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How Fast Do Wages Adjust to Human-Capital Productivity? Dynamic Panel-Data Evidence from Europe and the United States

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RESUMO/ABSTRACT

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Keywords: Mincer Equation, Wages, Human Capital.
JEL codes: I21, J31.

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1. Introduction

In the standard human-capital model proposed by Mincer (1974), the logarithm of the hourly observed earnings of an individual is explained by schooling years, potential labor-market experience and experience squared. This section presents the theoretical foundations of the standard Mincerian 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 ($k_0 = ... = k_{s-1} = 1$),
- the return to schooling in terms of potential earnings is constant over time ($r_0 = ... = r_{s-1} = \beta$),
- the return to the 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) $$\ln E_t = \ln E_0 + s\ln(1 + \beta) + \sum_{j=s}^{t-1}\ln(1 + \lambda k_j)$$

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:

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

which can also be written as:

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

where $\ln npe_t = \ln E_t - \eta\left(1 - \frac{z}{T}\right)$, $\alpha = \ln E_0 - \eta\lambda - \eta$, $\delta = \eta\lambda + \frac{\eta\lambda}{2T} + \frac{\eta}{T}$ 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 argue in the next section):

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

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

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

The reminder of this paper is as follows. Section 2 presents a dynamic adjustment model where assumption (10) is relaxed. Section 3 discusses the implications of the adjustment model for the computation of wage return to schooling. Section 4 shows that a dynamic wage equation can be seen as the solution of a simple wage-bargaining model. Section 5 presents some extensions of the empirical evidence proposed in the previous sections. Section 6 summarizes the main results of the paper in the light of the existing literature on human-capital regressions.

2. Adjustment model

Following Heckman et al. (2003), the standard Mincerian framework seems to be characterized by two main features. First, it provides an explanation why the logarithm

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

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). 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).
This paper does not question expression (9) and focuses on assumption (10). On the lines of Flannery and Rangan (2006), 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:

$$(12) \qquad \ln w_t - \ln w_{t-1} = \rho(\ln npe_t - \ln w_{t-1})$$

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) 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, replacing expression (9) into (12) gives:

$$(13) \qquad \ln w_t \approx (1-\rho)\ln w_{t-1} + \rho\left(\alpha + \beta s + \delta z + \phi z^2\right)$$

or alternatively:

$$(14) \qquad \ln w_t \approx \upsilon_0 + \upsilon_1 \ln w_{t-1} + \upsilon_2 s + \upsilon_3 z + \upsilon_4 z^2$$

where $\upsilon_0 = \rho\alpha$, $\upsilon_1 = 1-\rho$, $\upsilon_2 = \rho\beta$, $\upsilon_3 = \rho\delta$ and $\upsilon_4 = \rho\phi$.
Expression (14) is a dynamic version of the Mincer equation, which we label the adjustment model. Note that, 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 (14) can be tested. The main requirement for the theory to be consistent with the data is to find that the coefficient υ_1 is significantly different from zero.
Table 1 presents estimates based on model (14). We use OLS and GMM techniques to explore data on male workers (we restrict to males in order to minimize sample-selection problems), aged between 18 and 65, from the European Community Household Panel for Belgium, Denmark and Finland. The Appendix contains a detailed description of the sample statistics and describes how the variables of model (14) are obtained from the original ECHP variables.
Our preferred estimates in Table 1 are the GMM-SYS estimates, accounting for the endogeneity, individual heterogeneity and time effects (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. So, the main empirical result is that the observed wage at time t is not equal (does not adjust) to the monetary value of the individual net human-capital productivity (the net potential wage) at time t (within period t) since no country has a speed of adjustment either equal or closed to one. Hence, assumption (10) in the standard Mincerian model is rejected by the ECHP data for Belgium, Denmark and Finland.

Note that all standard tests are passed, *although* it is likely that extended versions of the adjustment model, with additional covariates, would probably fit the data better than the simple model (14). As expected, the OLS estimator over-estimates the autoregressive coefficient while the GMM-SYS estimates without year effects are not reliable because the corresponding model that does not pass either the Hansen J over-identification test (Finland) or the Arellano-Bond 2^{nd} order autocorrelation test[2] (Denmark), or both (Belgium).
As one would reasonably expect, due to different labor-market institutions, the speed of adjustment of observed hourly wages to human-capital productivity is heterogeneous across the three European countries considered in this study. Particularly, Finland is the country with the highest speed of adjustment, while Denmark is the country with the lowest speed.
The next section analyses the implications for the computation of the return to schooling deriving from the adoption of a dynamic approach to the Mincer equation. However, before moving to the next section, we would like to stress that model (14) has an additional interesting feature which will not be further explored in this paper. Particularly, it can be used to further justify some macroeconomic studies estimating the impact of schooling on GDP growth[3] and some microeconomic studies that estimate the impact of human capital on wage growth[4]. Indeed, by subtracting $\ln w_{t-1}$ at both sides of expression (14), we get a version of model (14) where schooling and labor-market experience affect wage growth, i.e. $\ln w_t - \ln w_{t-1} \approx \upsilon_0 - \rho \ln w_{t-1} + \upsilon_2 s + \upsilon_3 z + \upsilon_4 z^2$.

3. Implications for the return to schooling

This section shows that a dynamic version of the Mincer equation implies that the return to schooling in terms of observed earnings is not independent of labor-market experience. This result is consistent with the empirical evidence provided by Heckman et. al. (2005) and Belzil (2007). In addition, it is shown that the return to schooling in terms of net potential earnings, provided by the standard Mincer equation, can also be computed using its dynamic version.

3.1 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:

$$(15) \qquad \frac{\partial \ln w_t}{\partial s} = \frac{\partial \ln w_{s+z}}{\partial s} \approx \beta$$

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].

[2] This test has been introduced by Arellano and Bond (1991).

[3] See Krueger and Lindahl (2001) for a review.

[4] See Rubinstein and Weiss (2006) for a review. Another interesting contribution on this issue is provided by Connolly and Gottschalk (2006).

[5] See expression (9).

We label β as static return to schooling in terms of net potential earnings and show, in subsection 3.3, that our interpretation of β in terms of *net potential* rather than *observed* earnings is the most appropriate.

