Earnings Instability and Tenure

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ABSTRACT

This paper develops a tractable empirical approach to estimate the effect of on-the-job tenure on the permanent and the transitory variance of earnings. The model is also used to evaluate earnings instability associated with fixed-term contracts (short-tenure contracts) in Italy. Our results indicate that each year of tenure on the job reduces earnings instability on average by 15%. Workers on a fixed-term contract on average have an earnings instability 10% higher than workers on a permanent contract. Workers who spend their entire working life on fixed-term contracts can expect an earnings instability twice as high.

NON-TECHNICAL SUMMARY

Estimating the changes in the dispersion of earnings is the topic of the large literature on earnings inequality and mobility. Much of the literature focuses on cross-sectional evidence and assesses competing explanations of increasing inequality such as technical change, trade, institutions. A complementary literature looks at panel data on individual earnings and asks questions such as: What is the extent of intertemporal mobility in the distribution of earnings? Is the change in inequality due to long term earnings components (e.g. ability) or to increasing volatility that make the earnings process more unstable?

This paper models explicitly the role of tenure on-the-job and studies its effect on the long-term and volatile components of earnings. There are reasons why the two can be related. If wages are paid on the basis of worker's marginal product and this is observed with error, then a negative relationship between instability and tenure emerges inasmuch as measurement error in productivity decreases with the length of the worker-firm match. Alternatively, firms may be willing to insure workers' incomes against transitory shocks to profitability, and their willingness to do so may increase the more they know about workers' productivity.

These theoretical relationships may have policy implications. In consequence of changes in labour market legislation, fixed-term (temporary) contracts they spread in many European countries in the nineties. These are short tenure contracts which typically last two or three years and can be renewed only once. A large literature has studied the effect of fixed-term contracts on employment, unemployment and job flows but nobody has looked so far at their effects on earnings instability. Yet one of the main concerns about the diffusion of fixed-term contracts is their implications in term of earnings instability and welfare in as much as earnings instability is strictly related to the uncertain component of earnings.

We use Italian matched employer-employee data with an accurate measure of on-the-job tenure. The data also contain information on the type of contract (standard or fixed-term).

Our results indicate that workers with four years of tenure have on average an earnings instability three times lower than workers with zero years of tenure or in other words each year of tenure on the job reduces earnings instability by 15%. Workers on fixed term contract on average have an earnings instability 10% higher than workers on permanent contracts. But workers who spend their entire working life on temporary contract can expect a earnings instability twice as high than somebody on a permanent contract.

1 Introduction

Estimating the changes in the variance of earnings is the topic of the large literature on earnings inequality and mobility. Much of the literature focuses on cross-sectional evidence and assesses competing explanations of increasing inequality such as technical change, trade, institutions. A complementary literature looks at panel data on individual earnings and asks questions such as: What is the extent of intertemporal mobility in the distribution of earnings? Is the change in inequality due to long term earnings components (e.g. ability) or to increasing volatility of shocks that make the earnings process more unstable? In the latter case, the individual earnings variance over time is typically studied as the sum of a permanent component (which has to do with changes in the quantity and prices of permanent individual characteristics) and a transitory component that captures the extent of earnings instability.[1]

Gottschalk and Moffitt (1994) were the first to focus on the role of earnings instability in explaining inequality trends. They showed that the increase in the variance of the transitory component of earnings has been an important contributor to the increase in overall earnings inequality in the US, accounting for about one third of the observed total change. Subsequent research extended Gottschalk and Moffitt's approach to several countries (Dickens, 2000, Ramos 2003 and Alessie and Kalwij 2006 on the UK, Baker and Solon 2003 on Canada, Haider 2001 and Gottschalk and Moffitt 2002 on the US, Cappellari 2004 on Italy). However, while the evolution of earnings instability has been described for many countries, there is no consensus on the main determinants of the increase in the transitory component of the wage variance.

This paper models explicitly the role of tenure on-the-job and studies its effect on the permanent and the transitory variance of earnings. The motivation to focus on tenure may be found in a recent study by Guiso et al. (2005) who estimate the amount of insurance which firms provide to their workers. Using Italian matched employer-employee data, they compute permanent and transitory shocks to firms' profits and workers' wages and find that a 10% change in firms' performance induces a 0.7% permanent change in the wage (i.e. permanent shocks are not fully insured) while a transitory shock to firms' profits has no significant effect on the wage (i.e.

