Equivalent total parental income	0.038 **	0.015	0.041 ***	0.011	0.042 ***	0.012
Equivalent total parental income^2	-0.001	0.001	-0.001 ***	0.000	-0.001	0.001
Two parents present, at least one not from birth	-0.117	0.075	-0.109 *	0.060	-0.180 ***	0.055
Two birth parents present	-0.038	0.042	-0.075 *	0.041	-0.021	0.042
Female	0.122 ***	0.034	0.247 ***	0.029	0.396 ***	0.028
Related course	0.458 ***	0.137	0.482 ***	0.139	0.436 ***	0.137
Québec	0.269 ***	0.047	0.374 ***	0.041	0.169 ***	0.041
Intercept	56.229	78.467	140.645	86.537	62.598	75.286
Adjusted R^2	0.118		0.190		0.136	
N	4,857		4,857		4,857	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Appendix A4.3: Test scores by date of birth

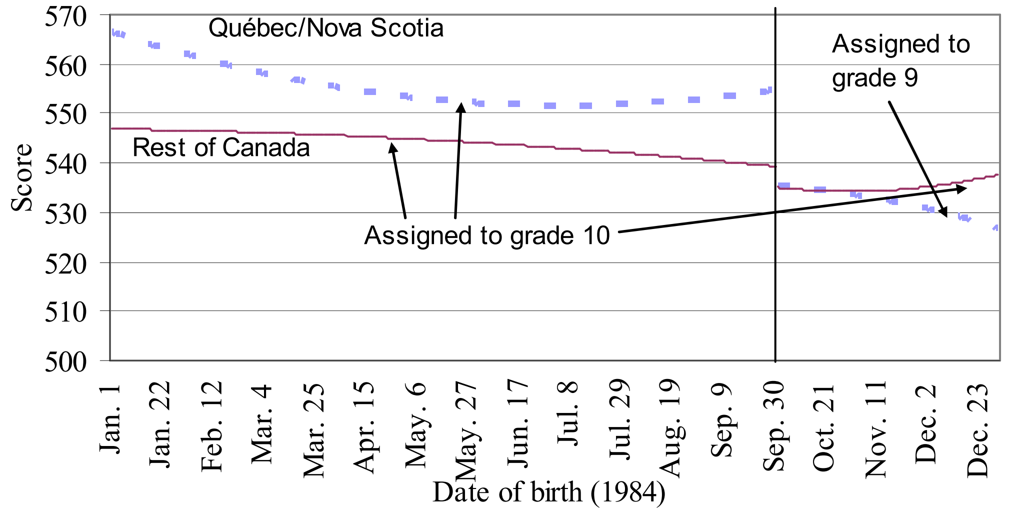


Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.



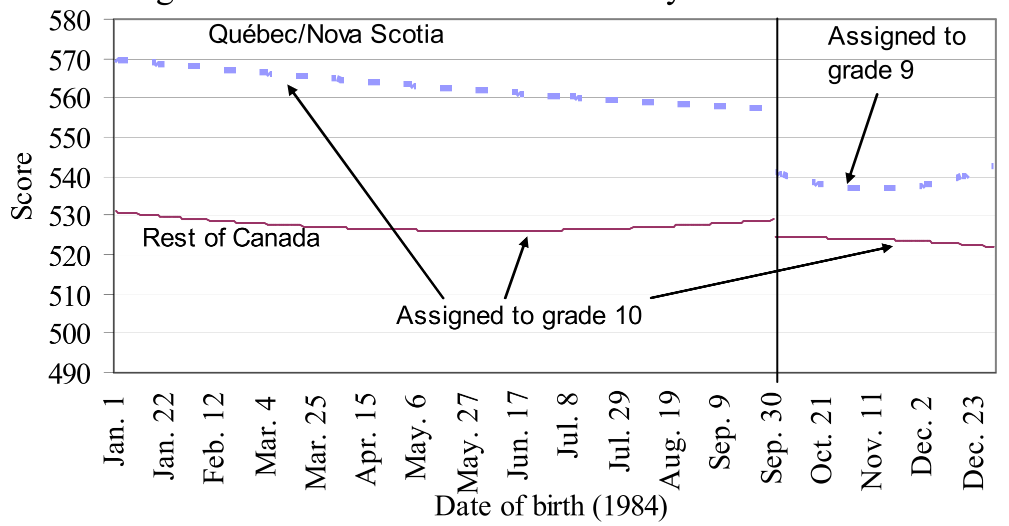
Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.

Figure A.4.3.3: Reflecting scores by date of birth

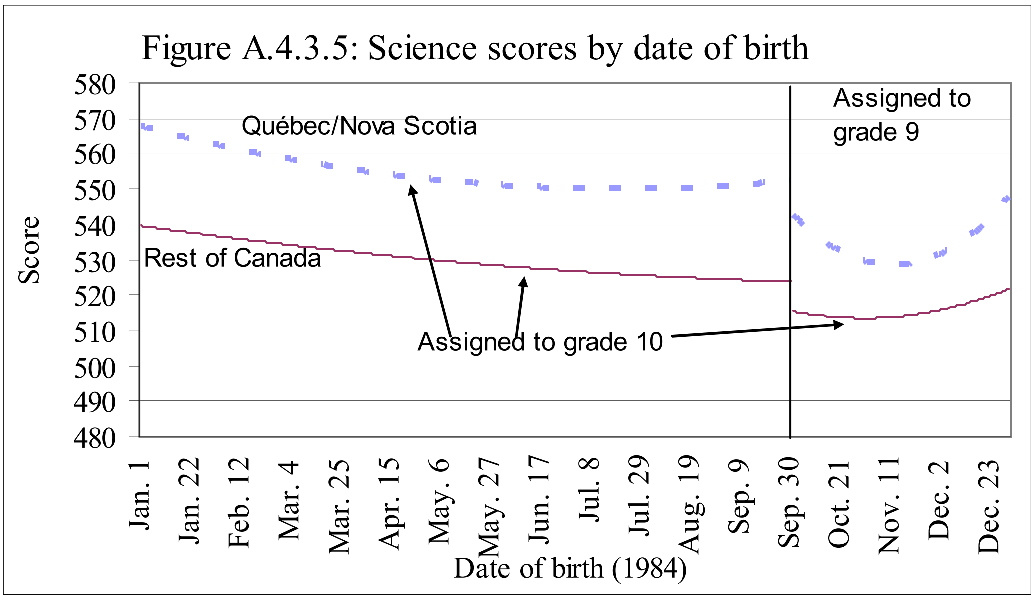


Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.

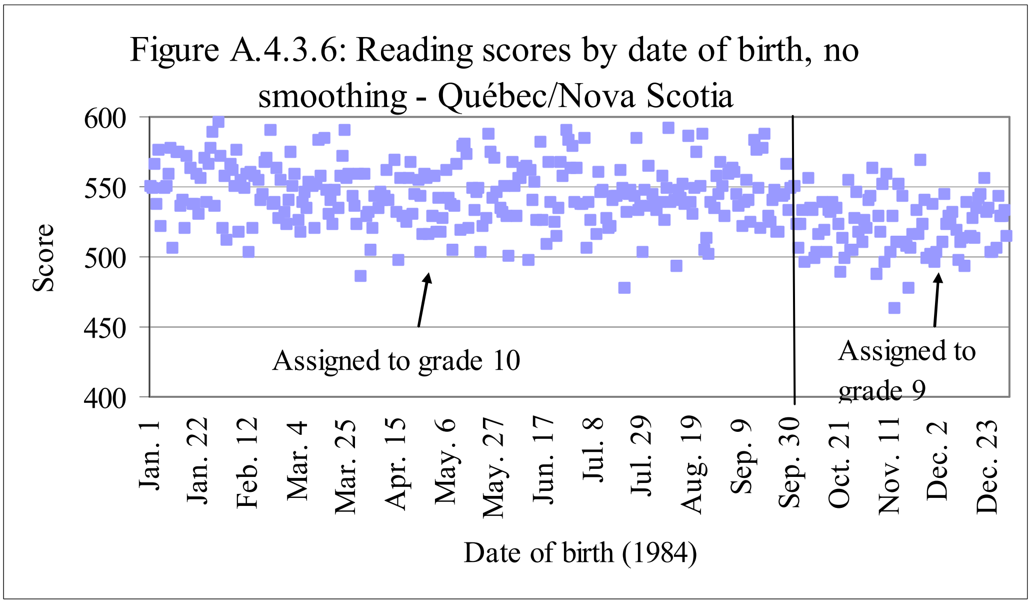
Figure A.4.3.4: Mathematics scores by date of birth