3.2 Returns to schooling in terms of observed earnings

The dynamic model (14) allows obtaining the evolution of the schooling return over the entire working life. For instance, at time s, expression (14) can be written as follows:

$$(16) \quad \ln w_s \approx \rho\alpha + (1-\rho)\ln \overline{w}_{s-1} + \rho\beta s + \rho\delta 0 + \rho\phi 0^2$$

where $\overline{w}_{s-1}$ is the minimum wage[6] at time $s-1$, assumed to be independent of schooling years. Therefore, the return to schooling at time s, i.e. when an individual enters the labor market, is given by:

$$(17) \quad \beta(0) = \frac{\partial \ln w_s}{\partial s} \approx \rho\beta .$$

Analogously, at time $s+1$, expression (14) can be written as follows:

$$(18) \quad \ln w_{s+1} \approx \rho\alpha + (1-\rho)\ln w_s + \rho\beta s + \rho\delta 1 + \rho\phi 1^2$$

and the total return to schooling is given by:

$$(19) \quad \beta(1) = \frac{\partial \ln w_{s+1}}{\partial s} \approx \rho\beta + \rho\beta(1-\rho) .$$

At time $s+2$, expression (14) is as follows:

$$(20) \quad \ln w_{s+2} \approx \rho\alpha + (1-\rho)\ln w_{s+1} + \rho\beta s + \rho\delta 2 + \rho\phi 2^2$$

and the total return to schooling is given by:

$$(21) \quad \beta(2) = \frac{\partial \ln w_{s+2}}{\partial s} \approx \rho\beta + \rho\beta(1-\rho) + \rho\beta(1-\rho)^2 .$$

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

$$(22) \quad \beta(z) = \frac{\partial \ln w_{s+z}}{\partial s} \approx \rho\beta\left[1 + (1-\rho) + (1-\rho)^2 + (1-\rho)^3 + ... + (1-\rho)^Z\right],$$

[6] If current observed earnings depend on both past observed earnings and current net potential earnings, as suggested by model (14), it is easy to see that, at time s, i.e. at labor-market entry, the reference past wage for the representative individual cannot be the wage at time $s-1$ because this wage is not observed (the individual is still enrolled in school at time $s-1$). Therefore, we find reasonable to assume that, for an individual at labor-market entry, the reference past wage is the minimum wage at time $s-1$. So, at time s, the individual tries to obtain a salary that is above the minimum wage as a reward to his human-capital investment (the schooling years accumulated at time s). Note that considering the minimum wage at time s rather than at time $s-1$ does not change the argument.

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:

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

3.3 Dynamic return to schooling in terms of net potential earnings

The return in expression (22) is, in general, lower than the return in expression (15), 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:

$$(24)\qquad \beta(\infty)=\lim_{z\to\infty}\beta(z)\approx\rho\beta\left[\frac{1}{1-(1-\rho)}\right].$$

Therefore, the dynamic model (14) is able to provide a measure of β comparable[7] with expression (15). We label $\beta(\infty)$ as dynamic return to schooling in terms of net potential earnings.
Expression (24) 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 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 $\rho=1$.

3.4 Final remarks

It is easy to prove that the following inequalities hold:

$$(25)\qquad \beta(0)<\beta(z)<\beta(T)<\beta$$

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:

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

for every z and T such that $0<z<T<\infty$ and $\beta>0$, if $\rho=0$.
Finally, it is easy to show that:

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

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

3.5 Numerical example

As a matter of example, we use the adjustment model (14) to compute returns to schooling in terms of both potential and observed earnings using our preferred estimates in Table 1 (GMM-SYS, controlling for year effects).

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

Using expression (24), it is easy to 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 (11), is equal to 0.053, 0.089 and 0.093 in Denmark, Finland and Belgium, respectively.
In addition, we can use expression (22) to calculate the average 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 actual return to schooling at labor-market entry $\beta(0)$ (estimated at 0.031, 0.062 and 0.070 in Denmark, Belgium and Finland, respectively) may be well below the potential one ($\beta(\infty)$).
Since a dynamic version of the Mincer equation seems sufficiently robust on the empirical ground, the next step consists of discussing its possible theoretical foundations. Specifically, the next section shows that a dynamic Mincer equation can be obtained as the solution of a simple wage-bargaining model.

4. Bargaining model

From a theoretical point of view, assumption (10) fits within the perfect-competition framework where the nominal wage equals the monetary value of the marginal labor productivity. However, if one believes that the imperfect-competition framework is a more realistic view of the labor market[8], then *several* arguments can support the statement that assumption (10) is unlikely to hold. This section focuses on *one* of the possible arguments: the existence of wage bargaining at worker-employer level. Some possible criticisms are discussed in the next section of this paper.
The standard Mincerian model puts emphasis on the supply side: the more an individual invests in his human-capital development, the higher his wage is. The model that is presented in this section aims at enhancing the role played by demand factors in determining wages, without diminishing the one played by supply factors. More explicitly, the argument is that 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 likely to be the result of both worker's skills (supply) and employer's willingness to pay (demand). Since real-life labor markets are characterized by wage bargaining, the possibility of a margin-formation between observed earnings and net potential earnings should not be ruled out a-priori. This implies that observed earnings may not coincide with net potential earnings at any time, although the former generally depend on the latter.
As additional feature, the model keeps into account the stylized fact that observed earnings exhibit path-dependence (persistence). To the best of our knowledge, this feature is novel because the existing (micro and macro) evidence on the autoregressive nature of observed earnings[9] has not received attention in Mincerian studies so far.
To anticipate the model's conclusion, current observed earnings are shown to be dependent on both past observed earnings and current net potential earnings.

Let us assume that the logarithm of the observed earnings of a worker arises from a simple, decentralized Nash bargaining between a worker and an employer and that:

[8] A general reference is the New Keynesian view of the labor market.

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

- Worker objective function: the worker maximizes his observed earnings at time t[10], namely the worker maximizes $U_t^w = \ln w_t$

- Employer objective function: the employer maximizes the difference between the monetary value of the worker's net productivity at time t and the salary that he has to pay to the worker, namely the employer maximizes $U_t^e = \ln npe_t - \ln w_t$

- Worker outside option: if bargaining fails, the outside option for the worker depends of whether he is employed or unemployed and, in case he is employed, on whether he bargains with his own employer or not:

