How Fast Do Wages Adjust to Human-Capital Productivity? Dynamic Panel-Data Estimates

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ABSTRACT

Mincer suggested that, by investing in human capital, an individual can increase the monetary value of his productivity and achieve a certain level of potential earnings. If the labor market were characterized by perfect competition at any point in time, the potential earnings of an individual and his observed earnings would coincide at any point in time. That is, an individual would always earn the monetary value of his human-capital productivity. However, without departing from the perfect-competition hypothesis in the long run, there may be frictions in the labor market in the short run that may cause the observed wages to adjust to the potential wages with some lag. In this case, the return to the individual human-capital investment measured in terms of observed earnings - say the observed return - may be different, at some point in time, from the return to the same investment measured in terms of potential earnings - say the potential return. This paper investigates this hypothesis and shows that the observed return to schooling is substantially lower than its potential level at the beginning of the working life.

Keywords: Mincer Equation, Wages, Human Capital.
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1. Introduction

In the standard human-capital model proposed by Mincer (1974), the logarithm of the hourly observed wage of an individual is explained by schooling years, potential labor-market experience and experience squared. This section presents the theoretical foundations of the standard Mincer equation as 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.

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 potential earnings with a return of r_t in each period t. Therefore we have:

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

which, after repeated substitution, becomes:

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

or alternatively:

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

Under the assumptions that:

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

we can write expression (3) as follows:

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

which yields:

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

for small values of β, λ and k [1].

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:

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

Then, by subtracting (6) from (7), we obtain an expression for net potential earnings, i.e. potential earnings net of post-schooling investment costs[2]:

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

which can also be written as:

$$(9) \qquad \ln npe_t \approx \alpha + \beta s + \delta z + \phi z^2 + \ln E_0$$

where $\ln npe_t = \ln E_t - \eta\left(1 - \frac{z}{T}\right)$, $\alpha = -\eta\lambda - \eta$, $\delta = \eta\lambda + \frac{\eta\lambda}{2T} + \frac{\eta}{T}$ and $\phi = -\frac{\eta\lambda}{2T}$.

Assuming that observed earnings are equal to net potential earnings at any time $t \geq s$ (a key-assumption, as shall be seen in the next section):

$$(10) \qquad \ln w_t = \ln npe_t$$

and, using expression (9), we get:

$$(11) \qquad \ln w_t \approx \alpha + \beta s + \delta z + \phi z^2 + \ln E_0$$

By adding subscripts where necessary, we get:

$$(12) \qquad \ln w_{it} \approx \alpha + \beta s_i + \delta z_{it} + \phi z_{it}^2 + \ln E_{0i}$$

[1] Note that the symbol of equality (=) in expression (4) becomes a symbol of rough equality ($\approx$) in expression (5). It happens because, if a variable x is closed to zero, then $\ln(1 + x) \approx x$.

[2] Note the post-schooling investment costs are given by $k_t E_t$ with $t \geq s$. Therefore, net potential earnings in levels are given by $E_t - k_t E_t$, or $E_t(1 - k_t)$ which, after taking logarithms, if k is small, is equal to $\ln E_t - k_t$, i.e. the left-hand side of expression (8).

By making the model stochastic, we obtain:

(13) $$\ln w_{it} = \alpha + \beta s_i + \delta z_{it} + \phi z_{it}^2 + \ln E_{0i} + e_{it}$$

Normally, the error e_{it} is assumed to be a pure well-behaved individual wage shock, uncorrelated with the explanatory variables. Instead, as $\ln E_{0i}$ represents the value of the individual potential earnings at birth, it is usually interpreted as the value of the individual unobserved ability and is therefore assumed be correlated with s_i and z_{it}. Hence, the estimation of model (13) is non-trivial.
To conclude this section, it is important to stress that the total return to schooling in the static model (13) is given by the following expression:

(14) $$\frac{\partial \ln w_{it}}{\partial s_i} = \beta$$

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.
We label β as 'the static return to schooling in terms of net potential earnings' and show, in Section 5, that our interpretation of β in terms of *net potential* rather than *observed* earnings is the most appropriate.