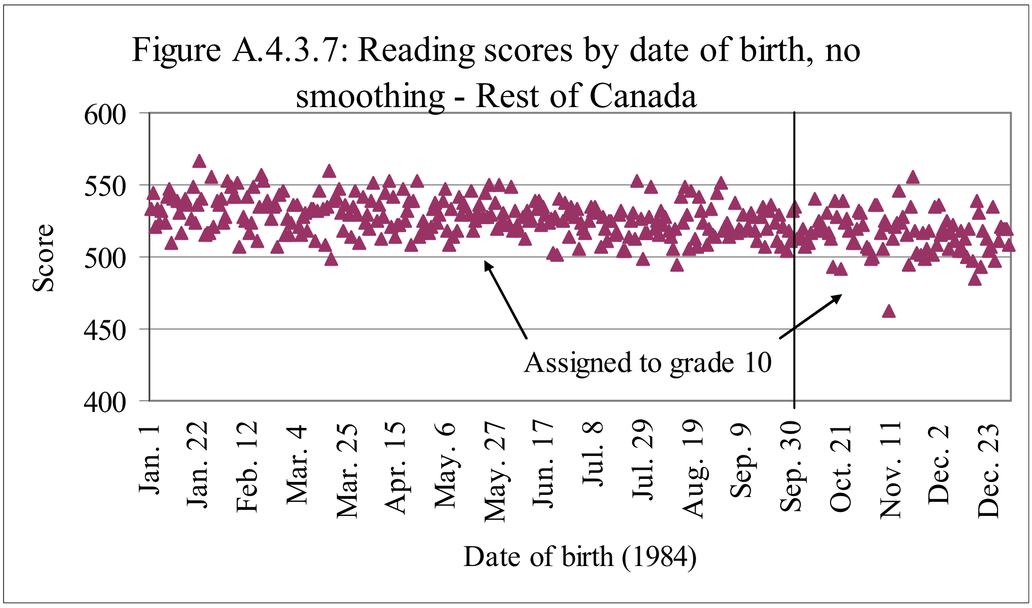
Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.



Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.



Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.



Note: The sample consists of youth born in Canada who were within one grade of the usual one for their age.
Source: Youth in Transition Survey, Cohort A.

Appendix A4.4: Full regression results for robustness tests

Table A4.4.1: IV regressions of standardized test scores on the school grade - No age controls

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.325 ***	0.045	0.279 ***	0.049	0.298 ***	0.047	0.253 ***	0.045	0.327 ***	0.047	0.238 ***	0.062
Second born	-0.127 ***	0.039	-0.121 ***	0.040	-0.110 ***	0.038	-0.087 **	0.041	-0.061	0.046	-0.102 **	0.051
Third born	-0.218 ***	0.063	-0.168 ***	0.060	-0.178 ***	0.068	-0.210 ***	0.069	-0.076	0.088	-0.239 ***	0.080
Fourth born	-0.087	0.117	0.028	0.118	-0.134	0.121	-0.049	0.108	-0.045	0.170	-0.348 ***	0.130
Fifth born	-0.637	0.421	-0.474	0.501	-0.294	0.372	-1.322 **	0.665	0.769 **	0.378	-0.915	0.697
Sixth born	-0.456	0.989	-0.496	0.832	-0.490	0.580	-0.384	1.154	-1.127 **	0.561	0.589 **	0.299
Age of parent most knowledgeable of youth	0.009	0.033	0.021	0.027	-0.009	0.036	-0.006	0.040	0.031	0.045	0.008	0.034
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.192 ***	0.027	0.158 ***	0.035	0.175 ***	0.026	0.145 ***	0.030	0.223 ***	0.051	0.210 ***	0.048
Parent with a bachelor's degree	0.414 ***	0.042	0.306 ***	0.046	0.391 ***	0.040	0.322 ***	0.040	0.292 ***	0.072	0.324 ***	0.071
Parent with a graduate or professional degree	0.537 ***	0.049	0.501 ***	0.063	0.544 ***	0.054	0.336 ***	0.054	0.504 ***	0.118	0.361 ***	0.100
Equivalent total parental income	0.051 ***	0.011	0.039 ***	0.013	0.048 ***	0.011	0.042 ***	0.011	0.048 **	0.022	0.059 **	0.025
Equivalent total parental income^2	-0.001 **	0.000	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.174 ***	0.057	-0.135 **	0.068	-0.146 **	0.057	-0.206 ***	0.050	-0.117	0.072	-0.154	0.102
Two birth parents present	-0.053	0.038	-0.032	0.040	-0.076 *	0.039	-0.024	0.040	0.020	0.053	-0.118 *	0.069
Female	0.316 ***	0.029	0.132 ***	0.032	0.261 ***	0.029	0.393 ***	0.027	-0.168 ***	0.038	-0.034	0.045
Related course	0.545 ***	0.139	0.456 ***	0.140	0.502 ***	0.132	0.436 ***	0.125	0.461 ***	0.155	0.612 ***	0.115
Québec	0.356 ***	0.038	0.303 ***	0.040	0.382 ***	0.034	0.179 ***	0.036	0.630 ***	0.052	0.412 ***	0.044
Intercept	-4.699 ***	0.838	-4.248 ***	0.759	-3.928 ***	0.879	-3.388 ***	0.999	-5.062 ***	1.046	-3.754 ***	0.907
Adjusted R^2	0.214		0.138		0.180		0.155		0.202		0.142	
N	5,507		5,507		5,507		5,507		3,074		3,025	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.2: IV regressions of standardized test scores on the school grade - Linear age specification

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.309 ***	0.074	0.236 ***	0.086	0.360 ***	0.073	0.194 ***	0.070	0.249 ***	0.082	0.141	0.104
Age of the youth	0.029	0.100	0.075	0.108	-0.111	0.091	0.104	0.103	0.136	0.119	0.173	0.140
Second born	-0.127 ***	0.039	-0.121 ***	0.040	-0.110 ***	0.038	-0.086 **	0.041	-0.060	0.046	-0.101 **	0.051
Third born	-0.218 ***	0.063	-0.167 ***	0.060	-0.179 ***	0.067	-0.209 ***	0.069	-0.076	0.089	-0.239 ***	0.081
Fourth born	-0.088	0.117	0.027	0.118	-0.132	0.120	-0.050	0.107	-0.049	0.172	-0.356 ***	0.132
Fifth born	-0.640	0.421	-0.484	0.501	-0.281	0.360	-1.335 **	0.652	0.765 **	0.377	-0.939	0.678
Sixth born	-0.453	0.985	-0.489	0.821	-0.501	0.598	-0.374	1.139	-1.085 **	0.543	0.561 *	0.288
Age of parent most knowledgeable of youth	0.009	0.033	0.022	0.027	-0.011	0.035	-0.005	0.040	0.031	0.046	0.012	0.034
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Parent with a non-university PS certificate	0.193 ***	0.028	0.161 ***	0.036	0.171 ***	0.026	0.150 ***	0.031	0.228 ***	0.052	0.220 ***	0.048
Parent with a bachelor's degree	0.416 ***	0.043	0.312 ***	0.048	0.382 ***	0.040	0.330 ***	0.042	0.303 ***	0.073	0.338 ***	0.071
Parent with a graduate or professional degree	0.540 ***	0.050	0.509 ***	0.066	0.533 ***	0.054	0.347 ***	0.055	0.519 ***	0.120	0.383 ***	0.102
Equivalent total parental income	0.051 ***	0.010	0.040 ***	0.013	0.046 ***	0.011	0.044 ***	0.011	0.051 **	0.023	0.060 **	0.025
Equivalent total parental income^2	-0.001 **	0.000	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.176 ***	0.057	-0.139 **	0.067	-0.141 **	0.056	-0.211 ***	0.052	-0.126 *	0.074	-0.163	0.104
Two birth parents present	-0.053	0.038	-0.031	0.040	-0.076 **	0.039	-0.023	0.040	0.019	0.054	-0.114 *	0.069
Female	0.317 ***	0.029	0.135 ***	0.033	0.257 ***	0.029	0.397 ***	0.027	-0.161 ***	0.038	-0.029	0.046
Related course	0.546 ***	0.139	0.458 ***	0.141	0.500 ***	0.130	0.438 ***	0.127	0.462 ***	0.159	0.641 ***	0.125
Québec	0.355 ***	0.038	0.300 ***	0.040	0.387 ***	0.034	0.175 ***	0.036	0.625 ***	0.052	0.405 ***	0.045
Intercept	-4.995 ***	1.349	-5.031 ***	1.291	-2.778 **	1.298	-4.463 ***	1.452	-6.418 ***	1.683	-5.618 ***	1.803
Adjusted R^2	0.211		0.131		0.191		0.144		0.187		0.127	
N	5,507		5,507		5,507		5,507		3,074		3,025	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).