  Case 1) if the worker is employed at time $t-1$, bargains with his own employer at time t and bargaining fails, then the outside option for the worker at time t is the unemployment benefit b at time t, i.e. $\tilde{U}_t^w = \ln b_t$
  Case 2) if the worker is employed at time $t-1$, bargains with an employer different from his own employer at time t and bargaining fails, then the outside option for the worker at time t is the salary that he receives from his own employer at time t, i.e. $\tilde{U}_t^w = \ln \tilde{w}_t$.
  Case 3) if the worker is unemployed at time $t-1$, bargains with an employer at time t and bargaining fails, then the outside option for the worker at time t is the unemployment benefit b at time t, i.e. $\tilde{U}_t^w = \ln b_t$
  Case 4) if the worker has never been employed, bargains with an employer at time t and bargaining fails, then the outside option for the worker belongs to the continuous interval between zero and the miminum wage (depending on the generosity of the welfare assistance) because he is not entitled to receive the unemployment benefit (he has not paid any unemployment-benefit contribution) but may be entitled to receive some welfare aid, unlikely to be above the minimum wage[11], i.e. $\tilde{U}_t^w = \ln a_t$

- Employer outside option: if bargaining fails, the outside option for the employer is $\tilde{U}_t^e = 0$ because the employer neither gets the monetary value of the worker's net productivity nor pays a salary

- Nash bargaining function: the Nash bargaining function has a Cobb-Douglas specification, i.e. $U_t = (U_t^w - \tilde{U}_t^w)^\rho (U_t^e - \tilde{U}_t^e)^{1-\rho}$

As usual in the literature, the coefficient $\rho \in [0,1]$ in the Nash bargaining function is interpreted as the bargaining power of the worker, while $1-\rho$ is the bargaining power of the employer. The reason why the bargaining power of the worker is labeled in the same way as the speed of adjustment will be clarified after presenting the solution of the model, expression (31).

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[10] Note that both observed and net potential earnings must be measured in logarithms to be consistent with the Mincerian assumption (10).

[11] We assume $\ln \overline{w}_t > 0$ and $\ln a_t \in [0, \ln \overline{w}_t]$ where $\ln \overline{w}_t$ is the logarithm of the minimum wage at time t and $\ln a_t$ is the logarithm of the welfare aid at time t.

The solution of the worker-employer model under case 4) does not lead to a dynamic Mincer equation. Note that this is an obvious result. If the worker has never worked, past wages cannot affect current wages by definition. Therefore, we will not consider case 4) in what follows.

In addition, note that, since $\ln \widetilde{w}_t$ is the result of successful bargaining process between the worker and an employer under either case 1) or case 3), the only relevant outside option for the worker in the model must necessarily be $\widetilde{U}_t^w = \ln b_t$. Let us focus on it.

The level of the unemployment benefit of an individual usually depends on the whole wage history of the individual. For sake of simplicity, we assume that the unemployment benefit is a simple linear function of the worker's wage history[12] starting from time s (labor-market entry), i.e. $\ln b_t = \theta_1 \ln w_{t-1} + \theta_2 \ln w_{t-2} + ... + \theta_{t-s} \ln w_s$.

The solution of the worker-employer bargaining problem under the latter assumption provides the following first-order condition:

$$(28) \qquad \frac{\rho}{\ln w_t - \theta_1 \ln w_{t-1} - \theta_2 \ln w_{t-2} - ... - \theta_{t-s} \ln w_s} = \frac{1-\rho}{\ln npe_t - \ln w_t}$$

which, in turn, yields:

$$(29) \qquad \ln w_t = (1-\rho)\theta_1 \ln w_{t-1} + (1-\rho)\theta_2 \ln w_{t-2} + ... + (1-\rho)\theta_{t-s} \ln w_s + \rho \ln npe_t$$

Hence, if the worker has full bargaining power ($\rho = 1$), then expression (29) becomes expression (10) and the standard Mincerian model holds. Intuitively, only when the worker has full bargaining power, he is actually able to earn all his net potential earnings. In this case, the employer is indifferent between employing and not employing because $U_t^e = \widetilde{U}_t^e = 0$.

On the other hand, if the worker has zero bargaining power ($\rho = 0$), then expression (29) implies $\ln w_t = \theta_1 \ln w_{t-1} + \theta_2 \ln w_{t-2} + ... + \theta_{t-s} \ln w_s$. In this case, the worker is indifferent between working and being unemployed because $U_t^w = \widetilde{U}_t^w$.

In general, when the bargaining power of the worker is neither null nor full ($0 < \rho < 1$), replacing expression (9) into (29) yields:

$$(30) \qquad \ln w_t \approx (1-\rho)\theta_1 \ln w_{t-1} + (1-\rho)\theta_2 \ln w_{t-2} + ... + (1-\rho)\theta_{t-s} \ln w_s + \rho\left(\alpha + \beta s + \delta z + \phi z^2\right)$$

or alternatively:

$$(31) \qquad \ln w_t \approx \upsilon_0 + (1-\rho)\theta_1 \ln w_{t-1} + (1-\rho)\theta_2 \ln w_{t-2} + ... + (1-\rho)\theta_{t-s} \ln w_s + \upsilon_2 s + \upsilon_3 z + \upsilon_4 z^2$$

[12] For example, the unemployment benefit today can be seen as the capitalized value of the contributions made in the past. For instance, if we define $\tau_t \ln w_t$ as the contribution to the unemployment benefit paid at time t (τ is the hourly-wage rate of contribution) and r as the nominal interest rate, then the capitalized value of the unemployment benefit at time t is given by:
$\ln b_t = (1+r)\tau_{t-1} \ln w_{t-1} + (1+r)^2 \tau_{t-2} \ln w_{t-2} + ... + (1+r)^{t-s} \tau_s \ln w_s$

where the all the υ coefficients are those defined in section 2. We label model (31) as the bargaining model[13].

Note that, under the hypothesis that the surplus of the worker is the pure wage increase ($U_t^w - \tilde{U}_t^w = \ln w_t - \ln w_{t-1}$), model (31) and model (14) perfectly match. In this case, the bargaining power of the worker can be interpreted as a proxy of the speed of adjustment and vice-versa. Specifically, the fact that the speed is far from being one indicates that the bargaining power of the worker is far from being full and vice-versa.

In addition, it is worth stressing that expression (31) can also be obtained if one assumes that the outside option of the worker is given by his reservation wage $\ln w^{res}$, defined as the minimum wage-offer for the worker to accept a job, and that the latter is a function of the worker's wage history[14]. Formally, this means $\tilde{U}_t^w = \ln w_t^{res} = f(\ln w_{t-1},...,\ln w_s)$.

Model (31), as it is, cannot be estimated with usually available panel data because it requires information about the whole wage history of each individual in the dataset, typically not available. However, standard longitudinal datasets usually allow to test for the significance of wage lags up to a certain point in the past. Using our dataset, we are able to test several possibilities and find that the most appropriate specification of model (31) for Belgium and Finland has two significant wage lags while, for Denmark, it has just one lagged wage. Additional wage lags are not statistically significant.

