Returns to Seniority: Time or Rank?*

Sebastian Buhai, Miguel Portela, Coen Teulings and Aico van Vuuren†

Abstract

A large number of studies have investigated why more senior workers tend to be paid higher wages than their less senior colleagues. Most empirical research in this area has focused on job tenure as a continuous function of the time spent in the current job. This specification can be defended by theories of firm-specific investment, efficiency-wages or adverse-selection models. However, rent extracting arguments, as suggested by the theory of internal labor markets, indicate that the relative position of the worker in the seniority hierarchy of the firm, ie. her "seniority rank", may also explain part of the observed returns to tenure. We explore this idea in our paper. Both seniority and seniority rank are included in the empirical analysis. Although there is a strong relationship between the time spent in a job and the seniority rank, identification is not problematic since the seniority rank always jumps discontinuously in a non-determined fashion, while seniority is by definition time-continuous. We use matched employer-employee data from Denmark and Portugal. The first country is similar in terms of labor protection to the United States, while the second has much stricter firing rules. We find a significant and negative impact of the seniority rank on wages, in both countries. We also verify that labor protection increases the bargaining power of individuals with a lower seniority rank, as predicted by theories on unionized and insider-outsider markets. Differences between industry sectors in terms of seniority rank patterns are similar in in the two countries analyzed.

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†Buhai: Tinbergen Institute, Erasmus Univ.Rotterdam and CCP-Aarhus School of Business, buhai@tinbergen.nl (corresponding author); Portela: Tinbergen Institute, IZA and NIPE-Minho Univ., portela@tinbergen.nl; Teulings: SEO Economic Research, Univ. of Amsterdam and Tinbergen Institute, c.teulings@seo.nl; van Vuuren: Free Univ. Amsterdam and Tinbergen Instutute, vuuren@tinbergen.nl

1 Introduction

Labor economists have devoted a lot of attention to the empirical observation that more senior workers tend to be paid higher wages than their less senior colleagues. The prominent answer is the theory of human capital that explains wage returns to seniority by firm-specific investments of workers, see Becker (1962). Other explanations are for instance from efficiency wage theory, see Lazear (1981) or from adverse selection models, see Salop and Salop (1976). On the other hand, some theoretical models cast doubt on the apparent relationship between wages and seniority by the argument that worker heterogeneity and selection may cause this relationship to be spurious, see for instance a Bayesian learning model about match quality in Jovanovic (1979) or a random growth productivity framework in Buhai and Teulings (2005). Most empirical research has focused on the Panel Study of Income Dynamics (PSID) in the USA, eg. Abraham and Farber (1987), Altonji and Shakotko (1987), Topel (1991), Altonji and Williams (1997, 2005), Buchinsky et al (2005), with few other studies on data mainly from France, Germany and UK, eg. Abowd, Kramarz and Margolis (1999), Dustmann and Pereira (2005), Dustmann and Meghir (2005). These studies agree that there is a positive non-spurios part in the relationship between wages and seniority, though the magnitude of the estimated "true" returns to seniority varies greatly, from negligible to large.

All empirical research focused so far on seniority as a deterministic (polynomial) function of the time spent in the present job. Although the theoretical explanations listed above all indicate this to be the right specification, a new model obtained by combining the individual random productivity growh framework by Buhai and Teulings (2005) and the firm random demand growth model by Bentolila and Bertola (1990), via a Last-In-First-Out firing rule justified by Kuhn (1988) and Kuhn and Robert (1989), suggests that the seniority position of the worker in the firm relative to the seniority of the other workers, what we call *the seniority or the tenure rank of a worker*[1], may also explain part of the observed returns to tenure found in previous literature. In this paper we explore and extend this idea, investigating whether we can find returns to the time-stochastic seniority rank*,* in top of returns to the time spent in the present job. XXX

The empirical methods we use are based on standard techniques designed to identify separate wage returns to tenure and labour market experience. Namely, we follow the two-stage first-difference estimation procedure (2SFD) of Topel (1991) and the instrumental variable (IV) techniques by Altonji and Shakotko (1987) and several fol-

[1] In the empirical specification section of this paper we focus on the *relative seniority rank*, that is the *actual seniority rank* divided by the *firm size* measured as total number of employees. In this way, the actual seniority rank effect is not separately identified from the firm effect, but rather we identify a combination of their effects. In the estimations we use however also specifications where the two parts are entered separately. We show that, although it is generally difficult to completely disentangle the two separate effects, very similar estimates obtained with our different estimation methods strongly suggest that our data allows us to largely disentangle them.

lowing studies, among which Dustmann and Pereira (2005). We extend these methods so that they incorporate seniority rank as independent variable in the wage regression. We show that under a minimum set of assumptions the effect of the seniority rank is identified and consistently estimated. Applying different estimation procedures allows us to check the robustness of the results.

Despite that one expects a strong (negative) relationship between a worker's time spent in a job and her seniority rank, identification of the different parts is not necessarily problematic. Our identification strategy is based on the fact that seniority rank jumps in a non-determined fashion with time, while the tenure in a job is by definition time-deterministic; hence, there is generally no correlation between *changes over time* in seniority rank and respectively tenure, in time series cross-section data. Therefore a technique that relies on first-differencing the initial wage regression, such as the adapted 2SFD, secures separate identification of the seniority rank effect from the tenure effect, under one assumption that we will discuss shortly, independent on whether the effects of tenure and experience are identified. Furthermore, IV methods consisting in instrumenting tenure (or both tenure and experience) with its deviations from the individual-job (or individual, as appropriate) means over time, extended with instrumenting seniority rank in a similar way, identify the seniority rank effect under the standard conditions ensuring identification of the tenure and experience effects. We briefly introduce these identification assumptions in the next paragraph, while detailing on them in the empirical framework section.

For the identification of the return to seniority rank via 2SFD, we need only make the one (reasonable) assumption that seniority rank has *no direct impact* on the unobservable term of the wage regression representing the (time-varying) quality of the match, but that eventually only affects this component via its correlation with tenure. We show that identification of the seniority rank effect using 2SFD is no longer possible if we relax this conditional independence assumption, though it is hard to think of reasons that could invalidate it. When using the extended IV methods, our favourite variant where we instrument all three key variables (tenure, experience and seniority rank) appropriately, allows for joint identification of the three effects under the standard conditions of the initial method, namely, the general assumption requiring time-invariant worker-firm match quality and respectively, the more subtle condition requiring experience not to be correlated with this unobservable worker-firm match effect. Other variants of the IV procedures where we do not instrument for seniority rank but only for experience and/or experience, allow the identification of the seniority rank effect under the standard conditions *plus* the conditional independence assumptions between seniority rank and both unobservable components, the quality of the worker-firm match and the individual worker heterogeneity, respectively. The use of the several IV variants enables us to check, inter alia, the (joint) validity of the conditional independence assumptions for the seniority rank.

Although using the PSID in our analysis would be useful in order to directly compare our results with previous estimates of the wage returns to tenure, we cannot adopt this strategy. The main reason is that the seniority ranks of individual workers are not reported in the PSID and retrieving them would require data collection of all individuals in a particular firm; since the PSID is just a sample from the total US labor force, this is not feasible. Instead we use matched employer-employee data sources from Denmark and Portugal. There are several advantages that come with using these data in our context. These data sets are all encompassing and allow us to retrieve the ranks of all workers in every firm in the private sector. At the same time, this data enables us to overcome major problems typical in survey data such as attrition or measurement-error. In addition, comparing these two countries in the context of this study is of major interest. While both countries are small open economies within the European Union, Denmark has got one of the lowest employment protection legislation among OECD countries and one of the highest job mobility rates, while Portugal stands out in the other extreme as one of the countries with very high firing costs and relatively rigid labour market. Moreover, both countries have kept low average unemployment rates, according to European standards, at least over the last decade. If the effect of the seniority rank is proxying somewhat the job security of "insiders", that is, the more senior workers, we expect it to be more relevant for wage determination in the country with higher labor protection rules. Finally, The Danish and Portuguese data sources have been proven to be extremely useful for labor market analysis in previous research, see for instance Bingley and Westergaard-Nielsen (2005), Christensen et al. (2005), Blanchard and Portugal (2001), Cabral and Mata (2003) etc.

In order to link our results to estimates from the previous literature and to assess how much of the returns attributed to the time spent in the job are rather returns to the seniority rank of the worker in that firm, we first derive the results without incorporating the seniority rank and compare them with the results obtained including also the seniority rank of the workers. We can also compare the estimated effects of the firm size on wage determination with estimates from previous research.in this area, such as Brown and Medoff (1989). A final remark we make is that our analysis has the additional merit of being the first study to estimate wage returns to firm tenure and labour market experience by means of standard techniques, on economy-wide data, in either Denmark or Portugal.

The paper is set up as follows. The next section presents the theoretical framework justifiying our approach. The empirical framework is put forward in Section 3. Section 4 describes the data and presents some relevant labour market features for the two countries analyzed. We present estimation results in Section 5. The last section summarizes and concludes.

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2 Theoretical Motivation

We show how a parsimonious model, where single firms match with homogeneous workers according to a specific hiring-firing rule and where both the job productivity and the demand for the firm's products are stochastic, can justify considering the position of a worker in the seniority hierarchy of that firm as an essential determinant of wages, eventually in the detriment of rewarding the actual time the worker spent in that job. We have already available all ingredients for building such a framework: we combine the efficient bargaining model at the individual level by Buhai and Teulings (2005) with the model of stochastic firm demand evolution by Bentolila and Bertola (1990), by means of the Last-In-First-Out firing rule rationalized in Kuhn (1988) and Kuhn and Robert (1989). Below we explain briefly the main features of these models and focus on the way we link them together.

Buhai and Teulings (2005) consider an efficient bargaining model between a worker and a firm where both the productivity of the worker in the job P_t and the alternative outside wage R_t follow geometric Brownians. The labour market consists of risk neutral workers and firms. The market for alternatives is Walrasian. Instantaneous specific investments proportional to the reservation wage, RI, are made at the job start and are lost upon separation. These investments are verifiable so that there are no hold-up problems. Since separation is irreversible the specific investments have an option value. We have efficient bargaining on wages: as long as there is a surplus of the inside productivity P_t over the reservation value R_t, the worker and the firm will agree on a sharing rule. In this model the tenure distribution and wage dynamics parts are separable since matching and separation decisions maximize the joint surplus. By definition there is separation whenever the inside productivity P_t falls below the outside productivity R_t. It is shown that the separation depends only on

$$B_t \equiv \frac{P_t}{R_t} \tag{1}$$

Writing the relation above in logarithms, the worker separates as soon as $b_t = p_t - r_t$ falls below a critical lower barrier b_t^-, with $b_t^- \leq 0$.

