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A Dynamic Mincer Equation with an Application to Portuguese Data

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ABSTRACT

This paper argues in favor of a dynamic specification of the Mincer equation, where past observed earnings play the role of additional explanatory variable for current observed earnings. A dynamic approach offers an explanation why the return to schooling in terms of observed earnings is not independent of labor-market experience, as suggested by some recent empirical evidence for the United States.

Keywords: Mincer Equation, Return to Schooling, Wage Level, Panel Data.
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1. Introduction

A seminal work by Jacob Mincer (1974) has been the starting point of a large body of literature dealing with the estimation of a wage equation where the logarithm of hourly earnings is explained by schooling years, labor-market experience, and experience squared. Within this framework, the coefficient of schooling years is usually interpreted as being the return to an additional year of schooling in terms of *observed* earnings.

An excellent synthesis of the research papers adopting the Mincer equation as underlying framework has been provided by David Card (1999). The reviewed works generally focus on the estimation of the *average* impact of schooling on earnings, by means of both ordinary least squares and instrumental-variable techniques.

Today, 'the state of the art' described by Card looks outdated. This is partly because the last decade was characterized by a special interest in adopting the Mincer equation for identifying the effect of schooling not only on the mean but also on the *shape* of the conditional wage distribution, by using the quantile-regression techniques due to Koenker and Bassett (1978). Starting from a seminal work by Buchinsky (1994), the last few years saw the publication of numerous estimates of the schooling-coefficient along the conditional wage distribution, with the frequent finding that education has a positive impact on within-groups wage inequality, as suggested by Martins and Pereira (2004) among others. Additional results using instrumental-variable-quantile-regression techniques have been provided by Arias *et al.* (2001), Lee (2004) and Andini (2006a).

In spite of its wide acceptance within the profession, the spread of the framework developed by Mincer over the last forty years has not been uncontroversial. Some authors criticized the Mincerian framework by arguing that the equation is not able to provide a good fit of empirical data; some stressed that the average effect of schooling on earnings is likely to be non-linear in schooling; some suggested that education levels

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should replace schooling years in the wage equation. As a matter of example, Murphy and Welch (1990) maintained that the standard Mincer equation provides a very poor approximation of the true empirical relationship between earnings and experience, while Trostel (2005) argued that the average impact of an additional year of schooling on earnings varies with the number of completed schooling-years.

In summary, despite some critical voices, the history of human-capital regressions seems characterized by a generalized attempt of *consistently* estimating the coefficient of schooling (both on average and over the conditional wage distribution), under an implicit acceptance of the theoretical interpretation of the schooling-coefficient itself. Nevertheless, the important issue of the theoretical interpretation of the schooling-coefficient has been recently rediscovered and discussed by Heckman, Lochner and Todd (2005), who empirically tested several implications of the classical Mincerian framework, using Census data for the United States. Among other implications of the Mincerian approach, the authors tested and often rejected the implication that the return to schooling in terms of observed earnings is *independent* of labor-market experience.

On the lines of Heckman *et al.* (2005), our paper will provide additional theoretical and empirical arguments against the usual interpretation of the coefficient of schooling in the standard Mincer equation. Indeed, we will argue that the return to schooling in terms of observed earnings is, in general, *dependent* of labor-market experience. As we will see, the latter result can be easily derived from a dynamic specification of the Mincer equation where past observed earnings play a role in explaining current observed earnings.

The reminder of this paper is as follows. Section 2 describes the standard theory behind the Mincer equation. Section 3 develops the theoretical foundations of a new Mincer equation that we label dynamic, in contrast to the standard static framework. Section 4

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uses the dynamic Mincer equation to show that, in general, the return to schooling in terms of observed earnings is not independent of labor-market experience. Section 5 presents estimation results for the dynamic Mincer equation, which are consistent with the theoretical arguments proposed in section 3 and section 4. Section 6 concludes the manuscript.