[1] We use the term permanent variance to indicate the variance associated to permanent individual characteristics, even if at times we will model it with a time-varying process. Equivalently the term transitory refers to a mean-reverting process which can be serially correlated.

transitory shocks are fully insured). These results apply only to workers employed in the firm on a continuing basis and imply that the permanent and transitory shocks to workers' wages vary with tenure on-the-job.

In addition to the insurance motive, also matching models predict a relationship between instability and tenure. In a standard model of matching wages are paid on the basis of match quality which reflects the worker's marginal product. The quality of the match is observed with error and is updated upon observation of workers' output. This implies that the variance of the error and therefore the variance of wage offer distribution (offers from alternative employers and the current employer) facing each individual declines with tenure on-the-job as workers and firms make an increasingly precise assessment of the quality of the match (see Mortensen, 1988 and Parent, 2002).

In the context of standard wage regressions, the returns to tenure have been at the centre of a controversy for long. Two competing explanations of the positive correlation between tenure and wages found in OLS regressions are the theory of human capital and the theory of matching. According to the latter the positive returns to tenure reflect the correlation of tenure with the unobservable quality of the firm-worker match rather than the accumulation of firm-specific skills, implying that tenure is endogenous. Altonji and Shakotko (1987), Abraham and Farber (1987), Altonji and Williams (1997), Neal (1995) and Parent (2000) find very small tenure effects once they control, in various ways, for the endogeneity of tenure. To distinguish the two theories, in a paper related to ours Parent (2002) exploits their different implications in terms of covariance structure of earnings. He finds that, in line with the human capital theory, those who start out with a lower wage in a job have a steeper tenure profile. While Parent (2002) looks at the relationship between tenure and long term earnings, in this paper we take a different perspective and assess the impact of tenure on the unstable component of earnings.

Other studies have established that both displacement (Huff-Stevens 2001) and voluntary job change (Leonardi 2004) may impact on the transitory variance of wages. It is plausible that the frequency of voluntary and involuntary job moves, the associated periods of job search on- and off-the-job and the wage changes in consequence of the change also affect the transitory variance of earnings. Low et al. (2006) look at earnings variance components to study income risk and precautionary savings. They show that accounting for endogenous mobility in the equation for wage levels leads to lower estimates of the dispersion of permanent earnings, while earnings instability remains unaffected. While that work looks at the effect of mobility on earnings levels, the main contribution of our paper is to estimate the permanent and the transitory part of the wage variance for workers at various points of their tenure. We estimate the impact of tenure on instability by exploiting the variability of average tenure across birth cohorts and time periods.

We use Italian matched employer-employee data with an accurate measure of on-the-job tenure. The data also contain information on the type of contract (standard or fixed-term) and this gives us the opportunity to study the impact of tenure on the wage variance from a different angle. Fixed-term (also called temporary) contracts are short tenure contracts which typically last two or three years and can be renewed only once. In consequence of changes in labor market legislation, they spread in many European countries in the nineties. A large literature has studied the effect of fixed-term contracts on employment, unemployment and job flows but nobody has looked so far at their effects on earnings instability. Yet one of the main concerns about the diffusion of fixed-term contracts is their implications in term of earnings instability and welfare in as much as earnings instability is strictly related to the uncertain component of earnings. In this paper we explicitly model the type of contract (standard or fixed-term) in the decomposition of the wage variance, and provide an estimate of the earnings instability associated with a fixed-term contract.[2] In particular we ask two questions. How different is average earnings instability of an individual who works on a permanent contract with respect to somebody who has worked at any time on a fixed-term contract? and with respect to somebody who has worked on temporary contracts his entire working life?

Our results indicate that workers with four years of tenure have on average an earnings instability three times lower than workers with zero years of tenure or in other words each year of tenure on the job reduces earnings instability by 15%. Workers on fixed term contract on average have an earnings instability 10% higher than workers on permanent contracts. But workers who spend their entire working life on temporary contract can expect a earnings instability twice as high than somebody on a permanent contract.

The rest of the paper proceeds as follows. Section 2 describes the data with particular attention to the evolution of average tenure on the job and the diffusion of fixed-term contracts in Italy. Section 3 explains the statisti-

[2] As in the case of employer tenure, clearly part of earnings instability associated with fixed-term contracts may be due to instability in the employment status. We leave the analysis of employment instability and endogenous mobility for further work.

cal model. Section 4 describes the results and section 5 concludes.