An important issue to be taken into account before estimating model (31) is that the model is more suitable to explore data from countries where unemployment benefits are actually paid and cover a large share of the working force. To this respect, we would like to stress that Boeri and van Ours (2008, p. 283) indicate Belgium, Finland and Denmark as the countries with the highest generosity index of unemployment benefit adjusted for coverage in a sample of 12 European countries. Besides issues of data availability with other countries, the latter is the main reason why these three countries have been chosen for the empirical analysis in this paper.

Note that the number of relevant wage lags (also called wage persistence) may depend on the specific way the unemployment-benefit policies are designed in a given country (duration, eligibility, administrative rules regarding the determination of the benefit level, and so on). As a matter of example, it may be the case that i) recent earnings are relatively more important than older earnings for the determination of the benefit level, or that ii) just the most recent wages really matter for the benefit. This would imply that some of the θ coefficients in the simple benefit-determination rule assumed in the bargaining model may be either i) not statistically different from zero or ii) zero by assumption. For instance, if $\theta_i = 0$ for $i = 3,...,t-s$, then model (31) would just have two relevant lagged wages.

Of course, many other country-level aspects related to labor-market institutions and legislation may also explain different degrees of wage persistence. For instance, if the share of temporary contracts relative to permanent contracts is higher in country A

[13] Apart from the simple theoretical model presented so far, another reason for using a dynamic multiple-lags wage model is that, unlike the static one, this model keeps into account that the evolution of the wage of a worker over time depends, very often, on a multi-period labor contract. This contract can regulate the wage increase from one year to another, independently of the accumulation of human capital made by the worker. The only thing that determines a given wage at a given point in time is a predetermined rule on the wage increase over the next 5, 10 or 20 years, agreed by the worker and the employer when the labor contract is signed. Of course, this rule can be affected by the worker's human capital at the time the contract is signed but, afterwards, the agreed rule changes only if a new contract is signed (which means a new bargaining).

[14] It seems quite reasonable to assume that the reservation wage of a worker depends on his wage history. Again, for model (31) to hold, we need to assume simple linear dependence.

relative to country B, this may imply a higher number of bargaining processes among workers and employers taking place in country A and may affect the persistence of wages in country A relative to B. Alternatively, if firing is more costly or difficult in country B, this would imply a different outside option of the worker in country B relative to A and may affect the relative degree of wage persistence in the two countries.
Table 2 presents our GMM-SYS estimates based on model (31), controlling for endogeneity, individual heterogeneity and year effects. All standard tests are passed and their results indicate a specification improvement for Belgium, no real gain with respect to the adjustment model for Denmark, some mixed evidence for Finland where the second wage lag is significant but the Hansen J test does not significantly improve and the 2nd order autocorrelation test shows a lower p-value.
The main conclusion is that a micro-founded dynamic wage model, the bargaining model, can fit the data better than a simple adjustment model but requires more (sometimes non-testable) theoretical assumptions.

5. Extended bargaining model

Up to now, we have only used data on wages and human-capital variables because we primarily aimed at:

- Testing the equality between the observed wage of an individual and the monetary value of his human-capital productivity, assumed by the static Mincer model (adjustment model)
- Documenting that a dynamic Mincer equation, obtained as the solution of a simple wage-bargaining model at worker-employer level, is not rejected by the data (bargaining model)

In this section, we explore three possible criticisms that are mainly related to the theoretical assumptions behind the bargaining model presented in the previous section. Eventually, they are extensible to the adjustment model because the latter can be seen as a particular case of the bargaining model when the surplus of the worker is the pure wage increase from time $t-1$ to time t.
Particularly, we aim at answering the following three questions:

- What if wages are set by collective bargaining?
- What if the employer is the government?
- What if a full set of control variables is used?

An important aspect that has not been mentioned so far is that individual wages can be set by collective bargaining, i.e. bargaining between unions and employers' associations, rather than by worker-employer direct negotiation. If collective bargaining plays a very important role in wage determination, then our simple bargaining model may not be very suitable for use, unless one assumes that the surplus of the bargaining parties coincides with the surplus of the average worker and of the average employer (i.e. the representative union behaves exactly like the representative worker and the representative employers' association behaves exactly like the representative employer). Unfortunately, the ECHP dataset does not contain information neither on whether the individual wage is set by collective bargaining not on union membership (see also Sanz-de-Galdeano and Turunen, 2006). So, in order to investigate this potentially important issue, we use a publicly-available dataset provided by Verbeek (2008), which has information on wages set by collective bargaining.

The data are taken from the National Longitudinal Survey of Youth (NLSY) and contain detailed information on 545 male workers from 1980 to 1987, a period of decreasing union membership in the United States, but still high unionization compared to the last decade. This dataset has been used by Vella and Verbeek (1998) to study union-wage premia. On average, 24% of the individuals in the dataset have their wages negotiated at collective level but this percentage varies over time because there are individuals who change their status over the sample period.

If our bargaining model is not able to capture the fact that the wages set by collective bargaining are set differently, i.e. the process of wage formation through collective bargaining cannot be approximated by a simple worker-employer model, we should find evidence of a collective-bargaining effect on wages, not captured by the bargaining model. That is, if we estimate a bargaining model with a dummy controlling for whether wages are set by collective bargaining or not, this dummy should be statistically significant (it should contribute to explain wages).

The collective-bargaining dummy is treated as endogenous because an individual can choose to work in a sector or industry where wages are bargained at collective level or not, and this choice is likely to be correlated with individual unobserved characteristics.

Table 3 provides benchmark estimates for the simple dynamic models estimated so far with European data. Note that only the bargaining model with three wage lags (the fourth is not significant) passes the standard specification tests.

Table 4 presents the estimation results for the bargaining model with a collective-bargaining dummy. For completeness, we also present GMM-SYS estimates for the adjustment model, finding that the model does not fit the data well enough because the standard tests are not passed. Our preferred estimates are those of the bargaining model with three wage lags (the fourth is not significant). In all the specifications, the collective-bargaining dummy (equal to 1 if the individual wage is bargained at collective level) is not significant, meaning that the bargaining model fits the data well even if wages are bargained at collective level.

The latter is, of course, just evidence based on a particular sample, and the United States is not the best country to test our model because collective bargaining is relatively less important than in Europe. If anything, we have additional evidence that the bargaining model can fit the data well not only in Belgium and Finland but also in the United States.