Bentolila and Bertola (1990) model the hiring and firing of homogeneous workers by a profit-maximizing firm with randomly changing profit expectations, where the source of these changing expectations is random growth. Following their exposition, a firm using only homogeneous labour as factor of production produces output

$$Q_t = A_t N_t \tag{2}$$

where A_t is labour productivity and N_t is the firm's employment size at date t. The firm faces a constant elasticity demand function

$$Q_t = Z_t P_t^{-\nu} \tag{3}$$

with elasticity $\nu > 1$, product price P_t and Z_t a market index capturing an exogeneous evolution of demand. Z_t is assumed to be a geometric Brownian with drift. The continuous-time random shocks of a geometric Brownian market index imply that a firm should permanently adjust its income expectations. We assume without loss of generality A_t normalized to 1 in (2); then output will be equal to total employment and (3) written in logs will be

$$n_t = z_t - \nu p_t \tag{4}$$

In this model firms pay hiring and firing costs proportional to the number of workers hired and respectively, fired. Assuming that hiring costs, firing costs and wages are constant, Bentolila and Bertola (1990) derive that the firm optimally hires a worker whenever p_t reaches a constant upper barrier $p^+ > 0$ and fires a worker whenever p_t reaches a lower barrier $p^- < 0$. Note here that when hiring and firing costs are close to 0, so that the upper and lower bounds for p_t also converge to 0, p_t is a constant and therefore firm size n_t is a Brownian, just like z_t. Since the distribution of instantaneous Brownian increments is constant, the Gibrat law is then implied for the firm size, stating that the growth of the log firm size does not depend on its level. This theoretical implication is consistent with the fact that the Gibrat law tends to hold for large firms, see for instance Jovanovic (1982).

We proceed to link the random growth firm demand model with the random growth individual productivity model. Consider a worker who is fired at some date T in Bentolila and Bertola's model. If this worker preferred to remain in the firm or to be already out of the firm at date T, then he would actually separate from the firm sooner, or respectively later, than it were efficient. Suppose this worker has outside option r_t, as in Buhai and Teulings (2005), and assume that r_t is a Brownian independent of z_t. Since homogeneous workers are perfect competitors for jobs, r_t would in fact be the log wage rate that a firm faces at date t. In this generalized setting, the firm's optimal turnover policy is to hire a worker whenever $b_t = p_t - r_t$ reaches a constant upper barrier b^+ and to fire a worker whenever b_t reaches a constant lower barrier b_t^- , or, in other words, the date at which any worker is fired is the "first passage time" of the lower barrier by a Brownian b_t, starting from the upper barrier. This is exactly what Buhai and Teulings (2005) show for the individual worker-firm match, see relation (1) above, where the hiring costs are identified as the initial specific investment and the firing costs are zero[2]. The ingredient missing in order to link the two models is a rule for firing individual workers. We use a Last- in-First-Out (LIFO) layoff rule, discussed in previous literature by Kuhn (1988) and Kuhn and Roberts (1989), meaning that the worker who is hired last, is fired first. We return to the justification of this rule in our context after explaining some notation.

We introduce the LIFO rule by attaching every worker a seniority index s_t, set equal to log total employment n_t at the moment the worker is hired. If the firm wants to fire workers, it will have to fire the workers with the highest seniority index, which, by construction, are the workers last hired. Consider the log marginal revenue $\mathrm{mr}(s_t, z_t)$ of the worker with seniority s_t, conditional on the state of demand, z_t. This log marginal value can be calculated by considering that the firm does not hire

[2]Constant positive firing costs are straightforward to consider, so this is without loss of generality. Hiring costs can be seen here as initial specific investments supported entirely by the firm.

any workers beyond worker with seniority index s_t. Then, log total revenue for all workers up to s_t would be equal, by using relation (4), to $\frac{\nu-1}{\nu}s_t + \frac{1}{\nu}z_t$, and hence the log marginal revenue of the last hired worker is

$$\mathrm{mr}(s_t, z_t) = -\frac{1}{\nu}s_t + \frac{1}{\nu}z_t + ln(\frac{\nu-1}{\nu}) \tag{5}$$

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Since z_t follows a random walk, the log marginal revenue also follows a random walk. When $\mathrm{mr}(s_t, z_t)$ is equal to the surplus of the job's productivity over the outside option, b_t, the optimal hiring and firing thresholds of the firm are the same as the entry and exit thresholds of a worker in a worker-firm match from Buhai and Teulings (2005). In fact, every worker is attributed her marginal product of labor as if no further workers were hired. The additional revenues collected by hiring extra workers are attributed to these extra workers. Given this, the hiring and firing decision of a worker indexed s_t can be decoupled from the hiring and firing decisions of workers with higher or lower seniority ranks. As long as the rank-order of hiring and firing is preserved, the only relevant information for the hiring and firing decision of a particular worker is the marginal revenue, given her seniority index. LIFO imposes a hiring-firing rule in the firm, providing thus a device for decoupling the hiring and separation decisions of workers with different seniority degrees within the same firm. Applying LIFO in this setting gets practical importance as soon as workers pay for some share β of the specific investments (hiring costs), $0 < \beta < 1$. Workers are compensated for these investments by awarding them a share β of the surplus of log productivity above their outside option, namely the marginal revenue $\mathrm{mr}(s_t, z_t)$:

$$w(s_t, z_t) = \beta \ \mathrm{mr}(s_t, z_t) \tag{6}$$

Since $\mathrm{mr}(s_t, z_t)$ plays the same role as b_t, this setup relates the wage setting at the firm level to the discussion on tenure profiles from Buhai and Teulings (2005). The expected discounted value of the tenure profile is equal to the worker's share in specific investment. However, the actual return depends on the (stochastic) evolution of the firm's demand curve, so on future realizations of z_t. The implication is that otherwise homogeneous workers who only differ by their degree of seniority s_t, receive different wages.

How can LIFO be rationalized in this context? This goes back to senior workers versus recent hires in the firm. The senior worker's wages are vulnerable to the firm hiring new workers, since these are perfects substitutes for incumbents, given the homogeneity assumption. The firm could negotiate a lower wage to pay the newcomers today, by promising them parts of the returns on specific investments that would otherwise go to incumbents. This threat of the firm induces a hold-up problem: workers invest less because they know that they will not be able to appropriate their full expected share in future surpluses. What are possible strategies for the incumbents? A first one, consistent with the extreme insider-outsider theory, would be for incumbents to oppose any further hiring since this endangers their claims on the surplus. However, the drawback of this strategy is that gains of trade remain unexploited. A more efficient solution would be to protect the claims of the incumbents by a LIFO layoff rule, which prevents the firm from replacing expensive incumbents with cheap new hires. A LIFO lay-off rule can therefore be viewed as a device to deal with the hold-up problem in firms with homogeneous workers who bear part of the cost of specific investments and therefore share in subsequent surpluses. A similar argument can be found in Kuhn (1988), who considers a world where first (unions representing) workers set wages and then the firm sets employment.

This model of wage setting has direct testable empirical implications. The firm hires worker with seniority s_t such that $\text{mr}(s_t, z_t) = b_t$, where b_t is the logarithm of B_t defined in (1), or, equivalently, by substituting in (5), the firm sets employment such that

$$s_t = z_t - \nu b_t + ln(\frac{\nu - 1}{\nu}) \tag{7}$$

If our model is correct, log wages are a function of the seniority rank s_t; from (6) and (5), the coefficient of a worker's seniority rank in a wage earnings regression would be $-\frac{\beta}{\nu}$,

$$w(s_t, z_t) = -\frac{\beta}{\nu} s_t + \frac{\beta}{\nu} z_t + \beta ln(\frac{\nu - 1}{\nu}) \tag{8}$$

depending thus on the worker's bargaining power β and on the demand elasticity of the firm ν. Although clearly negatively correlated with seniority rank s_t (workers with lower s_t will have higher tenure), tenure does not play a direct role in wage determination: as in Buhai and Teulings (2005), we cannot talk about "the" returns to tenure in this framework. Hence, the first and main testable implication of the model is that the tenure variable showing up significantly in a (pooled) cross-section log earnings regression is just a proxy for the worker's seniority rank, controlling for firm size [3]. With proper[4] matched employer-employee data we can thus test the relevance of seniority rank in a wage regression and its prevalence over the worker's tenure as wage determinant.

[3] As will become more clear in the empirical specification section, there are two ways in which we control for firm sizes when estimate the effect of the seniority rank. One is to actually identify the effect of the *relative seniority rank* $\overline{s_t} = s_t - n_t$, which has the effect of the firm size n_t incorporated. The disadvantage here is that the effects of seniority rank and firm size would not be separately identified. A second technique we use is to work directly with both the actual seniority rank s_t and firm size n_t in the empirical specification and claim that we can identify their separate effects, since different empirical methods give robust results. Yet a third alternative would be to consider firms in the same firm size classes and to perform the empirical analysis for each of those separate classes.

[4] Note that ideally we would have firms with homogeneous workers, differing only by the dates at which they were hired, as required by our theoretical framework. Since this is implausible in practice, our working assumption is that the workers' heterogeneity is not affecting the separation rates in a way that would interfere with the last-in-first-out rule (eg. workers with certain attributes are less likely to be fired than their more senior colleagues or viceversa).

A second testable prediction is that log firmsize n_t follows approximately a random walk, particularly clear when firing and hiring costs converge towards 0. We are in an ideal position to check for this since we use data from Denmark where there are no employment protection rules. An analogous implication is that log wages w_t can approximately be characterized as a random walk with transitory shocks, hence there should be no autocorrelation of the log earnings in time, once one controls for individual and job place characteristics.

A last implication of this model that we can test is that separation rates are positively related to the seniority rank of the workers (implicitly, this is equivalent to testing that workers with higher tenure separate less than those with low tenures).