2 Data Description

The data are drawn from the Italian Social Security Administration (INPS) archives and spans the years 1985-1999. The original dataset collects social security records of a 1/90 random sample of employees born on the 10th of March, June, September, and December of every year. The original archives only include information on private sector firms in the manufacturing and service sectors, therefore all workers in the public sector, agriculture and self-employment are excluded.

The dataset contains individual longitudinal records generated using social security numbers. However, since the INPS collects information on private sector employees for the purpose of computing retirement benefits, employees are only followed through their employment spells. The dataset stops following individuals who move into self-employment, the public sector, the agricultural sector, the underground economy, unemployment and retirement.

We have information on employees' age, gender, occupation (blue collar-white collar), yearly earnings, number of paid weeks, the initial and final month of job matches and the type of contract (permanent-temporary). The dataset also includes longitudinal records for firms employing the randomly selected workers in the sample using the firms' name, address, social security and fiscal codes and information on firms' location, sector of employment and average number of employees.

Crucial for this paper, we have information on tenure on the job (number of months since the start of the contract) and we can define firm changers making use of the firm identifier, however we do not know whether they are quits or layoffs. Furthermore we have information on the type of contract (permanent or fixed-term).

2.1 Sample selection rules

We keep in the sample all male workers aged 21 to 55 with positive yearly earnings and positive weeks of work. As customary in this literature, we focus on males since their labour force participation is less endogenously intermittent relative to females. The selection on age is aimed at avoiding the extremes of the working career, because employment volatility just after entry into the labour market or close to retirement may blur the measurement of structural earnings instability. In the course of the paper we use weekly earnings (yearly earnings divided by the number of weeks paid). For the cases of multiple individual spells in the same year we consider the longest spell.

The administrative data in electronic form start in January 1985 and the start date of all contracts already running at that date are artificially set to zero at January 1985. We drop all those zeros because we are not able to establish the exact tenure on the job of all those workers whose contracts started before the1st of January 1985. Thus we consider only tenures which started after the 1st of January 1985. Since such a selection rule leaves few observations in 1985 compared to the other years in the panel, we consider data from 1986 onwards. The final dataset includes 120,616 individuals, with 632,105 person-year observations over the years 1986-1999.

We will identify the effect of tenure on the permanent and transitory earnings variance separately from life-cycle effects by modelling the covariance structure of earnings within birth cohorts. To this end, we form subsamples defined by the year of birth. In order to ease the identification of tenure-related earnings profiles within each cohort we set the minimum period of observation of a cohort to five years. Given our sample selection on age, this implies that we consider cohorts of individuals born between 1935 (who turn 55 in 1990, in the fifth year of data in the sample) and 1974 (who turn 21 in 1995, and can be observed five times before the end of the sample). We therefore estimate the intertemporal covariance structure of earnings separately for these forty birth cohorts. Individuals born between 1944 and 1965 are observed fourteen times (i.e. over the whole sample period), while for individuals in cohorts born further apart from such interval the number of points in time monotonically decreases, going from 13 for those born in 1943 and 1966 to 5 for the oldest and youngest cohort, 1935 and 1974.

2.2 Descriptive statistics on tenure

We describe some salient features of the data focusing on selected birth cohorts. Additional descriptive statistics for the remaining cohorts can be provided upon request. Table 1 shows the average tenure in months in the full sample and within each cohort. There is large variation in average tenure both between and within cohorts. All cohorts observed since the beginning of the panel start with low average tenure because the average refers only to contracts started after January 1985. Comparing cohorts from 1940 to 1960 up to 1995 (i.e. the last year in which we observe cohort 1940), it is evident that older cohorts accumulate on average longer tenure as a result of the lower job mobility of old workers relative to younger ones. In 1995, the difference between average tenure of the cohort born in 1940 and 1960 is 6.5 months. After 1995, cohorts 1950 and 1960 remain in the sample, and their accumulation of tenure proceeds up until 1997, but stops in 1998 and 1999. The reason is that in 1997 the Italian labour market was reformed and employment flexibility increased mainly through the diffusion of temporary jobs (the so called 'Treu Package', named after the Minister of Labour of the time), which reduced the rate of tenure accumulation within each cohort (more details on this points are provided below). The youngest cohort depicted in Table 1 (cohort 1970) starts being observed in 1991. Also in this case we can see that tenure accumulation is slower compared with older cohorts. For example, in 1997, after 7 years in the sample and before the reforms came into effect, this cohort accumulated 28.7 months of tenure, well below the comparable average tenure of cohorts 1940, 1950 and 1960 in 1993, i.e after 7 years of observations.

