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- The Swiss Case

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Abstract

Whether or not seniority has a substantial effect on wages has been the subject of much controversy in the past decade, mainly in the U.S. Several economists have noted that unobserved heterogeneity across individuals and across job matches may produce inconsistent OLS-estimates of the effect of tenure on wages and turnover. Hence, labor economists have put forward two empirical strategies to deal with unobserved heterogeneity: Altonji and Shakotko (1987) use an instrumental variable for tenure, which is uncorrelated with the individual and job-specific component of the error term, but highly correlated with job tenure, whereas Topel's (1991) basic idea is that within-job wage growth combines the returns to general and job-specific experience. These two empirical strategies revealed different returns to seniority and experience for the U.S. labor market. Our goal is, on one hand, to use the different methodologies for the Swiss labor market and, on the other hand, to evaluate the sources of these differences.

Thus, we replicate these methods with Swiss data (Swiss Labor Force Survey, SLFS). In a first step, we estimate returns to tenure and experience with the standard regression method, OLS. Subsequently, we apply the Topel and the Altonji/Shakotko estimator, and use different specifications for each. We find that (i) Topel's approach delivers similar returns to tenure to OLS, i.e. about 8% within ten years of job seniority, while the Altonji/Shakotko method delivers substantially lower returns (4%). (ii) Returns to tenure are minor in Switzerland compared to the U.S.

1   Introduction

The idea that wages rise with job seniority is the foundation of the theory of specific human capital, as well as other commonly accepted theories of compensation. The extent to which tenure affects wages is important for several reasons: First and foremost, the wage-tenure profile gives fundamental insight to the structure of earnings over careers. Second, the wage-tenure profile is a key determinant of the extent to which the earnings power of individuals is tied to specific jobs, and it is important for assessment of the losses suffered by "displaced" workers. Third, evidence that wages rise with job tenure has been used to explain the decline in quit rates with tenure, since the wage growth on the current job lowers the probability that the worker will locate a superior alternative.

In our paper, we first discuss the problem of the empirical identification of returns to tenure. Returns to tenure and experience are expected to be biased when estimated with the traditional regression method, OLS (Ordinary Least Squares). The reason for these distortions lies in the likely correlations between experience, tenure and unobserved individual and job match specific effects. For example, since tenure is simply a function of past quit and layoff decisions, it will be positively correlated with individual characteristics and jobs which lead to lower quit rates and layoffs. These same characteristics are likely to be positively related to worker productivity, and, in competitive labor markets, to wages. For this reason, the traditional regression method (OLS) is likely to overestimate returns to tenure.

To handle these biases, we concentrate on two methodological approaches, which have been widely discussed in the literature on specific human capital, namely the instrumental variables approach proposed by Altonji and Shakotko (1987, hereafter, AS) and the two-stage estimation procedure of Topel (1991). In their paper "Do Wages Rise with Job Seniority?", AS propose to solve the correlation problem between tenure and the components of the error term by using an instrumental variable for tenure, which is uncorrelated with the individual and job-specific component of the error term, but highly correlated with job tenure. Topel's basic idea is that within-job wage growth combines the returns to general and job-specific experience. Thus in a first stage he estimates wage growth within the same job, and in a second stage he makes a cross-sectional comparison of the wages of workers who started new jobs at different points in their careers. This gives an upper bound on the returns to experience

and thus allows separating these two wage growth effects while eliminating the biases that arise with OLS.

However, the two approaches revealed diverse estimates for returns to tenure and experience in the United States. While AS named a wage effect of 6,8% within 10 years with the same employer in their preferred specification (which is only about one fifth of the corresponding OLS estimate!), Topel estimated a tenure effect of 28% within the same period of time. Altonji and Williams (1997, hereafter, AW) responded Topel's article with the replication and re-estimation of Topel's sample, and got substantially different returns. They argued that these differences arise due to mainly two reasons: First, the two methodologies differ in their responsiveness to measurement errors in tenure and second, they are sensitive to different methods that may be used to control for economy-wide trends in wages and inflation.

The main aim of this paper is to compare the two alternative methodologies with a data set covering a time period during which only moderate economy wide wage growth occurred. With this property, remaining differences between the methodologies must have other causes than different detrending approaches. To show that remaining differences are not due to detrending we use different procedures to deal with economy wide trends in wages. First, we run our regressions with deflated wages - as suggested by Topel -, then use nominal wages with year dummies in accordance with AS, and finally run the regressions with nominal wages for a restricted time period where inflation was very close to zero.

