Uncertainty, Education, and the School-to-Work Transition: Theory and Evidence from Brazil

Lorenzo Guarcello
Università di Roma Tor Vergata
and UCW-Project

Furio Camillo Rosati
Università di Roma Tor Vergata
and UCW-Project

Pasquale Scaramozzino
Università di Roma Tor Vergata
and DeFiMS, SOAS, University of London

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Abstract

This paper develops a model of investment in education and school-to-work transition under uncertainty. The main predictions of the model are tested for Brazilian households using PNAD data. Increased uncertainty on labour market outcomes is shown to be associated with higher levels of schooling by young people, consistent with a real options approach to education as an investment.

Acknowledgements

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1. Introduction

This paper analyses the school-to-work transition by young individuals in a developing country context. In particular, we seek to examine the determinants of the school-leaving age by young people. The decision of when to leave school in order to enter the labour market is intrinsically linked to the choice of how much education individuals, and their families for them, wish to acquire. Consistent with human capital theory, households can regard education as a form of investment, and the decision about leaving school to enter the labour market can thus be directly related to the desired amount of human capital. The benefits from a higher level of human capital can include increased wages and/or a steeper earnings profile over their lifetime.

In developing countries, however, there is fundamental uncertainty about employment and wage outcomes, once an individual enters the labour market. The first source of uncertainty pertains to the length of time that will elapse before individuals are able to find a job. These are standard search costs. The second source of uncertainty involves the conditions of the labour market after an individual leaves school, and in particular the level of wages over the course of their work life. It may prove impossible for individuals or their families to diversify away these risks, and the absence of fully developed insurance markets can make it difficult for individuals or their families to insure against them (Cigno, Rosati and Tsannatos, 2002; Cigno and Rosati, 2005).

The role of uncertainty on the demand for education in both developed and developing countries has already been explored, notably by Kodde (1986) and Fitzsimons (2007). Kodde (1986) presents a two-period model where individuals can invest in education during the first period, and face wage uncertainty in the second period. In general, the effects of increased uncertainty on the demand for education are ambiguous, but their empirical analysis on Dutch data shows that an increase in the perceived risk associated with future income is associated with an increase in the probability of pursuing higher education. Fitzsimmons (2007) considers the effects of household risk and village risk on the education of children, and finds that greater village-level risk tends to be associated with lower educational attainment. A related issue is examined by Duryea, Lam and Levison (2007), who consider the impact on Brazilian schoolchildren of the male household head becoming unemployed.

The main contribution of the present paper is to endogenise the choice of the time when it is optimal to leave school. The decision about how much education it is desirable to acquire is modelled as a choice about the optimal timing of leaving school and joining the labour market.

The decision to leave school is largely an irreversible one. It can prove problematic for a young individual to re-enter school after a spell in the labour market, because of the potentially high opportunity cost of leaving an occupation. At the same time, when a young individual leaves school, there will usually be a large degree of uncertainty about her future labour market prospects. Given this uncertainty, and in the light of the irreversibility of the decision to leave school, young individuals may decide to be more cautious with respect to the choice of when to interrupt their education in order to join the labour market.

The school-to-work transition is formally modelled in this paper as the exercise of a real option under uncertainty. A young individual who is attending school can be seen as the holder of an option about entering the labour market. When the individual does leave school, she is exercising her option. The framework of real option analysis is increasingly seen as an appropriate modelling strategy for the analysis of investment decisions (Dixit and Pindyck, 1994). Real options have also recently been applied to demographic issues in developing countries (see Iyer and Velu, 2006). However, to the best of our knowledge they have never before been applied to the analysis of investment in education, and specifically to the school-to-work transition (which can formally be seen as a *disinvestment*). In our view, this approach is particularly suited to explore schooling decisions in developing countries, because of the pervasive nature of uncertainty in those labour markets and of the difficulty of re-entering education once a young person has left school.

We study the impact of uncertainty on the schooling choice of young individuals in Brazil. We make use of cross-sectional survey data from the *Pesquisa National por Amostra de Domicílios* (PNAD) to examine whether the work or study status of young individuals can be influenced by a measure of wage variability at the level of States of the Brazilian Federation. Recent policy reforms aimed at improving the flexibility of labour markets in Brazil imply that these effects are potentially important (de Barros, Corseuil and Leite, 2000, and Marshall, 2004). The issues analysed in the paper have acquired increased momentum, especially given the crucial role attached to education in the *Programa de Aceleração do Crescimento* that sets

out the main objectives of the second mandate of President Lula da Silva (see Pietrobelli and Pugliese, 2007, for a discussion).

The structure of this paper is as follows. Section 2 sets forth the theoretical model of the demand for education under uncertainty and derives the main testable predictions. Section 3 describes the micro data on Brazilian households used in the empirical analysis. Section 4 estimates the impact of uncertainty on the activity status of young individuals by applying multinomial regression methods. Section 5 concludes.

2. Schooling, uncertainty, and entry into the job market

We consider the school-to-work decision in a stochastic dynamic setting. Consistent with Becker's (1964) human capital theory, schooling is seen as a form of investment. Households face both direct costs and opportunity costs to acquire education. Expected future benefits can take the form of a higher starting wage on the job and, possibly, also of a steeper earnings profile over time.

