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Why do larger families reduce parental investments in child quality, but not child quality per se?

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Abstract Becker's Quantity–Quality model (Becker in Demographic and economic change in developed countries, Princeton University Press, Princeton, pp 209–240, 1960; Becker and Lewis in J Polit Econ 81(2): S279–S288, 1973; Becker and Tomes in J Polit Econ 84(4): S143–S162, 1976) suggests a trade-off between family size and parental investments in children. To date, only Cáceras-Delpiano (J Hum Resour 41(4): 738–754, 2006) tests this theory by considering private school enrolment. This study extends this work by using a unique data set containing a broader range of parental investments that are arguably linked to parental intentions for producing higher quality children, such as overall and non-sectarian private school enrolment, the number of computers in the home per child, and saving for the child's education. Both studies find that fertility reduces parental investments. However, the literature generally finds that fertility has no impact on child outcomes. The study offers three potential explanations for this 'puzzle'.

Keywords Fertility · Parental investments · Child quality

JEL Classification J13 · J24

1 Introduction

One of the most important demographic trends in recent decades has been the incredible decline in the fertility rate in developed countries. From 1960 to 2006, the fertility rate decline by 49% in OECD countries; since 1980, the rate has declined by 22% (OECD 2009). This downward trend in fertility, as well as subsequent attempts to raise fertility through financial incentives (see Milligan 2005), has fuelled

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research on the impact of fertility on other outcomes. One of the areas of particular concern has been child development. According to Gary Becker's 'Quantity–Quality' theory of children, the household faces a trade-off between the number of children they have and the average 'quality' of children (Becker 1960; Becker and Lewis 1973; Becker and Tomes 1976). Researchers then began investigating the empirical link between fertility and child quality. Using clever instruments to correct for the possible endogeneity of fertility to child quality (e.g. the incidence of twins, the sex composition of children, or China's one child policy), they looked at measures such as educational attainment (Rosenzweig and Wolpin 1980; Angrist et al. 2005; Black et al. 2005, 2010), grade retention (Cáceras-Delpiano 2006), labour market outcomes (Angrist et al. 2005), marriage and fertility (Angrist et al. 2005), and school enrolment (Qian 2009). What has emerged from this literature is that there is no consistent negative link between fertility and child outputs. In fact, the balance of the literature points to no relationship between the two.[1]

As noted by Cáceras-Delpiano (2006), however, the true spirit of Becker's model is that households will reduce their investments in children as family size grows. The resulting level of child quality is beyond complete control of the parents. Using the 1980 US Census, he demonstrates that increased fertility (instrumented with a twin birth on a second or later birth) exerts a negative impact on private school enrolment. The question that remained was simple, "Why does fertility reduce parental investments in children, but has no consistent impact on various measures of child output?" Cáceras-Delpiano points to one possible factor, namely the reduction in maternal labour supply suggested by theories of household allocation of labour. When faced with more children, men and women further specialize in household activities, which for men is typically paid work and for women is typically unpaid housework (Becker 1985). In addition, a new child will increase the demand for parental involvement in general (Lundberg and Rose 1999). In combination, these two complementary theories suggest an ambiguous impact of fertility on men's labour supply, and an unambiguous decline in women's labour supply. Cáceras-Delpiano showed that maternal labour supply does indeed tend to decline with fertility. Unfortunately, the data available only contained information on hours of paid work, so it is not clear what mothers are actually doing in the home (i.e. taking care of children or not).

This study extends the work of Cáceras-Delpiano (2006) in two important ways. First, using the same twin birth strategy and a unique Canadian data set (the Youth in Transition Survey—YITS, linked to the Programme for International Student Assessment—PISA), I explore the link between fertility and a broader range of investments that are arguably linked to parental intentions for producing higher quality children (overall and non-sectarian private school enrolment, the number of computers in the home per child, and saving for the child's education). I find a strong negative link between fertility and each of these measures of parental investments. I also demonstrate that fertility is not negatively associated with child cognitive ability (a measure of child output).