Source: Youth in Transition Survey, Cohort A.

Table A4.4.3: IV regressions of standardized test scores on the school grade - Quadratic age specification

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.419 ***	0.119	0.292 **	0.117	0.480 ***	0.129	0.249 **	0.108	0.298 **	0.133	0.265 *	0.151
Age of the youth	-14.060	9.906	-7.115	9.760	-15.392	10.810	-6.964	9.452	-5.863	12.141	-16.737	13.748
Age of the youth^2	0.451	0.316	0.230	0.312	0.489	0.345	0.226	0.302	0.192	0.388	0.541	0.440
Second born	-0.127 ***	0.039	-0.121 ***	0.040	-0.111 ***	0.038	-0.086 **	0.041	-0.060	0.046	-0.102 **	0.051
Third born	-0.218 ***	0.061	-0.167 ***	0.060	-0.179 ***	0.067	-0.209 ***	0.069	-0.077	0.089	-0.236 ***	0.080
Fourth born	-0.101	0.115	0.021	0.116	-0.146	0.121	-0.057	0.105	-0.053	0.172	-0.363 ***	0.131
Fifth born	-0.585	0.423	-0.456	0.503	-0.222	0.358	-1.307 *	0.672	0.772 **	0.380	-0.869	0.720
Sixth born	-0.455	0.985	-0.490	0.821	-0.504	0.598	-0.375	1.139	-1.088 **	0.544	0.561 *	0.287
Age of parent most knowledgeable of youth	0.006	0.033	0.020	0.027	-0.014	0.036	-0.006	0.040	0.030	0.046	0.006	0.036
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Parent with a non-university PS certificate	0.184 ***	0.028	0.156 ***	0.036	0.161 ***	0.026	0.145 ***	0.030	0.224 ***	0.051	0.206 ***	0.048
Parent with a bachelor's degree	0.402 ***	0.045	0.304 ***	0.051	0.366 ***	0.043	0.323 ***	0.043	0.298 ***	0.074	0.318 ***	0.074
Parent with a graduate or professional degree	0.523 ***	0.051	0.500 ***	0.067	0.514 ***	0.055	0.338 ***	0.057	0.510 ***	0.120	0.362 ***	0.104
Equivalent total parental income	0.048 ***	0.010	0.039 ***	0.013	0.043 ***	0.010	0.043 ***	0.011	0.049 **	0.024	0.059 **	0.024
Equivalent total parental income^2	-0.001 **	0.000	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.165 ***	0.059	-0.134 *	0.070	-0.129 **	0.057	-0.206 ***	0.053	-0.121	0.074	-0.149	0.106
Two birth parents present	-0.053	0.037	-0.031	0.040	-0.077 **	0.038	-0.023	0.040	0.020	0.053	-0.116 *	0.069
Female	0.309 ***	0.028	0.131 ***	0.033	0.248 ***	0.028	0.393 ***	0.028	-0.166 ***	0.039	-0.038	0.047
Related course	0.536 ***	0.139	0.453 ***	0.141	0.489 ***	0.130	0.433 ***	0.127	0.457 ***	0.157	0.606 ***	0.127
Québec	0.362 ***	0.038	0.303 ***	0.041	0.395 ***	0.034	0.178 ***	0.037	0.628 ***	0.053	0.412 ***	0.044
Intercept	104.058	76.670	50.626	75.486	115.506	83.740	50.246	73.177	40.001	93.623	125.323	106.617
Adjusted R^2	0.231		0.141		0.207		0.154		0.196		0.147	
N	5,507		5,507		5,507		5,507		3,074		3,025	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.4: IV regressions of standardized test scores on the school grade - Cubic age specification

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.422 ***	0.120	0.294 **	0.119	0.488 ***	0.130	0.251 **	0.108	0.311 **	0.133	0.294 *	0.157
Age of the youth	-9.161	22.693	-4.352	22.443	-2.961	26.229	-3.421	28.021	16.663	37.899	30.597	37.509
Age of the youth^2	0.119	1.434	0.043	1.458	-0.352	1.641	-0.014	1.808	-1.330	2.434	-2.666	2.462
Age of the youth^3	0.007	0.032	0.004	0.033	0.019	0.036	0.005	0.040	0.034	0.053	0.072	0.056
Second born	-0.127 ***	0.039	-0.121 ***	0.040	-0.111 ***	0.038	-0.086 **	0.041	-0.061	0.045	-0.102 **	0.051
Third born	-0.218 ***	0.061	-0.167 ***	0.060	-0.179 ***	0.066	-0.209 ***	0.069	-0.076	0.088	-0.237 ***	0.079
Fourth born	-0.101	0.115	0.021	0.116	-0.147	0.122	-0.057	0.105	-0.053	0.173	-0.359 ***	0.130
Fifth born	-0.587	0.423	-0.456	0.503	-0.225	0.356	-1.308 *	0.674	0.768 **	0.378	-0.879	0.718
Sixth born	-0.456	0.989	-0.490	0.822	-0.505	0.607	-0.376	1.142	-1.111 **	0.554	0.611 *	0.313
Age of parent most knowledgeable of youth	0.006	0.033	0.020	0.027	-0.014	0.036	-0.006	0.039	0.030	0.045	0.006	0.036
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.184 ***	0.028	0.156 ***	0.036	0.161 ***	0.026	0.145 ***	0.030	0.223 ***	0.051	0.204 ***	0.048
Parent with a bachelor's degree	0.402 ***	0.045	0.304 ***	0.051	0.366 ***	0.043	0.323 ***	0.043	0.298 ***	0.074	0.316 ***	0.074
Parent with a graduate or professional degree	0.522 ***	0.050	0.500 ***	0.067	0.512 ***	0.054	0.337 ***	0.056	0.506 ***	0.119	0.352 ***	0.103
Equivalent total parental income	0.048 ***	0.010	0.039 ***	0.013	0.043 ***	0.011	0.043 ***	0.011	0.049 **	0.024	0.058 **	0.024
Equivalent total parental income^2	-0.001 **	0.000	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.165 ***	0.059	-0.134 *	0.070	-0.129 **	0.057	-0.206 ***	0.053	-0.120	0.074	-0.147	0.106
Two birth parents present	-0.054	0.037	-0.031	0.040	-0.077 **	0.038	-0.023	0.040	0.019	0.053	-0.119 *	0.068
Female	0.308 ***	0.028	0.131 ***	0.032	0.248 ***	0.028	0.393 ***	0.027	-0.167 ***	0.038	-0.041	0.047
Related course	0.536 ***	0.139	0.453 ***	0.141	0.488 ***	0.130	0.433 ***	0.128	0.454 ***	0.155	0.602 ***	0.127
Québec	0.362 ***	0.038	0.303 ***	0.042	0.395 ***	0.034	0.178 ***	0.037	0.628 ***	0.052	0.412 ***	0.044
Intercept	79.990	125.000	37.053	120.874	54.434	144.936	32.838	148.948	-70.892	201.269	-106.958	197.471
Adjusted R^2	0.232		0.141		0.208		0.154		0.199		0.151	
N	5,507		5,507		5,507		5,507		3,074		3,025	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.5: IV regressions of standardized test scores on the school grade - Quartic age specification