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3 Empirical Framework

We start with the standard logwage equation used in this literature. We denote by i the individual worker and by t the period of observation. In addition we introduce the function $j(i,t)$ to indicate the firm of worker i in period t. We drop the arguments of this function whenever the identification of the individual and the period of observation are clear. For example we use $W_{ijt} = W_{ij(i,t)t}$ to denote the wage of an individual in period t, who is working for firm $j(i,t)$. We extend the standard specification with the *relative seniority rank*, $\overline{S_{ijt}}$, defined as the fraction between the *actual seniority rank* S_{ijt} and the *firm size* N_{jt}, measured as total number of employees of firm j. S_{ijt} is set equal to N_{jt} at the moment the worker is hired and in practice it can only change when more senior workers (that is, workers with lower seniority rank) in the firm separate from the firm.

$$\overline{S_{ijt}} \equiv \frac{S_{ijt}}{N_{jt}} \tag{9}$$

Using lowercases for the logarithms of the corresponding variables denoted by capitals, definition (9) is written as:

$$\overline{s_{ijt}} \equiv s_{ijt} - n_{jt} \tag{10}$$

Since changes in $\overline{s_{ijt}}$ reflect both changes in the log actual seniority rank s_{ijt} and changes in the log firm size n_{jt}, we will also report estimations where instead of $\overline{s_{ijt}}$ we use s_{ijt} and n_{jt} as separate covariates. Note that in a Last-in-First-Out (LIFO) setting as introduced in the previous section, the actual log seniority rank s_{ijt} is at its maximum when the worker joins the firm, it decreases monotonically- but in a non–determined fashion- with time, and it's at its minimum by the time he separates from the firm. The firm size n_{jt} also evolves stochastically with time, as discussed in the theoretical section, but non-monotonically (hence $\overline{s_{ijt}}$ is also non-deterministic and non-monotonic). As stated above, s_{ijt} is identical to n_{jt} when the individual starts the job and it changes over time so that any change in s_{ijt} will be a change in

n_{jt}, while n_{jt} can also change for other reasons, hence the dependency between both levels and changes of n_{jt} and s_{ijt} is in general ambiguous. Therefore we are not able, theoretically, to completely disentangle the two separate contributions (ie., generally $\widehat{\overline{s_{ijt}}}^{OLS} \neq \widehat{s_{ijt}}^{OLS} - \widehat{n_{jt}}^{OLS}$). Applying our different identification and estimation strategies below gives however an informed indication on the separate effects of s_{ijt} and n_{jt}, while similar results obtained by different methods and comparison to estimates for the effect of the log relative seniority rank $\overline{s_{ijt}}$ in the other specification, would be an indication of their robustness. We claim that with our data we are largely able to identify these separate effects. While the discussion in this section will focus on the specification using the relative log seniority rank $\overline{s_{ijt}}$, the alternative estimation case is treated analogously and estimates obtained by both methods are presented in the estimation section.

We use therefore the following econometric specification for the regression of log-wages w_{ijt}:

$$w_{ijt} = \alpha + X_{ijt}\beta + T_{ijt}\gamma + \overline{s_{ijt}}\eta + \varepsilon_{ijt} \tag{11}$$

where X is the number of years of work experience, T is tenure, and $\overline{s_{ijt}}$ is the relative log seniority rank defined above. We drop higher order terms in experience and tenure from equation (11) for convenience, but use them later in the estimation; in the estimation we also add basic (time-invariant) control variables likely to be important for the determination of individual wages[5]. We follow the standard approach and decompose the unobservable term as

$$\varepsilon_{ijt} = \varphi_{ijt} + \mu_i + \nu_{ijt} \tag{12}$$

where φ_{ijt} represents the stochastic component of wages that may be specific to a worker-firm match, while μ_i is a worker fixed effect that captures unmeasured heterogeneity (eg. ability). ν_{ijt} is the remainder term accounting for idiosyncratic shocks and measurement error, identically and independently distributed among the observations. If the unobserved individual and/or job match effects in (12) are correlated with tenure, experience or seniority rank, then least squares estimates of β, γ and respectively η from the wage equation (11) are likely to be biased. To see this, write φ_{ijt} and respectively μ_i as follows:

$$\varphi_{ijt} = X_{ijt}b_1 + T_{ijt}b_2 + \overline{s_{ijt}}b_3 + \xi_{ijt} \tag{13}$$

$$u_i = X_{ijt}c_1 + T_{ijt}c_2 + \overline{s_{ijt}}c_3 + \zeta_{ijt} \tag{14}$$

Reasons justifying why both the worker-firm match φ_{ijt} and the individual effect u_i might be correlated with tenure T_{ijt} and experience X_{ijt} in (13) and (14) have

[5] We also use exogeneous time dummies (or detrend the wages to start with), see the last paragraph of this section for more details on the treatment of time effects.

been extensively discussed in the previous literature. We cannot however think of any reason why φ_{ijt} or u_i should be correlated with $\overline{s_{ijt}}$, conditional on T_{ijt} and X_{ijt}. In other words $\overline{s_{ijt}}$ might only affect φ_{ijt} or u_i via its interdepence with T_{ijt}, insofar T_{ijt} itself is correlated with these unobserved terms. Hence, it would be reasonable to assume the conditional independence relations $\varphi|X, T \perp \overline{s}$ and $u|X, T \perp \overline{s}$, which translate in $b_3 = 0$ and $c_3 = 0$ in the auxiliary regressions (13) and respectively (14). Note that under these conditional independence assumptions, were it not for the correlation between $\overline{s_{ijt}}$ and T_{ijt}, η would be in fact consistently estimated directly by OLS applied to (11) and the biases for the OLS estimates for tenure and experience would be identical to the ones reported in previous literature, $\widehat{\beta}^{OLS} - \beta = b_1 + c_1$ respectively $\widehat{\gamma}^{OLS} - \gamma = b_2 + c_2$, see for instance Dustmann and Pereira (2005) for a discussion on these biases and their likely signs[6]. However, for separately identifying the effects of T_{ijt} and $\overline{s_{ijt}}$, the two conditional independence assumptions and OLS will not generally suffice. We discuss below suitable methods that will ensure identification of these separate effects.

Recall that our goal is to consistently estimate separate returns to tenure, experience and seniority rank, in order to see what are the wage returns to seniority rank, in top of the returns, to the time spent in the job. To achieve this we follow and extend standard techniques in the literature of wage returns to tenure and experience.

Consider first the 2SFD method of Topel (1991). The main idea behind this method is that, given that one is- rightly- worried about the endogeneity of T_{ijt} in an earnings regression, one can use the average within-job wage growth of workers who do not move; if wages are a random walk with a transitory trend as Topel (1991) shows for his PSID sample, then the wage growth for job stayers would be the wage growth for all workers and movers do not decide to move based on wages[7].Taking within-jobs first differences of equation (11), we eliminate the unobserved individual effect u_i and any other time-invariant regressors:

$$w_{ijt} - w_{ij,t-1} = \beta + \gamma + (\overline{s_{ijt}} - \overline{s_{ij,t-1}})\eta + \varepsilon_{ijt} - \varepsilon_{ij,t-1} \tag{15}$$

Compared to the first stage equation of the classical 2SFD, we obtain an additional component, related to the relative log seniority rank $\overline{s_{ijt}}$. The key identication principle for η is the following. Unlike β and γ, η can be directly identified in (15), since it jumps in a non-determined fashion, while the other two components are by definition increasing linearly with time, at the same pace. This means that only their combined linear effect $\beta + \gamma$ can be identified from (15). Remark that these results are crucially dependent on the conditional independence assumption $\varphi|X, T \perp \overline{s}$, hence on $b_3 = 0$

[6] We shall report also OLS estimates of β, γ, η from (11), but use them just as indicators and comparison with results obtained via appropriated methods.

[7] As we will mention in the estimation results section, we also verify that within-job log wages approximately follow a random walk, by checking that the residuals of the wage growth model are serially independent.

in equation (13), as discussed above. Note also that we do not need the second conditional assumption $u|X,T \perp \overline{s}$ in this particular estimation strategy, since u_i was completely eliminated by first differencing in (15)[8].

Using the least square consistent estimates of $\beta+\gamma$ and η from (15) above, we can identify separate effects of β and respectively γ from a second stage equation analogous to the one used in the standard 2SFD:

$$w_{ijt} - T_{ijt}(\beta+\gamma) - \overline{s_{ijt}}\eta = X_{ij0}\beta + e_{ijt} \tag{16}$$

X_{ij0} is the initial experience. The variable e_{ijt} is the error term of this equation. In the actual estimation of (16) higher order terms in experience and tenure are also subtracted (multiplied by their first-difference estimates from (15)) from the left hand side, and all the control variables eliminated by first differencing from the initial equation (11) are included as regressors. One of the crucial preconditions for Topel's (1991) approach to be valid for estimating consistent returns to tenure and experience (having already assumed $\varphi|X,T \perp \overline{s}$) is that unobserved characteristics of the individuals u_i are unrelated to observed job tenure T, see Topel (1991) for the discussion why this might be the case. In his argument Topel (1991) relies on the fact that $b_1 + b_2$, the bias in the first stage (15) of the 2SFD is negligible and positive in the PSID, so 2SFD would estimate a lower bound on tenure even if T and u_i were correlated. Moreover he shows that if such a correlation is present, then using X_{ijt} as instrument for X_{ij0} in the second stage (16) should obtain a lower estimate for T and in his case he gets just a negligibly lower effect. We will see that Topel's (1991) preconditions for the identification of the tenure and experience effects are not met in our data, in the section presenting the estimation results. The strong advantage of the extended 2SFD method in our context remains the immediate identification of the log relative seniority effect $\overline{s_{ijt}}$ under a very reasonable assumption[9].

A second empirical methodology often employed in studies concerning wage returns to tenure and experience are the instrumental variables methods used in such studies as Altonji & Shakotko (1987) and Dustmann and Pereira (2005). These studies start with the assumption that the worker-firm specific match term φ_{ijt} from (13) is time-invariant, $\varphi_{ijt} = \varphi_{ij}$. Given this first condition, there are a few related instrumental variable methods all using deviations from job or individual means to instrument the initial regressors, applicable to (11)[10]. We discuss in what follows variants of these IV methods and the conditions under which identification and consistent estimation of the parameters of interest is achieved.

[8] The 2SFD standard case requires no correlation between T and u as a condition for the consistenty of the estimate of the return to tenure, as we will also mention below. Note however that independent on whether orthogonality between T and u is met, η is still identified from the first stage equation given the conditional independence assumption $\varphi|X,T \perp \overline{s}$.

[9] We will see that in the alternative specification where we use separately the log actual seniority rank s_{ijt} and the firm size n_{jt}, 2SFD is the most unsuitable method since changes in s_{ijt} and n_{jt} are highly correlated.

[10] Higher order terms of the instrumented variables are instrumented analogously.