In the context of developing countries, there is fundamental uncertainty about labour market outcomes following investment in education. This uncertainty involves both the possibility of finding a suitable job when a worker enters the labour market, and the income received once a job has been found. The impact of uncertainty is exacerbated by the lack of insurance markets in developing countries. The present section presents a model of investment in human capital with stochastic search in the labour market and uncertainty on the wage rate. The main concern is to analyse the timing of the school-to-work transition by young people.

Households have to decide when to interrupt their children's investment in education without fully knowing the future conditions that will prevail in the labour market. Uncertainty thus plays a central role on the education decision, both directly and through its interactions with the key parameters of the model, and in particular with the costs and benefits of education. Formally, this consists of considering the optimal exit strategy for households, which can be seen as equivalent to the decision to abandon an investment (Dixit and Pindyck, 1994, chapter 7).

Uncertainty in the labour market is modelled in terms of a search process, with the wage rate following a continuous-time stochastic process. When a young

individual leaves school, she enters the labour market and has to go through a process of search in order to find a job. Once a successful labour match is formed, schooling and, later, seniority allow the worker to receive a premium over and above the wage of an unskilled worker. The premium of a skilled worker is expressed as a mark-up over the wage of an unskilled worker.

We model the education choice in terms of a dynamic programming approach, rather than using a contingency claims analysis as is often common in investment analysis (see Dixit and Pindyck, 1994, chapter 4). In our view the dynamic programming approach is more appropriate to the context of developing countries, since the incompleteness of insurance markets makes it impossible to replicate the returns from education through other instruments.

The notation pertaining to the timing of events is as follows (see Figure 1). The child starts attending school at time $t = 0$ and remains at school until time $t = t^*$. The choice of the optimal timing t^* is endogenous. She then starts searching for a job. The search continues until time $t = T$, when a successful job match is formed. Starting from $t=T$, the worker accumulates seniority $s = t - T$. The instantaneous cost of education is c, income during search is 0 and the wage rate at time t is w_t (payoffs are measured relative to a subsistence level).

The wage of an unskilled worker over the subsistence level, v_t, is assumed to follow a geometric Brownian motion stochastic process:

$$dv = \mu v dt + \sigma v dz \tag{1}$$

where μ is the instantaneous drift parameter, σ is a variability parameter, and where dz is a Wiener process with independent increments: $dz \sim \text{NID}(0, dt)$. According to the specification (1), wage dynamics has both a deterministic component, given by the trend parameter μ, and a stochastic component, expressed by the Wiener increments dz. These stochastic increments represent the uncertainty in labour markets faced by workers. Despite its analytical simplicity, the specification (1) is able to capture the fact that wages in a developing country exhibit both a predictable and an unpredictable component, and that the latter is characterised by inherent and on-going uncertainty.

The wage of a skilled worker is a mark-up over the wage of an unskilled worker:

(2) $$w_t = m \cdot v_t$$

where *m* denotes the mark-up, which is assumed to be an increasing function of human capital and seniority:

(3) $$m = m(h, s) = m(h(t^*), t - T) \geq 1 \qquad m_h > 0\,, \qquad m_s > 0$$

Consistent with the theoretical analysis on education and training, we interpret schooling as providing the individual with general human capital, and on-the-job seniority as providing specific human capital (see Cahuc and Zylberberg, 2004). The stochastic process for the wage of a skilled worker therefore follows a stochastic differential equation with variable coefficients:

(4) $$\begin{aligned} dw = m \cdot dv &= \mu m(h, s)v \cdot dt + \sigma m(h, s)v \cdot dz \\ &= \mu m(h(t^*), t - T)v \cdot dt + \sigma m(h(t^*), t - T)v \cdot dz \end{aligned}$$

The stochastic process *w* described in (4) is an Itô process. However, by using the definition of the wage mark-up (3), equation (4) can be written in the simpler form:

(5) $$dw = \mu w \cdot dt + \sigma w \cdot dz$$

which is a geometric Brownian motion in *w*.

The instantaneous rate of arrivals of jobs during search is denoted by $\lambda > 0$. The expected duration of unemployment after leaving school is therefore $1/\lambda$.

We conjecture that a young individual decides to leave school when the wage rate reaches a critical value *w**, and remains in the labour market thereafter. The decision rule is therefore as follows: the child stays at school if $0 \leq w < w^*$ and leaves school to start searching for a job when $w \geq w^*$. Hence, *w** is the school-

leaving wage. The corresponding time when the young individual leaves school is denoted by t^*. Thus, $t^* = \min\left(t \in [0,\infty) \middle| w \geq w^*\right)$.

Let $F(w)$ be the value function of a child when she is at school. The Bellman equation associated with the dynamic optimization programme is:

$$\rho F dt = -c dt + E_t(dF) \qquad 0 \leq w < w^*, \quad 0 \leq t < t^* \tag{6}$$

where ρ is the rate of time preference and $E_t(\cdot)$ denotes the expectation conditional on the information set at time t. Applying Itô's Lemma (Dixit and Pindyck, 1994, and Neftci, 2006) to dF yields:

$$\begin{aligned} dF &= F'(w)dw + \frac{1}{2}F''(w)(dw)^2 \\ &= F'(w)dw + \frac{1}{2}\sigma^2 w^2 F''(w)dt \\ &= \left[\mu w F'(w) + \frac{1}{2}\sigma^2 w^2 F''(w)\right]dt + \sigma w F'(w)dz \end{aligned} \tag{7}$$

using (5). Taking expectations of (7) gives

$$E_t(dF) = \left[\mu w F'(w) + \frac{1}{2}\sigma^2 w^2 F''(w)\right]dt \tag{8}$$

since $E_t(dz) = 0$. We can replace (8) into (6) to obtain the Bellman equation for a child in education:

$$\frac{1}{2}\sigma^2 w^2 F''(w) + \mu w F'(w) - \rho F(w) = c \tag{9}$$

Note that the value w=0 is an absorbing state for the geometric Brownian motion (5). Hence, the stochastic differential equation (9) must satisfy the initial condition