Table 2 shows the proportion of temporary workers and their average tenure for some of the youngest cohorts in our sample for whom the incidence of temporary contracts is more relevant. In the late 1980s the so-called 'work and training' contracts (temporary contracts in which the employer had to pay reduced social security contributions and had to provide training on-the-job) were very popular, so that the overall share of temporary contracts reached 13 percent in 1988 for the cohort born in 1960. During the mid 1990s, reduced contributions to social security were no longer sustainable, and temporary employment in Italy lost popularity. Finally, the 1997 reform introduced new forms of temporary employment, and our data show that their incidence increased substantially between 1997 and 1998 for the youngest cohorts. Compared to Table 1, Table 2 also shows that while permanent workers accumulate tenure on the job, the average tenure of temporary workers is always below 13 months. Moreover, their on-the-job tenure drops dramatically after the reform of the late 1990s, indicating that such reforms may have made temporary employment even more unstable than it was before.

2.3 The intertemporal covariance structure of earnings

We use all valid wage observations in our sample to estimate the covariance structure of earnings for the forty birth cohorts. While not solving issues of endogenous panel attrition, such an unbalanced panel design is certainly

Table 1: Average tenure in months

Year	Cohort born 1940	Cohort born 1950	Cohort born 1960	Cohort born 1970	Full sample	Obs.
1986	9.8	9.3	7.8		8.7	26413
1987	16.4	16.1	12.7		14.1	32170
1988	23.2	22.0	16.3		18.6	37361
1989	29.0	26.3	20.1		22.3	41120
1990	34.7	32.7	23.4		25.5	43030
1991	37.7	34.9	26.0	11.8	27.8	48322
1992	43.2	40.8	30.9	14.9	31.7	49588
1993	42.4	39.5	33.9	18.7	33.7	46795
1994	45.9	41.7	36.3	20.8	35.4	49254
1995	46.4	44.8	39.9	23.6	36.6	52233
1996		47.8	43.5	26.3	39.0	51897
1997		50.8	45.1	28.7	41.1	51553
1998		47.5	45.0	31.5	41.6	49681
1999		49.4	46.0	31.9	42.2	52688
N obs.						632105

Table 2: Incidence and tenure of temporary contracts: Selected Cohorts.

Year	Cohort born 1960			Cohort born 1970			Cohort born 1974		
	obs.	%	Tenure temp.	obs.	%	Tenure temp.	obs.	%	Tenure temp.
1986	1056	0.07	6.4						
1987	1267	0.1	8.7						
1988	1449	0.13	9.5						
1989	1494	0.11	11.7						
1990	1491	0.04	17						
1991	1636	0.01	16.4	1772	0.2	8.7			
1992	1643	0.01	9.1	1892	0.19	11.7			
1993	1524	0.01	11.1	1807	0.16	12.8			
1994	1583	0.01	12.3	1916	0.13	10.9			
1995	1611	0.01	13.1	2019	0.12	10.8	1583	0.14	7.4
1996	1614	0.01	6.3	2106	0.11	10.7	1760	0.17	9.5
1997	1631	0.02	9.1	2168	0.12	11.1	1945	0.17	10.9
1998	1588	0.05	3.5	2102	0.16	5.2	1973	0.29	7.3
1999	1714	0.06	3.6	2397	0.17	5.2	2245	0.29	7.7