Another interesting issue, not investigated so far, is that the employer of a worker can be the government, that is, an individual can work in the public sector rather than in the private sector of the economy. If we focus on the public sector, the assumption that the employer maximizes profits (regardless of how they are defined), made in the bargaining model, can be inappropriate. Consequently, the bargaining model can be unable to properly fit the data in countries where the share of the public-sector employment is important or, empirically, if many individuals in the sample work in public sector.

Likewise the collective-bargaining effect, if the bargaining model is not able to capture the fact that, when the employer is the government, wages are set differently, we should observe a public-sector effect on wages, not captured by the bargaining model presented in the previous section. That is, if we estimate a bargaining model with a dummy controlling for whether an individual works in the public sector or not, this dummy should be statistically significant (there should be a share of wage variability explained by the dummy).

The public-sector dummy is treated as endogenous because, likewise the previous case, an individual can choose to work in the public sector, and this choice is likely to be correlated with individual unobserved characteristics.

Table 5 presents the estimation results. They are very similar to those presented in Table 4. As before, we present GMM-SYS estimates for the adjustment model, finding evidence that the model does not fit the data well enough because the standard tests are not passed. Again, our preferred estimates are those of the bargaining model with three wage lags (the fourth is not significant). In all the specifications, the public-sector dummy (equal to 1 if the individual works in the public sector) is found to be not significant, meaning that the bargaining model fits the data well even if the employer is not a profit-maximizing private firm or organization.

For completeness, in Table 6, we also present estimates of the bargaining model with both collective-bargaining and public-sector dummy. They are found to be not jointly significant in all the specifications.

Going back to the theoretical foundations of our bargaining model, the reason for not observing neither a collective-bargaining effect nor a public-sector effect can be that, ultimately, the fundamental individual behaviors of the bargaining model still work even if the wage is bargained at collective level or the employer is the government. The choice of keeping a job paid a certain amount, or not, is made by the worker. So, if a worker believes that the wage offer is too low (given his human-capital investment and his wage history), he does not accept the job and we do not observe him in the data. If he keeps the job, it is because the wage is high enough to satisfy the condition $U_t^w > \widetilde{U}_t^w$. Analogously, if a profit-maximizing employer offers a job paid a certain amount, it is because $U_t^e > \widetilde{U}_t^e$. Therefore, if the Government wants to hire an individual with certain human-capital skills and a certain wage history, the wage offer must be consistent with the one potentially made by a private employer. This may explain why we do not observe a public-sector effect (after controlling for human capital, wage lags and individual unobserved heterogeneity). On the other hand, if the wage is determined at collective level, and both unions and employers' associations care about employment, the equilibrium wage cannot be very different from the one that would result from a decentralized bargaining process. This may explain why we do not observe a collective-bargaining effect.

Since the formation of individual wages is a rather-complex phenomenon, there may be other determinates of wages that are not kept into account by our simple bargaining model. As a matter of example, it could be argued that the model does not take into account whether the worker is black or hispanic, and that race matters in the labor market. So, the last part of this section investigates what happens if we extend the bargaining model using a full set of covariates in order to control for potentially important determinates of wages, other than those considered so far. Specifically, we control not only for collective bargaining and public sector but also for race, marriage, health, residence, private-sector industry and occupation. We use dummies equal to one if the individual is black, hispanic, married, has health disabilities, lives in south, northern central, north east, or in a rural area. In addition, we distinguish between eleven industries (agriculture, mining, construction and so on) and nine different occupations (professionals, managers, sales workers and so on). All the covariates that are individual-choice variables are considered endogenous (public sector, collective bargaining, marriage, residence, private-sector industry and occupation) while the remaining ones are taken as exogenous (race and health).

The results in Table 7 show that the standard tests are passed in all the specifications. Looking at the big picture, we observe that wage history matters, that human capital is important, and that the remaining covariates are not significant. In our preferred specification, the bargaining model with three significant wage lags[15] (note that there are higher p-values for the Arellano-Bond 2nd order autocorrelation test and for the

[15] The fourth lag is not significant.

Hansen test), the only covariate that is significant at 5% level is the dummy for black, meaning that the bargaining model is unable to take into account some kind of wage discrimination for black males. However, this race-discrimination result is not confirmed neither by the adjustment model not by the bargaining model with two wage lags.
Therefore, to really conclude this section, it is worth stressing that a simple bargaining model can provide a very good fit of earnings data, even in its very simple formulation. Once individual (time-invariant) unobserved heterogeneity is taken into account, controlling for individual observed characteristics other than wage history and human capital may not radically improve the model specification.

6. Conclusions

The main conclusions of this paper are the following:

a. The equality between the observed wage of an individual and the monetary value of his net human-capital productivity (the so-called net potential wage), assumed by the standard Mincerian model, is rejected by the ECHP data for Belgium, Denmark and Finland

b. A dynamic approach to the Mincer equation based on a simple wage adjustment model implies that the return to schooling in terms of observed earnings is not independent of labor-market experience

c. The return to schooling in terms of net potential earnings, provided by the standard Mincer equation, can also be computed using a dynamic wage adjustment model

d. A dynamic adjustment model allows the estimation of the average return to schooling at labor-market entry

e. A dynamic wage equation can be seen as the solution of a simple wage bargaining model where the role played by demand factors is enhanced with respect to the standard supply-side Mincerian framework

f. A micro-founded dynamic wage model, the bargaining model, can fit both European and US data better than a simple adjustment model but requires more theoretical assumptions

g. Individual wages are well explained by a simple worker-employer bargaining model even if they are negotiated at collective level, the employer is the government, and the dataset does not allow to control for a large set of covariates.

The rest of this section discusses the above results in the light of the existing literature on human-capital wage equations, with special emphasis on result b. which we consider the most important (although it is a consequence of result a.)

The seminal book by 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 the hourly wage of an individual is explained by his schooling years, potential 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 Card (1999). The reviewed works generally focused on the estimation of the *average* impact of schooling on earnings, by means of both OLS 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, 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 techniques for quantile regression have been provided by Arias et al. (2001), Chernozhukov and Hansen (2006), Lee (2007), Andini (2008), and many others.

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 framework 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 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, 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, there have been some critical voices but, looking at the big picture, we must reasonably conclude that the history of human-capital regressions has been characterized by a generalized attempt of *consistently* estimating the coefficient of schooling (both on average and along 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 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), our paper has provided additional theoretical and empirical arguments against the usual interpretation of the coefficient of schooling in the standard Mincer equation. Indeed, we have argued that the return to schooling in terms of observed earnings is, in general, *dependent* of labor-market experience (result b.). This result is also consistent with more recent empirical evidence provided Belzil (2007) and with some earlier evidence presented by Andini (2005)[16].