(10) $$F(0) = -\frac{c}{\rho}$$

The boundary condition that must hold for the value function $F(w)$ at the critical school-leaving time t^* is:

(11) $$F(w^*) = E_{t^*}\left[\int_{t^*}^{\infty} \lambda e^{-\lambda s} e^{-\rho s} w_s \, ds\right] = \frac{\lambda w^*}{(\rho + \lambda) - \mu}$$

In evaluating (11), use has been made of Itô's Lemma (see Dixit and Pindyck, 1994, page 82). The corresponding condition that must hold at the margin is:

(12) $$F'(w^*) = \frac{\lambda}{(\rho + \lambda) - \mu}$$

Equations (11) and (12) are respectively the value-matching (VM) and smooth-pasting (SP) conditions for the dynamic optimization programme. From (11) and (12), it is apparent that the condition $(\rho + \lambda) > \mu$ must hold.

In order to solve the Bellman equation (9), we must first consider the general solution to the corresponding homogeneous differential equation:

(13) $$\frac{1}{2}\sigma^2 w^2 F''(w) + \mu w F'(w) - \rho F(w) = 0$$

Our guess solution has the form $F(w) = Aw^{\beta}$: it follows that $F'(w) = \beta F(w)/w$ and $F''(w) = \beta(\beta - 1)F(w)/w^2$. Replacing into (13) and dividing through by $F(w)$ we obtain the following parametric equation in β:

(14) $$\frac{1}{2}\sigma^2 \beta^2 + \left(\mu - \frac{\sigma^2}{2}\right)\beta - \rho = 0$$

The roots of the quadratic equation (14) are:

(15a) $$\beta_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2\rho}{\sigma^2}} > 0$$

(15a) $$\beta_2 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0$$

Note that β_2 would be inconsistent with the initial condition (10), since w^{β_2} would tend to infinity as $w \to 0$. Hence, the general solution of the homogeneous equation (13) is $F(w) = Aw^{\beta_1}$. A particular solution of the inhomogeneous equation (9) is $F(w) = -c/\rho$. Therefore, the general solution of the Bellman equation (9) is

(16) $$F(w,t) = Aw^{\beta_1} - \frac{c}{\rho}$$

It remains to determine *A* and *w** (the critical school-leaving wage). These can be obtained from the value-matching and the smooth-pasting conditions (11) and (12). Using (16), these become respectively:

(17) $$F(w^*) = A(w^*)^{\beta_1} - \frac{c}{\rho} = \frac{\lambda w^*}{\rho + \lambda - \mu}$$

(18) $$F_w(w^*) = A\beta_1(w^*)^{(\beta_1 - 1)} = \frac{\lambda}{\rho + \lambda - \mu}$$

Multiplying (18) by w^*/β_1, replacing into (17) and solving for *w** we obtain:

(19) $$w^* = \left(\frac{\beta_1}{1-\beta_1}\right)\left(\frac{\rho + \lambda - \mu}{\rho\lambda}\right)c$$

Note that, since $(\rho + \lambda) > \mu$, equation (19) requires that the underlying parameter values must be such that $\beta_1 < 1$. Note also that, if $\lambda \to \infty$ (that is, the unemployment spell tends to zero), the critical wage *w** converges to $(\beta_1/(1-\beta_1))(c/\rho)$.

The threshold wage w^* indicates to the remuneration of a skilled worker, and is given by a mark-up over the wage of an unskilled worker v. From (2) and (3), the critical school-to-work condition can be expressed in terms of the unskilled wage rate, v^*:

$$w^* = m(h(t^*),0) \cdot v^* \tag{20}$$

where $t^* = \min\left(t \in [0,\infty) \middle| w \geq w^*\right)$ is a random variable that denotes the optimal transition time and where $m(h(t^*),0)$ is the corresponding mark-up (for a school leaver, on-the-job experience is of course still zero). A high sensitivity of the wage mark-up to education-acquired general human capital could therefore lower the critical school-leaving value of the unskilled wage rate, v^*.

Figures 2-4 illustrate how the critical school-leaving wage w^* varies with the main parameters of the model, for a configuration of parametere values. The critical wage w^* is a decreasing function of the instantaneous drift rate of the wage process, μ (Figure 2) and an increasing function of the instantaneous rate of arrival of jobs during search, λ (Figure 3). Children leave school earlier if they expect that wages will increase faster in the long term, and will remain longer at school if they anticipate a shorter unemployment spell before they find a job (given by $1/\lambda$ in expected value). From equation (19), young people also remain longer at school in response to an increase in the cost of schooling c. The reason for this result is that the higher wages associated with higher education would enable them to recover the cost of schooling.