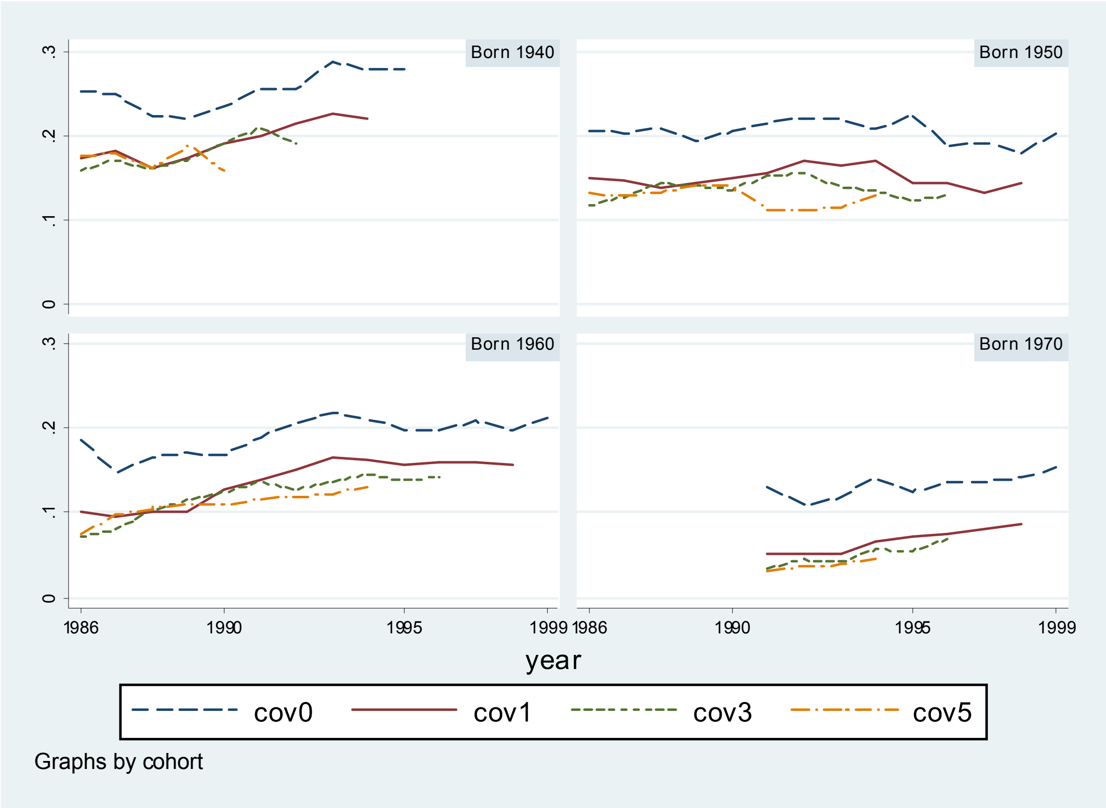

Figure 1: Earnings Covariances at Various Lags

less restrictive compared with analyses based on balanced panels.[3]

We plot estimated variances and covariances for selected birth cohorts in Figure 1. For most of the cohorts, earnings dispersion appear to increase at a moderate pace over the intial part of the period investigated, while trends of earnings inequality seem to level off towards the end of the sample period. These patterns reproduce the evidence for Italy provided by other studies, see e.g. Brandolini et al. (2002). Covariances at various lags are at a lower level compared with the variance, but still show the upward trends discussed above. The distance between covariances at increasing

[3]Approximately 70,000 individuals in our sample are observed over the whole period investigated. We estimate earnings second and fourth moments from the unbalanced panel following the procedure described in Dickens (2000).

lags, moreover, decreases over lags, and covariances tend to stabilize to a long-term level. Such a pattern is consistent with an underlying process of earnings dynamics formed by some long-term component plus some mean-reverting component characterized by low order autoregression. We now turn to the modeling of such processes.

3 Econometric Model

We characterise the link between earnings instability and tenure by modelling the intertemporal covariance structure of earnings. Specifically, we use panel data on individuals to separately identify a long term earnings component and a mean reverting one. We define earnings instability as the dispersion of mean reverting earnings shocks, i.e. that part of earnings inequality that fades away over time.

Our data enable us to observe forty sub-samples defined according to the year of birth over the period 1986-1999, yielding the possibility to separate time and birth cohort effects.[4] We achieve this by estimating the within-cohort earnings covariance structure and jointly modelling the second earnings moments of all cohorts. In particular, let w_{ict} be the deviation of log-earnings for individual i in cohort c and year t from the cohort and period specific mean, with $i = 1 \ldots N_c$, $t = t_{0c}, \ldots T_c$, and c=1935,…,1974. Since we restrict our sample to individuals aged between 21 and 55, the initial and final year of observation are cohort specific. Namely, cohorts born before 1966 are observed since 1986, while those born from 1966 onwards turn 21 (and are included in the sample) in 1987 or later, so that the youngest cohort enters the sample in 1995. Similarly cohorts born after 1943 are observed until 1999, while older cohorts turn 55 (and leave the sample) in 1998 or earlier, the oldest cohort exiting from the sample in 1990.

Earnings differentials within each cohort can be analysed by modelling the earnings covariance structure $E(w_{ict}\ w_{ic(t-k)})$, $k = 0, ..K_c$. Given the unbalanced design by cohort, the longest time interval over which earnings covariances can be estimated is cohort specific. Therefore K_c=13 for individuals born between 1944 and 1965, while for cohorts born further apart from such interval K_c monotonically decreases, going from 12 for those born between 1943 and 1966 to 4 for the oldest and youngest cohorts born in 1935 and 1974.