2. Adjustment model

If we take as a starting point the presentation of the Mincer's model made in the previous section, it is possible to argue that the Mincer's model is characterized by two main features. First, it provides an explanation why the logarithm of the net potential earnings of an individual at time $t = s + z$ can be approximately represented as a function of s and z, i.e. expression (9). This expression can be seen as 'the building block' of the Mincer's model. Second, it is based on the assumption that, at any time $t \geq s$, the logarithm of the observed wage of an individual is equal to the monetary value of his net human-capital productivity, measured by his net potential wage, i.e. assumption (10).
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 model is not able to provide a good fit of empirical data; some stressed that the average effect of schooling on earnings is non-linear in schooling; some suggested that education levels should replace schooling years in the wage equation. For instance, Murphy and Welch (1990) maintained that the standard Mincer equation provides a very poor approximation of the true empirical relationship between earnings and experience, Trostel (2005) argued that the average impact of an additional year of schooling on earnings varies with the number of completed schooling years, while Belzil (2007) argued that schooling and experience are not separable in a wage equation.
Nevertheless, if one looks at the big picture, the history of human-capital regressions has been characterized by a generalized attempt of *consistently* estimating the coefficient of schooling, under an implicit acceptance of the theoretical interpretation of the coefficient itself, and therefore of both (9) and (10).

A few years ago, however, the important issue of the theoretical interpretation of the schooling coefficient has been rediscovered by Heckman et al. (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), this paper provides additional 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 *dependent* of labor-market experience even if the building block of the Mincer's theory is assumed to hold. The empirical analysis supports some earlier evidence presented by Andini (2005)[3].

Unlike previous studies, this paper does not question the building block of the Mincer's theory, i.e. expression (9). Although expression (9) can be criticized, and has been criticized in the past, it has a feature that is very appreciated by the applied economist: it allows the estimation of a wage model that is linear in parameters (see model (13)). In this paper, we show that, keeping the linearity in parameters of the model, and therefore assuming that (9) holds (an assumption made in hundreds of studies), one can actually obtain a better estimate of the return to schooling in terms of observed earnings by relaxing assumption (10) in a simple and flexible way.

The main argument to relax assumption (10) is as follows. As we have seen, Mincer suggested that, by investing in human capital, an individual can increase the monetary value of his productivity and achieve a certain level of net potential earnings. If the labor market were characterized by perfect competition at any point in time, the net potential earnings of an individual and his observed earnings would coincide at any point in time, as in assumption (10). That is, an individual would always earn the net monetary value of his human-capital productivity. However, without departing from the perfect-competition hypothesis in the long run, there may be frictions in the labor market in the short run that may cause the observed wages to adjust to the potential wages *with some lag*. In this case, the return to the individual human-capital investment measured in terms of observed earnings - say the observed return - may be different, at some point in time, from the return to the same investment measured in terms of net potential earnings - say the potential return. This paper investigates this hypothesis and shows that the observed return to schooling is substantially lower than its potential level at the beginning of the working life.

On the lines of Flannery and Rangan (2006) among others, we argue that assumption (10) can be replaced by a more flexible assumption. Particularly, observed earnings can be seen as dynamically adjusting to net potential earnings, according to the following simple adjustment model:

$$(15) \qquad \ln w_t - \ln w_{t-1} = \rho(\ln npe_t - \ln w_{t-1})$$

where $\rho \in [0,1]$ measures the speed of adjustment.

If $\rho = 1$, then assumption (10) holds, observed earnings are equal (adjust) to net potential earnings at time t (within period t), and the standard Mincerian model (11)

[3] Some of the ideas that are presented in this paper can also be found in Andini (2007), Andini (2009) and Andini (2010a). However, these works do not use GMM techniques in the estimation of the wage equation.

holds. If instead $\rho = 0$, then observed earnings are constant over time, always equal to the labor-market entry earnings $\ln w_s$, and do not adjust at all to variations of net potential earnings. In general, when the speed of adjustment is neither zero nor one, by replacing expression (9) into (15), we get:

$$(16) \qquad \ln w_t \approx (1-\rho)\ln w_{t-1} + \rho(\alpha + \beta s + \delta z + \phi z^2 + \ln E_0)$$

or alternatively:

$$(17) \qquad \ln w_t \approx \upsilon_0 + \upsilon_1 \ln w_{t-1} + \upsilon_2 s + \upsilon_3 z + \upsilon_4 z^2 + \rho \ln E_0$$

where $\upsilon_0 = \rho\alpha$, $\upsilon_1 = 1-\rho$, $\upsilon_2 = \rho\beta$, $\upsilon_3 = \rho\delta$ and $\upsilon_4 = \rho\phi$.
By adding subscripts where necessary, we get:

$$(18) \qquad \ln w_{it} \approx \upsilon_0 + \upsilon_1 \ln w_{it-1} + \upsilon_2 s_i + \upsilon_3 z_{it} + \upsilon_4 z_{it}^2 + \upsilon_i$$

where $\upsilon_i = \rho \ln E_{0i}$.
By making the model stochastic, we get:

$$(19) \qquad \ln w_{it} = \upsilon_0 + \upsilon_1 \ln w_{it-1} + \upsilon_2 s_i + \upsilon_3 z_{it} + \upsilon_4 z_{it}^2 + \upsilon_i + e_{it}$$