[1] The one exception is the very recently published paper by Black et al. (2010), which finds a negative link between fertility and IQ in Norway.

Second, I consider three possible reasons for the ‘puzzle’ presented in the literature (i.e. fertility is negatively related to parental investments, but is not always related to child outputs). The first is that the literature has not definitively linked parental investments in children to their cognitive ability. In fact, quasi-causal and experimental studies suggest no link with certain measures of parental investments. The second is that there may be economies of scale associated with larger families, with respect to rearing children and selecting effective sibling interactions. I present evidence suggesting that economies of scale explain some, but not all, of the puzzle. The third possible reason follows up on Cáceras-Delpiano’s work. Specifically, recent work suggests that mothers (and fathers!) do in fact respond to increased fertility by spending more time taking care of children without pay. However, the literature offers mixed evidence on the role of parental childcare in determining cognitive ability (ranging from no effect to a positive effect).

The remainder of this study is as follows. In the next section, I describe the methodology, including the identification strategy and the data used in the study. I then present the descriptive and econometric results in the following two sections. Next, I identify and discuss three possible reasons why fertility is negatively associated with parental investments in children, but generally does not lead to reduced child outputs. Finally, the study is summarized in the last section.

2 Methodology

The identification strategy is based on instrumenting family size with a variable indicating the presence of a multiple (twin, triplet, etc.) birth on the second or later birth, similar to Black et al. (Black et al. 2005, 2010) and Cáceras-Delpiano (2006). I begin with the Wald estimate, which is simply the ratio of the difference in average child input or output ($\bar{Y}$) between youth with (1) and without (0) multiple birth siblings, to the difference in the average number of children ($\bar{N}$) generated by the incidence of multiple birth siblings, as shown in Eq. 1:

$$\text{Wald} = \frac{(\bar{Y}_1 - \bar{Y}_0)}{(\bar{N}_1 - \bar{N}_0)}. \tag{1}$$

The standard error of the Wald is (Angrist 1990):

$$\text{SE(Wald)} = \frac{\sqrt{\left(\sigma^2_{\bar{Y}_1}/n_1\right) + \left(\sigma^2_{\bar{Y}_0}/n_0\right)}}{(\bar{N}_1 - \bar{N}_0)}, \tag{2}$$

where ‘n’ refers to the sample size. For significance testing, note that the Wald 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, no instrument is perfect. For this reason, I also estimate instrumental variable (two-stage least squares) regression, shown in Eqs. 3 and 4 (where Z is the multiple birth instrument, $(\hat{N})$ is the predicted value of N from the first stage, and X is a series of control variables):

$$\text{First - stage: } N_i = \alpha_0 Z_i + \alpha_1 X_i + \varepsilon_i \quad (3)$$

$$\text{Second - stage: } Y_i = \beta_0 \hat{N}_i + \beta_1 X_i + \mu_i. \quad (4)$$

In the case of categorical IVs (used here), the estimated effects of IV regression should be interpreted as Local Average Treatment Effects, or LATE (Imbens and Angrist 1994). In other words, the results only pertain to compliers (those induced to change their treatment status based on the instrument value). Unfortunately, it is impossible to identify compliers precisely since we do not know their counterfactual treatment status.

The data are drawn from the Canadian portion of the Programme for International Student Assessment (PISA), a project of the Organisation for Economic Co-operation and Development. In Canada only, the PISA is matched to the Youth in Transition Survey (YITS), Cohort A, Cycle 1. The YITS was developed in conjunction with PISA by Statistics Canada in order to add more contextual information than is available in PISA. For the purposes of this study, the YITS data set is unique in that it contains several measures of parental investments, child standardized test scores, family size, sufficient information to proxy multiple births with very high accuracy, and a large enough sample to conduct meaningful analyses. The YITS contains about 28,000 youth who were 15 years old on December 31, 1999 (i.e. they were born in 1984).[2,3,4]

The measure of child output is the PISA reading score. Conducted in April and May of 2000, the PISA assessment consisted of a reading test delivered to all students, and a mathematics and science test (each delivered to half of the students). I focus on the reading score since the sample size is crucial (I use a multiple birth IV). 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, so that regression coefficients are expressed in standard deviation units. In principle, PISA tests the ability of students to apply the

[2] 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 1 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.