The first instrumental variable technique (we label it IV1a) in this literature is the one introduced by Altonji and Shakotko (1987) and consists in instrumenting tenure T_{ijt} with its deviations from *individual-job means over time,* DT_{ijt}, keeping experience X_{ijt} and log relative seniority rank $\overline{s_{ijt}}$ unchanged in (11):

$$\text{IV1a:} \begin{cases} DT_{ijt} \equiv T_{ijt} - \overline{T_{ij}} \\ X_{ijt} \\ \overline{s_{ijt}} \end{cases} \tag{17}$$

By construction, DT_{ijt} is orthogonal to both φ_{ij} and u_i. We need to assume from start both additional conditional independence relations of the log relative seniority rank and the unobservable terms, $\overline{s_{ij}} \perp \varphi_{ij}|X_{ijt}, DT_{ijt}$ and respectively $\overline{s_{ijt}} \perp u_i|X_{ijt}, DT_{ijt}$. Under these conditions application of IV1a might still produce biased estimates of all parameters of interest when applied to (11), since experience X_{ijt} might be correlated with the job-specific match effect φ_{ij}[11], bias reinforced by any correlation between X_{ijt} and the individual effect u_i. Although most studies cited above assume that X_{ijt} is orthogonal to the individual specific effect u_i, this might not hold, particularly with considerable heterogeneity in the sample, such as when using all the working population, as here[12]. Therefore, in order to identify η and γ by using IV1 we need the conditional independence assumptions above satistified plus the extra assumption $X_{ijt} \perp \varphi_{ij}$. In order to also identify the experience effect β we need to add to the previous three assumptions also $X_{ijt} \perp u_i$.

We do not have a method to deal with the possible correlation between X_{ijt} and φ_{ij}, but can control for the correlation between X_{ijt} and u_i by instrumenting experience with its deviations from *individual means over time,* next to instrumenting tenure as before, as done for instance by Dustmann and Pereira (2005). Thus we can use a second IV procedure (IV2a) that employs both the deviations of tenure from its job means explained above and DX_{ijt}:

$$\text{IV2a:} \begin{cases} DT_{ijt} \equiv T_{ijt} - \overline{T_{ij}} \\ DX_{ijt} \equiv X_{ijt} - \overline{X_i} \\ \overline{s_{ijt}} \end{cases} \tag{18}$$

Since by construction $DX_{ijt} \perp u_i$, IV2 will now identify all three parameters of interest, β, γ and η under the same three assumptions: $\overline{s_{ij}} \perp \varphi_{ij}|DX_{ijt}, DT_{ijt}$;

[11] Altonji and Shakotko's (1987) correction to this error is acknowledged not to be generally valid by Altonji and Williams (2005)

[12] Altonji and Shakotko (1987), Topel (1991) and Altonji and Williams (1997, 2005) use white males heads of households only and assume $X_{ijt} \perp u_i$, which, as indicated by Altonji and Williams (2005), boils down to different cohorts of workers being similar in terms of ability and to workers receiving high wages having the same attachment to the labour market as workers receiving low wages (Altonji and Shakotko (1987) test for this using potential experience as instrument for experience). If the sample is much more heterogeneous, as when comprising the whole labour, this is less likely to be the case. Moreover, using potential experience instead of actual experience, as here, makes accounting for a possible correlation between X and u even more relevant.

$\overline{s_{ijt}} \perp u_i | DX_{ijt}, DT_{ijt}$ and $DX_{ijt} \perp \varphi_{ij}$.

Both IV1a and IV2a assumed $\overline{s_{ijt}}$ orthogonal to φ_{ij} and u_i. However the instrumental variable approach offers us a way to relax these conditional independence assumptions. Namely, we can also instrument $\overline{s_{ijt}}$ with its deviations from job means over time, just as we instrumented T_{ijt} in the two IV approaches above, so that $D\overline{s_{ijt}}$ is orthogonal by construction to both φ_{ij} and u_i. We use thus the following IV variants which we call IV1b and IV2b, respectively[13]:

$$\text{IV1b:} \begin{cases} DT_{ijt} \equiv T_{ijt} - \overline{T_{ij}} \\ X_{ijt} \\ D\overline{L_{ijt}} \equiv \overline{L_{ijt}} - \overline{L_{ij}} \end{cases} \tag{19}$$

$$\text{IV2b:} \begin{cases} DT_{ijt} \equiv T_{ijt} - \overline{T_{ij}} \\ DX_{ijt} \equiv X_{ijt} - \overline{X_i} \\ D\overline{L_{ijt}} \equiv \overline{L_{ijt}} - \overline{L_{ij}} \end{cases} \tag{20}$$

Through IV1b, γ and η are identified under $X_{ijt} \perp \varphi_{ij}$, while the experience effect β is identified under $X_{ijt} \perp \varphi_{ij}$ and $X_{ijt} \perp u_i$. Through IV2b all three parameters of interest, β, γ and η, are identified under the single assumption $DX_{ijt} \perp \varphi_{ij}$. Using all IV variants provides a check on the validity of different additional assumptions we make. Moreover comparing estimates obtained via the 2SFD and the IV methods gives us a means to check the robustness of the results. A detailed discussion will follow when presenting the estimation results.

Finally, we want to say a few words about the treatment of the time effects. In all previous studies mentioned above a lot of attention has been paid to the use of exogeneous time dummies or alternatively, to the correct detrending of the wages. An important part of the criticism to Altonji and Shakotko (1987) by Topel (1991), and respectively to Topel (1991) by Altonji and Williams (1997, 2005), originates in the treatment of the time trends. All these studies used the PSID. Altonji and Shakotko (1987) control for changes in real wages by including a time trend in their regressions, which can only be appropriate, as indicated by Topel (1991), if aggregate wage growth is truly linear and if cross sections of the panel are random samples of the population at each point in time. Topel (1991) is using a real wage index calculated from cross-sections of the CPS by Murphy-Welch (1992), to overcome problems with the non-random cross-sections samples within the PSID, but gets ex-post criticised by Altonji and Williams (1997, 2005) precisely on the use of the CPS in this case, as

[13] In the alternative estimation where we use separately the actual seniority rank s_{ijt} and the firm size n_{jt}, instead of the relative seniority rank $\overline{s_{ijt}}$, we have 6 variants of IV methods that we apply and report on. IV1a and IV2a are similar as above, with tenure and respectively tenure and experience instrumented and s_{ijt} and n_{jt} used as simple regressors. IV1b (and IV2b) have tenure (and respectively tenure and experience) and both s_{ijt} and n_{jt} instrumented with their deviations from the individual-job means. Finally, IV1c (respectively IV2c) uses only s_{ijt} instrumented next to tenure (respectively, tenure and experience), with n_{jt} as simple regressor.

inappropriate. In our case the Danish and respectively the Portuguese economy-wide employer-employee datasets are all-encompassing and comprise all the population of interest and thus we need not worry at all about these issues. As expected, empirical results show that whether we detrend before or use year dummies in each regression does not matter in our context.

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4 Country features and data description

4.1 Labour market features in Denmark and Portugal

We use data from Denmark for 1980-2001 and from Portugal for 1991-2001. Choosing these two European countries provides us with a suitable and very interesting framework for comparison. While they are both members of the European Union, both small open economies and both countries with relatively low (in European terms) average unemployment rates over the targeted period[14], they differ greatly in rules containing the employment protection. We discuss shortly the relevant labour market features of these two countries.

Denmark is a prosperous Northern European country of 5.4 million people, with a labour force of 2.9 million people (2005 estimates). The Danish economy features, inter alia, modern small-scale industry, extensive government welfare measures and high dependence on foreign trade[15]. In 2004 the labour force was distributed accross sectors as follows: agriculture 3%, industry 21%, services 76%. The Danish labour market is characterized by very low employment protection compared to most other other OECD countries, similar to the legislation in this area from the United States[16]. The employment protection legislation applicable to the private sector is limited to basic provisions such as white-collar workers being given an advance notice of maximum of six months and some minimum EU enacted rules relating to mass layoffs. General rules (including severance payments) and any procedures for dismissal are completely absent, suggesting a perfect "right to manage" setting where employers have unlimited formal rights in deciding whom to fire or hire, see Albaek et al (1999) for more details. The "probation period" for newly hired workers in Denmark is 9 months for blue collar workers under the collective agreements and 12 months for white collars, similar to UK and Ireland (OECD 2004). However, given the very low

[14]The OECD standardized unemployment rates for both Denmark and Portugal are taken from Table 1 of Nickell et al (2005). We report them for (period averages) within 1980-2001. Denmark: 7% in 1980-1987, 8.1% in 1988-1995, 5.3% in 1996-1999 and 4.4 % in 2000-2001. Portugal: 7.8% in 1980-7, 5.4% in 1988-95, 5.9% in 1996-1999 and 4.1% in 2000-2001. Note that since 1995 the average unemployment rates have been very similar for the two countries.

[15]Denmark is a net exporter of food and energy, enjoying a comfortable balance of payments surplus.

[16]The OECD Employment Outlook (2004) classifies Denmark with scores 1 and respectively 0 (on a 0-3 scale) on the administrative procedures for individual notice and dismissal. This is similar for instance to countries like the United States, United Kingdom or Australia.

level of employment protection further on the jobs with lack of dismissal procedures and severance payments, as discussed above, the trial period is probably just a formality. The wage setting undertook some changes in the period analysed, cf. Bingley and Westergaard-Nielsen (2005). Briefly, prior to 1987 wage bargaining was characterized as central, but with a two level bargaining (ie. wages fixed at the national or industry level between the confederation of trade unions and respectively of the employers associations, but with decentralized negotiations afterwards that could decrease the agreed wage down to a fixed minimum also at the higher level); in 1987 bargaining was shifted to industry and/or firm level but was still characterized as coordinated wage bargaining with rather strict guidelines; these guidelines were finally abandoned in 1993 since when most contracts are negotiated at the firm level and the collective agreements have very limited role in the wage bargaining by setting minimum wages for the various areas. All in all, wage bargaining has been decentralized de jure since 1993, but de facto was also done (at least partly) at the firm level before. Unemployment benefits in Denmark are relatively high for wage earners and can be obtained for a long period, being considered relatively "generous" with respect to most other countries; however the unemployment rate has been one the lowest in Europe since the second half of the 1990's.