Expression (19) is a dynamic version of the Mincer equation, which we label as the ‘adjustment model’. When individual-level longitudinal data are available, the complement to one of the speed of adjustment $(1-\rho)$ can be estimated and the theory underlying (19) can be tested. The minimum requirement for the theory to be consistent with the data is to find that the coefficient υ_1 is significantly different from zero.

3. Methods

To explore wage adjustment dynamics, we need to estimate a dynamic panel-data model with unobserved individual heterogeneity (due to the presence of initial potential earnings $\ln E_{0i}$ in model (19)) of the following type:

$$(20) \qquad Y_{it} = \upsilon_i + \upsilon_1 Y_{it-1} + \upsilon_2 X_{it} + e_{it}$$

Since $Y_{it-1} = \upsilon_i + \upsilon_1 Y_{it-2} + \upsilon_2 X_{it-1} + e_{it-1}$, then Y_{it-1} is a function of υ_i. Therefore, Y_{it-1} is correlated with the composite error term $\upsilon_i + e_{it}$, making the OLS estimator to be inconsistent.
Even if the within-transformation $Y_{it} - \overline{Y}_i = \upsilon_1\left(Y_{it-1} - \overline{Y}_{i,-1}\right) + \upsilon_2(X_{it} - \overline{X}_i) + (e_{it} - \overline{e}_i)$ eliminates υ_i, the FE estimator is not consistent as $E\left[(Y_{it-1} - \overline{Y}_{i,-1})(e_{it} - \overline{e}_i)\right] = 0$ does not hold. This is because $Y_{it-1} - \overline{Y}_{i,-1}$ is correlated with $e_{it} - \overline{e}_i$. Indeed $\overline{e}_i$ contains e_{it-1} and thus is correlated with Y_{it-1}.
The RE estimator is inconsistent as well since, likewise the case of the FE estimator, $E\left[(Y_{it-1} - \theta\overline{Y}_{i,-1})(e_{it} - \theta\overline{e}_i)\right] = 0$ does not hold. The main difference is the presence of the

coefficient θ which comes from the GLS quasi-demeaning transformation $Y_{it} - \theta\overline{Y}_i = \upsilon_1\left(Y_{it-1} - \theta\overline{Y}_{i,-1}\right) + \upsilon_2(X_{it} - \theta\overline{X}_i) + (e_{it} - \theta\overline{e}_i)$.

An alternative transformation that eliminates υ_i is the first-difference transformation:

$$(21) \qquad Y_{it} - Y_{it-1} = \upsilon_1\left(Y_{it-1} - Y_{it-2}\right) + \upsilon_2(X_{it} - X_{it-1}) + (e_{it} - e_{it-1})$$

Based on model (21), Anderson and Hsiao (1978) propose to use $Y_{it-2} - Y_{it-3}$ or simply Y_{it-2} as instruments for $Y_{it-1} - Y_{it-2}$. These instruments are mathematically linked to (hence correlated with) $Y_{it-1} - Y_{it-2}$ and uncorrelated with $e_{it} - e_{it-1}$, as long as e_{it} is not serially correlated.

Arellano and Bond (1991) provide a useful test for autocorrelation in the errors. The test has a null hypothesis of 'no autocorrelation' and is applied to the differenced residuals $\Delta e_{it} = \vartheta_1 \Delta e_{it-1} + \vartheta_2 \Delta e_{it-2} + \omega_{it}$. The test for the AR(1) process in first differences should reject the null hypothesis as Δe_{it-1} is mathematically linked to Δe_{it} through e_{it-1}. The test for the AR(2) process in first differences is more important because it detects first-order serial correlation in levels by looking at second-order correlation in differences. That is, if $\vartheta_2 \neq 0$, then the residuals in levels are serially correlated of order one (i.e. $e_{it} = \tau_1 e_{it-1}$). This makes the second-lags instrument set invalid since Δe_{it} is correlated to the $t-2$ instruments. In this case, one should restrict the instrument set to longer lags.