[3] 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 ten 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, all standard errors are calculated using 100 bootstrap weights designed by Statistics Canada specifically for this purpose.

[4] The birth timing of the sample is fortunate since fertility treatments were in their infancy in the mid-1980s. This increases the probability that multiple births were exogenous events.

knowledge they have learned. In this sense, it is a hybrid between an IQ test and a scholastic test.[5]

Background questionnaires were administered to students through both 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. From these, three measures of child inputs were derived. The first is a binary indicator of enrolment in a private school, which is derived from the principal questionnaire. As we shall see, the majority of Canadian private schools are sectarian. Since parents may be motivated to enrol their children in sectarian schools for spiritual, as opposed to academic reasons, I also look at enrolment in private, non-sectarian schools.[6] The second measure of parental investment is the number of computers in the home per child, derived from the PISA student questionnaire.[7] The third measure of parental investment is a binary indicator of the presence of parental savings that are earmarked for the child's postsecondary studies (i.e. started a savings account, started a Registered Education Savings Plan (RESP), set up a trust fund for this child, or made investments).

The instrumental variable (a multiple birth on a second or later birth) 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 lead to additional children), and the multiple birth siblings must have occurred on the last birth (otherwise, they could not possibly lead to additional children since the couple chose to have more children following the multiple birth).

I also create variables indicating the number of children in the household (the fertility measure) and the birth order. The age of household members is measured in discrete years on the YITS parent questionnaire, which poses two challenges. First, two children who were the same age in years can not be distinguished in terms of birth order. Second, multiple birth siblings cannot be precisely identified. However, the incidence of siblings of the same age in years is likely more common in blended families where the husband and wife each have children from a previous marriage. I thus 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 that under

[5] Using a regression discontinuity approach based on school entry cut-off dates, Frenette (2010) finds evidence that additional schooling is strongly associated with PISA scores, suggesting that the scores are malleable (and not simply subject to innate ability).

[6] Students in private non-sectarian schools only perform slightly better than public school students on a standardized reading test (about 0.1 standard deviations higher). Nevertheless, enrolling a student in a private non-sectarian school is likely motivated by the *intention* to raise child quality, which is the essence of Becker's model.

[7] Students were asked how many computers are in the home. The answers are right-censored at three in the survey. About 10% of responses fall in the top category. However, according to the Canadian General Social Survey, Cycle 14 (2001), 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 likely only very little actual censoring in the YITS data.

these conditions, multiple birth siblings can be correctly identified in about 98% of the cases.[8]

The other variables used in the analysis include the sampled child's age (reported in months, but rescaled to years in the analysis), the child's sex, whether the child's mother tongue is the same as the test language, the age at arrival to Canada (in categories), the mother and father's age (reported in discrete years) and their highest level of education, and finally, the household's province of residence.[9] Note that the parental age variables are in quadratic form since their range is potentially quite high. For the child's age, a linear specification is used since the age range is quite narrow, as all children in the sample were born in 1984.

The initial sample consists of all youth with two opposite sex parents in the home, including the biological mother of the child.[10] As shown in the left side of Table 1, this includes 18,756 youth. The mean and standard error of each variable used are also shown. The process of selecting the final sample involved three more steps. First, 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. The impact of applying this criterion is minimal. The sample declines moderately by 351. The average values of the child input and output variables are virtually unchanged as a result. The average number of children is marginally lower, but this is expected since multiple birth siblings obviously come from larger families. The proportion of youth with a multiple birth sibling is cut in half, from 0.012 to 0.006, which is expected for the same reason. 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 18,405 to 15,471. 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 third step consists of dropping youth in families with a multiple birth on the first birth. This measure is

[8] Details are available upon request.