The paper is organized as follows: Section 2 presents the different empirical methodologies that have been suggested to measure returns to tenure. Section 3 describes the Swiss data set. The regression results are presented in section 4. Our main findings will be summarized in section 5.

2 Methodological Background

2.1 The Basic Wage Model

Most studies investigating returns to tenure, including AS, Topel and AW, work with the basic wage model

(1) $$W_{ijt} = b_0 t + b_1 X_{ijt} + b_2 T_{ijt} + e_{ijt}$$

where W_{ijt} denotes the log real wage of person i in job j in period t, X_{ijt} is total labor market experience, and T_{ijt} is tenure with the current employer. Parameters b_1 and b_2 represent average returns to experience and tenure, respectively, and are the parameters of interest in this paper. The equation abstracts from a set of control variables, and from nonlinear terms in experience and tenure.

The error term is decomposed as

(2) $$e_{ijt} = m_i + q_{ij} + h_{ijt} + u_{it},$$

where m_i is a fixed individual specific error component, q_{ij} is a fixed job match specific error component, h_{ijt} is a time varying job match specific component, and u_{it} is the sum of measurement errors in the wage and a person specific error component that affects wages of all employees. AS, Topel and AW all ignore u_{it} because it is unlikely to be related to turnover behavior. Topel argues that h_{ijt} is unlikely to influence his analysis if it is a random walk and shows that the data are consistent with that. In our study, we mainly rely on these findings and concentrate on the individual and the job match specific error components.

The key parameters of interest are b_0, b_1 and b_2, where b_1 is the partial effect of an additional year of experience on the wage, and b_2 is the partial effect of tenure. The parameter b_0 is an economy wide trend in real wages. Many studies have used OLS to estimate these parameters, and they consistently find large returns to tenure. AS and Topel find that using OLS, the wage effect of tenure within ten years is about 30% and 35% respectively.

However, using OLS to estimate these parameters is inappropriate because of the likely correlation between experience and tenure with the unobserved heterogeneity (individual and job match specific). Tenure and experience are likely to be correlated with the components of the error term because of several reasons:

- Tenure is likely to be a negative function of past layoff and quit decisions; the lower personal productivity is (the lower m_i), the lower tends to be the time with the same

employer. This likely behavior will lead to an upward bias in estimating returns to tenure with OLS.

- Matching and search models (Burdett, 1978) imply that job shopping over a career will induce a positive correlation between experience and the unobserved job match component, q_{ij} (experienced workers had more time to locate a good job).

- The correlation between tenure and q_{ij} is ambiguous. On the one hand, workers will be less likely to quit high wage jobs, inducing that the correlation is positive. On the other hand, voluntary job changes will lead to low tenure values and therefore induce this relationship to be negative. Thus it is difficult to sign the effect of this correlation on the estimation results for returns to tenure.

2.2 Altonji and Shakotko's Instrumental Variables Estimator

Altonji and Shakotko's general wage model differs only slightly from the general wage model. The authors propose an instrumental variable to address the problems of individual and job match heterogeneity in the wage model. They specify the principal instrumental variable as the *deviation of tenure from its mean* for the sample observation *on a given job match, $D\tilde{T}_{ijt}=T_{ijt}-\overline{T}_{ijt}$*. This variable is *uncorrelated by construction* with both the individual specific error component of the wage equation and the permanent job match component. Abstracting from h_{ijt}, this variable is a valid instrument because it is orthogonal to the job match specific and personal error components. AS refer to this estimator as the IV1 estimator. They get estimated returns to tenure, which are only about one fifth of what they would get with OLS. However, there are different possible sources of biases in the IV1 estimator:

- The likely positive correlation between experience and the job match specific error component q_{ij} leads to a positive bias in b_1^{IV1}, and therefore to a negative bias in estimating returns to tenure (b_2^{IV1}).

- There are problems in measuring tenure. This might arise with OLS too, but the importance on the estimations is likely to be greater with AS, because the variance

of measurement error is larger in the instrument for tenure than in raw tenure[1].