[4]Estimating age, time and cohort effects would require some parametric restrictions, see Alessie and Kalwji (2006).

3.1 Basic model

We start by characterising the benchmark decomposition of earnings differentials between earnings instability and long-term persistence. Later we introduce on-the-job tenure.

Let w_{ict} be the sum of two orthogonal components, the long-term one (w_{ict}^{P}) and the mean-reverting shock (w_{ict}^{T})

$$w_{ict} = w_{ict}^{P} + w_{ict}^{T}; \qquad E(w_{ict}^{P} w_{ict}^{T}) = 0 \tag{1}$$

The first component represents those earnings determinants that depend on long-term personal attributes such as education or learning ability on-the-job; the second component captures in each year the deviations of individual earnings from the person-specific long-term component. The orthogonality assumption allows separate identification of the two components.

In this basic set-up, we allow long-term earnings to depend upon an idiosinctratic term μ_i, which is shifted by a period-specific loading factor π_t (where π_0 is normalized to one for identification) and a cohort specific loading factor λ_c (where λ_{1952} is normalized to one):

$$w_{ict}^{P} = \lambda_c \pi_t \mu_i; \qquad \mu_i \rightsquigarrow iid(0, \sigma_{\mu}^{2}) \tag{2}$$

Period-specific loading factors account for aggregate shifts in the long-term earnings distribution, whereas cohort-specific ones control for the fact that individual in different cohorts are observed at different stages of their life cycles, and between-cohort earnings inequality may reflect such differences. Given (2), the theoretical covariance structure of long-term earnings is

$$E(w_{ict}^{P} w_{ic(t-k)}^{P}) = \lambda_c^2 \pi_t \pi_{(t-k)} \sigma_{\mu}^{2} \tag{3}$$

For the volatile component we assume a non-stationary AR(1) process and we allow for non-stationarity modelling the (variance of the) initial conditions of the autoregressive process:[5]

$$w_{ict}^{T} = \varphi_c \tau_t u_{it}; \quad u_{it} = \rho u_{i(t-1)} + \epsilon_{it}; \quad \epsilon_{it} \rightsquigarrow iid(0, \sigma_{\epsilon}^{2}); \quad u_{i0} \rightsquigarrow iid(0, \sigma_{0}^{2}) \tag{4}$$

[5] We also experimented with ARMA(1,1) specifications. However, when we modelled the impact of tenure on instability, moving average components proved difficult to identify, possibly because much of the serial correlation in the volatile component was absorbed by the coefficient on tenure. For the sake of comparability, we therefore adopt the AR(1) specification throughout the paper.

Again, period and cohort specific shifters (τ_t and φ_c) are allowed for in order to control for aggregate shifts. It follows that

$$E(w_{ict}^T w_{ic(t-k)}^T) = \varphi_c^2 \tau_t \tau_{(t-k)} \begin{Bmatrix} d_0 \sigma_0^2 + d\left(\sigma_\epsilon^2 + E(u_{i(t-1)} u_{i(t-1)})\right) \rho^2 + \\ +(1 - d_0 - d) E(u_{i(t-1)} u_{i(t-k)}) \rho \end{Bmatrix} \quad (5)$$

where $d_0 = I(k = 0, t = t_{0c})$ and $d = I(k = 0, t > t_{0c})$, $I(.)$ being an indicator function.

The orthogonality assumption given in 1 implies that the theoretical covariance structure of this model results from the sum of 3 and 5.

3.2 Modelling the impact of tenure

Our specific interest is in the impact of on-the-job tenure on earnings variance components. In principle, both components may vary with tenure. Permanent earnings can depend upon tenure because of differential learning ability or the release of information on match quality over time. In each case we should expect a positive relationship. Earnings instability, on the other hand, may decrease with job duration if the quality of the match is initially measured with error, or if firms are more willing to insure earnings against volatile shocks the more they know match quality.

We model long-term earnings using a random walk in tenure:

$$w_{ict}^P = \lambda_c \pi_t v_{ijt}; \quad v_{ijt} = v_{ij(t-1)} + \phi_{ijt}\ ; \quad \phi_{ijt} \rightsquigarrow iid(0, \sigma_\phi^2) \quad (6)$$

where v_{ijt} represents earnings at job j, which are assumed to be equal to their past value in the same job, plus an idiosyncratic and serially independent innovation. Assuming the job started in period $h(< t-1)$, iterating the autoregression back to the start of the job yields $v_{ijt} = v_{ijh} + \sum_{s=h+1}^{t} \phi_{ijs}$ and thence:

$$E(w_{ict}^P w_{ic(t-k)}^P) = \lambda_c^2 \pi_t \pi_{(t-k)} \left\{\sigma_v^2 + E(tenure_{ic(t-k)}) \sigma_\phi^2\right\} \quad (7)$$

with $\sigma_v^2 = var(v_{ijh})$. The model implies that the variance of the long-term component grows linearly within a job, with slope coefficient given by the variance of innovations to the random walk process.