[9] One variable that is absent from this list is parental income. The reason for excluding it is that family size may influence child inputs or outputs 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. However, the findings I will present were unchanged when I included parental income in the models. These results are available upon request.

[10] Since the YITS only contains information on the father if he is present in the household, it would 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. In analysis not presented here, I assess the impact of the number of children on lone motherhood, using the multiple birth IV strategy described in this study. The results were far from achieving significance, suggesting that focusing on households with couples should not bias the results. These results are available upon request.

Table 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	SE	Mean	SE	Mean	SE	Mean	SE
Reading score	537.8	1.297	537.9	1.319	539.2	1.314	539.3	1.315
Attends a private school	0.064	0.011	0.064	0.011	0.063	0.011	0.063	0.011
Attends a private, non-sectarian school	0.014	0.005	0.014	0.005	0.014	0.005	0.014	0.005
Computers per child	0.653	0.007	0.657	0.007	0.563	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	2.575	0.012	2.572	0.011
Multiple birth	0.012	0.001	0.006	0.001	0.007	0.001	0.007	0.001
Child's birth order	1.584	0.009	1.585	0.009	1.689	0.010	1.685	0.010
Child's age (months/12)	15.788	0.003	15.788	0.003	15.787	0.003	15.788	0.003
Child is a female	0.497	0.006	0.496	0.006	0.493	0.006	0.493	0.006
Test language same as mother tongue	0.880	0.006	0.881	0.006	0.880	0.006	0.881	0.006
Child born in Canada	0.910	0.006	0.911	0.005	0.912	0.005	0.912	0.005
Child arrived before age 5	0.025	0.002	0.025	0.002	0.024	0.002	0.024	0.002
Child arrived between ages 5 and 10	0.037	0.003	0.037	0.003	0.037	0.003	0.038	0.003
Child arrived after age 10	0.027	0.003	0.027	0.003	0.026	0.003	0.026	0.003
Mother's age (years in integers)	43.110	0.067	43.117	0.068	42.993	0.071	42.990	0.071
Father's age (years in integers)	45.623	0.073	45.631	0.073	45.481	0.078	45.480	0.079
Mother has less than a high school diploma	0.117	0.004	0.117	0.004	0.106	0.004	0.106	0.004
Mother has a high school diploma	0.392	0.006	0.393	0.006	0.395	0.006	0.395	0.006
Mother has a college certificate	0.302	0.005	0.302	0.005	0.305	0.005	0.305	0.005
Mother has a bachelor's degree	0.144	0.005	0.143	0.005	0.148	0.005	0.148	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	0.030	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	0.149	0.005	0.149	0.005	0.138	0.005	0.139	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	0.303	0.005	0.304	0.005	0.306	0.005	0.306	0.006
Father has a bachelor's degree	0.149	0.005	0.148	0.005	0.154	0.005	0.154	0.005
Father has a professional degree	0.024	0.002	0.025	0.002	0.026	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	0.017	0.002
Newfoundland and Labrador	0.021	0.001	0.021	0.001	0.020	0.001	0.020	0.001
Prince-Edward-Island	0.006	0.000	0.006	0.000	0.006	0.000	0.006	0.000
Nova Scotia	0.034	0.001	0.034	0.001	0.032	0.001	0.032	0.001

Table 1 continued

	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	SE	Mean	SE	Mean	SE	Mean	SE
New Brunswick	0.029	0.001	0.029	0.001	0.029	0.001	0.029	0.001
Quebec	0.227	0.004	0.227	0.004	0.217	0.005	0.217	0.005
Ontario	0.379	0.007	0.380	0.007	0.390	0.008	0.390	0.008
Manitoba	0.037	0.001	0.037	0.001	0.039	0.001	0.039	0.001
Saskatchewan	0.041	0.001	0.041	0.001	0.042	0.002	0.042	0.002
Alberta	0.109	0.003	0.109	0.003	0.109	0.003	0.109	0.003
British Columbia	0.117	0.004	0.116	0.004	0.117	0.004	0.117	0.004
N	18,756		18,450		15,471		15,429	

Source: Youth in transition survey, cohort A

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 42 and virtually no change in the sample statistics.