2. Static Mincer equation

This section presents the theoretical foundations of the standard Mincer (1974) equation as recently reported by Heckman *et al.* (2003). Therefore, we make no claim of originality at this stage and mainly aim at helping the reader with notations and terminology adopted in the next sections[1].

Jacob Mincer argues that potential earnings today depend on investments in human capital made yesterday. Denoting potential earnings at time t as E_t, Mincer assumes that an individual invests in human capital a share k_t of his/her potential earnings with a return of r_t in each period t. Therefore we have:

$$(1) \qquad E_{t+1} = E_t(1 + r_t k_t)$$

which, after repeated substitution, becomes:

$$(2) \qquad E_t = \prod_{j=0}^{t-1}(1 + r_j k_j)E_0$$

or alternatively

[1] Although not original, we believe that section 2 is crucial for the paper.

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$$(3) \qquad \ln E_t = \ln E_0 + \sum_{j=0}^{t-1} \ln(1 + r_j k_j) .$$

Under the assumptions that:

- schooling is the number of years s spent in full-time investment[2] ($k_0 = ... = k_{s-1} = 1$),
- the return to schooling in terms of potential earnings is constant over time ($r_0 = ... = r_{s-1} = \beta$),
- the return to post-schooling investment in terms of potential earnings is constant over time ($r_s = ... = r_{t-1} = \lambda$),

we can write expression (3) in the following manner:

$$(4) \qquad \ln E_t = \ln E_0 + s \ln(1 + \beta) + \sum_{j=s}^{t-1} \ln(1 + \lambda k_j) ,$$

which yields to:

$$(5) \qquad \ln E_t \approx \ln E_0 + \beta s + \lambda \sum_{j=s}^{t-1} k_j .$$

[2] It is assumed that schooling starts at the beginning of life.

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for small values of β, λ and k[3].

In order to build up a link between potential earnings and labor-market experience z, Mincer assumes that the post-schooling investment linearly decreases over time, that is:

$$(6) \qquad k_{s+z} = \eta\left(1 - \frac{z}{T}\right)$$

where $z = t - s \geq 0$, T is the last year of the working life and $\eta \in (0,1)$.

Therefore, using (6), we can re-arrange expression (5) and get:

$$(7) \qquad \ln E_t \approx \ln E_0 - \eta\lambda + \beta s + \left(\eta\lambda + \frac{\eta\lambda}{2T}\right)z - \left(\frac{\eta\lambda}{2T}\right)z^2 .$$

In addition, following Mincer, we are interested in potential earnings net of post-schooling investment costs, which are given by:

$$(8) \qquad \ln E_t - \eta\left(1 - \frac{z}{T}\right) \approx \ln E_0 - \eta\lambda - \eta + \beta s + \left(\eta\lambda + \frac{\eta\lambda}{2T} + \frac{\eta}{T}\right)z - \left(\frac{\eta\lambda}{2T}\right)z^2$$

or alternatively by:

$$(9) \qquad \ln E_t - \eta\left(1 - \frac{z}{T}\right) \approx \alpha + \beta s + \delta z + \phi z^2$$

[3] Notice that the symbol of equality $(=)$ in expression (4) becomes a symbol of rough equality $(\approx)$ in expression (5).

For Peer Review

where $\alpha = \ln E_0 - \eta\lambda - \eta$, $\delta = \eta\lambda + \frac{\eta\lambda}{2T} + \frac{\eta}{T}$ and $\phi = -\frac{\eta\lambda}{2T}$.

Finally, assuming that observed earnings are equal to net potential earnings at any time t (a key-assumption, as we will see in the next section):

$$(10) \qquad \ln w_t = \ln E_t - \eta\left(1 - \frac{z}{T}\right),$$

and, using expression (9), we obtain the standard Mincer equation:

$$(11) \qquad \ln w_t \approx \alpha + \beta s + \delta z + \phi z^2 .$$

We will label expression (11) as *static Mincer equation* in order to distinguish the latter from the dynamic equation obtained in the next section.