In 2005 the Portuguese labour market comprised more than 5.5 million workers, corresponding to an activity rate of 53%. If we look to economic sectors, 10% of the labour force works in the agriculture, 30% in the industry, and 60% are employed in the services sector. Out of the total employees in 2004, 88% had a full time job, and 80% of the employed workers have a permanent contract. Self-employees correspond to 24.2% of total employment. Portugal has a very strict employment protection legislation. According to OECD Employment Outlook (2004), Portugal presents the highest overall summary index on labor protection[17] and it used to have even stricter job protection in the recent past, than it has now. The overall strictness of protection against dismissals has decreased over the last 15 years, and it became somewhat easier to dismiss workers. The maximum number of successive contracts for temporary employment has increased from 3 to 4, and the maximum cumulated duration went from 30 months to 48 months. The use of temporary work agencies has been extended. The conclusion is that the overall strictness regulating the use of temporary employment has decreased. The notice period is 60 days for all workers, and the severance payment for individual dismissals is 1 month per year of service, with a minimum indemnity of 3 months. There is a probation period in the Portuguese labor market. For unlimited contracts the trial period is 90 days for most workers, with the exception of high complexity or responsibility jobs, in which case it is 180 days. For managers and top personnel the probation period is 240 days. In case the contract is only valid for a limited period of time, the probation period is 30

[17] Portugal is classified with 2 on a scale of 0–3 on the administrative procedures for both individual notice and dismissal.

days for contracts with a duration above 6 months, and 15 days for those with less than 6 months. As a general rule, the minimum duration of a contract is 6 months, although the law defines exceptions that allow smaller contract periods. Following an unjustified dismissal the worker can be reinstated or compensated. The extent of reinstatement is graded 2 out of 3 possible. Fixed-term contracts are allowed, but the maximum number of successive contracts is 4, with a maximum cumulated duration of 48 months. There are restrictions to the use of temporary work agency employment. Some exceptions are seasonal activity and replacement of absent permanent workers. The continued use of temporary workers in the same post is illegal. The firm can apply a collective dismissal for 2 or more workers in firms with 50 or less workers, or 5 or more workers in firms with more than 50 workers.

4.2 Data description

For Denmark, we use the "Integrated Database for Labour Market Research" (IDA). The dataset is constructed by the Danish Bureau of Statistics from a variety of data registers used for the production of official statistics. IDA allows for matching of workers at establishments (local entities) and these to firms (legal entities). It tracks every single establishment and every single individual between 15 and 74 years old in Denmark; there is no attrition in the dataset. The data has been used and described in many previous studies, including Bingley and Westergård-Nielsen (1996), Albaek and Sorensen (1998), Koning et al. (2000), Christensen et al. (2001), Mortensen (2003), Van den Berg and Van Vuuren (2005) etc. IDA is collected as of 1980 and includes individual information on the level of education, labor market state, earnings, occupation, residence etc. We include all individuals[18] who worked in the private sector in the period 1980-2001, therefore excluding the sizeable public sector, the self-employed individuals and those out of the labour force. These exclusions makes sense since wage setting and other rules are different in the public sector than in the private one, while of course the latter two excluded categories do not receive wages. The labor market status of each person is recorded at the 30th of November each year. This gives one labor market state per individual per year. There are seven different occupation levels: CEO, high-level management, low-level management, office worker, skilled blue collar worker, unskilled blue collar worker and an unclassified worker category. We merge the first 3. The place of residence gives one of the 276 cities (*kommune*), which we aggregated into 12 regions (*amt*). Industries are defined at the local entity level and therefore to obtain the industry classification of a firm we categorize that firm according to the industry where most its employees work. Firm sectors are classified according to the Standard Industry Classification (SIC). We do not use the agriculture and fishing sector in the analysis and we also exclude the Danish enormous private health sector since these sectors are organized differently than typical private

[18]We work with the full age range 15-74. People younger than 18 constitute less than 2% of the total number of observations (<25 less than 15%) and people older than 65 less than 1%. Estimation results are virtually identical if we narrow the age range at 18-65 or 25-65.

industry sectors[19]. We perform the empirical analysis described above for the whole private sectors (less the discarded categories above) with industry controls, as well as for all sectoral categories that we distinguish, see the appendix for more details on this.

Deriving the seniority ranks of the workers is relatively straightforward since the data are all encompassing. We use the time spent in the current firm and count all individuals that hold primary jobs[20] in the same firm, with a longer period of seniority, assigning this number as the seniority rank of the individual. The construction of the time spent in the firm is however not trivial. One of the problems is related to people that started working in the period before 1980 since we do not have any information from the original dataset in this period. Bingley and Westergård-Nielsen (2005) solve this problem by using pension payments from a second dataset that collects information from contribution histories to a mandatory pension program, the ATP, established in 1964. This allows them to construct tenures from 1964 onwards. We follow their procedure. This implies that tenures are left censored in 1964 and therefore in 1980 tenures are topcoded at 17 years. Hence, we cannot use any of the workers that have been in a firm for 17 years or more in 1980 and we drop them from the sample; the discarded observations are less than 3% from the total number of observations and they come particularly from the early years in our time series. We can of course still construct the seniority rank for all other workers and we have the total firm size, hence this procedure does not affect our analysis. Another empirical problem is that firm identifiers might change over time when ownership changes in a legal sense. Denmark Statistics corrects for the cases when more than 50 percent of the employees are taken over by the new legal employer. In this case the tenure is said to be continuing. We derive thus continuous spells of tenure with each employer based on this correction. We use potential experience as measure of actual experience. Potential experience is defined as age-education-6, where education is measured in years and where we take education at entry in the labour market[21].

[19]The agriculture sector: is much different than all other private sectors, receiving important subsidies (such as EU agricultural subsidies) and being structured around very small, but modern, enterprises (farms etc). Moreover this sector has been considerably shrinking in the recent past in Denmark. The health private sector comprises mostly the private medical practioners but since health insurance is free in Denmark for all residents, they do not get their revenues from their customers. We performed however the empirical analysis also separately for these sectors, and will make a note of the results, when discussing the estimation results for the rest of the economy.

[20]Primary jobs are identified by Denmark Statistics to be the jobs where the individuals works more than 50% of their working hours. These jobs can be both fulltime and part-time jobs and an individual can also hold secondary jobs. We tried different alternative specifications in which we count firm size and seniority rank based on a). all jobs, both primary and secondary (but estimating only on the sample of the individuals holding primary jobs); b). full-time jobs (more than 30 hours a week). The results are remarkably robust to using either specification. Hence, we chose to report estimates for primary jobs since in Denmark a large percentage of the working population works part-time and has exactly the labour regime as anybody else.

[21]Results using education as the mean education over time for that individual instead of the

“Quadros de Pessoal” database is a matched employer-employee data provided by the Ministry of Employment in Portugal. Studies that used and described this dataset include Blanchard and Portugal (2001), Cabral and Mata (2003) etc. This database is the result of a compulsory survey of firms, establishments and its workers. It contains information about over two million workers each year, and 100 to 200 thousand companies are covered. There is a legal request for the data to be delivered by the firm, and for it to be displayed in a public space within the establishment. This enhances the response rate, while it reduces measurement error problems. The information available includes the worker's gender, age, skill, occupation, schooling, tenure, earnings and duration of work, and the establishment's and the firm's location, industry, and size, measured by both number of workers and sales. It covers fully the workforce within establishments, which makes it a census of the establishments employing paid labor. The survey excludes both the administrative sector and domestic work. In practice, this survey represents a census of firms, establishments and their workers. It includes detailed information about workers and their employers. More specifically, the analysis will be implemented for a population of full-time employees, aged between 18 and 65. Workers from agriculture, fishing, the public administrative sector and extractive industry were excluded. Our analysis will cover the period 1991-2000.

Gross earnings were computed as

$$hourw = (bw + sen + reg)/nh,$$

where bw stands for base-wage, sen are seniority-indexed components of pay, reg are other regularly paid components, and nh are normal hours of work.

Wages were deflated using the Consumer Price Index. Outliers in the log of real wage growth, defined as values below -2 or above 2, have been dropped. The industry of the establishment or firm is identified as that yielding the highest share of sales or, when the allocation of sales is not possible, that which employs the highest share of workers. Given that the major industry of the firm/establishment is reported, it can change over time. Sales were deflated using the GDP deflator. Observations with missing values or outliers in sales or its growth have been dropped. Outliers in sales were defined as half the percentile 10 and outliers in sales growth were defined as changes in log real sales below -5 or above 5. The empirical analysis is conducted, as in the case of Denmark, for each of the available sectors and for the whole economy as a whole using sectoral dummies.

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minimum education are virtually identical. In the case of the individuals who started to work before 1980 we use their earliest recorded education and drop those individuals for whom potential experience is lower than tenure for their first recorded job (less than 2% of the total number of observations are dropped). Results do not change at all if we keep these individuals in the sample

5 Estimation Results

We report results on each of the empirical specification discussed in section 3. and on the alternative when using both s_{ijt} and n_{jt} instead of the $\overline{s_{ijt}}$. Estimation results are reported for the entire private sector and for selected industries within the private sector, for both Denmark and Portugal. Next to a quartic in tenure,.a quartic in experience and the log relative seniority rank (or respectively the log seniority rank and the log firm size under the alternative specification), in all wage regressions (OLS, IV methods, second stage 2SFD) we introduce as controls occupational dummies, regional dummies, gender and years of education. While we present below only the estimates on the key variables, the full regression summaries are available by request from the authors.

The results for each unit (whole private sector or each separate sector) are split into 3 tables. Table A presents estimates for tenure T_{ijt} and experience X_{ijt}, without accounting in any way for seniority rank. Following the previous literature, estimates for the linear coefficient and for the returns to10 years are presented, for both tenure and experience. From top to bottom the rows show respectively results through ordinary least squares, 2SFD, IV1a and IV2a . Table B presents estimates for empirical specifications where next to tenure and experience we introduce the log relative seniority rank. From top to bottom the estimates are for OLS, 2SFD, IV1a, IV1b, IV2a and IV2b. Finally, Table C presents estimates for the empirical specification where we include tenure T_{ijt}, experience X_{ijt}, actual log seniority rank s_{ijt} and log firm size n_{jt}. Again, from top to bottom each row presents estimates for OLS, 2SFD, IV1a, IV1b, IV1c, IV2a, IV2b and respectively IV2c. Methods IV1a and IV2a are similar as above, with tenure and respectively tenure and experience instrumented, and s_{ijt} and n_{jt} used as simple regressors. IV1b (and IV2b) have tenure (and respectively tenure and experience) and both s_{ijt} and n_{jt} instrumented with their deviations from the individual-job means over time. Finally, IV1c (and IV2c) use only s_{ijt} instrumented next to tenure (tenure and experience), with n_{jt} as simple regressor. Under each coefficient estimates we present the corresponding t-statistic based on White standard errors accounting for person-specific heteroskedasticity and autocorrelation for the OLS and IV methods, as in Altonji and Williams (2005) and respectively on robust standard errors accounting for Topel's 2SFD procedure, correction based on Murphy and Topel (1985) and Greene (2003). Preliminary estimation results for Portugal and then Denmark are presented and discussed below. In the end of this section the conclusions for the test of the random walk assumptions for logwages and log firm sizes are presented.