Significantly, the threshold wage w^* is also an increasing function of the perceived uncertainty in the labour market, as measured by the wage variability parameter σ. Figure 4 illustrates how w^* varies with σ. This finding is one of the main implications of the model. The intuition for this result is as follows. The critical issue in a dynamic model of education is the optimal timing of the transition from school to work. In the presence of uncertainty on labour market outcomes, households prefer to be more cautious and postpone their children's entry into the labour market until the expected wage is sufficiently high. The decision to leave school is largely irreversible, and therefore it would be very costly to leave school at a time when the labour market conditions are not particularly favourable. As a result, young individuals decide to remain longer at school.

Figure 4 also shows that the critical wage w^* is an increasing function of the rate of time preference, ρ. A higher value of the rate of time preference is associated with a more cautious behaviour by young individuals, who tend to postpone their school leaving date until the labour market conditions are sufficiently favourable. From Figure 4 it is also possible to see that the impact of increased uncertainty on the decision to postpone entry into the labour market is reduced when the rate of time preference is lower. Hence, more "patient" individuals tend to be less affected by labour market uncertainty.

We proceed to test empirically the main implications of the model using data on school-leavers in Brazil.

3. The data

Our empirical analysis is based on micro data on households in Brazil from the *Pesquisa National por Amostra de Domicílios* (PNAD) for 2004. The survey has been run annually from 1981, and includes data from all the states in Brazil with the exception of the rural North-West. The survey contains information on both individual and household characteristics. This dataset has been used to analyse a number of aspects of labour demand and child labour by Manacorda and Rosati (2007).

A particularly attractive feature of the survey for our purposes is the attention it devotes to children and to young members of the family. The data set contains information on schooling and on the work activities of young individuals, as well as information on the labour market participation by adult members. Labour by young people includes paid and unpaid work, both inside and outside the family, with the exclusion of household chores.

Some descriptive features of the data are summarized in Tables 1 and 2. Our empirical analysis makes use of 2004 cross-sectional data, and focuses on young individuals aged from 15 to 24. The sample contains over 67,000 observations. About 48% of them are in employment, and 53% of them attend school (19% of them both work and study). Their average age is just over 19 years, and 51.6% of them are female. We have information on the education of the head of household.

The specific variables that capture labour market conditions are the share of youth employment, defined as the share of youth (15-24) to working age (25-50) population ratio, and the adult (25-55) employment to population ratio. In particular the first variable can be seen as a proxy for labour supply, whereas the second variable can be regarded as a proxy for the state of the economic cycle as in Card and Lemieux (2000).

Table 2 illustrates the work and study status of the young people in the sample. About 33% of them have study as their only occupation and 29% of them are in employment. A further 19% combine both work and study, whereas 19% of them are reported to be neither working nor studying.

4. Empirical analysis

The theoretical analysis of section 2 shows that uncertainty on the outcome of the investment in education is a critical determinant of the decision about the timing of transition from school to work. We exploit the cross-sectional variability across states of the survey on PNAD in order to obtain a measure of the variability of the returns to education in terms of residuals from individual Mincerian wage equations. We estimate wage equations across states, using a number of controls for individual and job characteristics consistent with human capital theory. The residuals from these estimated wage equations form the basis for the computation of the coefficient of variation of wages for each State of the Brazilian Federation, which is our measure of wage uncertainty used in the empirical analysis on the study *vs.* work status of young people.

4.1 Wage equations

We have estimated empirical wage equations for all individual workers aged 25-55 in the sample. Our equations include controls for both individual and job characteristics. The individual regression equations on wages are of the form:

(21)

$$\ln(wage)_{is} = \text{constant} + \beta_1(age)_{is} + \beta_2(age)_{is}^2 + \beta_3(education)_{is} + \beta_4(education)_{is}^2 + \beta_5(work\ age)_{is} + \beta_6(work\ age)_{is}^2 + \beta_7(urban\ dummy)_{is} + \gamma'(industry\ dummies)_{is} + \delta'(occupation\ dummies)_{is} + \varepsilon_{is}$$

where *wage*, *age* and *education* are characteristics of the individual worker *i*, and *work age* denotes the age when individuals started working. The subscript *s* denotes the state of residence. The equations also include urban, industry and occupation dummies.

The residuals from the estimated equations (21) can be seen as capturing the unpredictable and erratic component of wages, after controlling for general and specific human capital and other characteristics of the job. We interpret these residuals as a measure of the risk faced by individual workers, when they have to decide on their investment in education.

Equation (21) has been separately estimated for all workers in each state, and the resulting coefficient of variation (CV) of the residuals has been computed. These coefficients of variation measure the residual wage uncertainty in each state, and are used as our proxy for the uncertainty faced by workers in their education decision.

Table 3 reports the values of the coefficient of variation of wage residuals by gender across the states of the Brazilian Federation. The CV exhibits a large cross-sectional variability across states and gender. The values of CV range from 0.0895 in Santa Catarina and 0.0924 in São Paulo in the South to 0.1355 in Maranhão and 0.1441 in Piauí in the North-Est for male workers. For female workers, the CVs range from 0.0892 in Amazonas and 0.0916 in Roraima in the North-West to 0.1490 in Maranhão and 0.1701 in Piauí. The CV at State level is the measure of uncertainty about labour market outcomes that we use in our regressions on activity status.