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.422 ***	0.119	0.295 **	0.118	0.488 ***	0.130	0.253 **	0.109	0.310 **	0.134	0.294 *	0.159
Age of the youth	-9.340	22.895	-4.451	22.765	-3.110	27.078	-3.516	28.254	16.966	38.284	34.036	40.504
Age of the youth^2	0.127	10.258	0.263	11.424	-0.005	18.308	0.316	14.473	-0.290	18.435	0.000	14.920
Age of the youth^3	0.008	0.861	-0.014	0.981	-0.010	1.542	-0.023	1.232	-0.056	1.558	-0.172	1.224
Age of the youth^4	0.000	0.021	0.000	0.024	0.001	0.037	0.001	0.030	0.002	0.038	0.006	0.029
Second born	-0.127 ***	0.039	-0.121 ***	0.040	-0.111 ***	0.038	-0.086 **	0.041	-0.061	0.045	-0.102 **	0.051
Third born	-0.218 ***	0.062	-0.167 ***	0.060	-0.179 ***	0.067	-0.209 ***	0.069	-0.076	0.089	-0.237 ***	0.079
Fourth born	-0.101	0.116	0.020	0.116	-0.147	0.122	-0.057	0.106	-0.053	0.173	-0.358 ***	0.130
Fifth born	-0.587	0.421	-0.456	0.503	-0.225	0.353	-1.308 *	0.673	0.769 **	0.378	-0.883	0.716
Sixth born	-0.456	0.988	-0.490	0.823	-0.505	0.607	-0.376	1.144	-1.112 **	0.555	0.616 *	0.315
Age of parent most knowledgeable of youth	0.006	0.033	0.020	0.027	-0.014	0.036	-0.006	0.039	0.030	0.045	0.006	0.036
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Parent with a non-university PS certificate	0.184 ***	0.028	0.156 ***	0.036	0.161 ***	0.026	0.145 ***	0.030	0.223 ***	0.051	0.204 ***	0.048
Parent with a bachelor's degree	0.402 ***	0.045	0.304 ***	0.050	0.366 ***	0.043	0.323 ***	0.044	0.298 ***	0.074	0.317 ***	0.074
Parent with a graduate or professional degree	0.522 ***	0.051	0.499 ***	0.067	0.512 ***	0.054	0.337 ***	0.056	0.506 ***	0.120	0.352 ***	0.103
Equivalent total parental income	0.048 ***	0.010	0.039 ***	0.013	0.043 ***	0.011	0.043 ***	0.011	0.049 **	0.024	0.058 **	0.024
Equivalent total parental income^2	-0.001 **	0.000	-0.001 *	0.000	-0.001 ***	0.000	-0.001	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.165 ***	0.059	-0.133 *	0.070	-0.129 **	0.057	-0.206 ***	0.053	-0.120	0.074	-0.147	0.106
Two birth parents present	-0.054	0.037	-0.031	0.040	-0.077 **	0.038	-0.023	0.040	0.019	0.053	-0.119 *	0.068
Female	0.308 ***	0.028	0.131 ***	0.032	0.247 ***	0.029	0.393 ***	0.028	-0.168 ***	0.039	-0.041	0.047
Related course	0.536 ***	0.139	0.452 ***	0.141	0.488 ***	0.129	0.433 ***	0.128	0.454 ***	0.155	0.602 ***	0.128
Québec	0.362 ***	0.038	0.303 ***	0.041	0.395 ***	0.034	0.179 ***	0.037	0.628 ***	0.053	0.412 ***	0.044
Intercept	81.017	400.518	29.102	480.337	41.742	699.354	20.506	587.322	-114.870	738.748	-240.118	561.924
Adjusted R^2	0.232		0.141		0.208		0.155		0.198		0.151	
N	5,507		5,507		5,507		5,507		3,074		3,025	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).

Source: Youth in Transition Survey, Cohort A.

Table A4.4.6: IV regressions of standardized test scores on the school grade - Window of +/- three months

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.322 ***	0.057	0.255 ***	0.065	0.332 ***	0.058	0.243 ***	0.053	0.257 ***	0.058	0.206 ***	0.078
Second born	-0.183 ***	0.053	-0.181 ***	0.060	-0.170 ***	0.047	-0.107 **	0.054	-0.098 *	0.055	-0.143 **	0.062
Third born	-0.258 ***	0.094	-0.141	0.098	-0.281 ***	0.097	-0.222 **	0.096	-0.037	0.106	-0.211 *	0.111
Fourth born	-0.202	0.196	-0.104	0.157	-0.158	0.202	-0.243	0.212	0.092	0.275	-0.703 ***	0.268
Fifth born	-0.765 *	0.394	-0.613	0.478	-0.417	0.333	-1.424 **	0.708			-0.949	0.665
Sixth born	-1.680 **	0.831	-1.493 **	0.738	-1.241 **	0.616	-1.802 **	0.892	-1.048 **	0.522		
Age of parent most knowledgeable of youth	0.010	0.047	0.026	0.047	-0.004	0.049	0.013	0.045	-0.028	0.048	0.080	0.060
Age of parent most knowledgeable of youth^2	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	-0.001	0.001
Parent with a non-university PS certificate	0.209 ***	0.044	0.156 ***	0.057	0.200 ***	0.043	0.159 ***	0.042	0.262 ***	0.066	0.176 ***	0.062
Parent with a bachelor's degree	0.391 ***	0.054	0.319 ***	0.064	0.354 ***	0.055	0.282 ***	0.059	0.332 ***	0.098	0.300 ***	0.096
Parent with a graduate or professional degree	0.517 ***	0.073	0.532 ***	0.080	0.498 ***	0.087	0.267 ***	0.075	0.450 ***	0.143	0.298 **	0.144
Equivalent total parental income	0.066 ***	0.019	0.044 **	0.019	0.062 ***	0.019	0.057 ***	0.019	0.078 ***	0.029	0.080 **	0.035
Equivalent total parental income^2	-0.001	0.001	-0.001	0.001	-0.001 **	0.001	-0.001	0.001	-0.002	0.001	-0.002	0.002
Two parents present, at least one not from birth	-0.170 **	0.071	-0.130	0.090	-0.148 **	0.072	-0.190 ***	0.064	-0.220 **	0.104	-0.192	0.119
Two birth parents present	0.000	0.053	0.010	0.060	-0.031	0.054	0.016	0.057	0.003	0.063	-0.076	0.081
Female	0.306 ***	0.043	0.116 **	0.045	0.231 ***	0.044	0.438 ***	0.042	-0.111 **	0.055	-0.021	0.072
Related course	0.377 **	0.166	0.204	0.148	0.415 **	0.178	0.307 *	0.166	0.237	0.186	0.690 ***	0.185
Québec	0.356 ***	0.049	0.306 ***	0.051	0.416 ***	0.045	0.143 ***	0.045	0.586 ***	0.059	0.380 ***	0.062
Intercept	-4.718 ***	1.141	-4.044 ***	1.153	-4.412 ***	1.193	-3.790 ***	1.145	-2.907 **	1.235	-5.328 ***	1.364
Adjusted R^2	0.227		0.144		0.198		0.172		0.207		0.152	
N	2,886		2,886		2,886		2,886		1,605		1,590	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.7: IV regressions of standardized test scores on the school grade - Window of +/- two months