In the final sample, a total of 119 youth have 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, 2010), it is still greater than the 25 available to Rosenzweig and Wolpin (1980), who looked at fertility and schooling among Indian households.

3 Descriptive results

The means of the outcome variables by the number of children in the family are shown in Table 2. There is little to no relationship between the reading score and the number of 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. In contrast, private, non-sectarian school attendance rates fall as families become larger. Family size and the number of computers per child are also negatively related.[11] Finally, the proportion of parents saving for postsecondary education (PSE) falls substantially as fertility rises.

[11] One could argue that there are economies of scale associated with computers since children may share the same computer by negotiating computer time. However, families with two children share 1.316 computers, while families with six children share 1.418 computers. Given these numbers, it is difficult to imagine that children in the larger families have the same access to a computer as children in smaller families.

Table 2 Means of outcome variables by the number of children in the family

	Number of children				
	2	3	4	5	6
Standardized reading score	0.002	−0.003	0.015	−0.060	0.005
Attends a private school	0.064	0.064	0.062	0.066	0.045
Attends a private, non-sectarian school	0.015	0.013	0.010	0.005	0.000
Computers per child	0.658	0.470	0.362	0.279	0.236
Parents have saved money for PSE	0.639	0.607	0.509	0.401	0.282
N	8,801	4,824	1,378	290	136

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

Source: Youth in transition survey, cohort A

Table 3 Wald estimates

	Mean		Wald	SE
	Multiple birth = 0	Multiple birth = 1		
Standardized reading score	−0.002	0.283	0.235	0.116
Attends a private school	0.064	0.013	−0.042*	0.011
Attends a private, non-sectarian school	0.014	0.000	−0.011*	0.004
Computers per child	0.565	0.393	−0.142*	0.031
Parents have saved money for PSE	0.611	0.504	−0.088	0.056
Average number of children	2.564	3.776		
N	15,310	119		

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 *Source*: Youth in transition survey, cohort A

The evidence presented in Table 2 is very preliminary since the number of children is largely a choice given the widespread availability of contraceptives. In Table 3, I show the Wald estimates. 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 (albeit not statistically significant), but a 4.2 (1.1) 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 8.8 percentage point decline in the probability of having parents who saved money for the child's postsecondary studies.

An even more convincing analysis should account for differences in other covariates. First, multiple births may not be fully exogenous, as they have been associated with fertility drugs in recent years. Even though all youth in the sample were born in 1984 (well before the widespread use of fertility drugs), it is possible that some multiple births result from the drugs. Second, sampling variability in small samples may generate differences in socioeconomic characteristics between youth with and without a multiple birth in the family. In Table 4, I show the means and standard errors of the relevant covariates by multiple birth status.

In general, the differences in means 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 can not 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 1 year younger on average, while fathers are about 2 years younger. Again, this is related to the definition of a multiple birth, which implies that youth with a multiple birth in the family can not be last born children. Moreover, all youth in the sample were born in 1984. Most of the remaining covariates are similar in mean values, with some exceptions. Given these non-negligible differences, 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.

4 Econometric results

In this section, I use ordinary least squares (OLS) and instrumental variable (two-stage least squares) regressions to estimate the relationship between child input and output variables and the number of children and other covariates described earlier in Table 1. The coefficients on the fertility variable appear below in Table 5.

The OLS results suggest that one additional child is associated with higher reading scores (significant at 1%), but is negatively associated with the number of computers per child and 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.