3. Dynamic Mincer equation

Let us start stressing again that the standard Mincer equation assumes, in expression (10), that observed earnings are equal to net potential earnings at any time $t \geq s$. This section simply argues that *observed earnings do not instantaneously adjust to net potential earnings* because of two reasons.

First, employee's skills are not the only determinant of observed earnings. Schooling and post-schooling investments provide individuals with *net potential* earnings, meaning skills required to earn a given amount of money. However, *observed* earnings are the result of both employee's skills and employer's willingness to pay. Since real-life labor markets are characterized by asymmetric information and wage-bargaining,

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the possibility of a margin-formation between observed earnings and net potential earnings should not be ruled out a-priori. Empirically, this implies that observed earnings may not coincide with net potential earnings, although the first generally depend on the latter.

Second, observed earnings are sticky as already documented in the literature[4]. This means that observed earnings do not instantaneously adjust to changing environments and exhibit path-dependence. That is, current observed earnings partly depend on past observed earnings, for several reasons such as multi-period labor contracts both in unionized and non-unionized industries. However, despite the existing evidence (both at macroeconomic and microeconomic level) on the autoregressive nature of observed earnings, this stylized fact has not received enough attention in Mincerian studies so far.

Based on the above arguments, this section maintains that assumption (10) can be modified such that current observed earnings depend on both past observed earnings and current net potential earnings. For computational simplicity, we assume that current observed earnings are a Cobb-Douglas function of both past observed earnings and current net potential earnings. Hence, at any time $t \geq s$, observed earnings are given by the following expression:

$$(12) \qquad \ln w_t = \rho\left[\ln E_t - \eta\left(1 - \frac{z}{T}\right)\right] + (1-\rho)\ln w_{t-1}$$

with $\rho \in [0,1]$ and the following initial-condition:

$$(13) \qquad \ln w_{s-1} = \ln \overline{w}_{s-1}.$$

[4] See Taylor (1999) for a good survey.

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Expression (13) basically implies that the *first* observed wage at time s depends on both net potential earnings at time s and the minimum wage $\overline{w}$ at time $s-1$, which is set by law and therefore independent of schooling years.

Notice that the coefficient ρ can be interpreted as the bargaining power of the employee. Indeed, if the employee has full bargaining power ($\rho = 1$), observed earnings are equal to net potential earnings as in the expression (10) of the standard Mincer framework. However, if the employer has full bargaining power ($\rho = 0$), observed wages are completely independent of net potential earnings and equal to the legal minimum at any time $t \geq s$. Reality is likely to range between these two extreme scenarios, and expression (12) allows capturing this fact. Section 5 will provide empirical evidence supporting (12).

If we use expression (9) to replace net potential earnings in equation (12), then (12) becomes:

$$(14) \qquad \ln w_t \approx \rho\left(\alpha + \beta s + \delta z + \phi z^2\right) + (1-\rho)\ln w_{t-1}$$

or alternatively

$$(15) \qquad \ln w_t \approx \rho\alpha + (1-\rho)\ln w_{t-1} + \rho\beta s + \rho\delta z + \rho\phi z^2$$

which is equal to (11) if the employee has full bargaining power, i.e. setting $\rho = 1$. We will label expression (15) as *dynamic Mincer equation*.

For Peer Review

4. Returns to schooling

Based on model (11) and on model (15), this section provides several definitions of returns to schooling, which will be useful for the empirical application in the next section.

4.1 Static return to schooling in terms of net potential earnings

To begin, we find of interest stressing that the total return to schooling in the static model (11) is given by the following expression:

$$(16) \qquad \frac{\partial \ln w_t}{\partial s} = \frac{\partial \ln w_{s+z}}{\partial s} \approx \beta$$

and is constant over the working life, meaning independent of labor-market experience z. Further, because of assumption (10), the return to schooling in terms of observed earnings and the one in terms of net potential earnings coincide[5].