As shown, the result b. can be easily derived from a dynamic specification of the Mincer equation where past observed earnings contribute to explain current observed earnings. This specification is supported by the ECHP data for three European countries, once endogeneity, individual heterogeneity and time effects are accounted for

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

(result a.), and allows to compute the return to schooling at labor-market entry (result d.) as well as the standard Mincerian return to schooling (result c.).
This paper also provides a theoretical micro-foundation of a dynamic Mincer equation, where demand factors are considered as important as supply factors for wage determination (result e.). It is worth stressing that, of course, we do not claim for generality. Clearly, the bargaining model in section 4 holds under a set of specific assumptions. The main issue, at this point, is whether these assumptions bring us closer to reality (enhanced role of demand factors in determining wages) or not. The bargaining model is presented here as a micro-founded alternative to the simple adjustment model. The former can perform better than the latter in terms of data fitting because it allows for more than one wage lag but it is based on more theoretical hypotheses (result f.). Finally, we find that the bargaining model can provide a good fit of the data even in its very simple formulation (result g.), i.e. wage history + human capital.
Summing up, to really conclude this paper, we would like to stress that there seems to be substantial empirical evidence supporting the argument that past observed earnings, *together with* accumulated human capital (schooling and post-schooling investments), play an important role in explaining current observed earnings. This finding should open the door to new research efforts looking for alternative, and perhaps more general, theoretical foundations of a *dynamic* Mincer equation. Issues related to asymmetric information (for instance, the case where the employer does not observe the net potential earnings of the worker), role of unions (insider-outsider considerations) and efficiency wages (the employer cannot observe the worker's effort) are interesting topics for future investigation.

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Table 1. Adjustment model (ECHP)

Dependent variable: Logarithm of gross hourly wage	Belgium 1994-2001	Denmark 1994-2001	Finland 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 2. Bargaining model (ECHP)

Dependent variable: Logarithm of gross hourly wage	Belgium 1994-2001	Denmark 1994-2001	Finland 1996-2001
GMM-SYS			
Constant	0.815 (0.007)	2.071 (0.000)	1.248 (0.006)
Logarithm of gross hourly wage (-1)	0.574 (0.000)	0.499 (0.000)	0.342 (0.020)
Logarithm of gross hourly wage (-2)	0.169 (0.000)	-0.014 (0.870)	0.280 (0.000)
Schooling years	0.044 (0.000)	0.018 (0.014)	0.022 (0.088)
Potential labor-market experience	0.011 (0.024)	0.021 (0.073)	0.008 (0.351)
Potential labor-market experience squared	-0.000 (0.340)	-0.000 (0.129)	-0.000 (0.689)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.139)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.723)	(0.516)	(0.284)
Hansen J overid. test (p-value)	(0.519)	(0.226)	(0.120)
GMM-SYS, controlling for year effects			
Constant	1.607 (0.000)	2.648 (0.000)	1.316 (0.003)
Logarithm of gross hourly wage (-1)	0.511 (0.000)	0.409 (0.000)	0.296 (0.050)
Logarithm of gross hourly wage (-2)	-0.130 (0.000)	-0.092 (0.324)	0.228 (0.001)
Schooling years	0.033 (0.002)	0.032 (0.000)	0.043 (0.023)
Potential labor-market experience	0.016 (0.002)	0.026 (0.073)	0.010 (0.266)
Potential labor-market experience squared	-0.000 (0.048)	-0.000 (0.144)	0.000 (0.794)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.136)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.978)	(0.407)	(0.262)
Hansen J overid. test (p-value)	(0.730)	(0.682)	(0.145)

P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

Table 3. Simple dynamic models (US-NLSY)

Dependent variable: Logarithm of gross hourly wage	Adjustment model (AR1)	Bargaining model (AR2)	Bargaining model (AR3)
GMM-SYS			
Constant	-0.230 (0.134)	-0.305 (0.025)	-0.425 (0.011)
Logarithm of gross hourly wage (-1)	0.315 (0.000)	0.369 (0.000)	0.337 (0.000)
Logarithm of gross hourly wage (-2)		0.172 (0.000)	0.169 (0.000)
Logarithm of gross hourly wage (-3)			0.060 (0.004)
Schooling years	0.091 (0.000)	0.074 (0.000)	0.079 (0.000)
Potential labor-market experience	0.061 (0.000)	0.042 (0.005)	0.049 (0.018)
Potential labor-market experience squared	-0.001 (0.010)	-0.001 (0.203)	-0.001 (0.204)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.000)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.001)	(0.144)	(0.462)
Hansen J overid. test (p-value)	(0.001)	(0.047)	(0.481)

P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

Table 4. Testing collective-bargaining effect (US-NLSY)

Dependent variable: Logarithm of gross hourly wage	Adjustment model (AR1)	Bargaining model (AR2)	Bargaining model (AR3)
GMM-SYS			
Constant	-0.239 (0.122)	-0.328 (0.018)	-0.442 (0.012)
Logarithm of gross hourly wage (-1)	0.317 (0.000)	0.369 (0.000)	0.335 (0.000)
Logarithm of gross hourly wage (-2)		0.174 (0.000)	0.170 (0.000)
Logarithm of gross hourly wage (-3)			0.059 (0.005)
Schooling years	0.091 (0.000)	0.075 (0.000)	0.079 (0.000)
Potential labor-market experience	0.061 (0.000)	0.042 (0.005)	0.049 (0.018)
Potential labor-market experience squared	-0.001 (0.009)	-0.001 (0.195)	-0.001 (0.200)
Collective bargaining	0.009 (0.899)	0.036 (0.548)	0.033 (0.683)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.000)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.001)	(0.139)	(0.467)
Hansen J overid. test (p-value)	(0.011)	(0.127)	(0.608)

P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

Table 5. Testing public-sector effect (US-NLSY)

Dependent variable: Logarithm of gross hourly wage	Adjustment model (AR1)	Bargaining model (AR2)	Bargaining model (AR3)
GMM-SYS			
Constant	-0.239 (0.118)	-0.299 (0.027)	-0.428 (0.012)
Logarithm of gross hourly wage (-1)	0.319 (0.000)	0.370 (0.000)	0.334 (0.000)
Logarithm of gross hourly wage (-2)		0.172 (0.000)	0.166 (0.000)
Logarithm of gross hourly wage (-3)			0.057 (0.005)
Schooling years	0.091 (0.000)	0.074 (0.000)	0.079 (0.000)
Potential labor-market experience	0.063 (0.000)	0.044 (0.003)	0.051 (0.014)
Potential labor-market experience squared	-0.001 (0.006)	-0.001 (0.144)	-0.001 (0.169)
Public sector	-0.145 (0.228)	-0.110 (0.205)	-0.055 (0.393)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.000)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.001)	(0.141)	(0.450)
Hansen J overid. test (p-value)	(0.002)	(0.035)	(0.134)