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.377 ***	0.078	0.293 ***	0.081	0.395 ***	0.084	0.255 ***	0.066	0.282 ***	0.081	0.195 *	0.106
Second born	-0.152 **	0.070	-0.151 *	0.077	-0.111 *	0.065	-0.103	0.071	-0.017	0.073	-0.122	0.090
Third born	-0.238 **	0.097	-0.115	0.103	-0.268 ***	0.098	-0.207 *	0.111	-0.015	0.163	-0.194	0.129
Fourth born	-0.340	0.218	-0.135	0.215	-0.289	0.212	-0.442 *	0.247	0.048	0.328	-0.331	0.360
Fifth born	-0.755 *	0.388	-0.586	0.488	-0.403	0.332	-1.444 **	0.697			-0.918	0.652
Sixth born	-1.712 **	0.845	-1.527 **	0.760	-1.248 **	0.617	-1.812 **	0.893	-1.030 **	0.519		
Age of parent most knowledgeable of youth	-0.010	0.054	0.004	0.057	-0.010	0.055	-0.015	0.051	-0.060	0.062	0.072	0.067
Age of parent most knowledgeable of youth^2	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.001	-0.001	0.001
Parent with a non-university PS certificate	0.189 ***	0.058	0.192 **	0.076	0.172 ***	0.054	0.107 *	0.058	0.191 **	0.078	0.178 **	0.073
Parent with a bachelor's degree	0.383 ***	0.071	0.349 ***	0.086	0.352 ***	0.066	0.224 ***	0.072	0.260 **	0.102	0.320 ***	0.120
Parent with a graduate or professional degree	0.531 ***	0.096	0.658 ***	0.103	0.502 ***	0.123	0.203 **	0.101	0.549 ***	0.174	0.325	0.205
Equivalent total parental income	0.037	0.023	0.023	0.026	0.030	0.024	0.043 *	0.024	0.094 **	0.037	0.133 ***	0.042
Equivalent total parental income^2	-0.001	0.001	0.000	0.001	-0.001	0.001	-0.001	0.001	-0.002	0.002	-0.006 **	0.003
Two parents present, at least one not from birth	-0.179 *	0.095	-0.172	0.119	-0.170 **	0.085	-0.190 **	0.086	-0.190	0.140	-0.262 **	0.130
Two birth parents present	-0.006	0.062	-0.004	0.078	-0.059	0.062	0.033	0.065	0.043	0.069	-0.137	0.101
Female	0.350 ***	0.053	0.135 **	0.053	0.277 ***	0.053	0.490 ***	0.052	-0.095	0.070	0.110	0.089
Related course	0.393 *	0.205	0.190	0.172	0.452 **	0.220	0.345	0.214	0.270	0.228	0.795 ***	0.202
Québec	0.317 ***	0.058	0.275 ***	0.062	0.399 ***	0.055	0.096 *	0.053	0.499 ***	0.067	0.306 ***	0.072
Intercept	-4.678 ***	1.290	-3.784 ***	1.356	-4.822 ***	1.257	-3.209 **	1.316	-2.299	1.699	-5.295 ***	1.384
Adjusted R^2	0.238		0.151		0.211		0.177		0.201		0.167	
N	1,949		1,949		1,949		1,949		1,067		1,080	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.8: IV regressions of standardized test scores on the school grade - Window of +/- one month

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade	0.407 ***	0.088	0.265 ***	0.089	0.493 ***	0.106	0.244 ***	0.080	0.332 ***	0.112	0.212 *	0.128
Second born	-0.099	0.083	-0.159 *	0.091	-0.038	0.082	-0.020	0.091	0.052	0.096	-0.201	0.127
Third born	-0.245 *	0.147	-0.176	0.136	-0.299 **	0.140	-0.184	0.171	-0.035	0.279	-0.395 **	0.195
Fourth born	-0.439	0.281	-0.379	0.265	-0.244	0.275	-0.661 **	0.315	-0.279	0.304	-0.943 ***	0.244
Age of parent most knowledgeable of youth	0.009	0.065	0.031	0.066	-0.006	0.066	0.025	0.070	-0.103	0.075	0.038	0.167
Age of parent most knowledgeable of youth^2	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000	0.002
Parent with a non-university PS certificate	0.203 ***	0.077	0.156 *	0.089	0.153 *	0.082	0.190 **	0.079	0.165	0.106	0.124	0.123
Parent with a bachelor's degree	0.467 ***	0.092	0.402 ***	0.123	0.439 ***	0.100	0.346 ***	0.098	0.426 ***	0.157	0.322 *	0.195
Parent with a graduate or professional degree	0.633 ***	0.116	0.830 ***	0.122	0.635 ***	0.166	0.209	0.128	0.702 ***	0.195	0.326	0.309
Equivalent total parental income	0.075 *	0.038	0.048	0.039	0.028	0.041	0.102 **	0.042	0.039	0.063	0.187 ***	0.064
Equivalent total parental income^2	-0.003 *	0.002	-0.003	0.002	0.000	0.002	-0.005 **	0.002	0.001	0.005	-0.011 *	0.006
Two parents present, at least one not from birth	-0.145	0.123	-0.117	0.143	-0.119	0.128	-0.174	0.132	-0.126	0.180	-0.230	0.200
Two birth parents present	-0.118	0.086	-0.092	0.109	-0.116	0.085	-0.102	0.107	0.150	0.113	-0.154	0.175
Female	0.420 ***	0.071	0.168 **	0.083	0.348 ***	0.071	0.580 ***	0.065	-0.083	0.094	0.229 *	0.120
Related course	0.341	0.292	0.227	0.297	0.557 *	0.303	0.093	0.250	0.894 ***	0.249	0.527 ***	0.165
Québec	0.354 ***	0.084	0.312 ***	0.092	0.426 ***	0.080	0.136 *	0.080	0.590 ***	0.097	0.254 **	0.104
Intercept	-5.329 ***	1.669	-4.026 **	1.707	-5.892 ***	1.764	-3.894 **	1.619	-2.265	1.877	-4.662	3.535
Adjusted R^2	0.269		0.151		0.255		0.197		0.260		0.172	
N	981		981		981		981		557		551	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).
Source: Youth in Transition Survey, Cohort A.

Table A4.4.9: OLS regressions of standardized test scores on the school grade initially assigned - Québec/Nova Scotia