We will label β as static return to schooling in terms of net potential earnings and will show, in section 4.3, that our interpretation of β in terms of *net potential* rather than *observed* earnings is the most appropriate.

4.2 Returns to schooling in terms of observed earnings

The dynamic model (15) allows obtaining the evolution of the schooling return over the entire working life. For instance, at time s, expression (15) can be written as follows:

$$(17) \qquad \ln w_s \approx \rho\alpha + (1-\rho)\ln \overline{w}_{s-1} + \rho\beta s + \rho\delta 0 + \rho\phi 0^2$$

[5] See expression (8).

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and the return to schooling is given by:

$$(18) \qquad \beta(0) = \frac{\partial \ln w_s}{\partial s} \approx \rho\beta .$$

Analogously, at time $s+1$, expression (15) can be written as follows:

$$(19) \qquad \ln w_{s+1} \approx \rho\alpha + (1-\rho)\ln w_s + \rho\beta s + \rho\delta l + \rho\phi l^2$$

and the total return to schooling is given by:

$$(20) \qquad \beta(1) = \frac{\partial \ln w_{s+1}}{\partial s} \approx \rho\beta + \rho\beta(1-\rho) .$$

At time $s+2$, expression (15) is as follows:

$$(21) \qquad \ln w_{s+2} \approx \rho\alpha + (1-\rho)\ln w_{s+1} + \rho\beta s + \rho\delta 2 + \rho\phi 2^2$$

and the total return to schooling is given by:

$$(22) \qquad \beta(2) = \frac{\partial \ln w_{s+2}}{\partial s} \approx \rho\beta + \rho\beta(1-\rho) + \rho\beta(1-\rho)^2 .$$

Therefore, at time $s+z$, the return to schooling in terms of observed earnings is given by the following expression:

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$$(23) \qquad \beta(z) = \frac{\partial \ln w_{s+z}}{\partial s} \approx \rho\beta\left[1 + (1-\rho) + (1-\rho)^2 + (1-\rho)^3 + ... + (1-\rho)^Z\right],$$

and is, in general, dependent of labor-market experience z.

Clearly, at the end of the working life, the total return in terms of observed earnings is as follows:

$$(24) \qquad \beta(T) = \frac{\partial \ln w_{s+T}}{\partial s} \approx \rho\beta\left[1 + (1-\rho) + (1-\rho)^2 + (1-\rho)^3 + ... + (1-\rho)^T\right].$$

For Peer Review

4.3 Dynamic return to schooling in terms of net potential earnings

The return in expression (23) is, in general, lower than the return in expression (16), although the first converges to the latter as labor-market experience z increases. Indeed, for a value of $\rho \in (0,1)$, the following expression holds:

$$(25) \qquad \beta(\infty) = \lim_{z\to\infty} \beta(z) \approx \rho\beta\left[\frac{1}{1-(1-\rho)}\right].$$

Therefore, the dynamic model (15) is able to provide a measure of β comparable[6] with expression (16). We will label $\beta(\infty)$ as dynamic return to schooling in terms of net potential earnings.

Expression (25) helps to show that our interpretation of β in terms of *net potential* rather than *observed* earnings is the most appropriate because nobody can live and work

[6] Notice that $\rho\beta\left[\frac{1}{1-(1-\rho)}\right] = \beta$.

forever. To the extent of T being a finite number, the return to schooling in terms of observed earnings $\beta(z)$ can never be equal to β, but in the very special case of $\rho = 1$.

4.4 Final remarks

It is easy to prove that the following inequalities hold:

(26) $\beta(0) < \beta(z) < \beta(T) < \beta$

for every z and T such that $0 < z < T < \infty$ and $\beta > 0$, if $\rho \in (0,1)$.

In addition, one can verify that:

(27) $\beta(0) = \beta(z) = \beta(T) = 0 < \beta$

for every z and T such that $0 < z < T < \infty$ and $\beta > 0$, if $\rho = 0$.