4.2 Uncertainty and schooling

The estimates of multinomial logistic equations on the activity status of young individuals in the sample are reported in Table 4. The reference status is given by young individuals who have work as their only occupation. These estimates can be

read in conjunction with Table 5, which presents the marginal effects from the multinomial logit estimates on the activity status. Most explanatory variables in the equations are highly significant and their signs conform to intuition. Age has a positive but decreasing effect on the probability of working, and a negative effect on the probability of studying. Female individuals are more likely either to be at work full-time or to be idle, which presumably includes attending to household chores. Having a female head of household also makes it more likely that the young individual is neither studying nor at work. The estimated coefficients on household size and on the number of siblings jointly imply that a large number of adults in the family makes it more likely that the young individual is at work, whereas a large number of children implies that the individual is more likely to be either idle or at work. Higher education of the head of household makes it more likely that the individual studies (consistent for instance with Brown, 2006). Also, higher family income, measured by family expenditures, is associated with an increased probability that the youth studies or combines work and study. Better-off households, therefore, are characterised on average by greater investment in the education of their children.

The labour market variables are also highly significant and have the expected sign. A higher share of youth employment makes it more likely that young individuals stay on at school or are idle, and less likely that they are at work (alone or in conjunction with studying). This could be interpreted as a labour supply effect, which is exogenous to the individual participation decision. By contrast, a higher employment-to-population ratio has a negative effect on the probability of young people studying. This ratio can be interpreted as a proxy of the demand for labour, which can be regarded as exogenous to the individual decision. The finding could be interpreted as evidence of the pro-cyclical nature of youth employment, as also borne out by the negative and significant on the idle status, which could be seen as related to the opportunity cost of not being active in the presence of high demand for labour.

The most important finding of our analysis concerns the role of risk on activity status. The coefficient of variation has a positive and significant effect on the probability of studying or of combining study and work. Thus, greater uncertainty on labour market outcomes is associated with a higher probability of staying on at school. The largest coefficient is on the work-and-study status. These results are consistent with a real options approach to education as an investment under uncertainty. Leaving school can be seen as the exercise of the real option to abandon

an investment. Under uncertainty, the value of the option increases, and therefore young individuals are more reluctant to exercise. Leaving school is a largely irreversible decision, and the wrong timing of entry in the labour market could have long-lasting consequences on an individual's income and career prospects. Hence, increased uncertainty leads young individuals to behave more cautiously and to postpone their disinvestment in education, possibly combining schooling with work.

When the coefficient of variation is interacted with household expenditures, however, the effect of uncertainty is reduced. Thus, it would appear that poorer households, whilst on average are characterised by lower investment in education, still tend to respond more strongly to increased uncertainty by postponing the timing of school leaving of their children. Young individuals from richer household are less vulnerable to the effects of uncertainty on their schooling *vs.* work decision. If we accept that poorer households effectively face higher discount rates, consistent with the literature on liquidity constraints (see *e.g.* Zeldes, 1989), this result can be explained in terms of the interaction between wage uncertainty and rate of time preference illustrated in Figure 4. Young individuals from poorer households are more sensitive to increased labour market uncertainty, and tend to postpone leaving school more than individuals from richer households.

It is important to note that, if liquidity constraints for households were perfectly binding, there could be no role for uncertainty as households would be on a corner solution. Thus, our results can be seen as suggesting at least some elements of choice in schooling decisions even for relatively poor households (for a recent analysis of the role of credit constraints on children education, see Chamarbagwala, 2008).

Finally, Table 6 presents the results of a probit estimation of the probability of employment, conditional on being out of school. The equation has been estimated for those individuals who have ever been at school. The labour market variables have the expected sign. In particular, the supply-side variable (share of youth employment) has a negative sign, whereas the demand-side variable (employment to population ratio) attracts a positive sign. The coefficient of variation has a positive and significant coefficient: the probability of employment is higher in those States with greater residual wage variability.

This finding appears to be supportive of the recent policy reforms aimed at increasing the degree of flexibility of labour markets (de Barros, Corseuil and Leite,

2000; and Marshall, 2004). The findings are potentially highly relevant for the economy, since investment in human capital has been identified as the single most important factor in improving the level of income and decreasing income inequality in Brazil (Menezes-Filho and Vasconcellos, 2004).

5. Conclusions

This paper sets forth a stochastic model of school-to-work transition in developing countries. Greater uncertainty on labour market outcomes leads to more cautious behaviour about the time when it is optimal to leave school to enter the labour market.

The main predictions of the model are confirmed by the empirical evidence on young individuals in Brazil. Greater uncertainty on residual wages is associated with an increased likelihood that individuals stay on at school, either as their only activity or in conjunction with working. Richer households are less responsive to increased uncertainty than poorer households. The empirical findings are consistent with a real options approach to the demand for education.

Figure 1. The school-to-work decision: timing and payoffs.