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade initially assigned	0.314 ***	0.096	0.219 **	0.092	0.359 ***	0.104	0.186 **	0.083	0.213 **	0.100	0.211 *	0.125
Age of the youth	-13.079	10.230	-6.431	9.770	-14.269	11.151	-6.381	9.553	-4.605	12.331	-16.828	14.238
Age of the youth^2	0.422	0.327	0.210	0.313	0.456	0.357	0.209	0.306	0.154	0.395	0.546	0.456
Second born	-0.124 ***	0.042	-0.119 ***	0.041	-0.107 ***	0.040	-0.085 **	0.043	-0.059	0.047	-0.098 *	0.052
Third born	-0.234 ***	0.068	-0.178 ***	0.063	-0.196 ***	0.073	-0.218 ***	0.072	-0.082	0.092	-0.249 ***	0.085
Fourth born	-0.087	0.121	0.030	0.125	-0.131	0.122	-0.048	0.109	-0.048	0.178	-0.355 ***	0.135
Fifth born	-0.792 *	0.450	-0.600	0.505	-0.458	0.417	-1.430 **	0.603	0.779 **	0.384	-1.019	0.654
Sixth born	-0.420	0.956	-0.465	0.801	-0.464	0.565	-0.354	1.121	-1.031 **	0.516	0.552 *	0.285
Age of parent most knowledgeable of youth	0.013	0.033	0.026	0.028	-0.005	0.036	-0.002	0.039	0.031	0.048	0.015	0.033
Age of parent most knowledgeable of youth^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Parent with a non-university PS certificate	0.215 ***	0.028	0.178 ***	0.036	0.197 ***	0.027	0.164 ***	0.030	0.247 ***	0.053	0.235 ***	0.049
Parent with a bachelor's degree	0.453 ***	0.044	0.340 ***	0.048	0.424 ***	0.042	0.353 ***	0.041	0.329 ***	0.073	0.355 ***	0.073
Parent with a graduate or professional degree	0.596 ***	0.051	0.551 ***	0.064	0.597 ***	0.055	0.381 ***	0.055	0.566 ***	0.118	0.414 ***	0.103
Equivalent total parental income	0.059 ***	0.011	0.046 ***	0.013	0.056 ***	0.011	0.049 ***	0.011	0.058 **	0.024	0.063 **	0.025
Equivalent total parental income^2	-0.001 ***	0.000	-0.001 **	0.000	-0.001 ***	0.000	-0.001 *	0.000	-0.001	0.001	-0.001	0.002
Two parents present, at least one not from birth	-0.205 ***	0.060	-0.161 **	0.070	-0.174 ***	0.058	-0.229 ***	0.051	-0.149 *	0.081	-0.176 *	0.102
Two birth parents present	-0.051	0.040	-0.029	0.043	-0.074 *	0.041	-0.022	0.040	0.022	0.058	-0.112	0.070
Female	0.338 ***	0.029	0.151 ***	0.032	0.282 ***	0.029	0.410 ***	0.027	-0.142 ***	0.039	-0.022	0.046
Related course	0.578 ***	0.149	0.482 ***	0.147	0.537 ***	0.140	0.458 ***	0.132	0.487 ***	0.170	0.680 ***	0.121
Québec	0.336 ***	0.040	0.285 ***	0.042	0.365 ***	0.035	0.163 ***	0.037	0.611 ***	0.054	0.398 ***	0.046
Intercept	96.469	79.254	45.336	75.627	106.822	86.450	45.737	74.003	30.372	95.165	125.932	110.403
Adjusted R^2	0.132		0.079		0.113		0.100		0.128		0.102	
N	5,507		5,507		5,507		5,507		5,507		5,507	

Note: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%).

Source: Youth in Transition Survey, Cohort A.

Table A4.4.10: OLS regressions of standardized test scores on the school grade initially assigned - Rest of Canada

	Reading		Retrieving sub-component		Interpreting sub-component		Reflecting sub-component		Mathematics		Science	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
School grade initially assigned	0.028	0.048	0.072	0.050	0.010	0.050	0.024	0.054	0.020	0.069	0.080	0.066
Age of the youth	0.259	5.379	1.851	6.339	0.358	5.840	-0.015	5.613	-0.587	7.189	-5.944	8.240
Age of the youth^2	-0.006	0.172	-0.059	0.203	-0.008	0.187	0.003	0.180	0.019	0.230	0.197	0.264
Second born	-0.117 ***	0.023	-0.098 ***	0.022	-0.127 ***	0.024	-0.058 **	0.025	-0.093 ***	0.030	-0.159 ***	0.036
Third born	-0.226 ***	0.041	-0.153 ***	0.043	-0.244 ***	0.042	-0.139 ***	0.042	-0.223 ***	0.062	-0.179 ***	0.058
Fourth born	-0.129	0.085	-0.200 **	0.083	-0.099	0.082	-0.084	0.096	-0.066	0.088	0.028	0.136
Fifth born	-0.435	0.286	-0.368	0.307	-0.451 *	0.248	-0.272	0.282	-0.472 *	0.247	0.261	0.405
Sixth born	-0.406 **	0.191	-0.053	0.335	-0.142	0.198	-0.934 **	0.364	0.495	0.362		
Age of parent most knowledgeable of youth	0.054 ***	0.020	0.054 ***	0.019	0.062 ***	0.019	0.026	0.018	0.103 ***	0.025	0.051	0.034
Age of parent most knowledgeable of youth^2	0.000 **	0.000	0.000 **	0.000	-0.001 ***	0.000	0.000	0.000	-0.001 ***	0.000	0.000	0.000
Parent with a non-university PS certificate	0.220 ***	0.028	0.191 ***	0.028	0.213 ***	0.027	0.185 ***	0.030	0.222 ***	0.032	0.225 ***	0.035
Parent with a bachelor's degree	0.522 ***	0.041	0.419 ***	0.036	0.496 ***	0.041	0.460 ***	0.039	0.492 ***	0.046	0.507 ***	0.051
Parent with a graduate or professional degree	0.723 ***	0.045	0.566 ***	0.043	0.708 ***	0.045	0.595 ***	0.044	0.739 ***	0.056	0.600 ***	0.057
Equivalent total parental income	0.026 **	0.012	0.022 **	0.011	0.025 **	0.011	0.024 *	0.012	0.004	0.011	0.056 ***	0.012
Equivalent total parental income^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002 ***	0.000
Two parents present, at least one not from birth	-0.217 ***	0.041	-0.175 ***	0.043	-0.215 ***	0.043	-0.181 ***	0.041	-0.196 ***	0.058	-0.250 ***	0.056
Two birth parents present	0.006	0.031	0.011	0.031	-0.020	0.031	0.021	0.031	0.032	0.045	-0.017	0.044
Female	0.315 ***	0.022	0.202 ***	0.021	0.275 ***	0.023	0.370 ***	0.024	-0.104 ***	0.029	0.063 **	0.028
Related course	0.576 ***	0.082	0.568 ***	0.082	0.509 ***	0.073	0.490 ***	0.077	0.415 ***	0.081	0.418 ***	0.074
Newfoundland and Labrador	0.376 ***	0.036	0.340 ***	0.035	0.250 ***	0.040	0.454 ***	0.037	-0.004	0.057	0.269 ***	0.060
Prince-Edward-Island	0.296 ***	0.038	0.277 ***	0.039	0.201 ***	0.038	0.352 ***	0.043	-0.055	0.059	0.058	0.063
New Brunswick - English sector	0.292 ***	0.045	0.252 ***	0.045	0.204 ***	0.045	0.366 ***	0.046	-0.112 **	0.057	0.046	0.060
Ontario	0.456 ***	0.041	0.390 ***	0.042	0.346 ***	0.042	0.514 ***	0.039	0.045	0.057	0.210 ***	0.059
Manitoba	0.490 ***	0.040	0.444 ***	0.041	0.380 ***	0.044	0.517 ***	0.038	0.261 ***	0.053	0.335 ***	0.067
Saskatchewan	0.470 ***	0.040	0.434 ***	0.039	0.362 ***	0.045	0.491 ***	0.038	0.113 *	0.058	0.245 ***	0.060
Alberta	0.663 ***	0.043	0.601 ***	0.038	0.545 ***	0.045	0.634 ***	0.043	0.331 ***	0.054	0.522 ***	0.072
British Columbia	0.526 ***	0.043	0.494 ***	0.040	0.424 ***	0.045	0.512 ***	0.042	0.152 ***	0.056	0.327 ***	0.064
No province code	-0.054	0.056	-0.103 **	0.052	-0.094 *	0.056	0.074	0.058	-0.482 ***	0.084	-0.222 ***	0.086
Intercept	-5.848	41.555	-17.817	48.973	-6.466	45.108	-2.895	43.430	1.308	55.611	41.815	63.785
Adjusted R^2	0.171		0.121		0.148		0.135		0.130		0.142	
N	17,918		17,918		17,918		17,918		9,909		9,970	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The omitted province is New Brunswick - French sector.

Source: Youth in Transition Survey, Cohort A.

Appendix A4.5: Quantile regression and QTE for IV

In an OLS regression, the objective is to minimize the sum of squared errors, and as a result, fit a line through the (conditional) means of the dependent variable. Specifically, the OLS minimand is simply $\sum_i \left(y_i - x_i^{'}b\right)^2$, based on standard notation. The end result is that OLS coefficients measure the relationship between the explanatory variables and the conditional mean of the dependent variable.