Finally, it is easy to show that:

(28) $\beta(0) = \beta(z) = \beta(T) = \beta$

for every z and T such that $0 < z < T < \infty$ and $\beta > 0$, if $\rho = 1$.

5. Empirical application

Based on the static Mincer equation (11) and its dynamic version (15), we compare estimation results from the following two empirical models:

For Peer Review

(29) $\ln w_{it} = \mu_{1\theta} + \mu_{2\theta} s_i + \mu_{3\theta} z_{it} + \mu_{4\theta} z_{it}^2 + \mu_{5\theta it}$

with $\mathrm{Exp}\left(\mu_{5it} | s_{it}, z_{it}, z_{it}^2\right) = 0$ and $\mathrm{Quant}\left(\mu_{5\theta it} | s_{it}, z_{it}, z_{it}^2\right) = 0$ for each θ

(30) $\ln w_{it} = \upsilon_{1\theta} + \upsilon_{2\theta} \ln w_{it-1} + \upsilon_{3\theta} s_i + \upsilon_{4\theta} z_{it} + \upsilon_{5\theta} z_{it}^2 + \upsilon_{6\theta it}$

with $\mathrm{Exp}\left(\upsilon_{6it} | s_{it}, z_{it}, z_{it}^2, \ln w_{it-1}\right) = 0$ and $\mathrm{Quant}\left(\upsilon_{6\theta it} | s_{it}, z_{it}, z_{it}^2, \ln w_{it-1}\right) = 0$ for each θ

using both ordinary least squares and quantile-regression techniques.

Therefore, following the most recent practices and using two different approaches, we look at the impact of schooling not only on the mean but also on the shape of the conditional wage distribution.

Notice that θ is an indicator of the regression quantile. Further, notice that a number of potentially-relevant additional explanatory variables are disregarded because the aim of the application consists of comparing results from two simple and alternative models: a static model and a dynamic model.

We use data for Portuguese male workers extracted from the European Community Household Panel (ECHP), in the period of 1994-2001. Our unbalanced panel is described in Table 1. To avoid distortions due to outliers, following a common procedure, we exclude individuals whose hourly earnings are very high (10 times the average) or very low (0.10 times the average).

Based on sections 3 and 4, we will refer to the estimate of:

- υ_3 as the return to schooling $\beta(0)$;
- υ_2 as the bargaining power of the employer $1-\rho$;
- $1-\upsilon_2$ as the bargaining power of the employee ρ;

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- μ_2 as the static return to schooling in terms of net potential earnings β;
- $\frac{\upsilon_3}{1-\upsilon_2}$ as the dynamic return to schooling in terms of net potential earnings $\beta(\infty)$;

The empirical validation of model (15) obviously requires that:

- $\hat{\upsilon}_2$ ranges between 0 and 1, both on average and over the conditional wage distribution.

Particularly, if one agrees that the bargaining power of the employer is generally higher than the bargaining strength of the employee, then we may reasonably expect that:

- $\hat{\upsilon}_2$ ranges between 0.5 and 1, both on average and over the conditional wage distribution.

Further, from expressions (16) and (18), we may expect that:

- $\hat{\upsilon}_3$ is lower than $\hat{\mu}_2$, both on average and over the conditional wage distribution;
- $\hat{\upsilon}_3$ is roughly equal to the product between $\hat{\mu}_2$ and $1-\hat{\upsilon}_2$, both on average and over the conditional wage distribution;
- $\hat{\upsilon}_3$ is positively correlated with $1-\hat{\upsilon}_2$ over the conditional wage distribution.

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Finally, from expressions (16) and (25), one can reasonably expect that:

- $\frac{\hat{\upsilon}_3}{1-\hat{\upsilon}_2}$ is roughly equal to $\hat{\mu}_2$, both on average and over the conditional wage distribution.