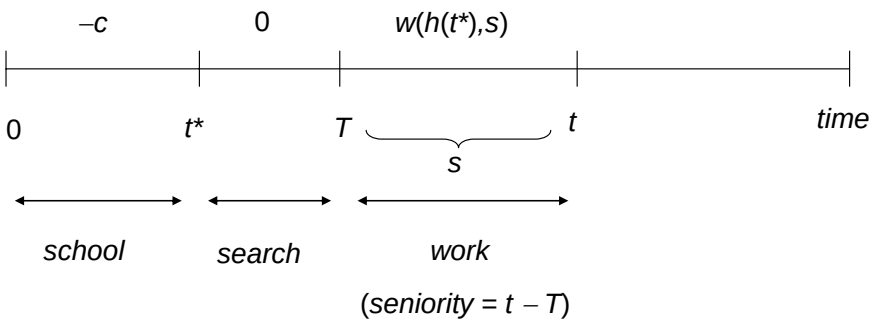
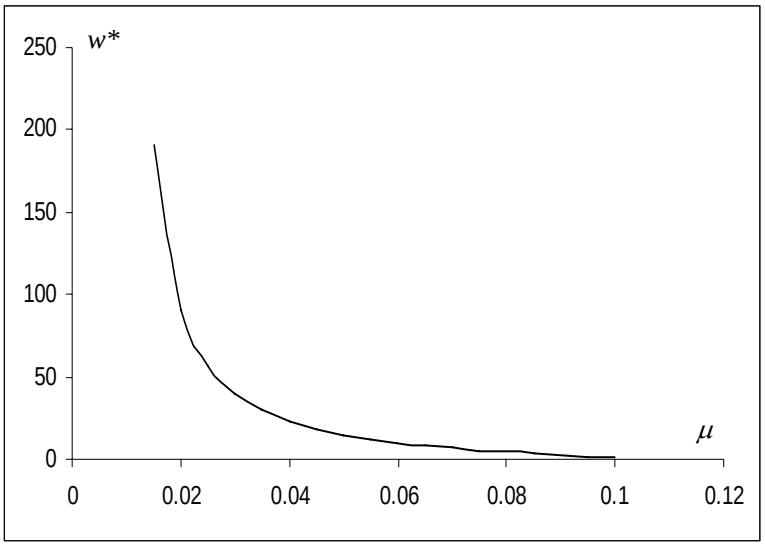


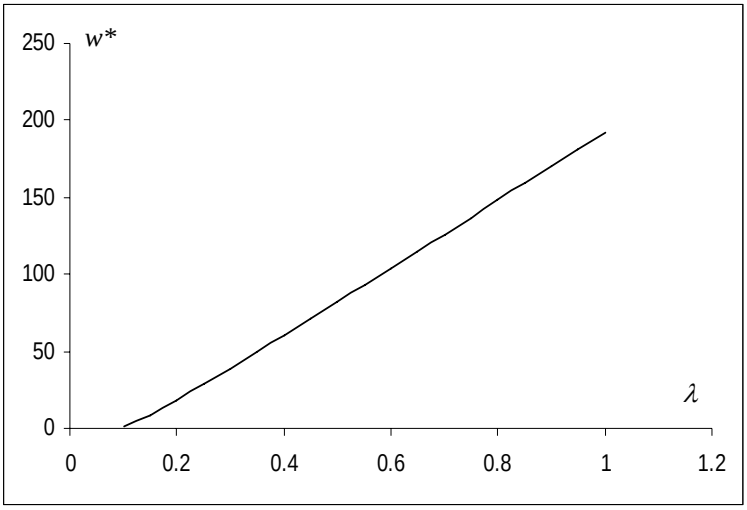
Figure 2. The school-leaving wage and the wage drift.



Note.

Parameter values are $\lambda = 0.1$, $\rho = 0.01$, $\sigma = 0.01$, $c = 1$.

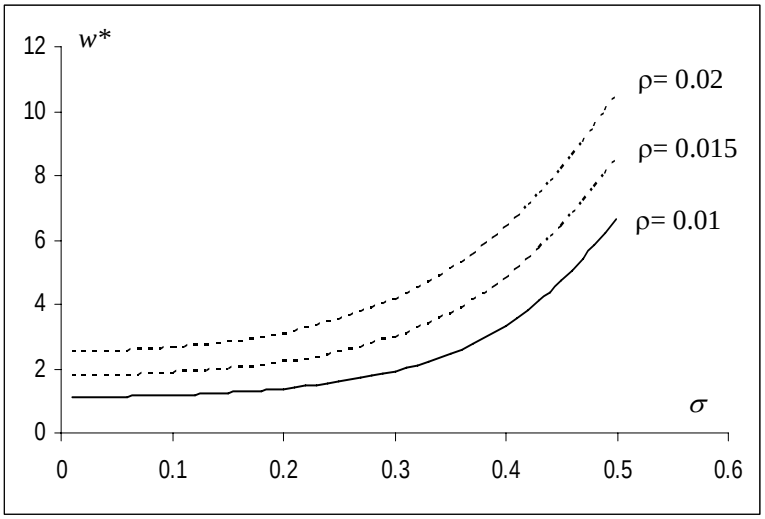
Figure 3. The school-leaving wage and the rate of job arrival.



Note.

Parameter values are $\mu = 0.1$, $\rho = 0.01$, $\sigma = 0.01$, $c = 1$.

Figure 4. The school-leaving wage and uncertainty.



Note.

Parameter values are $\lambda = 0.1$, $\mu = 0.1$, $c = 1$.

Table 1. Descriptive statistics.

Variable	Mean	Standard deviation
Employment	47.979	49.959
Attendance	52.669	49.929
Age	19.145	2.833
Gender (% female)	0.515	0.500
Gender of head of household (=1 if male)	0.682	0.466
Size of household	4.824	2.028
Number of siblings	0.360	0.693
Education of head of household (no education)	0.141	0.348
Education of head of household (primary)	0.524	0.499
Education of head of household (secondary or higher)	0.336	0.472
Log of household expenditure	9.559	3.294
Share of youth employment	0.307	0.032
Employment to population ratio	0.750	0.037
Coefficient of variation of residual from state wage equations	0.115	0.016

Note:

Number of observations: 67,476.
Employment: 1 if the individual works, 0 otherwise.
Attendance: 1 if the individual attends school, 0 otherwise.
Gender: 1 if female, 0 if male.
Gender of head of household: 1 if male, 0 if female.
Share of youth employment: share of youth (15-24) to working age population.
Employment to population ratio: adult (25-55) employment to population ratio.