As for earnings instability, we model the impact of tenure by specifying its relationship with transitory innovations, using either a linear or an exponential functional form. The latter ensures that predicted variances are positive:

$$\sigma^2_{\epsilon ct} = \sigma^2_{\epsilon} + \beta E(tenure_{ict}) \quad (8)$$

$$\sigma^2_{\epsilon ct} = \sigma^2_{\epsilon} \exp[\beta E(tenure_{ict})] \quad (9)$$

We exploit variation in average tenure across periods and cohorts to identify its impact on earnings instability. The expressions in 8 or 9 substitute σ^2_{ϵ} to form the theoretical covariance structure of the volatile component in 5. Notice that, differently form the base model, here $\sigma^2_{\epsilon ct}$ depends form cohort and time. Henceforth we will refer to the model in equation 6 and 8 as the linear model and to the model in equation 6 and 9 as the multiplicative model.

3.3 Modelling the impact of contract type

An alternative way to measure the relevance of firm seniority for earnings instability is to look at the type of contract, open-ended or fixed-term. The underlying idea is that fixed-term contracts do not favour the accumulation of seniority. From a theoretical point of view, working on a fixed-term contract may have an impact on each earnings component, say because of differential skill accumulation or exposure to economic fluctuations.

We allow for the effects of contract types by letting innovations to the permanent and transitory components in the basic model depend upon the proportion of workers on fixed-term contracts observed in a given cohort over time, again using linear or exponential functional forms. More specifically we either assume that:

$$\sigma^2_{\mu ct} = \sigma^2_{\mu} + \gamma E(g_{ict}); \qquad \sigma^2_{\epsilon ct} = \sigma^2_{\epsilon} + \eta E(g_{ict}) \quad (10)$$

or

$$\sigma^2_{\mu ct} = \sigma^2_{\mu} \exp[\gamma E(g_{ict})]; \qquad \sigma^2_{\epsilon ct} = \sigma^2_{\epsilon} \exp[\eta E(g_{ict})] \quad (11)$$

where g_{ict} signals whether individual i from cohort c is on a fixed-term contract in period t. The two parameters on the left hand side of 10 and 11 substitute their counterparts in 3 and 5 to form the theoretical covariance structure of long-term and volatile earnings components.

3.4 Identification

The identifying assumption of random walk models is that innovations are independently and identically distributed, which enables writing the second moments of the process as a linear function of the relevant time trend. In our case, therefore, we assume that the definition of random walk innovations holds within the job: $\phi_{ijt} \rightsquigarrow iid(0, \sigma^2_\phi)$. On the other hand, the relationship between on-the-job tenure and earnings instability is identified by the variation of tenure across period and cohort cells. Given this set-up, the identifying assumption of variance components models (i.e. orthogonality between long-term and transitory earnings) is not violated by introducing tenure into the model. To see this, write the transitory earnings component as

$$w^T_{ict} = \varphi_c \tau_t u_{it}; \quad u_{it} = \rho u_{i(t-1)} + \sigma_{\epsilon ct} \xi_{it}; \quad \xi_{it} \rightsquigarrow iid(0,1) \qquad (12)$$

with $\sigma^2_{\epsilon ct}$ given in 8 or 9. In order for the orthogonality condition $E(w^P_{ict} w^T_{ict})$=0 to hold, when the permanent wage is a random walk in tenure (i.e. as in 6) the following assumptions have to be satisfied:

$$E(v_{ijh} u_{ih}) = 0; \quad E(\phi_{ijt} \xi_{it}) = 0 \qquad (13)$$

which is the set of assumptions that would be required in a model without tenure. Modelling the impact of tenure does not require additional identifying restrictions.