P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

Table 6. Testing both collective-bargaining and public-sector effect (US-NLSY)

Dependent variable: Logarithm of gross hourly wage	Adjustment model (AR1)	Bargaining model (AR2)	Bargaining model (AR3)
GMM-SYS			
Constant	-0.270 (0.084)	-0.347 (0.014)	-0.475 (0.008)
Logarithm of gross hourly wage (-1)	0.320 (0.000)	0.369 (0.000)	0.330 (0.000)
Logarithm of gross hourly wage (-2)		0.175 (0.000)	0.168 (0.000)
Logarithm of gross hourly wage (-3)			0.056 (0.006)
Schooling years	0.092 (0.000)	0.075 (0.000)	0.082 (0.000)
Potential labor-market experience	0.063 (0.000)	0.046 (0.002)	0.053 (0.011)
Potential labor-market experience squared	-0.001 (0.005)	-0.001 (0.129)	-0.001 (0.154)
Collective bargaining	0.047 (0.526)	0.076 (0.208)	0.077 (0.313)
Public sector	-0.173 (0.159)	-0.147 (0.107)	-0.106 (0.157)
Test of joint significance - dummies	(0.365)	(0.215)	(0.342)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.000)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.001)	(0.134)	(0.446)
Hansen J overid. test (p-value)	(0.028)	(0.196)	(0.405)

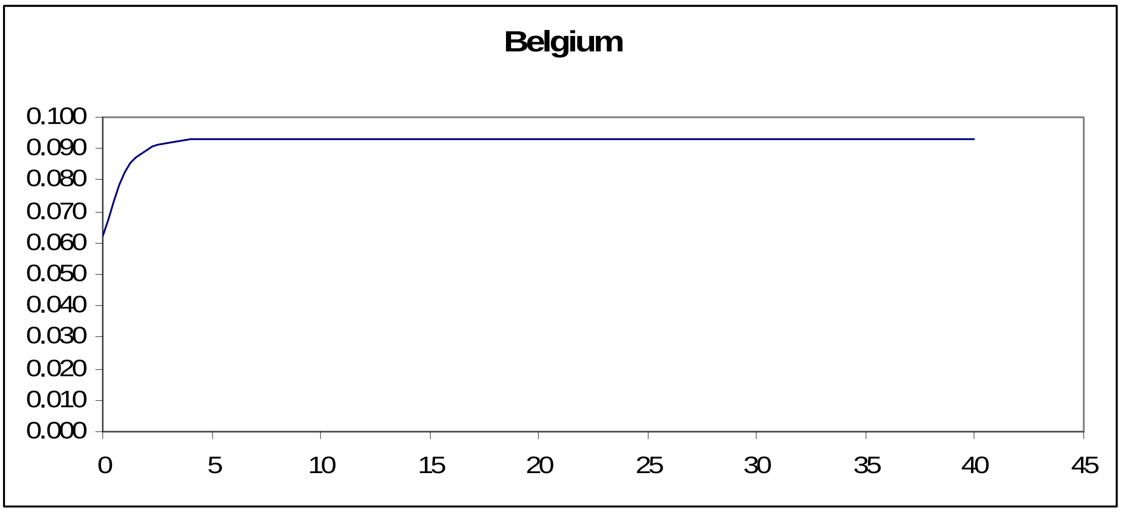
P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

Table 7. Using full set of covariates (US-NLSY)