The IV procedure suggested by Anderson and Hsiao (1978) provides consistent but not efficient estimates because it does not exploit all the available moment conditions. Arellano and Bond (1991) provide a more efficient GMM procedure that uses all the orthogonality conditions between the lagged values of Y_{it} and the first differences of e_{it}, that is $E\left[Y_{it-h}\left(e_{it} - e_{it-1}\right)\right] = 0$ for $h \geq 2$ and $t = 3, \ldots\ldots, T$. This is the simplest setup of the so-called Difference GMM estimator (GMM-DIF).

The null hypothesis of 'the model is not over-identified' can be tested using the Sargan test. A robust alternative is the Hansen J test which has the same null hypothesis of the Sargan test.

As the method by Arellano and Bond can generate a very high number of instruments, the evidence can suffer a problem of instruments proliferation, meaning that the endogenous variables can be over-fitted, and the power of the Hansen test to detect instruments joint-validity can be weakened. Hansen test p-values equal to 1, or very close to 1, should be seen as a warning (Roodman, 2006).

In model (21), if X is strictly exogenous (that is $E\left[X_{it}e_{ih}\right] = 0$ for all $t, h = 1, \ldots\ldots, T$), then all the X_{it} are valid instruments for (21). Specifically, the additional moment conditions that can be used are $E\left[X_{ih}\left(e_{it} - e_{it-1}\right)\right] = 0$ for each t, h. Additional efficiency is obtained if the first differenced Xs are also used as instruments. In this case, the additional moment conditions are $E\left[\left(X_{it} - X_{it-1}\right)\left(e_{it} - e_{it-1}\right)\right] = 0$ for each t.

If X contains predetermined variables rather than exogenous (that is $E\left[X_{it}e_{ih}\right] = 0$ only for $h \geq t$), then only the X_{it} for $t = 1, \ldots., h-1$ can be used as valid instruments for (21). In this case, the additional moment conditions that can be used are $E\left[X_{it-h}\left(e_{it} - e_{it-1}\right)\right] = 0$ for $h = 1, \ldots, t-1$ and for each t.

If X contains endogenous variables (that is $E[X_{it}e_{ih}]=0$ only for $h>t$), as in model (19), their first differences in model (21) can be instrumented with lagged levels of the variables in levels. In this case, the additional moment conditions are $E[X_{it-h}(e_{it}-e_{it-1})]=0$ for $h\geq 2$ and $t=3,......,T$.
Arellano and Bover (1995) and Blundell and Bond (1998) also propose to instrument endogenous variables in levels with their lagged first differences. In this case, the additional moment conditions are $E[(Y_{it-h}-Y_{it-h-1})(\upsilon_i+e_{it})]=0$ and $E[(X_{it-h}-X_{it-h-1})(\upsilon_i+e_{it})]=0$. Adding these moment conditions to those of the Difference GMM estimator originates the so-called System GMM estimator (GMM-SYS).
In this paper, we use the System GMM estimator because its Difference version is based on orthogonality conditions that do not allow to estimate the υ_2 coefficient of the schooling variable. This happens because all the orthogonality conditions of the Difference GMM estimator use the first difference of the residuals, i.e. $e_{it}-e_{it-1}=Y_{it}-Y_{it-1}-\upsilon_1(Y_{it-1}-Y_{it-2})-\upsilon_2(X_{it}-X_{it-1})$, and therefore time-invariant Xs are dropped out. Actually, this also happens with the System orthogonality condition $E[(X_{it-h}-X_{it-h-1})(\upsilon_i+e_{it})]=0$, but it does not happen with the orthogonality condition $E[(Y_{it-h}-Y_{it-h-1})(\upsilon_i+e_{it})]=0$, which is a key condition to estimate the coefficients of time-invariant variables in a dynamic panel-data model with unobserved heterogeneity. Blundell and Bond (2000) show that the joint stationarity of the Y and X processes is sufficient for the validity of this key condition, although not necessary (if the Y series has been generated for sufficiently long prior to the sample period, as in our sample, then any influence of the so-called initial-condition restriction is negligible).

