Reconsidering the Use of Nonlinearities in Intergenerational Earnings Mobility as a Test for Credit Constraints

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ABSTRACT

Intergenerational earnings regression among Canadian men is nonlinear; middle-earning families experience slower regression. This pattern appears to confirm economic models of educational choice with credit constraints. This paper reexamines the economic model and finds no connection between credit markets and earnings regression nonlinearities. In particular, credit constraints need not produce concavity and concavity does not imply credit market failure. Despite the invalidity of the test, data availability will likely lead to continued research along this path. The paper proposes an amended test using quantile regressions. Applied to Canadian data, the simple liquidity constraint conclusion is rejected.

I. Introduction

The model of Becker and Tomes (1979, 1986) represents the seminal explanation of the intergenerational transmission of financial status using the calculus of rational choice. In distinguishing this model from previous mechanistic efforts, Becker (1989) emphasizes the effects of credit market imperfections on earnings and consumption regressions and government investments in human capital. Given the recent creation of intergenerational earnings data sources, empirical efforts have

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focused on the model's implications for earnings regression. Assuming that parents with low earnings are most likely to lack access to credit markets, Becker and Tomes suggest that earnings of children in these families will be limited. As a result, earnings mobility will be slower among low-earning families. (In the remainder of this paper, I will call this the Becker-Tomes conjecture.)

Contrary to the conjecture, many studies find a convex relationship between father's and son's log earnings (see Behrman and Taubman 1990; Solon 1992; Mulligan 1997, 1999; Grawe 2001b; and Mazumder 2001). However, relatively small samples in these studies diminish the ability to accurately identify nonlinearities. With nearly 400,000 families, the Canadian Intergenerational Income Data (IID) addresses this limitation. Using this data source, Corak and Heisz (1999) report S-shaped earnings regression; regression is strongest among families with medium-earning parents. Corak and Heisz attempt to reconcile their findings with the model, tentatively suggesting that middle-income families may be most susceptible to constraints. If low-earning parents have children of lower ability, they may not require much education. Thus, access to credit would not be an issue.

This paper reexamines the Canadian data, questioning whether earnings regressions can reveal intergenerational credit constraints. In the following section, the pattern of earnings regression in Canada is presented in a bit more detail. Then I briefly outline Becker and Tomes' model, demonstrating the basis for the Becker-Tomes conjecture. Ultimately, however, the paper shows that nonlinearities in earnings regressions cannot be used either as evidence of binding credit constraints or to test the validity of the Becker-Tomes model; concave earnings regression need not follow from credit constraints nor is market failure implied by concave earnings regression. While the cessation of such "tests" is appropriate, data availability and the intuitive appeal of the Becker-Tomes conjecture may lead some researchers to continue along this path. If researchers choose to do so, the paper concludes by showing how quantile regression can supplement mean regression approaches.

II. The Intergenerational Distribution of Earnings among Canadian Men

The IID data used to estimate Canadian earnings persistence are derived from tax files. Boys aged 16–19 in 1982 are matched with the oldest male adult in the same household (not necessarily their biological fathers). I created a one-in-ten sample and then, from this sample, the oldest available son for each family was selected. (Note, the oldest available son may or may not be the oldest son in the family). This resulted in 56,141 father-son pairs. Removing those pairs with "fathers" born before 1908 or after 1952 resulted in a sample of 53,390 observations.[1]

For each father and son in the data set, the earnings report on T1 tax forms was collected from 1978 to 1998 and converted into 1992 dollars.[2] To mitigate measurement

1. A report of an exceptionally old or exceptionally young father may be the result of measurement error in year of birth or the adult male figure may be an older sibling or grandfather.

2. Through an examination of the mean and variance of reported incomes, several coding irregularities were found. It appears that a significant number of observations in 1978–82 were assigned a value of one dollar

Table 1
Summary Statistics for Age and Earnings of IID Men

Variable	Mean	Standard Deviation	Minimum	Maximum
Father's Age, 1982	47.75	6.23	30.00	74.00
Son's Age, 1998	33.59	1.10	32.00	34.00
Father's log-average earnings	10.57	0.52	3.96	14.67
Son's log-average earnings	10.37	0.57	3.64	14.75

Note: Fathers' real earnings (1992 dollars) are averaged over 1978–82. Sons' real earnings are averaged (1992 dollars) over 1994–98.

error, I define log earnings as the log of the average real wage and salary income in a five-year span conditional on reporting positive income in each of five years. (Fathers and sons are observed in 1978–82 and 1994–98 respectively.) Because the theory of the next section concerns permanent income, earnings are adjusted for fathers' and sons' age and age squared. Table 1 provides summary statistics for sons and fathers with earnings that meet the sample selection criteria.