2.3   Topel's Two-Stage Estimation Procedure

Topel estimates returns to tenure with an alternative two-stage method. First, he estimates the wage growth for employees within the same job. With this strategy, he is able to eliminate the biases that arise because of the individual and the job match specific error terms, because these terms are constant within the same job. In a second stage, he divides the effect of tenure and experience on wages. Topel subtracts the wage effect per year (using the coefficients from the first stage), such that he obtains the wage level at the beginning of a job. He uses this wage to identify the effect of experience on wages when a job begins.

Real Wage Growth within the Same Job

With the information on years within the same job, it is easy to see if the employees have changed their job. For the employees who stayed with the same employer over the years considered (stayers), one can compute within-job wage growth as follows:

(3) $W_{ijt} - W_{ijt-1} = \boldsymbol{b}_1 + \boldsymbol{b}_2 + \boldsymbol{e}_{ijt} - \boldsymbol{e}_{ijt-1}$

With this method, the individual and the job match specific effect are eliminated. Since there's always one year between two periods, one can say that $\Delta X = \Delta T = 1$. Therefore, wage growth $(W_{ijt} - W_{ijt-1})$ is the sum of returns to general and job specific human capital accumulation, and thus reflects the sum of returns to tenure and experience. In a second step, Topel regresses wage growth on a constant, and gets a consistent estimator of wage growth $(\beta_1 + \beta_2)$, if the estimator $(\varepsilon_{jjt} - \varepsilon_{ijt-1})$ has an average value of zero. In addition, he includes higher order terms of tenure and experience and changes in dummy variables[2].

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[1] See appendix for a theoretical illustration.

[2] For example: if an employee gets married in one year, in this year the variable "dmarried" has a value of one, otherwise a value of zero.

Estimated Returns to Experience and Job Tenure

The second stage of the Topel estimation separates the effects on wage growth of an additional year of job tenure (β_1) and market experience (β_2) respectively.

With $X = X_0 + T$, model (1) can be rewritten as:

(4) $$W = X_0 \boldsymbol{b}_1 + TB + \boldsymbol{e}$$

where T = number of years within the same job (tenure) and $B = \boldsymbol{b}_1 + \boldsymbol{b}_2$. The first term on the right side of the equation represents the wage at the beginning of the job, whereas the second term describes the wage effect of accumulated general and firm-specific human capital within the same job.

Equation (4) and the wage differentials from (3) lead us to:

(5) $$W - T\hat{B} = X_0 \boldsymbol{b}_1 + \boldsymbol{e}$$

where $\hat{B} = \overline{(\boldsymbol{b}_1 + \boldsymbol{b}_2)}$ is the consistent estimator from the first stage. Equation (5) describes the relationship between the estimated wage at the beginning of the job and the valuation of the employee's previous experience. With subtraction from the first estimator, a lower bound of the wage effect of job tenure can be identified.

Topel's model relies on the assumption that both the job match specific and the individual error terms are constant over time and thus disappear when the equation is expressed in wage differentials. If experience is uncorrelated with job match or individual heterogeneity, the Topel estimator of returns to tenure and experience is unbiased.

2.4 Differences and Problems of the Approaches

AS, Topel and AW used substantially the same sample of U.S. data collected in the Panel Study of Income Dynamics (PSID). All calculations were made for the years between 1968 and 1981. Only white male employees, aged between 18 and 65, were included. Table 1 gives a short overview of the results of Topel's and AS's estimations:

TABLE 1: ESTIMATED RETURNS TO TENURE WITHIN 10 YEARS FOR THE DIFFERENT
METHODOLOGICAL APPROACHES (LOG WAGE INCREASE)*

	OLS	AS – Method (IV1)	Topel's Method (2 - step estimator)
Altonji/Shakotko (1987)	0.263	0.066	
Topel (1991)	0.300		0.246

*: The results displayed in this table apply to the preferred estimations of the authors.

Let us first consider AS's estimations. With the standard estimation method, they get a value for the wage effect within ten years with the same employer of 0.263. This means that an employee who is on the same job since this time period would take a wage loss of about 30% ($e^{0.263}$ - 1) of his income if his job ended exogenously, or if he decided to quit. When AS run the estimations with their alternative method, they display a wage growth effect from tenure of 6.8% ($e^{0.066}$ - 1) in 10 years on the same job, which is only about one fifth of what was computed with OLS. These results imply that a large part of the differences to OLS is caused by the strong correlation between wages and tenure (or that with the IV1 approach, one can eliminate the mentioned biases). The small returns to tenure with AS's approach are accompanied by greater returns to general experience, namely 31.7% in the first ten years on the same job when computed with OLS or 48.2% with the IV1 procedure. This might be explained by the correlation between experience and tenure (a downward bias in tenure leads to an upward bias in experience). Thus, with the IV1 method, AS assign most of the wage growth to general experience, and only a modest part to tenure.