5.1 Key estimates for Portugal

The estimation results for the whole private sector in Portugal for the years 1990 to 2001 are displayed in Tables 1 to 3, below.

Table 1: Entire private sector Portugal Table A

	TenCoef	Ten10	ExpCoef	Exp10
OLS	0.0218	0.1349	0.0402	0.2730
(t-statistic)	70.6790	136.2142	71.2898	106.0838
2SFD	0.0277	0.1763	0.0515	0.3410
(t-statistic)	50.2107	31.0228	1.5e+03	105.4173
IV1	0.0215	0.1460	0.0417	0.2772
(t-statistic)	78.7980	102.4401	70.7383	102.1758
IV2	0.0107	0.0421	0.0552	0.3899
(t-statistic)	33.4520	19.3512	87.1329	112.2627

Table 2: Entire private Sector Portugal Table B

	TenCoef	Ten10	ExpCoef	Exp10	RLogRank
OLS	0.0179	0.1178	0.0394	0.2688	-0.0176
(t-statistic)	56.9536	114.0641	69.9183	104.3493	-50.9973
2SFD	0.0239	0.1530	0.0510	0.3361	-0.0151
(t-statistic)	42.8194	26.7717	1.5e+03	103.9571	-39.7451
IV1a	0.0210	0.1429	0.0415	0.2767	-0.0025
(t-statistic)	64.7515	71.6000	70.3726	102.2836	-3.8231
IV1b	0.0164	0.1150	0.0403	0.2723	-0.0247
(t-statistic)	56.0672	73.5485	68.2938	100.3045	-55.2063
IV2a	0.0060	0.0146	0.0547	0.3884	-0.0224
(t-statistic)	15.6010	5.4074	86.7071	112.1949	-34.2628
IV2b	0.0056	0.0120	0.0547	0.3883	-0.0246
(t-statistic)	16.5418	5.2984	86.3651	111.7617	-55.3099

Table 3: Entire private sector Portugal Table C

	TenCoef	Ten10	ExpCoef	Exp10	LogRank	LogFSize
OLS	0.0182	0.1013	0.0397	0.2730	-0.0199	0.0655
(t-statistic)	59.0941	100.3844	72.5904	109.3359	-59.7713	169.9933
2SFD	0.0245	0.1595	0.0521	0.3463	-0.0071	0.0281
(t-statistic)	43.8587	27.8267	1.6e+03	107.1954	-16.1964	55.3176
IV1a	0.0239	0.1731	0.0444	0.2839	0.0109	0.0272
(t-statistic)	74.9547	90.5516	76.3894	106.9273	17.7701	37.4930
IV1b	0.0186	0.1372	0.0423	0.2775	-0.0146	0.0417
(t-statistic)	62.7369	82.0010	72.6801	104.2369	-29.4551	65.4784
IV1c	0.0177	0.1360	0.0428	0.2780	-0.0189	0.0580
(t-statistic)	56.9905	79.7452	73.6531	104.6123	-28.7894	79.0037
IV2a	0.0069	0.0228	0.0554	0.3920	-0.0103	0.0568
(t-statistic)	18.0619	8.6102	88.5181	114.5002	-16.7347	75.6646
IV2b	0.0066	0.0201	0.0551	0.3905	-0.0148	0.0416
(t-statistic)	19.8085	8.9352	87.8881	113.8690	-30.3171	65.2483
IV2c	0.0043	0.0081	0.0551	0.3913	-0.0222	0.0692
(t-statistic)	12.1474	3.3847	87.8974	113.9600	-33.9861	93.0776

All estimations in levels are performed on 4811689 observations, which comprise 1244345 individuals and 61507 firms in 1329762 job spells.

Consider first Table A (1), where we start with the row reporting returns to tenure and experience from using the "standard" 2SFD method from Topel (1991). Before looking at the results we need to address whether the preconditions for applying 2SFD so as to estimate returns to tenure and experience are met. The bias $b_1 + b_2$ for the estimated intercept in the first stage of the 2SFD (not reported here) is negative (-0.005) rather than positive as in Topel (1991). This means that, even if the experience bias b_1 is most likely positive as usually assumed, it is not clear anymore how the estimates of experience and tenure will be biased in equations (8) of Topel (1991), this depending on the relative magnitude[22] of $b_1 + b_2$ versus b_1.As one can notice from Table A, with the 2SFD method of Topel we actually get a higher estimated linear coefficient for T than the onr estimated by OLS, which is an indication that in fact the returns to tenure are overstated, while the returns to experience are understated by using this method. This conclusion is reinforced by the fact that using X_{ijt} as instrument for X_{ij0} the estimate of the linear coefficient for tenure becomes considerably higher, namely 0.034 (not reported here) and not just negligibly lower as Topel obtains on the PSID. This suggests that there is ability bias in the returns to tenure and that this is due in the case of Portugal to the

[22] b_1+b_2 is multiplied by the least square coefficient from a regression of tenure on initial experience. This coefficient is virtually identical to Topel's (1991) both as sign and magnitude.

negative, not positive, correlation between T and u_i. Of course the validity of the instrument X_{ijt} used for initial experience X_{ij0}, depends on the assumption that X_{ijt} is orthogonal on u_i. This is however also questionable here. One of the assumptions made by Topel (1991), Altonji and Shakotko (1987) and Altonji and Williams (1997, 2005) is that experience X_{ijt} is orthogonal to the individual heterogeneity u_i, at least on their rather homogeneous sample of white men heads of households. Since we use potential experience as a proxy for actual experience, and since we are in the context of the whole population of all working men and women, it is much more likely that we have a correlation between X_{ijt} and u_i. So the instrument might not be valid here at all. This aside however, the fact that $b_1 + b_2$ is negative has the clear consequence of making inference on the direction of the tenure and experience bias ambiguous. Since the estimate for the tenure coefficient is actually higher than the OLS estimate, this is an indication that we obtain an upper estimate of the return to tenure.

Furthermore, the classical IV1 method of Altonji and Shakotko (1987) where we just instrument for tenure with its deviations from individual-job means over time is not suitable in the case of Portugal for the same reasons as Topel's (1991) 2SFD method. First, the correlation between X_{ijt} and ϕ_{ij} can induce, as stated above, either negative bias in tenure and positive in experience or viceversa, again the ambiguity being due to the fact that $b_1 + b_2$ is negative [23], see the expression of this bias in Altonji and Williams (2005). Second, the already biased estimates could be further influenced by the possible correlation of X_{ijt}(uninistrumented in IV1) with the individual heterogeneity u_i, which acts upward on X_{ijt} and downward on T_{ijt}, see for instance Dustmann and Pereira (2005) for the expressions of these biases. By looking at Table 1 we see that the estimate for tenure is somewhat lower than the one in the OLS case, while the one by experience gets higher. Nonetheless we want to also investigate results where we remove the correlation between X_{ijt} and u_i. We look therefore at the IV2 method from Table A, where the bias in the returns to tenure is due only to possible correlation of the instrument of experience, DX_{ijt}, with ϕ_{ij}[24]. XXX Then the returns to tenure are likely to be downward biased and the returns to experience upward biased. The estimates reported in the first table are suggesting that the linear coefficient of tenure is somewhere between 0.010 (the IV2 estimate) and 0.021 (the IV1 estimate), while the one for experience is between 0.041 (the IV1 estimate) and 0.055 (the IV2 estimate), with the corresponding returns over 10 years as reported in Table A.

What happens with the introduction of the relative log seniority rank $\overline{s_{ijt}}$,. see Table B (2)? As discussed above, with 2SFD we can identify the effect of the relative

[23] Topel (1991) shows that the IV1 estimator of Altonji and Shakotko (1987) should be equivalent to his 2SFD estimator where macro-effects are pre-estimated and where in teh second step experience is used as instrument for initial experience, hence the relation with the bias in the first step of the 2SFD, $b_1 + b_2$.

[24] Note that this correlation is different that the one of experience itself, X_{ijt}, with the time-invariant job-match effect.

seniority rank if we assume $\overline{s_{ijt}}$ orthogonal on the job match unobservable ϕ_{ijt}. This makes 2SFD a very attractive method, despite the fact that as we saw above it is not well suited to estimate tenure and experience effects in this data. The estimated coefficient of the log relative seniority rank is -0.0151. Further, in method IV1a there are multiple bias sources for the effect of $\overline{s_{ijt}}$: could be that one or the other of the conditional independence assumptions is not satisfied and moreover $\overline{s_{ijt}}$ could be correlated with DT_{ijt} which might be still biased for the reasons mentioned above in case of the estimates reported in Table A. This makes IV1 the least attractive method to identify the effect of $\overline{s_{ijt}}$. Indeed, from Table B, this is the only estimate markedly diffrent from the analogue ones obtained by different methods, with much lower magnitude. We get an idea of the size of the biases in IV1 by instrumenting $\overline{s_{ijt}}$ together with T_{ijt} in IV1b, so that we remove its possible correlation with both u_i and ϕ_{ij}[25]: in this case the effect of .$\overline{s_{ijt}}$ is revealed stronger than the one estimated with 2SFD: -0.0247. This estimate holds exactly when we apply method IV2b (so when X_{ijt} was also instrumented) and almost exactly IV2a (-0.0224), when we do not instrument for it but we instrument for the other two key variables. Since the tenure estimate differs between IV2a and IV2b to the same extent and in the opposite direction compared to how the relative seniority rank estimates differ between these 2 methods, this suggests that $\overline{s_{ijt}}$ is still somewhat correlated with DT_{ijt}, hence the b IV variants are more appropriate than the a ones. Among the IV estimates we prefer therefore methods IV2a and IV2b and among them, IV2b. There is a further issue to discuss here: why are the results obtained with these two methods for the effect of $\overline{s_{ijt}}$ so different in size than the analogue result obtained by 2SFD? Note that the IV methods assumed $\phi_{ijt} = \phi_{ij}$ and this could be part of the explanation. In any case the estimate for the relative log seniority rank is negative and strongly significant and it is likely that its value is between -0.024 (IV methods) and -0.015 (2SFD). What happens with the returns to tenure in Table B? When we account for the effect of the log relative seniority rank we obtain the remarkable result that the wage returns to tenure are reduced to 0 in terms of the linear coefficient and a mere 1% cumulative return over 10 years. Even if these are lower bounds, the difference with the lowest bounds of 1% linear coefficient and over 4% cumulative returns over 10 years from Table A is very large. This suggests that the joint effect of log seniority rank and log firm size (ie. the effect of the log relative log seniority rank) explains a large part of the observed "true" returns to tenure estimated without considering the position of the worker in the seniority hierarchy of his firm.