Because the next section demonstrates that observations away from the conditional mean are critical to the issue of credit market failure and earnings regression, I use quantile regression. Quantile regression is analogous to mean regression. For instance, where mean regression studies the dependence of the *mean* value of y conditional on x, median regression studies the dependence of the *median* value of y conditional on x. Koenker and Basset (1978) present the quantile regression estimator that estimates the relationship between x and *any* conditional centile of y, the median being a special case. Taken together, quantile regressions map out the shape of the entire joint distribution of x and y.

Corak and Heisz (1999) use a nonparametric method to estimate the degree of mean earnings persistence. Unfortunately, I know of no analogous method for quantile regression. Instead, I use a simpler, nonlinear estimation method—spline functions. The appendix shows how dummy variables were manipulated to estimate eight continuous segments. This study focuses on the four middle spline segments containing roughly 98 percent of observations.[3]

Figure 1 plots the ninety-fifth, ninetieth, fiftieth, twenty-fifth, tenth, and fifth quantile regression splines; Table 2 records coefficient estimates.[4] Looking at the figure, the S-shaped pattern found by Corak and Heisz appears at the median. (With more

when, in other years, they would have been reported as zero dollars. Similarly, in 1996, a significant number of observations were assigned an income of two dollars. It was not possible to determine why the data included these anomalies. "Positive earnings reports" means earnings greater than one dollar in 1978–82 and greater than two dollars in 1996.

3. It is nevertheless important to include splines outside this region since the splines are connected.

4. Qualitatively, the results are unaltered when log earnings are defined as the average of the five log-income observations, or total market income is used in place of wage and salary income, or when years with no reported income are included for those with at least one year of positive income, or when zero income is coded as one dollar.

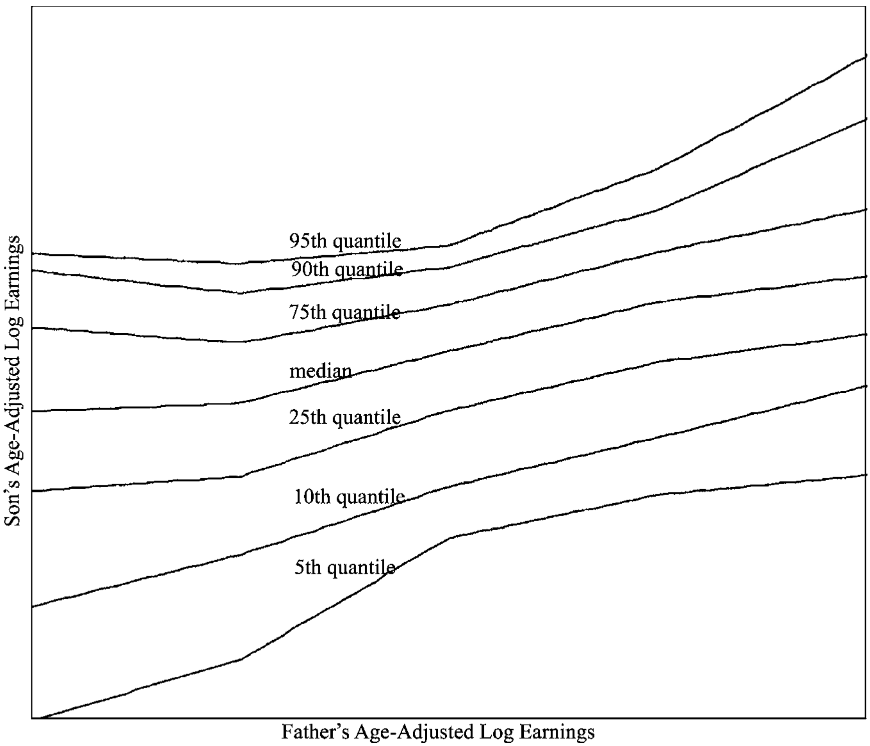

Figure 1
Relationship between Canadian Father's and Son's Age-Adjusted Log Earnings at 5th, 10th, 25th, 50th, 75th, 90th, and 95th Quantiles

than 53,000 observations, the hypothesis that all slopes are equal is easily rejected at all reasonable levels of significance.) However, this pattern is not found throughout the joint distribution; convexity at the top of the joint distribution contrasts with a strong S-shape at the bottom.