The contrary is the case with Topel's results. He estimates a wage effect of tenure of about 28% for 10 years with the same employer, which is little below his OLS estimation result (35%). Altonji and Williams get substantially smaller returns to tenure, namely about 11%, when they replicate the sample and re-estimate Topel's procedure.

These different results raise the question which method yields the better estimations. AW stress that there are mainly two reasons, which might explain the divergent messages

and which will be discussed in the following subsections:[3]

- different methods in controlling for economy wide time trends and changes in sample composition,

- measurement errors in tenure.

Different Methods to Control for Economy Wide Trends in Wages and Changes in Sample Composition

Topel argues that AS's estimates for returns to tenure are substantially biased down from their treatment of the time trend as exogenous. He deflates his log wages with the so-called Murphy-Welch index, which nets out both real aggregate wage growth and changes in any aggregate price level, so that wage data in different points in time are expressed in comparable units. From his point of view, there are two reasons for treating time as exogenous:

- Time is not statistically exogenous in panel data. With rising experience, job match quality (q_{ij}) rises with time (persons with high market experience have had more time to locate a good job). In this situation, treating time as exogenous might lead to an understatement of seniority and to an overstatement of temporal wage growth.

- Time may be correlated with the mean of m_i: Household heads with better unobserved characteristics m_i are likely to respond more often to the survey. Thus, sample attrition leads to an increase in average m_i with time.

To handle these problems, estimating returns to tenure with deflated wages could be a valuable solution. AW claim that the *simple correlation between time and average experience is likely to be weak*, and that this relationship is very weak in both their and Topel's sample.

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[3] We concentrate on these two explanations. Further possible causes for unequal results are the functional form and the inconsistent timing of the tenure and earnings measures. Both Topel and AS showed that the functional form doesn't influence the results substantially; this is in line with our findings. In the PSID data, most variables refer to the survey date, while the wage measure is annual earnings divided by annual hours in the previous calendar year. This possibility doesn't apply to our data set, because all variables refer to the survey year.

However, the use of a time trend in the second step of the Topel estimator is likely to have an effect because T_{ijt} is omitted from the wage equation and t is correlated with T_{ijt} conditional on X_{0ijt}.

AW use different treatments of the time trend to check the influence on the estimators of returns to tenure; they conclude that the use of the Murphy-Welch wage index to detrend real wages (used by Topel) has little effect on the OLS estimates (they are persistent at 0.27 within 10 years of job tenure). The same outcome applies to the Topel estimator; here the coefficients of returns to tenure range between 0.22 (year dummies) and 0.25 (deflated wages). The effect of the use of different time trends is substantial to the IV1 approach; here AW observe a large upward bias in the estimator for returns to tenure when deflating the wage data (0.246) compared to the results which arise from treating time as exogenous using year dummies (0.093). So the net result of using deflated wage data is to move the Topel estimator closer to OLS and the IV1 estimator closer to both the Topel and OLS estimates.

Measurement Errors in Tenure

Topel specifies measurement errors in tenure in the AS sample as one of the leading factors to the differences in conclusions of the two articles. He argues that tenure is often measured in intervals of several years, such that year-to-year changes in recorded job tenure often don't have the theoretical value of one. Topel reports that the estimated effect of tenure on wages rises substantially when he uses the IV1 estimator with his corrected tenure measure.

AW state that AS were aware of the problems with measuring tenure. They found that eliminating the effects of bracketing of tenure values in the early years and unusual changes in tenure or smoothing the tenure variable increased their basic estimate from 0.067 to 0.084. They concluded that the measurement error is important, but not substantial, to their conclusions. Thus, the magnitude of the results seems to stay the same, in the sense that AS do not find very large wage effects from tenure. One could argue that if there's a problem in measuring tenure, it is the same, no matter which estimation method is implemented. All the same, as we discussed before, the changes in the variance of the error term when different methods are used (see appendix) has a larger impact on AS's results, because overall variance is greater than with the other approaches.