Quantile regressions are based on the least absolute deviation technique, which fits a line through a given series of (conditional) percentiles of the dependent variable. The minimand in this case is $\left\{\sum_{y_i \geq x_i^{'}b} \gamma\left|y_i - x_i^{'}b\right| + \sum_{y_i \prec x_i^{'}b}(1-\gamma)\left|y_i - x_i^{'}b\right|\right\}$, where γ is a specified percentile.

The intuition behind a quantile regression is that the regression 'penalizes' data points that are above or below the regression line, much like with OLS, except that the penalty factors—γ and $(1-\gamma)$—are chosen explicitly to try to yield a line that runs through the specified conditional quantile.

The benefit of the quantile regression is that it permits the researcher to estimate heterogeneous effects (i.e. effects across the conditional distribution of the dependent variable). See Koenker and Bassett (1978), Buchinsky (1998), or Eide and Showalter (1999) for a more detailed exposition of quantile regression methods.

In Chapter 4, I estimate the impact of schooling on academic performance across the conditional distribution of academic performance in an IV framework. Abadie, Angrist, and Imbens (2002) developed an appropriate approach for this purpose. They refer to their approach as the Quantile Treatment Effects (QTE) estimator for IV. As with regular IV, the results of the QTE estimator apply to compliers. The approach consists of estimating a weight that indicates the probability that individuals comply. From this, weighted quantile regression can be estimated and the results are analogous to IV regression, but for conditional quantiles rather than conditional means. To calculate standard errors, the authors suggest bootstrapping. A caveat to this approach is that both the assignment and treatment variables must be binary.

The weighting function, referred to as the 'Abadie kappa', is:

$$(A4.5.1) E[k_i \mid Y_i, TREAT_i, X_i] = 1 - \frac{TREAT_i * (1 - E[Z_i \mid Y_i, TREAT_i, X_i])}{1 - P(Z_i = 1 \mid X_i)} - \frac{(1 - TREAT_i) * E[Z_i \mid Y_i, TREAT_i, X_i]}{P(Z_i = 1 \mid X_i)},$$

where k is the Abadie kappa, Y is the outcome variable, $TREAT$ is the treatment variable, X represents the regressors, and Z is the instrument (or assignment variable).

The complete procedure thus involves five steps:

1. Probit Z on Y and X separately for the samples where $TREAT$=0 and $TREAT$=1 and save the predicted probabilities.
2. Probit Z on X for the full sample and save the predicted probabilities.

3. Enter predicted probabilities in Equation A4.4.1 to calculate the expected value of the Abadie kappa. Note that since Z is binary, the expected value of Z is simply a probability. Trim the function to fit within the appropriate interval for a probability (i.e. [0, 1]).
4. Apply the kappa values as weights in quantile regressions.
5. Bootstrap the results to obtain standard errors.

Appendix A5.1: Differences-in-differences estimator

One approach for studying policy changes is the differences-in-differences (DD) estimator. The idea behind this approach is to measure changes in outcomes (*Y*) among a group that is given a treatment (i.e. the policy change, denoted by *TREAT*) before (0) and after (1) the change, as shown in Equation A5.1.1:

$$(A5.1.1) E(Y_{i1} - Y_{i0} \mid TREAT_i = 1)$$

A challenge, however, is to find the counterfactual outcome (i.e. the outcome in the absence of the treatment). An obvious candidate is to examine the change in outcomes among a control group that did not receive the treatment, as shown in Equation A5.1.2:

$$(A5.1.2) E(Y_{i1} - Y_{i0} \mid TREAT_i = 0)$$

The difference in the two conditional expectations is known as a difference-in-difference estimator (or double difference estimator). More generally, a differences-in-differences estimator may include triple differences, quadruple differences, etc.

In a regression framework, differences-in-differences estimators are implemented by interacting the treatment group dummy with a vector of time dummies. In the case of a double difference, we have:

$$(A5.1.3) Y = \alpha_{0i} + \alpha_{1i} TREAT_i + \alpha_{2i} TIME_i + \alpha_{2i} TREAT_i * TIME_i + \varepsilon_i$$

An important caveat is that the differences-in-differences estimator assumes common trends (i.e. in absence of the treatment, trends in outcomes in the control and treatment would be similar). To verify this assumption, researchers need a relatively long time-series of data prior to the treatment period (studying the trends ex-post treatment may be fruitless since the trends may also be affected by the treatment).

Aside from the common trends assumption, differences-in-differences estimators face other challenges. First, there is the problem of confounding factors. Differences-in-differences estimators are designed to study policy changes. However, policy changes are often ‘bundled’ as part of a larger reform. As a result, it is difficult to isolate the impact of specific policy changes since other policies are changing at the same time. Second, it is often the case that a small number of policy changes are considered. This increases the likelihood that confounding factors come into play. Third, policy changes are not always random. In fact, one could argue that effective policies are ones that are enacted only when they are expected to have the maximum possible effect. Thus, it may be difficult to generalize findings from DD estimators. Fourth, Bertrand, Duflo, and Mullainthan (2004) note that most papers that employ differences-in-differences estimators focus on serially correlated outcomes, but ignore the fact that the resulting standard errors are inconsistent, which leads to overstatement of the t-statistics and significance levels.

Appendix A5.2: Calculating the distance between the parental residence and the nearest university

In Chapter 5, I estimate the distance between the student's parental residence and the nearest university institution. I do so by comparing the geographic co-ordinates (latitude and longitude) of both points. The co-ordinates of the parental residence are derived from the postal codes of households (available on the LAD), which was fed into the residential version of the Postal Code Conversion File Plus (PCCF+), a program developed by Statistics Canada that converts six character postal codes into various geographic units, including geographic co-ordinates (i.e. the latitude and longitude). University postal codes were collected manually from the website of the Association of Universities and University-Colleges of Canada (www.aucc.ca), and converted to geographic co-ordinates by using the institutional version of the PCCF+.

Using spherical geometry, and assuming the earth to be a perfect sphere with a radius of 6,370.997 km, the formula for the straight-line distance (in km) between the student's home and the nearest university is:

$$\text{(A5.2.1)}\quad \text{Distance} = 6{,}370.997 * \text{arcos}[\sin(\text{s\_latrad}) * \sin(\text{i\_latrad}) + \cos(\text{s\_latrad}) * \cos(\text{i\_latrad}) * \cos(\text{s\_longrad} - \text{i\_longrad})]$$

Where *latrad* is the latitude in radians, and likewise for *longrad*. The geographic co-ordinates (in degrees and decimals) were converted to radians by dividing by 57.29577951. Note that *s_* denotes the student's location and *i_* denotes the institution's location.

Appendix A5.3: Applying different distance to school thresholds

In Chapter 5, I estimate results using 40 km from a university as the distance threshold. This is likely to represent a long commute at a minimum (since it is the straight-line distance), but for many, it may require moving away from the parental home to attend. In either case, these students likely face higher costs of attending than students living closer to a university.

In this appendix, I re-estimate the models using alternative thresholds ranging from 20 km to 100 km, at 10 km intervals.[47] The results appear in Tables A5.3.1 (a and b) and A5.3.2 (a and b), for Ontario, 2005 and Ontario, 2006, respectively. At the lower thresholds (20, 30, and 40 km), the non-refundable grants had a significant, positive effect on university attendance in Ontario for both years (2005 and 2006). For thresholds of 50 to 70 km, the results are only significant for 2006. Beyond 70 km, the results are not statistically significant for both years.

[47] I adopt this approach, rather than breaking the results down by distance category, since the latter would involve very small cell sizes, which is less than ideal for regression discontinuity estimators.