Given that the data are taken from tax filings, selection in the data is a concern. Because elements of the Canadian welfare system are administered through tax filings, however, many untaxed citizens are captured in the sample. Corak and Heisz examine this issue and conclude that the IID is largely representative. However, one can address selectivity among the sons directly. It is reasonable to assume that sons who do not file taxes are predominantly low-earning and more likely to be found in families with low-earning fathers. Since quantile regression is an order statistic, including nonfiling sons in the analysis with earned income of one dollar will not bias the upper quantile regressions.[5] Grawe (2001a) shows that this correction only strengthens the qualitative

5. The reasons a son may not file include (1) income is so low that taxes are not due (but yet the individual did not claim welfare benefits on the T1 form), (2) the son is dead, (3) the son works in the underground economy, or (4) the son has left the country. I assume that few of the sons left the country.

Table 2
Quantile Regression Estimates of the Elasticity of Son Log Earnings with Respect to Father Log Earnings

Range of Father's Age-Adjusted Log Earnings	Estimated Elasticity at Son Centile						
	95th	90th	75th	50th	25th	10th	5th
[–2, –1]	–0.059	–0.129	–0.093	0.045	0.080	0.291	0.344
	(0.85)	(5.85)	(2.27)	(0.92)	(1.13)	(2.34)	(2.27)
[–1,0]	0.098	0.143	0.211	0.290	0.368	0.383	0.379
	(3.61)	(7.48)	(14.32)	(17.05)	(15.18)	(8.82)	(6.95)
[0,1]	0.423	0.313	0.294	0.269	0.269	0.270	0.240
	(14.90)	(16.15)	(20.26)	(15.70)	(10.91)	(6.14)	(4.31)
[1,2]	0.625	0.505	0.232	0.142	0.149	0.288	0.103
	(6.06)	(5.85)	(3.43)	(1.86)	(1.40)	(1.60)	(0.47)

Note: The reported coefficients show the estimated percent change in son's earnings due to a one percent change in father's earnings at a given centile. These quantile regression coefficients are estimated following the method of Koenker and Basset (1978) using connected splines described in Appendix 1. Both father's and son's log earnings are corrected for the age of the father and the son prior to the quantile regression. Absolute t-statistics in parentheses.

finding that lower quantile regressions are steeper than upper quantile regressions and does nothing to alter the shapes of the quantile regressions.

III. Theoretical Interpretations of Intergenerational Earnings Regression

A. An Economic Interpretation of Mean Regression

It is easy to see how the nonlinear regression at the mean could lead researchers to suspect credit market failure. Consider the two-generation version of the Becker-Tomes model. Each family is composed of one father and one son.[6] The father is endowed with ability a_f and schooling level h_f.[7] These inputs produce wage income $w(a_f,h_f)$. In addition, the father may have access to financial assets x_f. The father max-

6. While the model's predictions concerning consumption mobility are sensitive to the number of children in the family, earnings mobility is not qualitatively affected. In the absence of credit constraints, each child receives the (privately) efficient level of education; parents use sometimes-negative bequests to shift consumption among children. When credit constraints are imposed on a multi-child family, the educational investment must serve two goals: efficiency in producing income and equality in child consumption. As a result, high-ability children receive less education while low-ability children receive more; total education expenditure is lower. See Becker and Tomes (1986) for a fuller discussion.
7. By "ability" I have in mind all skills that are passed from parent to child *without regard for prices or incentives*. Clearly genetic characteristics fit this definition, but so might some environmental factors chosen by parents.

imizes utility U, a function of father's and son's consumption, by investing in the child's education h_s and/or physical assets x_s which earn interest at rate r.

$$(1)\quad \max_{cf,\, cs,\, hs,\, xs} U(c_f, c_s)$$
$$s.t.\, c_f + h_s + x_s \leq w(a_f, h_f) + x_f$$
$$c_s \leq w(a_s, h_s) + (1 + r)x_s.$$

Assuming diminishing returns to educational investment, the allocation of asset bequests and educational investment satisfies $w_h(a_s,h_s) = 1 + r$. If ability complements education and parents have equal access to credit, education increases with ability.[8] Note that equally able children receive the same education and earn the same wage *regardless of the parent's ability or income*. Regression toward the mean in observable physical characteristics suggests regression in unobservables like ability as well; earnings regression follows from ability regression.