4. Data

The empirical application proposed in the next section in based on data on male workers, aged between 18 and 65, for Belgium, Denmark and Finland. The data are extracted from the European Community Household Panel (ECHP) and cover the period of 1994-2001 for Belgium and Denmark while only 1996-2001 for Finland. Table 1 contains a description of the sample statistics. We restrict the analysis to males in order to minimize the classical sample-selection problems that would arise with females.
To obtain the variables for years of schooling (s), potential labor-market experience (z) and logarithm of gross hourly wage (lnw), we use the following ECHP variables:

- pt023. Age when the highest level of general or higher education was completed
- pe039. How old were you when you began your working life, that is, started your first job or business?
- pd003. Age
- pi211mg. Current wage and salary earnings – gross (monthly)
- pe005. Total number of hours per week (in main + additional jobs)

Specifically, to be consistent with the standard Mincerian model where the representative agent first stops schooling and then starts working, we select a sample of individuals whose age at the completion of the highest level of education was not higher than the age at the start of the working life (pt023 ≤ pe039) and define the human-capital variables as follows:

- $s = pt023 - 6$
- $z = pd003 - s - 6$

It is worth stressing that the variable s does not necessarily reflect successfully completed years of schooling. This is a compromise that allows us to obtain homogenous measures of schooling years (and potential labor-market experience) across three countries that are different in many aspects including educational systems.
The variable lnw represents the natural logarithm of the individual gross hourly wage. From the gross monthly wage (pi211mg), we obtain the daily (dividing the monthly wage by 30) and the weekly wage (multiplying the daily wage by 7). Dividing the latter by the number of weekly hours of work (pe005), we obtain the hourly wage.

5. Estimates

Table 2 presents estimates of model (19) based on both OLS and GMM techniques. Our preferred estimates are the GMM-SYS estimates, accounting for endogeneity, individual heterogeneity and time effects. Specifically, as referred in Section 3, these estimates are obtained using the estimator of Blundell and Bond (1998). In our preferred estimates, the coefficient $\upsilon_1 = 1 - \rho$ is statistically different from zero and estimated at 0.218, 0.335 and 0.420 in Finland, Belgium and Denmark, respectively. This implies that the speed of adjustment ρ is statistically different from one and estimated at 0.782, 0.665 and 0.580 in Finland, Belgium and Denmark, respectively. In addition, the standard Mincerian covariates, related to the individual human capital, are generally found to be significant. Note that all the standard specification tests are passed.
As expected, the OLS estimator over-estimates the autoregressive coefficient while the GMM-SYS estimates without year effects are not reliable because the model without time effects that does not pass the Hansen J over-identification test in the case of Finland, the Arellano-Bond 2[nd] order autocorrelation test in the case of Denmark, both these tests in the case of Belgium.
Andini (2010b) provides extensions of model (19) and shows that the main results of this paper are highly robust to different specifications of the wage equation. In particular, using a publicly available dataset for the United States, it is shown that the extension of the control set to a very large number of covariates does not affect the significance of the wage lag and of the human-capital regressors. Plus, controlling for more than one wage lag provides an even better fit of the empirical data.
Using model (19), it can be easily shown that 'the return to schooling in terms of observed earnings' is given by the following expression:

$$(22) \qquad \beta(z) = \frac{\partial \ln w_{it}}{\partial s_i} = \upsilon_2(1 + \upsilon_1 + \upsilon_1^2 + ... + \upsilon_1^Z) = \rho\beta\left[1 + (1-\rho) + (1-\rho)^2 + ... + (1-\rho)^Z\right]$$

and is, in general, dependent of labor-market experience z.
The return in expression (22) is, in general, lower than the return in expression (14), although the former converges to the latter as z increases. Indeed, for a value of $\rho \in (0,1)$, the following expression holds:

$$(23) \qquad \beta(\infty) = \lim_{z \to \infty} \beta(z) = \frac{\upsilon_2}{1 - \upsilon_1} = \frac{\rho\beta}{1 - (1-\rho)} = \beta\,.$$

Therefore, the adjustment model (19) is able to provide a measure of β comparable with expression (14). We label $\beta(\infty)$ as 'the dynamic return to schooling in terms of net potential earnings' to distinguish it from the 'the static return to schooling in terms of net potential earnings' defined in Section 1.
Expression (23) helps to show that the interpretation of β in terms of *net potential* rather than *observed* earnings, made in Section 1, is the most appropriate because nobody can live and work 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 $\rho = 1$ (which is rejected in our application).