Estimation results are reported in Table 2 and Figure 1. Surprisingly, the empirical analysis does not reject any of our six theoretical predictions. The results based on ordinary least squares are very satisfactory. Regarding the quantile-regression results, the only case where we obtain less satisfactory results is related to the second decile of the conditional wage distribution.

Compared to the standard model (29), the main advantage of model (30) consists of allowing for the estimation of the return to schooling in terms of *observed* earnings at several stage of the working life, by replacing estimation results for υ_2 and υ_3 into expression (23)[7].

A final note is about our specific results for the standard Mincer equation (29) in comparison with previous estimates for Portugal.

Despite the existence of several studies using Portuguese data and quantile-regression techniques[8], to the best of our knowledge, the only two recent journal articles adopting the basic Mincerian specification (29) as underlying empirical framework are due to Pereira and Martins (2002a) and Martins and Pereira (2004). In both the two studies, the authors focus on male workers as we do, but they use cross-sectional data for the year of

[7] See, for instance, expression (22).

[8] Examples are provided by Hartog et *al.* (2001), Machado and Mata (2001), and Andini (2006a), among others.

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1995, extracted from the so-called *Quadros de Pessoal* data-set, while we use longitudinal data for the period of 1994-2001, from the ECHP.

Specifically, Martins and Pereira find a coefficient of schooling years, estimated using ordinary least squares, that is four percentage-points higher than our estimated coefficient (12.6% vs. 8.2%, see Table 2, column 4). Further, we observe a similar gap regarding the impact of schooling on within-groups wage inequality, computed as difference[9] between the coefficient at the ninth decile of the conditional wage distribution and the coefficient at the first decile (8.9% vs. 4.9%).

Nevertheless, despite the reported gaps, our results for 1994-2001 are not really in contrast with those of Martins and Pereira for 1995 because there is evidence of a *decreasing* trend in both average returns and within-groups-wage-inequality measures in Portugal, after a peak in 1995[10].

6. Conclusions

Being conceived as a long-run equilibrium model, the standard Mincer framework disregards short-run earnings dynamics and assumes that current net potential earnings are equal to current observed earnings at any point in time. This framework, however, has some strong empirical implications which may or may not be consistent with data. Particularly, as argued by Heckman *et al*. (2005), one of the empirical implications of the classical Mincerian model, the independence of the return to schooling in terms of observed earnings from labor-market experience, seems often rejected by empirical tests

[9] Notice that, using our terminology, this difference measures the impact of schooling on within-groups *net potential* wage inequality.

[10] See Pereira and Martins (2002b) and Budría and Pereira (2005).

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performed using Census data on white and black male workers in the United States. This finding is very interesting and deserves, in our view, further investigation.

Our paper is primarily intended to offer an explanation why the return to schooling in terms of observed earnings may be dependent of labor-market experience. With an eye on real-life labor markets, we start our analysis from the hypothesis that observed earnings do not instantaneously adjust to net potential earnings, and argue in favor of a dynamic specification of the Mincer equation, where past observed earnings contribute to explain current observed earnings together with current net potential earnings. Within our dynamic framework, the return to schooling in terms of observed earnings turns out to be dependent of labor-market experience. We also provide empirical evidence in favor of a dynamic approach, using longitudinal data for Portuguese male workers over the period of 1994-2001. This evidence is roughly consistent with our earlier findings using data on male workers from the US Longitudinal Survey of Youth (see Andini, 2006b).