1. *The Becker-Tomes Conjecture*

Credit constraints raise the opportunity cost of education investments; parents who face the constraint must reduce their own consumption to pay for the child's education. Human capital investment falls and the earned income of constrained children will be lower than that of unconstrained children of like ability. And, because finances have a direct role in determining child education in constrained households, constraints increase intergenerational earnings persistence. Suspecting that low-earnings parents are most susceptible to such constraints, Becker and Tomes predict credit market failure produces concave earnings regression (1986 p. S14). As noted in the previous sections, empirical analyses have not produced the hypothesized pattern.

2. *Questioning the Conjecture*

The Becker-Tomes conjecture depends on two critical assumptions. Clearly, low parental earnings must be a good proxy for credit constraint susceptibility. Perhaps less obviously, the relationship between parent and child log earnings must be linear in the absence of credit constraints. After all, if regression is nonlinear in the absence of constraints, then how could we know whether an observed nonlinearity reflected complete or incomplete markets? As it turns out, neither of these assumptions need be true; ultimately, the model does not support the interpretation of nonlinear earnings regression as proof of credit constraints.

Of course, assumptions often pave the way for progress in economic understanding. Nevertheless, these two assumptions are peculiarly strong. The remainder of this section shows that (a) the model itself contradicts the first assumption, and (b) the second assumption has no basis whatsoever. Moreover, the assumption of linear intergenerational earnings regression (in the absence of constraints) is exceptional in this context since this literature is all about *testing* for nonlinearities in regression. While social scientists' work often rests on assumptions, we rarely make important assumptions

8. Very little can be observed concerning how ability enters the wage function since ability is very difficult to measure. However, the positive relationship between parent wages and child education found among very high-income (unconstrained) families suggests $w_a > 0$ and $w_{ha} > 0$.

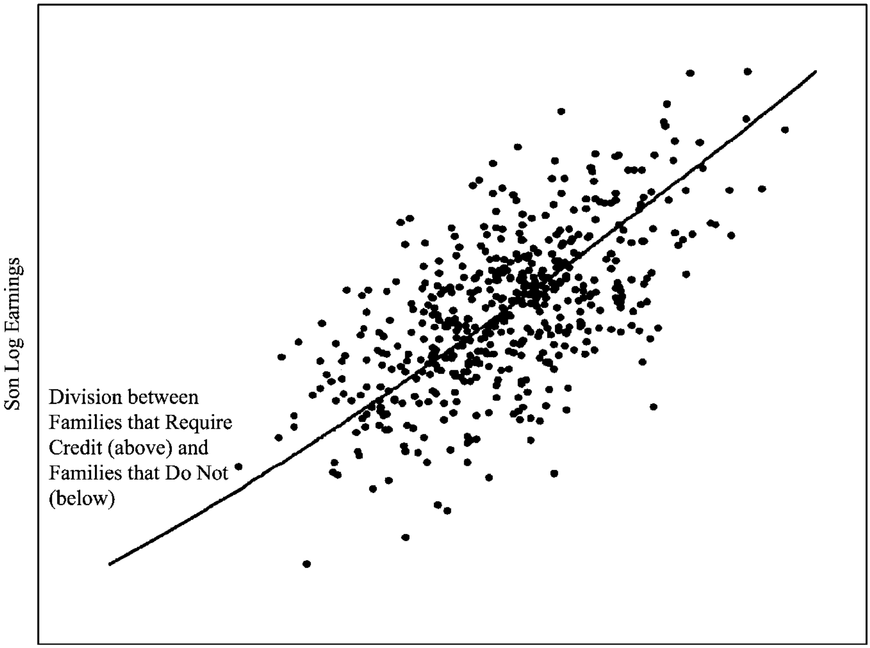

Figure 2
Identifying Families by their Use of Credit Markets in Financing Children's Educations Using Simulated Data

about the very phenomenon we are examining. If nonlinear earnings regression were the only hypothesis generated by the model that could reveal credit constraints, we might nevertheless be compelled to pursue this approach. But the model implies strong relationships between credit constraints and both consumption regression and crowding out of government investments without the imposition of these two assumptions (see Becker 1989).