The first-stage IV regression results (not shown) suggest that a multiple birth is associated with 1.3 additional children, which is significant at 1%.[12] The F-statistic (i.e. the square of the t-statistic on the multiple birth coefficient) is 175.033, which is well above the thresholds for strong IVs established by Stock and Yogo (2005). I show the second stage results of the IV regressions in Table 5. The results suggest that one additional child is associated with an improvement in the reading test score equivalent to 15% of a standard deviation, although the coefficient is not quite statistically significant. The key point is that the coefficient is not negative. In contrast, fertility is negatively associated with parental investments in child quality. Specifically, the additional child reduces the probability of the youth attending a private (private, non-sectarian) school by 4 (0.9) percentage points, which is significant at 1% (5%). The number of computers per child declines by 14.1

[12] As noted in Rosenzweig and Wolpin (1980), twins are more likely in later births, which may explain why this coefficient is larger than 1. Restricting the analysis to families with more than one birth reduces this correlation between twinning and family size to some extent. Low sample sizes prevented any further selection on number of births.

Table 4 Means of explanatory variables by presence of a multiple birth in the family

	Multiple birth = 0	Multiple birth = 1	Δ	SE
Child's birth order	1.687	1.359	−0.329***	0.070
Child's age (months/12)	15.788	15.785	−0.003	0.033
Child is a female	0.493	0.506	0.013	0.069
Test language same as mother tongue	0.880	0.930	0.049*	0.029
Child born in Canada	0.912	0.969	0.057**	0.022
Child arrived before age 5	0.024	0.012	−0.012	0.012
Child arrived between ages 5 and 10	0.038	0.020	−0.018	0.018
Child arrived after age 10	0.026	0.000	−0.026**	0.012
Mother's age (years in integers)	42.998	41.835	−1.164***	0.370
Father's age (years in integers)	45.494	43.454	−2.040***	0.600
Mother has less than a high school diploma	0.106	0.141	0.036	0.052
Mother has a high school diploma	0.396	0.367	−0.029	0.061
Mother has a college certificate	0.305	0.304	−0.002	0.056
Mother has a bachelor's degree	0.148	0.118	−0.030	0.042
Mother has a professional degree	0.011	0.038	0.027	0.038
Mother has a master's degree	0.030	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	0.139	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	0.306	0.321	0.015	0.056
Father has a bachelor's degree	0.155	0.070	−0.084**	0.040
Father has a professional degree	0.025	0.119	0.094**	0.046
Father has a master's degree	0.048	0.072	0.024	0.034
Father has an earned doctorate	0.017	0.009	−0.008	0.009
Newfoundland and Labrador	0.020	0.019	0.000	0.009
Prince-Edward-Island	0.006	0.008	0.002	0.003
Nova Scotia	0.032	0.053	0.021	0.017
New Brunswick	0.029	0.012	−0.016***	0.006
Quebec	0.217	0.199	−0.018	0.048
Ontario	0.391	0.338	−0.053	0.081
Manitoba	0.039	0.032	−0.007	0.012
Saskatchewan	0.042	0.043	0.002	0.013
Alberta	0.109	0.130	0.022	0.042
British Columbia	0.117	0.164	0.047	0.038
N	15,310	119		

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 5 OLS and IV regressions of child quality measures on the number of children and other controls

	OLS		IV	
	b	SE	*b*	SE
Standardized reading score	0.076***	0.014	0.149	0.092
Attends a private school	0.007*	0.004	−0.040***	0.013
Attends a private, non-sectarian school	−0.002	0.001	−0.009**	0.005
Computers per child	−0.147***	0.005	−0.141***	0.028
Parents have saved money for PSE	−0.048***	0.008	−0.110**	0.049

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

Source: Youth in transition survey, cohort A

percentage points (significant at 1%). So too does the probability that the parents save money for the youth's postsecondary education (a decline of 11 percentage points, which is significant at 5%).

5 Attempting to reconcile the findings

What factors may explain why family size is negatively associated with investments in 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), who 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 student performance. Computer use in the home may even be less beneficial if children use them to play video games.[13] With regards to parental savings for the child's postsecondary schooling, I am not aware of any studies devoted to credibly estimating its relationship with test scores.

[13] It may be argued that computers are more likely to improve mathematics ability. If so, then an increase in family size (leading to a reduction in the number of computers per child) would be more likely to lower mathematics scores. However, the findings were similar when I replaced the reading score with the mathematics scores. The same was true when I used the science score. Both sets of results are available upon request.