3   The Data

We applied the different methodological proposals to the *Swiss Labor Force Survey* (SLFS, Schweizerische Arbeitskräfteerhebung). For reasons of comparability to the U.S. studies by AS, Topel and AW, we included only male employees which are aged between 18 and 65. Our survey includes observations for the period of time between 1991 and 1998. One property of our sample which is different to the PSID sample is that our panel is a *rotating panel*, which means that every person is in the survey during five following years, while the sample used by AS, Topel and AW observes only people who were in the sample during the whole time from 1968 until 1981. This property of our sample is important for the considerations made before: The fact that our panel is rotating leads to the presumption that the problem of the correlation between time and experience or tenure is minor in our sample than in the PSID data set.

One interesting aspect of the time period under consideration is the fact that the economy-wide growth in wages was very low. This is due to the persistent recession that Switzerland suffered in the nineties of the last century. From 1991 to 1998 nominal wages for men in Switzerland only grew by a yearly average of 2.5%. This compares very favorably to the 8% wage growth from 1968 to 1983 in the U.S. labor market. Moreover, real wages of Swiss men only grew by an average of 0.4% in our sample. Therefore, the control of the economy-wide trend will only be of minor importance compared to the PSID sample used by AS and Topel. This is particularly the case for the years after 1995 with an average growth of nominal wages of 0.9% and real wages of 0.1% respectively. The development of real wages, nominal wages and consumer prices is shown in Table 2.

TABLE 2: CONSUMER PRICE INFLATION, NOMINAL AND REAL WAGE GROWTH FOR MEN IN SWITZERLAND, 1991-1998

	1991	1992	1993	1994	1995	1996	1997	1998
Consumer price inflation	5.9%	4.0%	3.3%	0.9%	1.8%	0.8%	0.5%	0.0%
Nominal wage growth (men)	7.1%	4.9%	2.6%	1.5%	1.1%	1.2%	0.4%	0.8%
Real wage growth (men)	1.9%	1.5%	-0.8%	0.4%	-0.4%	0.4%	0.0%	0.4%

Source: Swiss Federal Office of Statistics (1999), Swiss Statistical Yearbook 2000, Neue Zürcher Zeitung Verlag, Zürich; own calculations.

In the empirical part, we will utilize the low wage growth property of our sample and run regressions for different detrending procedures.

To get a short overview of our data set, Table 3 summarizes the properties of the most important variables in our sample:

TABLE 3: DESCRIPTIVE STATISTICS

	Full Data Set (N = 25'236)		Stayers (1st Stage Topel) (N = 12'252)	
	Mean	Standard Deviation	Mean	Standard Deviation
Real Hourly Wage (CHF.)	43.15	27.18	43.54	20.57
Yearly Real Wage	79'447	46'443	81'367	34'107
Ln of Real Hourly Wage	3.67	0.40	3.69	0.38
ΔReal Wage	0.020	0.307	0.014	0.205
Tenure	10.16	9.54	11.75	9.50
Experience	19.28	12.05	20.45	11.90
Age	39.34	10.94	40.41	10.74

The regressions were run with more than 25'000 observations for OLS and the second stage of Topel, 20'830 for the AS method, while in Topel's first stage (stayers) we used about 12'000 observation.

4   Estimation Results

As discussed before, the use of different methods to deal with general trends in real wages was the most striking point to explain the differences in the estimators. To evaluate the importance of the use of different time trends for the results in Switzerland, we run our regressions for all the three estimation methods by using different detrending procedures.

First, we deflate wages with the consumer price index, which is in line with Topel's detrending approach. As a second specification, we follow AS and use year dummies to deal with economy wide wage development. Third, we restrict our sample to the low-inflation, low-wage-growth period from 1995 to 1998, and use nominal wages.

Table 4 shows the estimation results for the three methodological approaches, with the described diverse real wage trend specifications:

TABLE 4: RETURNS TO TENURE WITHIN 10 YEARS (DEPENDENT: LOG WAGES)

	Real wages (Topel's approach)	Nominal wages with year dummies (AS's approach)	Nominal wages, no time trend ('95-'98)
OLS	0.075	0.075	0.076
TOPEL	0.078	0.075	0.081
AS	0.024	0.033	0.039

When we compute returns to seniority with the standard estimation method (OLS) and real wages, we get an effect of ten years on the same job of 7.8% ($e^{0.075}$ –1). This means that on average, a typical Swiss worker would suffer a wage loss (because of the "loss" of his specific human capital which he accumulated during the period of the employment) of nearly percents if he would quit his job or get laid off.