Let us examine the assumptions in turn. In suggesting that middle-earning families may be most susceptible to constraints, Corak and Heisz (1999) implicitly point out that parental earnings are not a good proxy for credit access. (Han and Mulligan 2001 also make this point.) The simulated data in Figure 2 clarify the issue.[9] The points in

9. The data are simulated according to the calibration of case three in Han and Mulligan (2001) except that I have eliminated market luck. This change is made so that the graph is more easily understood. The same qualitative results are obtainable including market luck. For the purposes of this paper, the most important assumption of Han and Mulligan is that all parents have equal financial assets. Han and Mulligan report that relaxing this assumption does little to alter the simulations. In the model of Han and Mulligan (2001) the constrained families are those which satisfy

$$\ln(x_f + w_f) - constant\ 1 * \ln(a_s) < constant\ 2.$$

(See Equation 9 in Han and Mulligan.)

the figure simulate the earnings that would result if credit markets were perfect and parents solve Problem 1, above. The solid line divides observations based on the asset bequest chosen by each parent. For a given level of parent earnings, more able children are given more education and smaller bequests. The families found above the curve are those in which parents would like to give a negative bequest; that is, the parents would like to leave debt to their children (x_s<0 in Problem 1, above). The imposition of credit constraints would affect only these families. Contrary to the first assumption, low-earning families are not especially likely to be constrained; middle-earning parents may be constrained with higher probability.

Becker and Tomes (1986) and Corak and Heisz (1999) cite two distinct regression shapes—strictly concave and S-shaped—as suggestive evidence of credit constraints. In fact, since the child's ability is correlated with the parent's earnings, *absolutely any* nonlinear intergenerational earnings regression shape can be justified by a properly crafted credit constraint story. As a result, nonlinearities cannot form the basis of a rejectable test for credit market imperfections without prescribing which families are presumed to be constrained.

If this were the only concern, the conjecture might only require slight amendment: regression will be nonlinear with steeper slopes found among constrained families. Unfortunately, a far more serious problem exists. It is clear from the model that credit constraints will slow the rate of regression. But if the relationship between log earnings of father and son were not linear in the *absence* of credit constraints, then credit constraints might only make the pattern less convex rather than concave. Whether regression is linear in the absence of credit constraints depends, of course, on the functional form of the wage function that transforms abilities into earnings. In what follows, simulations demonstrate that, absent strong assumptions about how unobservable ability enters the wage function, nonlinear earnings regression does not necessarily imply credit market imperfection.

To stack the deck against nonlinearities, let's make several simplifying assumptions that favor linearity. First, credit markets are perfect. Second, the intergenerational distribution of ability is joint normal with identical marginal distributions. Third, the wage function is the same in both generations. Presumably, relaxing any of these restrictive assumptions would make it even easier to create nonlinearities. Finally, we must make a minimal set of assumptions concerning the wage function. For simplicity, eliminate market luck. And following almost all existing literature, assume $w_h > 0$, $w_a > 0$, $w_{hh} < 0$, and $w_{ah} > 0$. Note how little is assumed about ability's role in the wage function: wages increase in ability and ability is a complement of education. Additional assumptions cannot be justified with empirical evidence.[10]

Table 3 and Figure 3 present three simulations demonstrating that nonlinear regression is consistent with perfect credit markets. In each example, I simulate a population with 25,000 father-son pairs. Given ability of father, ability of son is randomly generated according to $a_s = 0.5^{*}\text{mean}(a_f) + 0.5^{*}a_f + \varepsilon_a$. Given ability, an individual's

10. One might attempt to estimate ability's role in the wage function by regressing wages on human capital and IQ measures. Unfortunately, we know that IQ is influenced by education investments so it does not represent ability alone. In addition, recall that "ability" is defined as attributes that do not respond to incentives. And so it is likely that portions of human capital actually belong in "ability." The lack of clear distinctions between ability and human capital undermines the fruitfulness of this effort.

Table 3
Wage Functions that Produce Nonlinear Intergenerational Log Earnings Regression without Credit Constraints (as shown in Figure 3)

General shape	Wage Function
	$w(a,h) = constant*f(a)*ln(h)$
	$h^* = constant*f(a)/(1 + r)$
	$a_s = 0.5*mean(a_f) + 0.5*a_f + \varepsilon_a$
	$a_f \sim N(3.5,0.25)$, $\varepsilon_a \sim N(0,0.75*\sigma_{af})$
	$r = 2.5$
Convex	$f(a) = a^{0.02}$
Concave	$f(a) = exp(exp(a - 2))$
S-shaped	$f(a) = a^2$ *For* $a \leq 2$
	$f(a) = f(2) + ln(a - 1)$ *For* $2 < a \leq 3$
	$f(a) = f(3) + (a - 3)^2$ *For* $a > 3$

Note: These three simulations show that it is easy to produce nonlinear intergenerational log earnings regression even with perfect credit markets. All three simulations are the same except for the way that unobservable ability enters the wage function.