Let us now analyze the results from Table C for the whole Portuguese private sector (3) and see what can we say about the separate effects of the log seniority rank s_{ijt} and log firm size n_{jt} since in Table B we could say something only about the log relative seniority rank effect, $\overline{s_{ijt}}$, which accounted for their joint effect. From

[25] DT_{ijt} is unlikely to be correlated with $D\overline{s_{ijt}}$ because of the stochastic jumps in $\overline{s_{ijt}}$, similar to the reasoning for identification of $\overline{s_{ijt}} - \overline{s_{ijt-1}}$ in the first stage of Topel's 2SFD

the beginning we note that the results for the returns to seniority and experience hold as in Table B (they essentially dissapear when accounting for seniority rank and firm size, with our most prefered methods), hence we will focus this discussion on the separate estimates for s_{ijt} and n_{jt}. As discussed in the empirical specification section, these estimates are to be seen cautiously since theoretically we cannot completely disentangle them. This is obvious in the case of the 2SFD, which is based on changes over time since changes in s_{ijt} are by construction also changes in n_{jt} (but not necessarily the other way around). Similarly, for IV1a we are likely to have the same problem as above in the estimations within Table B, but even more exacerbated this time. As you can actually see from Table C these estimates for 2SFD and for IV1a are the only ones markedly different from all the other ones, in the sense that they give either a too small (in absolute value) negative estimate for s_{ijt} or even a positive highly significant one. However all other variants seem to give us values for the effect of the log seniority rank that are in the range for those of the relative seniority rank that we obtained in Table B, which is encouraging. At the same time the firm size seems to have the expected effect according to previous literature, see for instance Brown and Medoff (1989). The next thing to remark is that in the variants IV1c and IV2c, when we instrument for seniority rank s_{ijt} but do not instrument also for n_{jt}, the estimates are higher in absolute value (-0.0189 and respectively -0.0222) than when we instrument also for firm size n_{jt} in the IV1b and IV2b variants (-0.0146 and respectively -0.0148), which are remarkably close to each other. When we do not instrument at all for either s_{ijt} or n_{jt}, but we reduce as much as possible the bias in experience, ie. by using IV2a, we see that there is likely still some correlation beween s_{ijt} and DT_{ijt} and this could explain why the estimate is somewhat lower (-0.0103). We prefer therefore IV2b and IV2c as estimation methods. If this is correct, the actual seniority rank has an effect between -0.0148 (IV2b) and -0.0222 (IV2c), while the firm size has an effect between 0.0416 (IV2b) and 0.0692 (IV2c)

XXX

5.2 Key estimates for Denmark

Preliminarily, we report below, in Tables 4 to 6, the estimation results for the largest sector in terms of the number of observations, the manufacture of metals and metal products (category 7 in terms of our sectoral splitting, see the appendix of this paper), since part of the results (the standard errors) for the whole private sector (more than 25 million observations for the 20 years span we use) need still to be addressed. However in terms of magnitude of the estimated coefficients, the results are are virtually identical to the results reported for this sector. The estimations in levels are performed on 3788161 observations, including 628613 individuals, 18023 firms and 1012360 job spells.

We follow the same analysis order as in the case of Portugal in the previous subsection. The first thing to notice by looking at Table A for Denmark (4), is that

Table 4: Sector 7 Denmark Table A

	TenCoef	Ten10	ExpCoef	Exp10
OLS	0.0074	0.0417	0.1263	0.7489
(t-statistic)	17.5552	44.0234	211.3510	300.9105
2SFD	-0.0118	0.0344	0.0930	0.5782
(t-statistic)	-28.0227	6.0589	156.0246	173.0996
IV1	-0.0018	0.0051	0.1285	0.7618
(t-statistic)	-4.8003	4.5951	214.1870	303.3251
IV2	-0.0008	0.0005	0.1238	0.7235
(t-statistic)	-2.2903	0.4375	179.6867	229.7171

Table 5: Sector 7 Denmark Table B

	TenCoef	Ten10	ExpCoef	Exp10	RLogRank
OLS	0.0051	0.0318	0.1255	0.7423	-0.0126
(t-statistic)	12.1379	33.6287	210.0988	298.2306	-64.1894
2SFD	-0.0152	0.0193	0.0915	0.5654	-0.0233
(t-statistic)	-35.9994	3.3736	153.5441	169.3056	-39.0673
IV1a	-0.0033	-0.0034	0.1275	0.7539	-0.0133
(t-statistic)	-8.9293	-3.0410	212.6155	300.4122	-66.5708
IV1b	-0.0032	-0.0029	0.1275	0.7544	-0.0125
(t-statistic)	-8.6265	-2.5361	236.2252	26.9827	-23.1301
IV2a	-0.0020	-0.0039	0.1231	0.7166	-0.0119
(t-statistic)	-5.5119	-3.7326	178.3186	225.7470	-52.1099
IV2b	-0.0021	-0.0042	0.1231	0.7162	-0.0127
(t-statistic)	-5.6949	-3.9946	178.4173	225.8594	-24.5524

Table 6: Sector 7 Denmark Table C

	TenCoef	Ten10	ExpCoef	Exp10	LogRank	LogFSize
OLS	0.0042	0.0221	0.1243	0.7373	-0.0120	0.0288
(t-statistic)	10.0456	23.0174	208.4542	297.2113	-61.2945	98.9519
2SFD	-0.0143	0.0232	0.0922	0.5705	-0.0149	0.0252
(t-statistic)	-33.9934	4.0072	154.6065	170.7483	-16.0587	40.8012
IV1a	-0.0030	-0.0046	0.1260	0.7469	-0.0124	0.0294
(t-statistic)	-8.1446	-4.1375	210.5785	298.5984	-62.2127	100.0551
IV1b	-0.0025	-0.0019	0.1262	0.7487	-0.0079	0.0268
(t-statistic)	-6.5759	-1.6953	208.6773	294.1746	-13.3421	26.8794
IV1c	-0.0024	-0.0015	0.1264	0.7497	-0.0075	0.0246
(t-statistic)	-6.4768	-1.2553	209.7359	294.2830	-10.4485	33.2667
IV2a	-0.0021	-0.0077	0.1236	0.7195	-0.0107	0.0274
(t-statistic)	-5.9240	-7.3580	179.3395	227.4564	-46.8346	87.5163
IV2b	-0.0019	-0.0073	0.1238	0.7213	-0.0081	0.0272
(t-statistic)	-5.2986	-6.9632	179.3548	227.0879	-14.4951	27.9078
IV2c	-0.0018	-0.0066	0.1237	0.7213	-0.0077	0.0245
(t-statistic)	-5.0355	-6.1936	179.5471	227.1749	-11.3070	35.0284

OLS estimates are already very low and close to zero as returns to tenure. When applying the other methods we actually get negative linear coefficients[26], but small positive cumulative returns to tenure over 10 years. We get the highest returns for 10 years (0.03) but the lowest linear coefficient for tenure (-0.01) using the 2SFD. The bias $b_1 + b_2$ in this case is very small and positive, similar to what Topel (1991) finds (not reported here). However when looking at the correlation between u_i and T_{ijt} to test for ability bias we find enormous differences compared to the USA PSID: namely, using experience as instrument for initial experience decreases the coefficient of tenure enormously, down to -0.09, with corresponding implausible cumulated returns to 10 years of tenure -0.77. This is indication that one of the preconditions for the 2SFD is not met and thus it is very hard to interpret the estimaets obtained with 2SFD from Table A7, since in higher orders of the polynomial in tenure this bias is exacerbated. XXX By using IV1 and IV2 we get in both cases results for tenure and experience that are very close, which is suggestive of the fact that X_{ijt} is virtually not correlated to any of the unobservable components, u_i or ϕ_{ij}. We find of course that there is some heterogeneity among the workers in terms of the returns to tenure and experience. If we look separately at men versus women (not reported here), their returns to tenure are significantly lower, since on average their tenure with the firms

[26] We obtain lower returns to tenure than Bingley and Westergaard-Nielsen (2005), who attribute about 0.6% of the increase in wages as true returns to job tenure (the rest up to 2% being attributed to worker heterogeneity in their study, which uses plant closures so that the displacements can be taken exogeneous).

are higher. However we cannot run the analysis on these two separate groups since we need the seniority rank position in the firm is taking into account all workers. We also verify that the returns to tenure slightly increase in the 1990's compared to the 1980's, confirming thus the finding by Bingley and Westergaard-Nielsen (2005) who use exogeneous job displacements to investigate the returns to tenure.

Going to Table B for Denmark (5) we note that all IV methods give essentially the same result for the estimate of $\overline{s_{ijt}}$, indicative of the fact that the conditional independence assumptions are satisfied and that tenure is pretty accurately estimated with all of them (and we see indeed that estimaets for tenure are also very close- just sligly less than 0 for both the linear coef and for cumulative returns to 10 years). We prefer those where we instrument also for $\overline{s_{ijt}}$ hence IV1b and IV2b with estimates of -0.0127. The only difference is Topel's method where we obtain an estimate of -0.0233, so higher in absolute magnitude. It could well be the case that the assumption of $\phi_{ijt} = \phi_{ij}$ does not hold and hence that the IV methods, that use this as the first condition, would not be suitable. XXX In all cases the estimate for the relative log seniority rank is negative and strongly significant, but smaller in magnitude than the effect estimated in the case of Portugal. The discussion referring to the estimates of tenure and experience is exactly like in Table A. How does the estimated return to tenure change in Table B relative to the estimates in Table A? The return to tenure is actually going down although this is more difficult to note since the returns were already close to zero or even slighly negative. The returns to tenure become even more negative and even the cumulative returns to tenure over 10 years seem to have be negative now. However one should note that the t-statistics, although indicating significance at conventional significance levels, are low when taking into account the huge sample size involved. The effect of the seniority rank does not seem to follow the slight increase in the returns to tenure in the 1990's versus the 1980's and this could be explained by the fact that even in the more union-controlled labour setting from before the 90's, the firms still had the right to manage in terms of hiring and firing decisions..