6. Numerical example

As a matter of example, we use the adjustment model (19) to compute returns to schooling in terms of both net potential and observed earnings, using our preferred estimates in Table 1 (GMM-SYS, controlling for year effects).
Using expression (23), one can easily calculate that the return to schooling in terms of potential earnings $\beta(\infty)$, the equivalent of the static β return in the standard Mincer model, is equal to 0.053, 0.089 and 0.093 in Denmark, Finland and Belgium, respectively. For comparison, Figure 1 also reports the standard coefficients of the static Mincer equation (see expression (14)), as reported in column (6) of Table 3.
In addition, we can use expression (22) to calculate the return to schooling in terms of observed earnings over the working life $\beta(z)$. As shown in Figure 1 (the horizontal axis measures potential labor-market experience z), the standard static Mincerian model would not capture the fact that the return to schooling is increasing over time at the beginning of the working life and that the observed return to schooling at labor-market entry $\beta(0)$ (estimated at 0.031, 0.062 and 0.070 in Denmark, Belgium and Finland, respectively) is well below the potential one (β or $\beta(\infty)$).

7. Conclusions

Mincer suggested that, by investing in human capital, an individual can increase the monetary value of his productivity and achieve a certain level of net potential earnings. If the labor market were characterized by perfect competition at any point in time, the net potential earnings of an individual and his observed earnings would coincide at any point in time. That is, an individual would always earn the net monetary value of his human-capital productivity. However, without departing from the perfect-competition hypothesis in the long run, there may be frictions in the labor market in the short run that may cause the observed wages to adjust to the potential wages with some lag. In this case, the return to the individual human-capital investment measured in terms of observed earnings - say the observed return - may be different, at some point in time, from the return to the same investment measured in terms of net potential earnings - say the potential return. This paper has investigated this hypothesis.
Consistently with the original Mincer's model, the adjustment model presented in this paper suggests that the potential return and the observed return coincide in the long-run equilibrium because the latter converges to the former as time increases. However, the model allows to characterize the adjustment process toward the long-run equilibrium and highlights that, at the beginning of the working life, there may be a difference between the potential and the observed return whose size depends on the magnitude of the adjustment speed. In addition, the adjustment model is also able to provide a measure of the potential return, alternative to the standard Mincerian beta.

Under the assumption that the Mincerian theory of the individual human-capital productivity holds, we have shown that the return to schooling in terms observed earnings can be better estimated by allowing a dynamic wage adjustment process to take place rather than imposing an equality between observed and potential earnings at any point in time. An interesting implication of a dynamic adjustment model is that it allows to take into account the argument, proposed by Heckman et al. (2005), that the observed return to schooling is not independent of labor-market experience and allows to estimate this return at several stages of the working life, including labor-market entry.
The estimation exercise has been conducted using micro data for Belgium, Denmark and Finland extracted from the European Community Household Panel. The results show that the observed return to schooling is substantially lower than its potential level at the beginning of the working life.

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Table 1. Sample statistics

Belgium, 1994-2001	Obs.	Mean	Std. Dev.	Min	Max
Log. of gross hourly wage	6873	6.164	0.433	2.815	8.697
Schooling years	6873	13.858	3.240	4	25
Potential labor-market experience	6873	19.521	10.362	0	51
Denmark, 1994-2001	Obs.	Mean	Std. Dev.	Min	Max
Log. of gross hourly wage	2053	4.811	0.521	-0.326	6.368
Schooling years	2053	14.943	4.592	6	29
Potential labor-market experience	2053	17.173	11.486	0	52
Finland, 1996-2001	Obs.	Mean	Std. Dev.	Min	Max
Log. of gross hourly wage	2341	4.256	0.509	-0.405	7.522
Schooling years	2341	15.423	3.355	5	27
Potential labor-market experience	2341	14.800	9.999	0	46