Table 2. Work and job status of young people.

Work only	28.48%
Study only	33.26%
Work and study	19.37%
Idle	18.89%

Table 3. Coefficient of Variation across State (Unidade da Federação) and sex.

Unidade da Federação	Male	Female
Acre	0.1231	0.1168
Alagoas	0.1136	0.1140
Amapá	0.1005	0.1074
Amazonas	0.0937	0.0892
Bahia	0.1172	0.1384
Ceará	0.1196	0.1446
Distrito Federal	0.0949	0.0985
Espírito Santo	0.1167	0.1170
Goiás	0.1013	0.1141
Maranhão	0.1355	0.1490
Mato Grosso	0.1008	0.0994
Mato Grosso do Sul	0.0992	0.1078
Minas Gerais	0.1039	0.1205
Pará	0.1105	0.1213
Paraíba	0.1326	0.1405
Paraná	0.1090	0.1130
Pernambuco	0.1233	0.1437
Piauí	0.1441	0.1701
Rio de Janeiro	0.0958	0.1079
Rio Grande do Norte	0.1306	0.1294
Rio Grande do Sul	0.0996	0.1109
Rondônia	0.1039	0.1040
Roraima	0.1016	0.0916
Santa Catarina	0.0895	0.0968
São Paulo	0.0924	0.1030
Sergipe	0.1054	0.1227
Tocantins	0.1158	0.1192

Table 4. Multinomial logit on activity status.

	Study Only	***Workand Study***	***Idle***
Age	-2.7448***	-1.7281***	-0.8569***
	(0.0755)	(0.0743)	(0.0769)
$(Age)^2$	0.0552***	0.0356***	0.0178***
	(0.0019)	(0.0019)	(0.0019)
Female	0.7990***	0.1667***	1.0122***
	(0.0278)	(0.0283)	(0.0287)
Female Head of Household	-0.0449*	-0.0074	0.0902***
	(0.0259)	(0.0264)	(0.0266)
Household size	0.0751***	0.0822***	-0.0573***
	(0.0069)	(0.0068)	(0.0069)
Number of siblings	-0.5135***	-0.4114***	0.3562***
	(0.0220)	(0.0218)	(0.0176)
Education of Head of	0.1944***	0.0956***	0.0118
Household: primary	(0.0375)	(0.0361)	(0.0362)
Education of Head of	1.1978***	0.7147***	0.0904**
Household: higher	(0.0418)	(0.0411)	(0.0419)
ln(expenditure)	0.0656***	0.0628***	-0.0533
	(0.0254)	(0.0242)	(0.0403)
Share of youth employment	7.4990***	3.6355***	5.3191***
	(0.4788)	(0.4900)	(0.4749)
Employment to population	-5.9639***	0.0650	-6.1082***
Ratio	(0.3370)	(0.3347)	(0.3393)
Urban dummy	1.1996***	0.1783***	0.8013***
	(0.0366)	(0.0324)	(0.0348)
Coefficient of variation (CV)	7.9958***	9.3734***	1.4010
	(2.2966)	(2.2308)	(3.2120)
CV**ln*(expenditure)	-0.5799***	-0.4293**	-0.2602
	(0.2210)	(0.2106)	(0.3440)
Constant	31.2236***	16.5480***	11.9013***
	(0.8298)	(0.8219)	(0.9005)

Note:

Multinomial logit regressions.
Dependent variable: Dummy variable on activity status.
Reference status: Work only.
Number of observations: 67,476.
*** Significant at 0.1%.
** Significant at 1%.
* Significant at 5%.

Table 5. Marginal effects from multinomial logit estimates.

	Work only	***Study only***	***Work and study***	***Idle***
Age	0.3676***	-0.4032***	-0.0743***	0.1099***
	(0.0114)	(0.0126)	(0.0106)	(0.0098)
$(Age)^2$	-0.0075***	0.0080***	0.0016***	-0.0022***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Female	-0.1232***	0.0955***	-0.0745***	0.1022***
	(0.0043)	(0.0046)	(0.0042)	(0.0038)
Female Head of	-0.0004	-0.0143***	-0.0022	0.0170***
Household	(0.0041)	(0.0045)	(0.0040)	(0.0036)
Household size	-0.0082***	0.0132***	0.0123***	-0.0173***
	(0.0011)	(0.0012)	(0.0010)	(0.0010)
Number of siblings	0.0483***	-0.0996***	-0.0544***	0.1057***
	(0.0032)	(0.0040)	(0.0035)	(0.0026)
Education of Head of	-0.0219***	0.0334***	0.0027	-0.0142**
Household: primary	(0.0056)	(0.0066)	(0.0056)	(0.0051)
Education of Head of	-0.1382***	0.1992***	0.0282***	-0.0893***
Household: higher	(0.0056)	(0.0076)	(0.0064)	(0.0051)
ln(expenditure)	-0.0064	0.0124***	0.0092**	-0.0152**
	(0.0042)	(0.0047)	(0.0039)	(0.0060)
Share of youth	-1.0863***	1.0048***	-0.1366*	0.2181**
employment	(0.0749)	(0.0815)	(0.0743)	(0.0647)
Employment to	0.7736***	-0.9055***	0.7393***	-0.6074***
Population ratio	(0.0520)	(0.0579)	(0.0508)	(0.0468)
Urban dummy	-0.1462***	0.1721***	-0.0808***	0.0549***
	(0.0061)	(0.0047)	(0.0057)	(0.0042)
Coefficient of variation	-1.2871***	0.9197**	1.0639**	-0.6965
(CV)	(0.3714)	(0.4137)	(0.3500)	(0.4743)
CV**ln*(expenditure)	0.0857**	-0.0757*	-0.0237	0.0138
	(0.0364)	(0.0408)	(0.0337)	(0.0514)