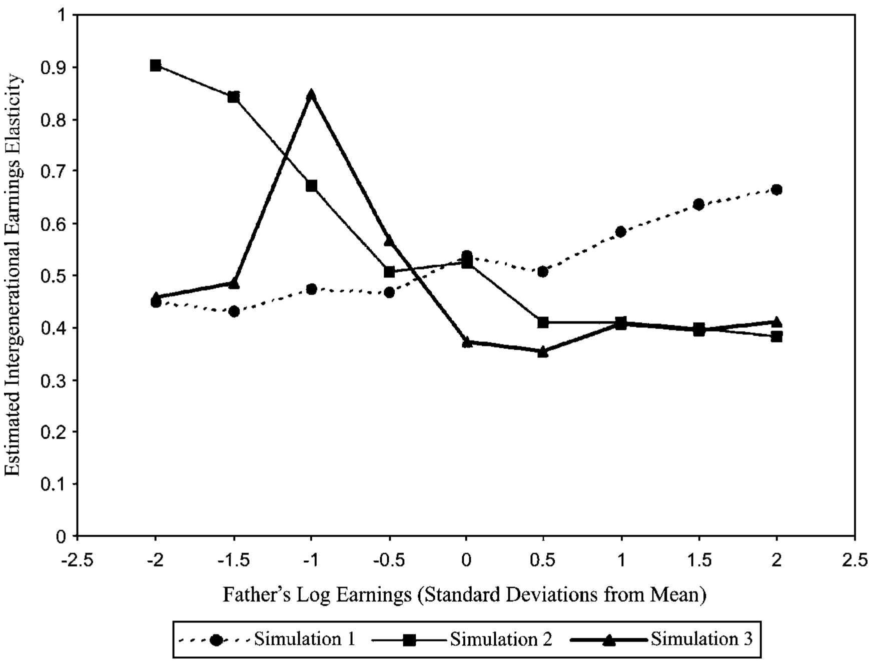

Figure 3
Different Possible Patterns of Elasticity of Intergenerational Earnings Elasticity vs. Father's Earnings–Three Simulations with Perfect Credit Markets

wages are calculated according to the posited wage function in Table 3. Then sons' log earnings are regressed on fathers' log earnings using locally weighted scatterplot smoothing with bandwidth 0.25.[11] Since this exercise is meant only to demonstrate that one can create nonlinearities in the absence of credit constraints, model calibration is set aside. The first simulation creates a convex regression; the intergenerational earnings elasticity increases more than 40 percent across the father-earnings distribution. In the second simulation, the elasticity decreases by an even larger magnitude. Finally, the third simulation produces S-shaped regression like that found in Canada.[12]

In total, we must conclude that credit constraints do not lead to predictable nonlinearities (since child ability correlates with parent earnings) and nonlinearities do not imply credit market failure (as the simulations demonstrate). And so it would be best to cease "tests" for credit constraints based on nonlinear intergenerational earnings regressions. Yet, the intuitive appeal of the Becker-Tomes conjecture and available earnings data will no doubt perpetuate efforts to interpret earnings regression in light of credit markets. The identification of constrained families shown in Figure 2 suggests an improved test developed in the next section. The improved "test" retains the fundamental flaws identified in this section: the researcher still must implicitly assume linear regression in the absence of credit constraints and must specify which group of families is assumed to face the constraint. However, the proposed method is a significant improvement, allowing the researcher to examine whether the observed nonlinearity is even consistent with a simple credit market story.

B. An Economic Interpretation of Quantile Regression

With Figure 2 in mind, consider two families, each with parental earnings equal to $20,000. Each family has one child. In the first family the child is very adept; the return to education is high enough to justify study at an elite college or university. In the second family, the child is less adept; beyond a high school education, the cost of education exceeds the return. If one of these families is constrained, it is obviously going to be the first. If constrained, this child's earnings will be reduced somewhat—though, not so much that his earnings fall below those of the low-ability child.

And so, if we are looking for sons whose earnings are distorted by credit market imperfections, we look at sons whose earnings are high conditional on their father-earnings. If a simple credit markets story explains nonlinearities in mean regression, we should see this evidenced by nonlinearities in upper quantile regressions that capture the outcomes of conditionally high-earning children. Similarly, on average, upper quantiles should be steeper than lower quantiles. Table 4 reports quantile and mean regression slopes from the simulation of Figure 2. The first column records the results when the credit constraint does not bind. Notice that in the Han and Mulligan model all of the quantiles roughly share a common slope in the absence of credit constraints.