Table 2. Adjustment model

Dependent variable: Logarithm of gross hourly wage	Belgium	Denmark	Finland
	1994-2001	1994-2001	1996-2001
OLS			
Constant	1.223 (0.000)	0.983 (0.000)	1.193 (0.000)
Logarithm of gross hourly wage (-1)	0.757 (0.000)	0.775 (0.000)	0.627 (0.000)
Schooling years	0.016 (0.000)	0.009 (0.000)	0.023 (0.000)
Potential labor-market experience	0.005 (0.001)	0.001 (0.562)	0.007 (0.018)
Potential labor-market experience squared	-0.000 (0.168)	-0.000 (0.787)	-0.000 (0.288)
OLS, controlling for year effects			
Constant	1.252 (0.000)	0.948 (0.000)	1.179 (0.000)
Logarithm of gross hourly wage (-1)	0.754 (0.000)	0.772 (0.000)	0.624 (0.000)
Schooling years	0.016 (0.000)	0.010 (0.000)	0.025 (0.000)
Potential labor-market experience	0.006 (0.000)	0.002 (0.493)	0.008 (0.014)
Potential labor-market experience squared	-0.000 (0.094)	-0.000 (0.684)	-0.000 (0.308)
GMM-SYS			
Constant	2.102 (0.000)	1.740 (0.000)	2.005 (0.000)
Logarithm of gross hourly wage (-1)	0.443 (0.000)	0.543 (0.000)	0.305 (0.016)
Schooling years	0.073 (0.000)	0.017 (0.001)	0.051 (0.000)
Potential labor-market experience	0.022 (0.000)	0.027 (0.003)	0.016 (0.126)
Potential labor-market experience squared	-0.000 (0.116)	-0.000 (0.011)	-0.000 (0.725)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.001)	(0.029)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.065)	(0.041)	(0.510)
Hansen J overid. test (p-value)	(0.030)	(0.552)	(0.006)
GMM-SYS, controlling for year effects			
Constant	2.901 (0.000)	2.145 (0.000)	2.109 (0.000)
Logarithm of gross hourly wage (-1)	0.335 (0.000)	0.420 (0.000)	0.218 (0.085)
Schooling years	0.062 (0.000)	0.031 (0.000)	0.070 (0.000)
Potential labor-market experience	0.032 (0.000)	0.028 (0.006)	0.014 (0.188)
Potential labor-market experience squared	-0.000 (0.000)	-0.000 (0.023)	0.000 (0.922)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.001)	(0.033)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.121)	(0.117)	(0.493)
Hansen J overid. test (p-value)	(0.256)	(0.738)	(0.127)

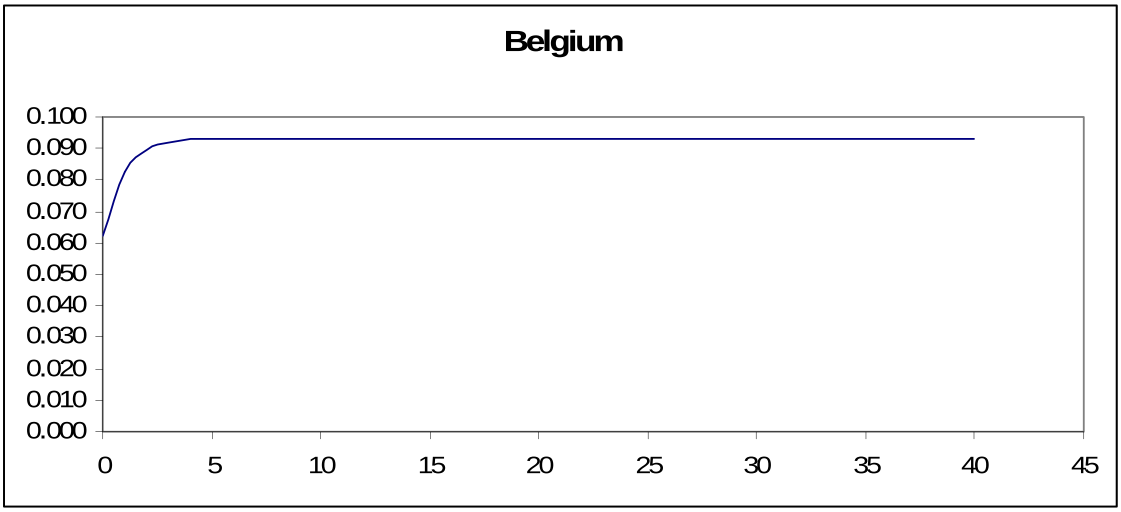
P-values of estimated coefficients, in parentheses, are based on White-corrected standard errors for OLS and on Windmeijer-corrected standard errors for GMM-SYS.