Table A5.3.1a: Results from regression discontinuity estimation of full-time university attendance by distance threshold ranging from ≥ 20 km to ≥ 60 km (Ontario, 2005)

	≥ 20 km		≥ 30 km		≥ 40 km		≥ 50 km		≥ 60 km	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.056 ***	0.018	0.046 **	0.021	0.055 **	0.027	0.032	0.031	0.003	0.039
Net parental income	2.E-06 ***	2.E-07	2.E-06 ***	3.E-07	3.E-06 ***	6.E-07	1.E-06 *	8.E-07	4.E-07	1.E-06
Net parental income^2	-4.E-12 ***	6.E-13	-4.E-12 ***	7.E-13	-4.E-12	2.E-12	5.E-12	4.E-12	9.E-12	1.E-11
Net parental income^3	2.E-18 ***	3.E-19	1.E-18 ***	4.E-19	2.E-18	3.E-18	-1.E-17 **	6.E-18	-2.E-17	2.E-17
Net parental income^4	-2.E-25 ***	5.E-26	-2.E-25 ***	5.E-26	-3.E-25	1.E-24	7.E-24 ***	2.E-24	1.E-23	2.E-23
Lone-parent family	-0.010	0.017	-0.003	0.019	-0.005	0.022	-0.007	0.024	-0.017	0.027
Number of children in family	0.053 ***	0.018	0.017	0.022	0.025	0.024	0.024	0.026	0.018	0.031
(Number of children in family)^2	-0.008 ***	0.003	-0.001	0.004	-0.002	0.004	-0.002	0.004	0.000	0.005
Female	0.162 ***	0.011	0.152 ***	0.013	0.147 ***	0.014	0.148 ***	0.016	0.147 ***	0.018
Intercept	-0.068 **	0.030	-0.055	0.036	-0.085 *	0.046	-0.042	0.054	0.008	0.071
Adjusted R^2	0.071		0.072		0.074		0.076		0.078	
N	6,790		4,435		3,250		2,515		1,975	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Table A5.3.1b: Results from regression discontinuity estimation of full-time university attendance by distance threshold ranging from ≥ 70 km to ≥ 100 km (Ontario, 2005)

	≥ 70 km		≥ 80 km		≥ 90 km		≥ 100 km	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	-0.025	0.045	-0.025	0.052	0.007	0.061	0.001	0.065
Net parental income	-1.E-06	2.E-06	-2.E-06	2.E-06	-2.E-06	2.E-06	-2.E-06	2.E-06
Net parental income^2	2.E-11 *	1.E-11	2.E-11 **	1.E-11	3.E-11	2.E-11	3.E-11	2.E-11
Net parental income^3	-4.E-17	3.E-17	-5.E-17 *	3.E-17	-7.E-17	6.E-17	-5.E-17	6.E-17
Net parental income^4	2.E-23	2.E-23	3.E-23	2.E-23	4.E-23	5.E-23	2.E-23	5.E-23
Lone-parent family	-0.050	0.031	-0.047	0.037	-0.076 *	0.041	-0.063	0.047
Number of children in family	0.038	0.036	0.044	0.041	0.065	0.047	0.033	0.052
(Number of children in family)^2	-0.003	0.006	-0.004	0.007	-0.007	0.008	-0.002	0.009
Female	0.155 ***	0.021	0.153 ***	0.024	0.177 ***	0.029	0.209 ***	0.031
Intercept	0.063	0.081	0.062	0.095	0.013	0.109	0.037	0.119
Adjusted R^2	0.078		0.084		0.110		0.127	
N	1,525		1,110		800		615	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Table A5.3.2a: Results from regression discontinuity estimation of full-time university attendance by distance threshold ranging from ≥ 20 km to ≥ 60 km (Ontario, 2006)

	≥ 20 km		≥ 30 km		≥ 40 km		≥ 50 km		≥ 60 km	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.026 *	0.015	0.050 ***	0.019	0.059 ***	0.020	0.063 ***	0.021	0.047 *	0.024
Net parental income	1.E-06 ***	2.E-07	2.E-06 ***	4.E-07	2.E-06 ***	4.E-07	2.E-06 ***	4.E-07	1.E-06 **	5.E-07
Net parental income^2	-1.E-12 ***	4.E-13	-3.E-12 **	1.E-12	-3.E-12 **	1.E-12	-2.E-12	2.E-12	-1.E-12	2.E-12
Net parental income^3	5.E-19 ***	2.E-19	1.E-18	1.E-18	2.E-18	1.E-18	9.E-19	1.E-18	-2.E-19	2.E-18
Net parental income^4	-5.E-26 ***	2.E-26	-2.E-25	3.E-25	-2.E-25	3.E-25	-1.E-25	3.E-25	1.E-25	4.E-25
Lone-parent family	-0.010	0.014	-0.007	0.015	0.010	0.017	0.008	0.018	0.023	0.020
Number of children in family	0.032 **	0.016	0.030	0.018	0.023	0.019	0.032	0.021	0.029	0.023
(Number of children in family)^2	-0.005 *	0.003	-0.004	0.003	-0.003	0.003	-0.004	0.004	-0.003	0.004
Female	0.061 ***	0.009	0.056 ***	0.011	0.058 ***	0.012	0.062 ***	0.013	0.058 ***	0.014
Intercept	0.004	0.026	-0.044	0.032	-0.066 **	0.033	-0.081 **	0.036	-0.066	0.040
Adjusted R^2	0.023		0.022		0.026		0.026		0.024	
N	6,630		4,235		3,205		2,500		1,975	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Table A5.3.2b: Results from regression discontinuity estimation of full-time university attendance by distance threshold ranging from ≥ 70 km to ≥ 100 km (Ontario, 2006)

	≥ 70 km		≥ 80 km		≥ 90 km		≥ 100 km	
	b	s.e.	b	s.e.	b	s.e.	b	s.e.
Eligible for NCBS	0.063 *	0.033	0.030	0.036	-0.007	0.045	0.004	0.054
Net parental income	2.E-06	1.E-06	9.E-09	1.E-06	-5.E-07	3.E-06	-6.E-08	3.E-06
Net parental income^2	-5.E-12	9.E-12	9.E-12	9.E-12	6.E-12	3.E-11	2.E-12	3.E-11
Net parental income^3	1.E-17	2.E-17	-2.E-17	2.E-17	1.E-17	1.E-16	2.E-17	2.E-16
Net parental income^4	-7.E-24	1.E-23	1.E-23	1.E-23	-5.E-23	2.E-22	-4.E-23	2.E-22
Lone-parent family	0.022	0.023	0.029	0.027	0.015	0.032	0.017	0.037
Number of children in family	0.049 *	0.025	0.038	0.032	0.050	0.036	0.068 *	0.041
(Number of children in family)^2	-0.006	0.004	-0.003	0.006	-0.005	0.006	-0.009	0.007
Female	0.051 ***	0.016	0.064 ***	0.019	0.071 ***	0.022	0.057 **	0.026
Intercept	-0.117 **	0.058	-0.056	0.063	-0.024	0.083	-0.052	0.090
Adjusted R^2	0.033		0.030		0.037		0.029	
N	1,540		1,115		835		640	

Notes: Statistical significance is denoted by "***" (1%), "**" (5%), and "*" (10%). The sample consists of 18 year-old youth. All variables are captured at age 17, except full-time PSE attendance (captured at age 18). The student is coded as having attended university full-time when tuition credits surpasses 80% of the mean full-time undergraduate university tuition in the province.
Source: Longitudinal Administrative Databank (LAD).

Although it is not clear why the effect of the grant is strongest when lower thresholds are used, there are at least two possibilities. Unfortunately, it is impossible to decipher which is the most likely candidate.

The first relates back to our discussion of net returns. Students raised 70 km or more from a university likely had to displace themselves to attend. Thus, their assessment of PSE as an investment in the absence of the grants may be quite negative – so much so that the grants may not have been sufficient to push them over the break-even point. For distance thresholds of 20 to 40 km, which may include many students within commuting distance (but at a considerable distance nonetheless), the costs of attending may be higher than students living closer due to direct transportation costs and travel time (i.e. opportunity costs), but lower than a student who has to move out of the parental home to attend. Thus, they may be close enough to the break-even point prior to the grant being offered.

A second possibility relates to sample size. Regression discontinuity estimators require large samples in order to look very closely for 'jumps' or 'dips' around the point of discontinuity. With well below 2,000 observations for thresholds of 70 km or above, there are very few observations near the actual point of discontinuity.