Let us now look at how much of the relative log seniority rank is accounted for by the actual seniority rank and how much is the effect of the firm size. The corresponding estimates are in Table C for Denmark (6). The whole discussion is very similar to that for tables A and B for the rest so we only discuss the estimates for s_{ijt} and respectively n_{jt} here. In the case of Denmark we have a meaningful figure also for the separate estimates of s_{ijt} and n_{jt} obtained via 2SFD, unlike in the case of Portugal. This could be explained recalling that in Denmark there is a lot of mobility and no firing costs, hence the changes over time in s_{ijt} and n_{jt} are less correlated than for Portugal. We also see that all methods where we instrument for s_{ijt} (whether we instrument for n_{jt} or not), namely IV1b, IV1c, IV2b and IV2c all give a similar estimate (-0.0075), lower in absolute magnitude than the one found by 2SFD and the IV1a and IV2a methods, which are close to those found for the relative log seniority rank in Table B above (-0.0149 for 2SFD, -0.0124 for IV1a, -0.0107 for IV2a) .By looking carefully at each b and c variant and comparing to its a counterpart, we notice that the differences in the point estimate for seniority rank are explainable by possible correlation and difficulty of separate identification with the instrument for tenure or with the firmsize. We prefere therefore the b and c variants and we believe those estimates to be more reliable. Hence in the case of Denmark the actual log seniority rank plays less of a role than in the case of Portugal, which is to be expected given the difference in the employment protection settings. In the case of Denmark the effect of the actual seniority rank is about -0.007 to -0.014 (with some sectors having even lower magnitudes, but also of the size of the effects in Portugal for a few sectors, such as sector 12, see the appendix for our numbering of the sectors). The firm size effect is estimated in the range 0.024 to 0.028 and this seems to hold for most industries[27] and it is clearly lower than in Portugal.

5.3 Comparison estimates Denmark-Portugal

Following the empirical analysis on each of the two countries, discussed in the previous subsections, we take in what follows a comparative look at the results. In Portugal the seniority rank has more importance in the determination of wages than in Denmark, although in both countries it is strongly significant and negative and in both countries this effect is separate from the firm size effect on wages which is highly significant and positive and stronger in Portugal. This is in agreement with the fact that the two countries differ greatly on the dimension of employment protection, as discussed when presenting the relevant features of their labour markets. In both countries an important part of the observed returns to tenure is explained by the seniority rank of the worker, once we account for Our favourite estimation methods indicate that the linear coefficient for the return to tenure is virtually 0 and the cumulative returns to 10 years are very low, in the order of 1%, in Portugal once we account for the seniority rank. In Denmark returns to tenure are estimated to be virtually 0 to start with, experience playing a much bigger role in wage determination. However, once accounting for the seniority rank effect, the low returns to tenure become even lower so that even cumulative returns to tenure over 10 years become negative in Denmark. In Portugal actual seniority rank s_{ijt} has an effect between -0.0148 and -0.0222, while the firm size n_{jt} has an effect between 0.0416 and 0.0692. In Denmark the effect of the actual seniority rank is about -0.0077 to -0.0149. The firm size effect is estimated in the range 0.024 to 0.028. Taking into account that, according to equation (8) in the theoretical part of this paper, the coefficient of the seniority rank is equal to -$\frac{\beta}{\nu}$ and assuming that the constant-over-time demand elasticity ν is constant also accross the two countries in context, we would obtain that the bargaining power of

[27] An exception from the usual trend of wages increasing with firm size is in the case of Denmark the financial intermediation sector (sector 16 in our division), where the effect of the firm size effect is slightly negative (using all our estimationg methods reported in Tables C), although significant.We do not have an interpretation of this peculiarity.

an insider worker in Portugal is somewhere in the range 1.5 to 2 times larger than the bargaining power of a worker in Denmark. These results largely hold for all sectoral categories that we consider. It is of interest here to discuss eventual discrepancies and to see whether they are similar in both countries.

Indeed, there are remarkable similarities between the two countries in this sense. There are a number of sectors in both Portugal and Denmark where the seniority rank effect is very low in magnitude (virtually 0) and sometimes it even changes sign. These sectors are 8, 11, 14, 15 and 20, see the appendix for the numbering[28]. In addition in Portugal seniority rank is virtually zero also in case of sectors 16, 17, while this is not the case in Denmark. At the same time, the strongest effect of the seniority rank in Denmark and one of the strongest in Portugal seems to be in sector 12.

We also tested the other hypotheses predicted by our model, in both datasets. As for the hypothesis that the log firm size n_{jt} follows a random walk, in the case of Denmark this seems to be clearly the case for the whole economy and for the vast majority of the sectors. A simple regression of $\Delta n_{jt} = n_{jt} - n_{jt-1}$ on n_{jt-1} gives a value for the estimated coefficient of -0.004 for the whole private economy, with very similar values for all separate sectors consider. For Portugal this does not seem to hold to the same extent: the value of the estimated coefficient is about -0.11 for the whole economy and similar for each of the industry categories, which is something we expected based on our theoretical motivation, given the high firing costs here. In the case of the within-job log wages evolution we check that the residuals of wage growth regressions controlling for relevant covariates are virtually zero after the second lag and exhibit negative correlation just at the first lag, which is what has been found in the previous literature using USA data (see for instance Abowd and Card (1989), Topel and Ward (1992) or Buhai and Teulings (2005)), both for Denmark and Portugal, supporting the fact that log wages are approximately a random walk with transitory shocks[29]. XXX

XXX

[28] An attempt to explain why seniority rank does not seem to play a big role in wage determination in sectors 11 (construction) and in the professional services in Denmark is that these sectors use fixed term contracts very frequently (according to the OECD employment outlook, 2004)). In Portugal the use of temporary contracts also increased and it is likely that these were also the targeted sectors. It is more difficult to find an explanation for why the manufacture of furnitures (sector 8) is in both countries "immune" to the seniority rank.

[29] Just by regressing $\Delta w_t = w_t - w_{t-1}$ on w_{t-1} as done in the case of log firm sizes we obtain a coefficient of about -0.14 for Denmark and -0.01 for Portugal, both strongly significant. Although it seems that the random walk assumption is not valid in the case of Denmark, bear in mind that here we do not control for potential covariates affecting wages. When we do that, as stated above-by looking at the covariogram of lagged resituals of wage growth regressions- we find strong support for the random walk with transitory shocks hypothesis.

6 Summary and Conclusions

Most empirical research investigating the role of job tenure in wage determination has focused on seniority as a continuous function of the time spent in the current job. This specification can be defended by theories of firm-specific investment, efficiency-wages or adverse-selection models. However, a simple theoretical model obtained by combining the random productivity growh framework by Buhai and Teulings (2005) and the firm random demand growth model by Bentolila and Bertola (1990), via a Last-In-First-Out firing rule justified by rent extracting arguments by Kuhn (1988) and Kuhn and Robert (1989), indicates that the relative position of the worker in the seniority hierarchy of the firm, ie. his "seniority rank", may also explain part of the observed returns to tenure. One of the implications of this model is that including both seniority and seniority rank in the empirical analysis of wage determination would show the prevalence of the seniority rank over the actual time the worker spent in the job. The empirical techniques we have used are extensions of standard techniques from previous literature, designed to identify separate wage returns to tenure and labour market experience.We adapted these methods so that they incorporate also a measure of seniority rank. We have shown that under a minimum set of assumptions the effect of the seniority rank is identified and consistently estimated. We tested the main implication and other predictions of our model on matched employer-employee data from Denmark and Portugal. The first country is on the very loose end regarding employment protection legislation, while the second has one of the strictest job protection regulations in the OECD. Denmark is also unusual in terms of the very high mobility of the labour force, the relatively low average tenure and it has, following our estimation, virtually no observed returns to tenure, with experience playing an essential role in wage determination, even before accounting for the role of the seniority rank. In Portugal the returns to tenure without accounting for seniority rank are sizable, in the range of the high returns to tenure found by previous studies for the USA. We found a significant and negative impact of the seniority rank on wages, in both countries. However, as expected, we verified that labor protection increases considerably the bargaining power[30] of senior individuals (the "insiders"), the absolute magnitude of the seniority rank in Portugal being a few times higher than the one in Denmark. We have further demonstrated that accounting for the seniority rank of the worker is essential, since a considerable part of the wage returns otherwise attributed to the tenure of the worker, are in fact returns to her tenure rank, vis-a-vis her co-workers. To this extent, our favourite estimates for Portugal indicate

[30] In fact it is the bargaining power of the workers divided by their firm demand elasticity, see the section presenting the theoretical model above, equation (8). If firm demand elasticity can be taken as about the same in both countries in context (they are both EU members after all and they are both small open economies) then indeed we can refer to differences in the bargaining power of the workers. As stated in the section above, under the condition that v is the same in DK and Portugal, we obtain an approximately 1.5 to 2 times higher bargaining power for a Portuguese worker vis-a-vis a Danish worker.

that the sizable returns to tenure entirely dissappear once we take into consideration the seniority rank, while for Denmark the already very low returns to tenure become slightly negative, even cumulated over 10 years. Finally, we have also concluded that discrepancies in what concerns the role of the seniority rank among different sectors within Denmark and respectively Portugal seem to be largely similar across the two countries, suggesting therefore that our analysis is applicable to labour markets in general and does not depend on country specificities.

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A Sectoral categories

1. SIC codes 01 to 05 (Agriculture and Fishing)
2. SIC codes 10 to 14 (Mining)
3. SIC codes 15 and 16 (Manufacture of food prod, beverages and tobacco)
4. SIC codes 17 to 19 (Manufacture of textiles, dressing, leather)
5. SIC codes 20 to 22 (Manufacture of wood products, cork, paper, but not furniture)
6. SIC codes 23-26 (Manufacture of non-metallic products)
7. SIC codes 27-35 (Manufacture of metals and metal products)
8. SIC code 36 (Manufacture of furniture,NEC)
9. SIC code 37 (Recycling)
10. SIC codes 40 and 41 (Electricity, gas and water supply)
11. SIC code 45 (Construction)
12. SIC codes 50-52 (Wholesale and retail trade; repair of vehicles, motocycles etc)
13. SIC code 55 (Hotels and restaurants)
14. SIC codes 60 to 63 (Transport, storage and communications)
15. SIC code 64 (Post and telecomucations)
16. SIC codes 65-67 (Financial intermediation)
17. SIC codes 70-74 (Real estate, renting and business activities)
18. SIC code 75 (Public administration and defense; compulsory social security)
19. SIC code 80 (Education)
20. SIC code 85 (Health and social work)
21. SIC codes 90 to 93 (Other community, social and personal service activities)
22. SIC code 95 (Private households with employed persons)
23. SIC code 99 (Extra-territorial organization and bodies)