Because of the correlation between tenure and experience with the components of the error term, we would suppose that OLS leads to overestimated returns to tenure. So our alternative approaches are expected to lead to smaller returns.

Our results with the Topel and AS estimation procedures are in accordance with the results that were obtained for the U.S., in the sense that with AS, returns to tenure are substantially smaller than with Topel. With AS, estimated returns to tenure within ten years of seniority are 2.4%, while with Topel, our coefficients are three times as high.

The second estimation strategy consists of detrending with nominal wages and year dummies, which is AS's proposition for dealing with trends in wages. In column three, we can see that our coefficients do not change for OLS or Topel, and neither do change substantially for the AS estimation method.

Third, we run the estimations for the low-inflation period of 1995 to 1998. As a whole, we are able to observe that the results stay the same in the sense that the difference between the estimation results does not change with all the three detrending approaches, which validates our proposition that with our data set, we can rule out the problem of differing results due to different detrending conventions.

After we have ruled out the other possibilities, the *last remaining explaining factor for the substantially different results appears to be the problem of measuring errors in tenure*. As we have discussed before, the different methods reveal different overall variance in tenure and thus lead to unequal estimations.

Finally, we can observe that as the experience in the U.S. showed, Topel gets very close to the OLS estimations. In our sample, his returns are even at least as high as OLS, which seems to contradict our preliminary prediction that with Topel's approach, we should get lower returns to tenure. There is an interesting parallel to our results in the literature concerned with the causal effects of education on wages. In the "returns to education" literature, the expectation is also that OLS leads to an upward bias in the effect of education on wages because individuals with higher unobserved productivity choose higher education. However, when Angrist and Krueger (1991) address ability bias using instruments for education, they find that the OLS estimator of returns to education is lower than the IV estimator for education. The interpretation put forward by Ashenfelter and Rouse (1998) is that ability bias and attenuation bias have offsetting effects on the OLS estimator. However, it would make sense if further research addressed this phenomenon.

We now turn to the question why returns to tenure and experience might differ between the U.S. and the Swiss labor market.

Our results *coincide* with the experiences with U.S. labor market data, in the sense that:

- We find very little returns to tenure with the AS method (about 4% within 10 years of job seniority), while with Topel's approach, the returns are in the same dimension as we get with OLS (about 8%). In the U.S., the respective values are 8% and 28%.

- The greater part of the yearly wage growth can be assigned to accumulated general human capital.

Although the direction of the estimated effects of job tenure and experience point into the same direction as in the observed U.S. studies, it seems that U.S. workers do get higher returns to tenure than Swiss workers. One possible explanation for the differences we found is an institutional one. In Switzerland, the apprenticeship is very common. After completing their compulsory schooling, nearly two-thirds of the country's young people undertake such training with alternating periods of enterprise-base training and attendance at a vocational school. Since we only included employees (with completed education) in our sample, these people don't appear. Due to the fact that tenure profiles are expected to be increasing the most in the first years, not including this group of workers leads to lower returns to tenure. As far as we are informed, the apprenticeship is not very usual in the U.S. labor market. This might be one of the reasons why we observe smaller returns to tenure in Switzerland.

5 Conclusions

The question of whether or not wages rise with job seniority is of practical as well as theoretical importance. From an employee/employer point of view, the wage-tenure profile gives valuable insight into the structure of earnings over careers. The wage-tenure profile determines to what degree the earnings power of an employee is linked to a specific job, and it is important for valuation of the losses suffered by "displaced" workers.

The problem of measuring returns to tenure has been widely discussed in the last decade, especially in the U.S. There are two well-known approaches to deal with unobserved heterogeneity, which, in general, tell different stories about the extent to which wages rise with job tenure. The first was proposed by Altonji and Shakotko (1987), where an attempt was made to solve the correlation problem between tenure and the components of the error term. AS use an instrumental variable for tenure, which is uncorrelated with the individual and job-specific component of the error term, but highly correlated with job tenure. Topel's (1991) basic idea is that within-job wage growth combines the returns to general and job-specific experience. He estimates returns to tenure with a two-stage-procedure.