Note:

Marginal effects from multinomial logit regressions (Table 4).
Dependent variable: Activity status.
Number of observations: 67,476.
*** Significant at 0.1%.
** Significant at 1%.
* Significant at 5%.

Table 6. Probability of employment conditional on being out of school.

	Study Only
Age	.3956***
	(.0491)
$(Age)^2$	-0.0078***
	(0.0012)
Female	-0.6609***
	(0.0184)
Female Head of Household	-0.0261
	(0.0169)
Household size	0.0304***
	(0.0042)
Number of siblings	-0.1993***
	(0.0113)
Education: primary	-0.0569***
	(0.1273)
Education: higher	-0.1933***
	(0.0176)
Education of Head of	0.0805**
Household: primary	(0.0272)
Education of Head of	0.0392*
Household: higher	(0.0184)
Share of youth employment	-3.5021***
	(0.2989)
Employment to population	3.6885***
Ratio	(0.2170)
Urban dummy	-0.5307***
	(0.0221)
Coefficient of variation (CV)	1.3086*
	(0.6316)
Constant	-5.5007***
	(0.5326)
Pseudo R^2	0.1047
LR (χ^2_{14})	4353.82***

Note

Estimation method: Probit regression.

Model estimated on sub-sample of individuals who have ever been at school.

No. observations: 31,092.

References

Becker, Gary S. (1964), *Human Capital*, Columbia University Press.

Brown, Philip H. (2006), "Parental Education and Investment in Children's Human Capital in Rural China", *Economic Development and Cultural Change*, Vol. 54, No. 4, July, pp. 759-789.

Card, David, and Thomas Lemieux (2000), "Adapting to Circumstances: The Evolution of Work, School, and Living Arrangements among North American Youth", in R.B. Freeman (ed.), *Youth Employment and Joblessness in Advanced Countries*, University of Chicago Press and NBER.

Cahuc, Pierre, and André Zylberberg (2004), *Labor Economics*, MIT Press, Cambridge (Mass.).

Chamarbagwala, Rubiana (2008), "Regional Returns to Education, Child Labour and Schooling in India", *Journal of Development Studies*, Vol. 44, No. 2, pp. 233-257.

Cigno, Alessandro, and Furio Camillo Rosati (2005), *The Economics of Child Labour*, Oxford University Press, Oxford.

Cigno, Alessandro, Furio Camillo Rosati and Zafiri Tsannatos (2002), *Child Labour Handbook*, Discussion Paper No. 0206, Special Protection, The World Bank.

De Barros, Ricardo Paes, Carlos Henrique Corseuil, and Philippe G. Leite (2000), "Labor Market and Poverty in Brazil", Texto para Discussão No. 723, Istitudo de Pesquisa Económica Aplicada, Ministério do Planejamento, Orçamento e Gestão.

Dixit, Avinash K. and Robert S. Pindyck (1994), *Investment under Uncertainty*, Princeton University Press, Princeton, New Jersey.

Duryea, Suzanne, David Lam and Deborah Levison (2007), "Effects of Economic Shocks on Children's Employment and Schooling in Brazil", *Journal of Development Economics*, Vol. 84, No. 1, September, pp. 188-214.

Fitzsimons, Emla (2007), "The Effects of Risk on Education in Indonesia", *Economic Development and Cultural Change*, Vol. 56, No. 1, October, pp. 1-25.

Iyer, Sriya and Chander Velu (2006), "Real Options and Demographic Decisions", *Journal of Development Economics*, Vol. 80, 39-58.

Kodde, David A. (1986), "Uncertainty and the Demand for Education", *Review of Economics and Statistics*, Vol. 68, No. 3, August, pp. 460-467.

Manacorda, Marco, and Furio Camillo Rosati (2007), "Local Labor Demand and Child Labor", UCW Working Papers, March.

Marshall, Adriana (2004), "Labour Market Policies and Regulations in Argentina, Brazil and Mexico: Programmes and Impacts", Working Paper 2004/13, Employment Analysis Unit, ILO.

Menezes-Filho, Naércio, and Ligia Vasconcellos (2004), "Operationalising Pro-Poor Growth: A Country Case Study on Brazil", mimeographed, World Bank.

Neftci, Salih N. (2006), *Introduction to the Mathematics of Pricing Financial Derivatives*, 3rd edition, Academic Press, San Diego.

Pietrobelli, Carlo, and Elisabetta Pugliese (2007), *L'economia del Brasile*, Carocci, Roma.

Zeldes, Stephen P. (1989), "Consumption and Liquidity Constraints: An Empirical Investigation", *Journal of Political Economy*, Vol. 97, No, 2, April, pp. 305-346.