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For Peer Review

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Table 1

Sample statistics based on ECHP data for Portuguese male workers: 1994-2001

	Obs.	Mean	S.E.	Min	Max
Logarithm of hourly wage	14145	6.34	0.50	4.28	8.78
Years of schooling	14145	8.44	3.68	3.00	27.00
Experience	14145	18.02	12.53	0.00	55.00
Age	14145	35.02	11.60	17.00	65.00

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Table 2

Estimation results based on ordinary least squares and quantile regression

Column	(1)	(2)	(3)	(4)	(5)
Theoretical parameter	$\beta(0)$	$1-\rho$	ρ	β	$\beta(\infty)$
Empirical parameter	$\hat{\upsilon}_3$	$\hat{\upsilon}_2$	$1-\hat{\upsilon}_2$	$\hat{\mu}_2$	$\frac{\hat{\upsilon}_3}{1-\hat{\upsilon}_2}$
$\theta = 0.1$	0.007 (0.001)	0.853 (0.010)	0.147	0.053 (0.002)	0.046
$\theta = 0.2$	0.002 (0.000)	0.935 (0.007)	0.065	0.062 (0.001)	0.034
$\theta = 0.3$	0.003 (0.000)	0.954 (0.003)	0.046	0.068 (0.001)	0.055
$\theta = 0.4$	0.003 (0.000)	0.953 (0.003)	0.047	0.074 (0.001)	0.063
$\theta = 0.5$	0.004 (0.000)	0.943 (0.004)	0.057	0.079 (0.001)	0.069
$\theta = 0.6$	0.006 (0.000)	0.916 (0.004)	0.084	0.087 (0.001)	0.075
$\theta = 0.7$	0.010 (0.000)	0.890 (0.004)	0.110	0.091 (0.001)	0.088
$\theta = 0.8$	0.014 (0.001)	0.855 (0.008)	0.145	0.097 (0.001)	0.099
$\theta = 0.9$	0.022 (0.002)	0.798 (0.011)	0.202	0.102 (0.001)	0.108
OLS	0.012 (0.001)	0.843 (0.004)	0.157	0.082 (0.001)	0.079

Standard errors in parentheses. Estimates of υ_2, υ_3 and μ_2 are all significant at 1% level.

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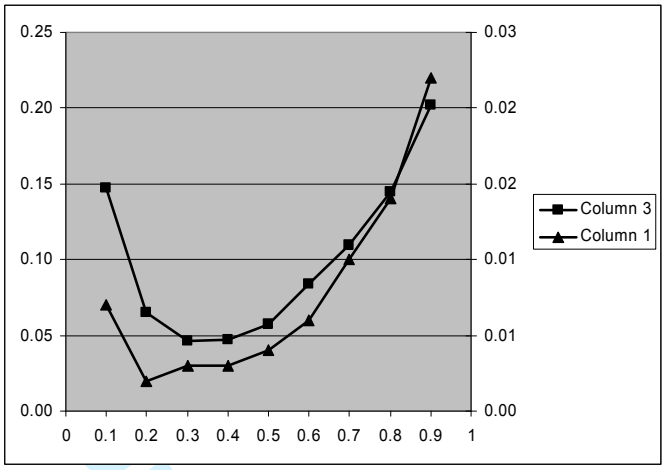
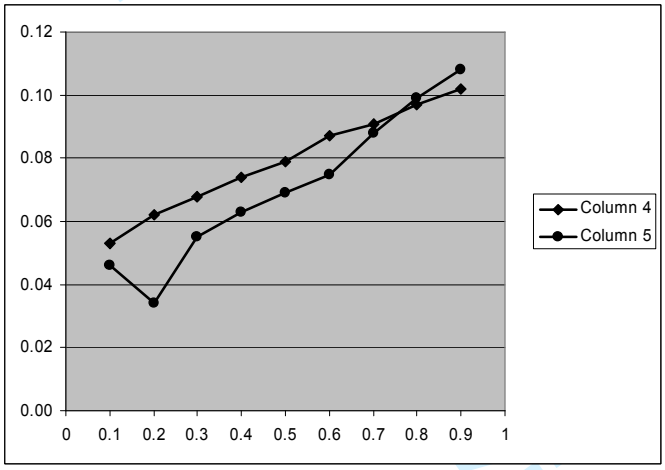
Figure 1

Plotted estimation results based on quantile regression