Table 3. Static returns to schooling in terms of net potential earnings

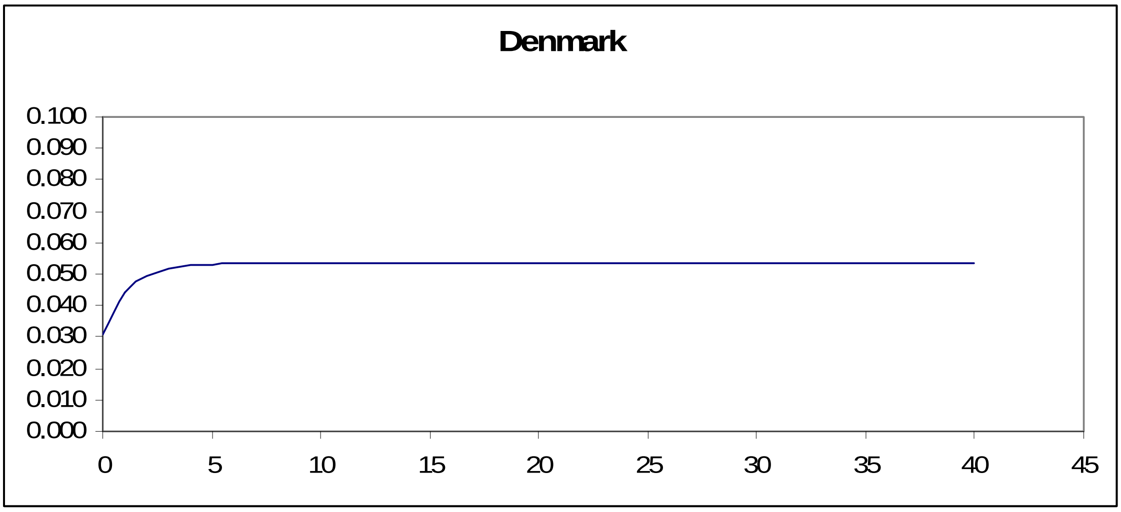
	(1) OLS	(2) OLS	(3) RE	(4) RE	(5) GMM-SYS	(6) GMM-SYS
Belgium	0.067 (0.000)	0.066 (0.000)	0.055 (0.000)	0.050 (0.000)	0.163 (0.000)	0.110 (0.000)
Denmark	0.043 (0.000)	0.046 (0.000)	0.042 (0.000)	0.044 (0.000)	0.043 (0.000)	0.054 (0.000)
Finland	0.059 (0.000)	0.062 (0.000)	0.048 (0.000)	0.053 (0.000)	0.093 (0.000)	0.102 (0.000)
Control for individual fixed effects	no	no	yes	yes	yes	yes
Control for year fixed effects	no	yes	no	yes	no	yes
Control for endogeneity	no	no	no	no	yes	Yes

Regression controls include constant term, experience and experience squared.
P-values of estimated coefficients, in parentheses, are based on White-corrected standard errors for OLS and on Windmeijer-corrected standard errors for GMM-SYS.

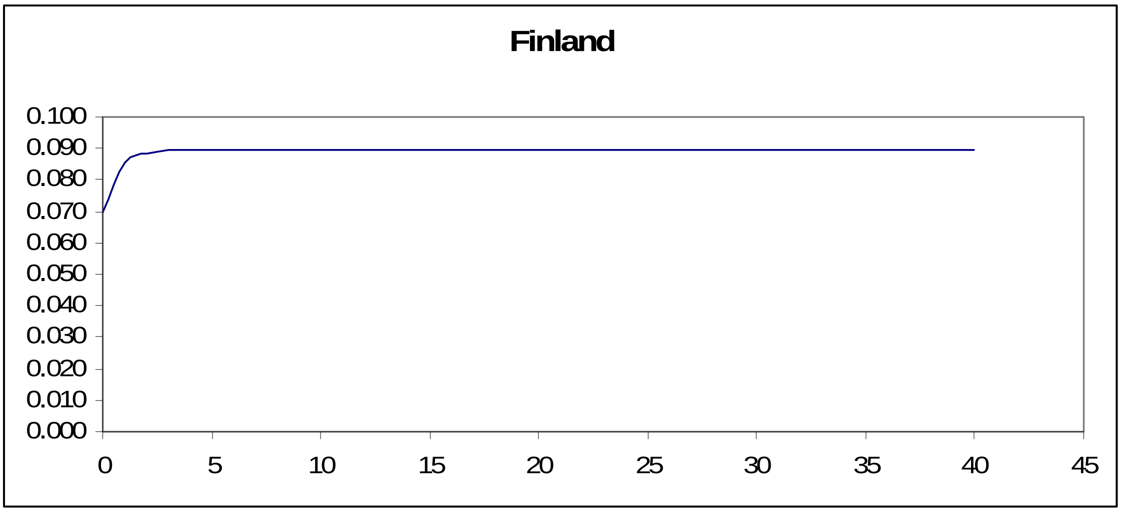
Figure 1. Returns to schooling in terms of observed earnings $\beta(z)$



Belgium: $\beta(0) = 0.062$, $\beta(\infty) = 0.093$, and $\beta = 0.110$



Denmark: $\beta(0) = 0.031$, $\beta(\infty) = 0.053$, and $\beta = 0.054$



Finland: $\beta(0) = 0.070$, $\beta(\infty) = 0.089$, and $\beta = 0.010$