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.[14]

A second possibility is that there may be economies of scale in rearing children and/or in selecting effective sibling interactions in larger families. In terms of rearing children, siblings in larger families may be more likely to 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. With regards to sibling interactions, the likelihood of finding a sibling who may be beneficial to interact with might be greater in a larger family. 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 2 years in age. The impact of fertility on the standardized reading scores falls to 0.025, which is not statistically significant. In the main IV results (Table 5), the coefficient was 0.149. Thus, part (but not all) of the reason why academic performance does not decline with fertility (despite falling parental investments in children) may be due to economies of scale.

A third possibility is that, following the birth of a child, parents (especially the mother) reduce their paid labour supply in favour of unpaid work.[15] The resulting increased maternal contact with the child may foster child quality. In the literature, the findings range from a positive association between maternal contact and child development (e.g. Bernal 2008; Bernal and Keane 2010; Waldfogel 2006) to no association (e.g. Baker and Milligan 2008; Ermisch and Francesconi 2005).

[14] Saving for the child's education may have an impact on educational attainment even if it has no impact on reading scores. To test this, I ran IV regressions on educational attainment indicators (attended postsecondary and attended university by age 19). No significant relationship was found (results available upon request).

[15] To date, only Frenette (forthcoming) examines fertility and parental time allocation between work and home using quasi-causal methods (albeit on a more general sample of parents). The study uses Canadian census data for 2006, which contains detailed information on hours spent doing paid work, unpaid housework, and unpaid childcare. Using two IVs—the same multiple birth variable used here and the sex composition of the first two children (see Angrist and Evans, 1998)—the study finds that mothers respond to additional children by reducing their hours of paid work and increasing their hours of unpaid childcare and housework. The size effect is substantial: one additional child is associated with 3.4–6.5 additional hours per week of unpaid childcare (significant at 1%). Although fathers do not reduce their paid labour supply in response to additional children, they do perform between 1.4 and 3 additional hours per week of unpaid childcare (significant at 1%). Combined, the mother and the father spend between 4.8 and 9.5 additional hours per week on childcare. Note that the sex composition IV is not used in the current study since it may play a direct role in child development (see Black et al. 2005).

6 Conclusion

The longstanding trend of declining fertility rates among industrialized countries has fuelled government initiatives aimed at raising family size through financial incentives. Although studies have shown that fertility is indeed amenable to policy intervention, it is less clear how children are affected by being raised in larger families.

Becker's Quantity–Quality model suggests a trade-off between family size and parental investments per child. Only one previous study has investigated this relationship empirically and finds evidence to support the theory by focusing on one particular form of parental investment – private school enrolment (Cáceras-Delpiano 2006). The current study extends this work by examining a broader range of parental investments (overall and non-sectarian private school enrolment, the number of computers in the home per child, and saving for the child's education). The evidence suggests a strong negative relationship between fertility and each measure.

The study also explored a 'puzzle' in the literature. Specifically, fertility has been found to reduce parental investments in children, but the balance of the evidence points to no link between fertility and child outputs. The current study adds to this literature by demonstrating no association between fertility and academic test scores. In terms of attempting to reconcile this puzzle, several explanations were offered. First, parental investments in child quality are not necessarily associated with improved child quality. In fact, the best empirical literature (based on credible identification strategies) has not reached a consensus on this issue when looking at cognitive ability (the measure used here). Second, there may be economies of scale associated with rearing more children and/or in selecting effective sibling interactions. Empirical investigation suggests that these factors contribute towards reconciling the findings, but not entirely so. The third possible explanation was raised by (Cáceras-Delpiano 2006), who suggested that larger families may increase maternal contact with the child. However, this argument critically rests on the availability of the mother in the home. Cáceras-Delpiano (2006) only had data on paid labour supply. Recent work suggests that mothers (and fathers!) spend more time in unpaid childcare when the family grows. However, the literature offers mixed evidence on the role of parental childcare in determining cognitive ability (ranging from no effect to a positive effect).

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