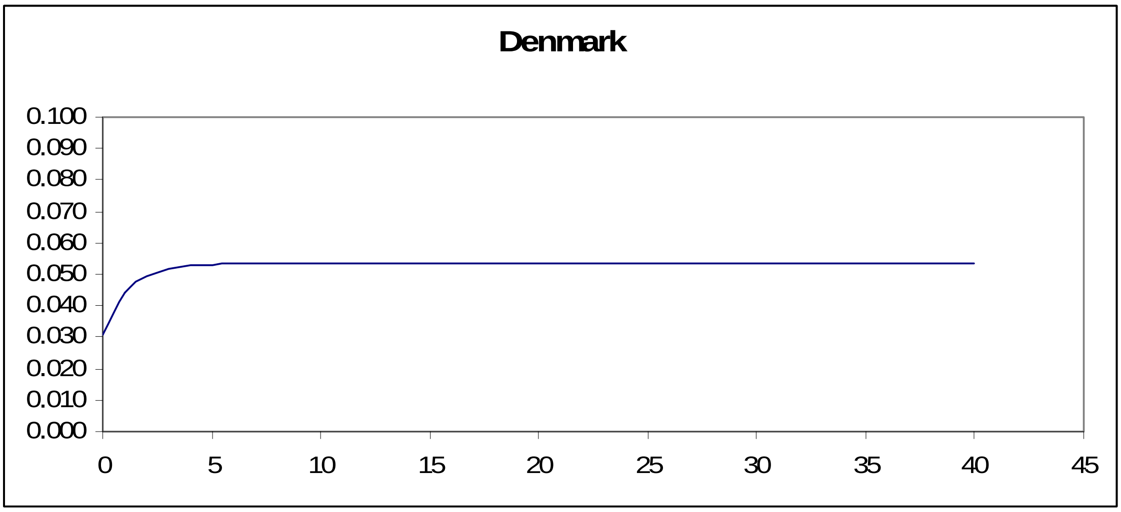
Dependent variable: Logarithm of gross hourly wage	Adjustment model (AR1)	Bargaining model (AR2)	Bargaining model (AR3)
GMM-SYS			
Constant	0.038 (0.928)	0.212 (0.540)	0.251 (0.483)
Logarithm of gross hourly wage (-1)	0.180 (0.000)	0.264 (0.000)	0.235 (0.000)
Logarithm of gross hourly wage (-2)		0.111 (0.000)	0.097 (0.001)
Logarithm of gross hourly wage (-3)			0.048 (0.082)
Schooling years	0.087 (0.002)	0.043 (0.055)	0.047 (0.055)
Potential labor-market experience	0.067 (0.000)	0.057 (0.001)	0.071 (0.001)
Potential labor-market experience squared	-0.002 (0.015)	-0.001 (0.047)	-0.002 (0.088)
Collective bargaining	0.135 (0.110)	0.215 (0.007)	0.144 (0.103)
Public sector	-0.029 (0.841)	0.036 (0.777)	0.023 (0.872)
Married	0.070 (0.135)	0.048 (0.262)	0.023 (0.616)
Black	-0.354 (0.316)	-0.225 (0.485)	-0.631 (0.024)
Hispanic	0.212 (0.503)	-0.311 (0.156)	-0.261 (0.298)
Health disabilities	-0.081 (0.309)	-0.122 (0.124)	-0.135 (0.135)
South	-0.340 (0.078)	-0.059 (0.672)	-0.195 (0.220)
Northern central	-0.418 (0.037)	-0.186 (0.242)	-0.134 (0.424)
North east	-0.019 (0.928)	-0.022 (0.907)	0.096 (0.661)
Rural area	-0.127 (0.145)	-0.090 (0.258)	-0.124 (0.144)
Agriculture	-0.016 (0.943)	-0.118 (0.575)	0.071 (0.760)
Mining	0.374 (0.119)	0.397 (0.080)	0.388 (0.097)
Construction	0.212 (0.212)	0.249 (0.158)	0.201 (0.279)
Trade	0.083 (0.498)	0.112 (0.373)	0.079 (0.557)
Transportation	-0.067 (0.707)	0.058 (0.729)	0.036 (0.847)
Finance	0.514 (0.001)	0.447 (0.002)	0.295 (0.096)
Business and repair services	0.160 (0.262)	0.073 (0.574)	0.132 (0.327)
Personal services	0.196 (0.422)	0.045 (0.861)	0.230 (0.353)
Entertainment	0.059 (0.826)	0.060 (0.798)	0.208 (0.439)
Manufacturing	0.126 (0.281)	0.115 (0.307)	0.125 (0.292)
Professional and related services	(dropped)	(dropped)	(dropped)
Professionals, technical and kindred	0.252 (0.033)	0.232 (0.040)	0.095 (0.422)
Managers, officials and proprietors	0.040 (0.743)	0.108 (0.362)	-0.014 (0.904)
Sales workers	0.020 (0.889)	0.043 (0.759)	-0.089 (0.569)
Clericals and kindred	-0.061 (0.601)	0.027 (0.814)	0.006 (0.958)
Craftsmen, foremen and kindred	0.105 (0.368)	-0.023 (0.845)	-0.166 (0.194)
Operatives and kindred	0.012 (0.905)	-0.025 (0.825)	-0.052 (0.647)
Laborers and farmers	0.198 (0.135)	-0.022 (0.869)	-0.105 (0.482)
Farm laborers and foremen	-0.376 (0.257)	-0.038 (0.895)	-0.476 (0.151)
Service workers	(dropped)	(dropped)	(dropped)
Arellano-Bond 1st order autocorr. test (p-value)	(0.000)	(0.000)	(0.000)
Arellano-Bond 2nd order autocorr. test (p-value)	(0.271)	(0.254)	(0.751)
Hansen J overid. test (p-value)	(0.127)	(0.363)	(0.589)

P-values of estimated coefficients, in parentheses, are based on Windmeijer-corrected standard errors.

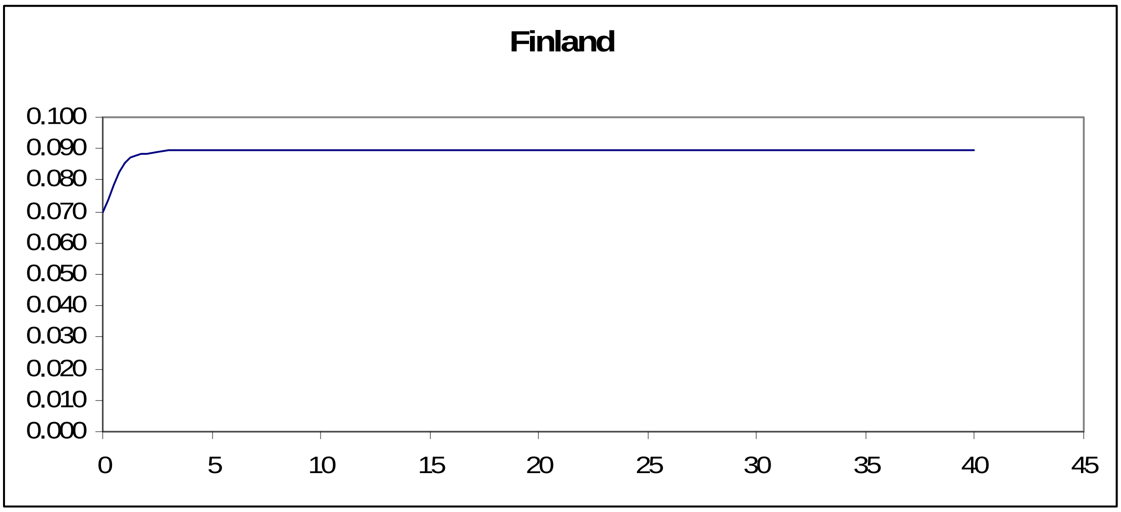
Figure 1. Returns to schooling in terms of observed earnings $\beta(z)$



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



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



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

Appendix. Sample descriptive statistics for ECHP data

The data for Belgium, Denmark and Finland are extracted from the European Community Household Panel. We focus on male workers aged between 18 and 65. In order to derive the variables for schooling years (ys), potential labour-market experience (plme) and the logarithm of the 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 (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 above-referred variables as follows:

- ys = pt023 – 6
- plme = pd003 – ys – 6

It is worth stressing that ys numbers do not necessarily reflect successfully completed years of schooling. This is a compromise that allows us to obtain homogenous measures of schooling years (and potential labour-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.

Belgium, 1994-2001

Variable	Obs.	Mean	Std. Dev.	Min	Max
lnw	6873	6.164	0.433	2.815	8.697
ys	6873	13.858	3.240	4	25
plme	6873	19.521	10.362	0	51

Denmark, 1994-2001

Variable	Obs.	Mean	Std. Dev.	Min	Max
lnw	2053	4.811	0.521	-0.326	6.368
ys	2053	14.943	4.592	6	29
plme	2053	17.173	11.486	0	52

Finland, 1996-2001

Variable	Obs.	Mean	Std. Dev.	Min	Max
lnw	2341	4.256	0.509	-0.405	7.522
ys	2341	15.423	3.355	5	27
plme	2341	14.800	9.999	0	46