11. See Cleveland (1993) for a detailed discussion of lowess estimation.

12. With 25,000 observations, the hypothesis that the slope is constant across father earnings is easily rejected at all reasonable levels of significance.

Table 4

Quantile Regression Estimates of the Elasticity of Son Log Earnings with Respect to Father Log Earnings using Simulated Data with and without Credit Constraints

	Estimated Elasticity	
Regression Type	Without Credit Constraint	With Credit Constraint
Mean	0.615 (0.008)	0.661 (0.006)
90th quantile	0.615 (0.014)	0.718 (0.008)
75th quantile	0.610 (0.011)	0.712 (0.006)
950th quantile	0.604 (0.010)	0.648 (0.009)
25th quantile	0.615 (0.010)	0.615 (0.010)
10th quantile	0.626 (0.014)	0.626 (0.014)
	n = 10,000	n = 10,000

Note: Standard errors in parentheses.

When the constraints are applied (Column 2), mean regression is slower. But the effect is not found equally at all quantiles. The top of the joint distribution is affected as upper quantiles exhibit slower regression; lower quantile regressions remain unchanged.

This reasoning suggests an amended method of "testing" for credit constraints using nonlinearities in mean regression. If a researcher considers citing nonlinear mean earnings regression as evidence of credit constraints, then the researcher implicitly must be assuming linearity would prevail in the absence of credit market imperfections. And a finding of nonlinear earnings regression is only consistent with the simple market failure explanation if the nonlinearity is also found in the upper quantile regressions and *not* in the lower quantile regressions. Alternatively, if a slower rate of mean regression is attributed to credit market failure, the slower rate should only be observed in upper quantile regression lines. If the researcher finds that the observed pattern at the mean is driven from observations at lower quantiles, the simple credit constraints story is inadequate.

While this proposed amendment is a significant improvement over a nonlinear mean regression approach, the validity of the method hinges on assumptions about heteroskedasticity. If the data are characterized by homoskedasticity the proposed test is entirely valid. (This additional assumption seems relatively small by comparison for a researcher willing to adopt the heroic assumption of linearity in the absence of credit constraints.) In general, however, homoskedasticity may not hold. Two cases are relevant. First, suppose the standard error of the error term varies linearly with fathers' log earnings. In this case the quantile regressions are linear with unequal slopes. While a simple comparison of the average rate of regression in upper and lower quantile regressions tells us nothing of credit constraints, a researcher might still examine whether nonlinearities are present in the quantile regressions that are consistent with credit constraints.

Second, suppose the pattern of heteroskedasticity is "irregular" in the sense that it produces nonlinear quantile regressions. In this case, quantile regressions tell us as little about credit constraints as mean regressions do.[13] Since all of this pertains to the error variance in the potentially counterfactual prefect-credit-markets world, it is impossible to test any of the assumptions concerning patterns of heteroskedasticity. Therefore, this section must end with the warning that introduced it: It would be best to cease "tests" for credit constraints based on intergenerational earnings regressions.

C. Application: Intergenerational Earnings Mobility among Canadian Men

To see how we can apply this proposed amendment, consider again the observed intergenerational earnings regression patterns found in Canada (see Figure 4). The results contradict the simple credit constraint hypothesis. Among low-earning fathers, the strongest earnings persistence is found among families with low-earning sons. The steeper mean regression in the middle of the fathers' earnings distribution is driven by the slope of *lower* quantiles. Credit constraints would be consistent with the fact that upper quantiles are steeper than lower quantiles for high-earning fathers. Yet this interpretation requires us to believe that wealthy parents have such able children that their exceptional wealth is unable to provide schooling at the efficient level.

The test proposed in this section is admittedly weak. It is clearly possible for nonlinearities that would have existed in the absence of credit constraints to dominate those caused by the market imperfections. Thus, it is impossible either to reject conclusively or to confirm the hypothesis that liquidity constraints are present in Canada. However, it is clear from the use of quantile regressions that the *simple* credit constraint explanation for the S-shaped earnings regression pattern is insufficient.