These two approaches yielded disparate estimates for returns to tenure in the United States, which prompted the debate on which strategy yields better estimates. While AS named a wage effect of 6,8% within 10 years with the same employer in their preferred specification (which is only about one fifth of the corresponding OLS estimate!), Topel estimated a tenure

effect of 28% within the same period of time. Altonji and Williams (1997) specify several reasons for these diverging results. The most important ones are measurement errors in tenure and the difficulty to control for economy-wide trends in wages and inflation.

We can rule out the latter argument because real wage changes and inflation were very low during the observation period. We use several approaches to detrend nominal wages to test this assumption. First, we run our regressions with deflated wages, then use nominal wages with year dummies, and finally run the regressions with nominal wages for a time period where inflation was very close to zero (1995 to 1998).

Our results are in accordance with the experiences in the U.S. in the sense that with Topel's method, we get substantially higher returns to tenure than with the AS approach. Topel's estimation results imply that a Swiss employee gets a wage increase of about 8% after 10 years with the same employer, compared to his wage at the beginning of the job. The estimation results are substantially smaller when AS's approach is used; they assign only between 2.4% and 4% (depending on the detrending convention) to this effect.

Thus, our results suggest that with using the advantageous properties of our data set, we can rule out one of the two main reasons why the estimators of the two approaches differ, namely the different detrending procedures. The remaining differences in the results we found might therefore be ascribed to measuring problems in tenure, which will hopefully be addressed in further research in this area.

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Appendix: The effect of measurement error in tenure on estimated returns to tenure

We discuss here the effects of random measurement error on estimated returns to tenure in OLS, Topel, and AS estimates. For simplicity, we assume that there is a sample of stayers (we drop the index j for the employer) and that we observe each individual for exactly N=2 periods (balanced panel).

The baseline log wage model (abstracting from other effects and the constant) is the following:

$$w_{it} = b_2 T_{it} + e_{it}$$

where w_{it} is the log of hourly wages, T_{it} is tenure of individual i at time $t=1$ or 2, b_2 is the return to tenure, and e_{it} is the unobserved component of wages.

There is random measurement error in tenure, thus T_{it} is

$$T_{it} = T_{it}^* + h_{it}$$

where T_{it}^* is true tenure, and h_{it} is mean zero i.i.d. measurement error with variance s_h^2.

What is the effect of measurement error on the OLS estimator of returns to tenure (β_2)?

$$\hat{b}_2 = \frac{\sum T_{it} w_{it}}{\sum T_{it}^2} = \frac{\sum (T_{it}^* + h_{it}) w_{it}}{\sum (T_{it}^* + h_{it})^2} = \frac{\sum T_{it}^* w_{it}}{\sum T_{it}^{*2} + s_h^2}$$

This estimator is downward biased when compared to the estimator that uses true tenure T_{it}^*. The estimator using true tenure is

$$\hat{b}_2^{true} = \frac{\sum T_{it}^* w_{it}}{\sum T_{it}^{*2}}$$

This is the familiar "attenuation bias". Attenuation bias increases in the variance of measurement error.

What is the effect of measurement error in wages on the Topel estimator? Information on tenure is used by the Topel estimator in the first stage (section 2). This stage uses information on wage changes from period t-1 to t. The Topel estimator is unaffected by measurement error in tenure, because increases in tenure from t-1 to t are measured without error (they are, by definition, 1).

What is the effect of measurement error on the IV estimator proposed by AS? The instrument proposed by AS is the deviation of tenure from the mean of tenure for each individual

$$\hat{T}_{it} = T_{it} - \frac{T_{i1} + T_{i2}}{2}$$

What is the variance of measurement error in the instrument for tenure? Consider the extent of measurement error in the first observation per individual (the same calculation holds for the second observation per individual). The measurement error variance is

$$\mathrm{var}(\hat{T}_{i1}) = \mathrm{var}(T_{i1} - \frac{T_{i1} + T_{i2}}{2})$$
$$= \frac{1}{\sqrt{2}} \mathrm{var}(T_{i2}^* + h_{i2} - T_{i1}^* - h_{i1})$$
$$= \sqrt{2} s_h^2$$

Clearly, measurement error is more problematic in the AS framework than in OLS. Attenuation bias increases the longer individuals are observed on average, i.e. the higher N_i.

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