Despite the qualifications placed on the conclusions, the fact that earnings of high-ability sons in low-earning families (those most likely to be constrained) regress so quickly suggests that financial constraints are not present. Perhaps after some reflection on the Canadian education system this is not surprising. The public sector finances most of the college and university system. Statistics Canada reports that in 1996–97 post-secondary education expenditures totaled $C15.6 billion, almost three-fourths of which was paid for by the government. With nearly one million full-time and 500,000 part-time students enrolled in Canadian universities and community colleges, this implies that the average annual responsibility of a full-time university student falls short of $C4,000.[14] In addition, $C4,000 to $C6,000 must be paid for room and board expenses. Individuals whose families are unable to pay these costs can

13. The possible presence of heteroskedasticity in the absence of credit constraints also undermines a second set of "tests" for credit constraints. Credit-constrained parents with any degree of preference for equality of consumption among their children will shift some human capital investments from high-ability children to low-ability children because constrained parents can only alter the consumption of children through human capital investments. As a result, credit constraints reduce earnings variance. Becker (1993, p. 190) concludes "the inequality in earnings among siblings would tend to be smaller" in credit constrained families. (See Mulligan 1997, 1999 and Grawe 2003 for applications of this test.) But if heteroskedasticity is present in the intergenerational earnings regression in the absence of credit constraints, then a comparison of earnings variances between unconstrained and potentially constrained families cannot distinguish between this heteroskedasticity and the effects of credit constraints.

14. In calculating this figure, I have assumed that the average enrollment of part-time students is one-third of a year. If part-time students are assumed to be enrolled very nearly full-time, the average full-time tuition bill would be little more than $C3,000. If part-time students are assumed to be enrolled very nearly no-time (or pay no tuition) the average full-time tuition bill would be less than $C4,250.

Figure 4
Relationship between Canadian Father's and Son's Age-Adjusted Log Earnings at 5th, 10th, 25th, 50th, 75th, 90th, and 95th Quantiles

apply for government-subsidized loans. In this context, it is plausible that few children are denied access to higher education for financial reasons.

IV. Conclusion

The observed S-shape of intergenerational earnings regression in Canada appears to suggest that credit constraints limit educational choice. However, a closer reading of the theory reveals that the relationship between constraints and nonlinear intergenerational earnings regression depends heavily on strong assumptions concerning the way ability enters the wage function. As a result, it would be better to focus on other implications of the model such as consumption regression and the offsetting of government investments in human capital. Recognizing that the availability of earnings data will likely continue to lead economists to examine earnings regression for evidence of credit market failure, this paper proposes an alternative quantile regression test to see whether data distant from the mean corroborate or refute the credit markets explanation. Since the model predicts that credit constraints will affect the most-able sons born into any given father-earnings bracket, credit market imperfections should only cause distortions in upper quantile regressions.

Contrary to the simple credit constraints explanation, the nonlinearity in Canada is caused by nonlinearities in lower quantile regressions. In addition, absolutely no earnings persistence is found among high-ability sons born to low-earning fathers. Since this group is the most susceptible to liquidity constraints, the data point away from binding credit constraints.

Appendix 1

Because the theory speaks to regression in permanent, lifetime earnings; earnings are adjusted for age prior to the final regression analysis. Let y_I ($I = s,f$) denote the residual from a regression of averaged earnings on age and age-squared for sons (s) and fathers (f).

Define a set of dummy variables

$$\text{(2)}\quad \begin{array}{ll} D1 = 1 \text{iff } y_f \in (0, 1] & D2 = 1 \text{iff } y_f \in (1, 2] \\ D3 = 1 \text{iff } y_f \in (3, \infty] & D4 = 1 \text{iff } y_f \in (-1, 0] \\ D5 = 1 \text{iff } y_f \in (-2, -1] & D6 = 1 \text{iff } y_f \in (-3, -2] \\ D7 = 1 \text{iff } y_f \in (-4, -3] & D8 = 1 \text{iff } y_f \in (-\infty, -4] \end{array}$$

Next, create the following interactions between the dummies and y_f

$$\text{(3)}\quad \begin{array}{ll} x1 = y_f & x2 = D2 * y_f \\ x3 = D3 * y_f & x4 = D4 * y_f \\ x5 = D5 * y_f & x6 = D6 * y_f \\ x7 = D7 * y_f & x8 = D8 * y_f \end{array}$$

Finally, (mean and quantile) regress y_s on $x1$, $x2$, $x3$, $x4$, $x5$, $x6$, $x7$, $x8$, and a constant. The estimated spline functions will have two important characteristics. First, just as with linear mean regression, the mean regression spline function will pass through the mean of both fathers' and sons' earnings. And second, the spline function will be continuous.

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