Cross- period and cohort variation provides identification also in the model for temporary contracts. In this case, write the transitory component as in 12, the permanent components as:

$$w^P_{ict} = \lambda_c \pi_t \sigma_{\mu ct} \psi_i; \qquad \psi_i \rightsquigarrow iid(0,1) \qquad (14)$$

and consider the specification of innovations to both components given in 10 or 11. For the orthogonality conditions to hold the following assumptions must be met:

$$E(\psi_i w^T_{i0}) = 0; \qquad E(\psi_i \xi_{it}) = 0 \qquad (15)$$

i.e. what would be required also without modelling the impact of contract types in the two earnings components.

3.5 Estimation

We estimate the parameters of interest by imposing the restriction implied by the theoretical covariance structure models on empirical variances and covariances by minimum distance.

Let M_c be the empirical earnings covariance structure for cohort c, $m_c = vech(M_c)$ and $m = (m_{1935}, \quad , m_{1974})$, the vector containing the 3180 variances and covariances that can be estimated for all cohorts in the sample. The models discussed above imply that the theoretical covariance structure of all cohorts $E(w_{it}w_{i(t-k)})$ is a non linear function of a parameter vector: $E(w_{it}w_{i(t-k)}) = f(\theta)$.

We estimate θ by solving the following minimisation problem:

$$\theta = \arg\min[m - f(\theta)]'[m - f(\theta)]$$

This is the so called Equally Weighted Minimum Distance estimator (EWMD). Altonji and Segall (1996) showed that although not efficient, such estimator is preferable to the Optimum Minimum Distance (OMD, which uses $[var(m)]^{-1}$ to weight the minimisation problem) in the presence of correlations in sampling errors between second and fourth earnings moments. To reduce the variance of the estimator, we adjust standard errors using the fourth moments matrix after estimation, i.e. we use $var(\theta) = (G'G)^{-1}G'var(m)G(G'G)^{-1}$ to estimate the variance of estimated parameters, where G is the gradient of $f(\theta)$ evaluated at the solution θ^*.

In our tables of results we show a χ^2 statistic (with degrees of freedom equal to the number of moment conditions that exceed the number of model parameter) for the null hypothesis of correct model specification against the alternative of an unspecified covariance structure. Following Newey (1985), the statistic is obtained as $(m-f(\theta))'R^{-}(m-f(\theta))$ where R^{-} is the generalised inverse of $R = Wvar(m)W$, with $W = I - G(G'G)^{-1}G'$.

4 Results

4.1 A model of tenure

We begin our discussion of estimation results by considering the model of equations 6 to 9 which introduces tenure in both the permanent and the transitory components of earnings. We also estimated the benchmark model of equations 2 and 4. Parameter estimates of the base model are in Appendix Table 1 for comparison purposes. The permanent variance is a random walk in tenure while the transitory variance allows for a linear or multiplicative effect of tenure on the innovation of the AR1, which is specified as a function of average tenure across year and cohort cells.

Table 3 shows the results of the estimation of the main coefficients of interest under the two alternative specifications (linear or multiplicative) of earnings instability, while the full set of results including birth cohort and period shifters is reported in Appendix Tables 2 and 3. The random walk specification implies that permanent wage differentials evolve linearly over the worker-firm match. The coefficient σ_{ϕ}^2 is positive and statistically significant at usual confidence levels in both specifications; it indicates that higher tenure increases the permanent variance of wages reflecting the higher heterogeneity in observed and unobserved permanent individual characteristics among long tenure workers. This may result from the differential accumulation of skills on the job or by the release of information upon the quality of the match in the presence of heterogeneous match quality.

Estimates of the β coefficient are negative irrespective of the specification adopted, indicating that a higher tenure is associated with significantly lower levels of earnings instability. This effect indicates that earnings profiles stabilise as individuals settle down in their new jobs, and again may be interpreted in a matching model framework in which earnings profiles tend to their long-term component as the quality of the match is revealed to employers. The insurance model of Guiso et al. (2005) can also account for these patterns.

Figure 2 plots the predicted variances on the basis of the coefficient estimates. The predicted variance of earnings resembles the patterns already observed in Figure 1, with increasing trends in the first part of the period and a leveling-off thereafter.

The figure shows how these patterns of overall earnings inequality were driven by different factors. Increasing overall inequality in the late 1980s and early 1990s is essentially the result of widening long term wage differentials, as would result from a widening distribution of skill premia, say in the presence of skill biased technical change.[6] Trends in the last part of the period analyzed have a different nature. While the level of permament inequality drops between 1995 and 1996 and levels off thereafter, earnings instability displays an upward pattern over the last years of observation, consistently with the increased labour market flexibility brought about by labour market reforms in this period. Another pattern that clearly emerges from these estimates is that while for old cohorts permanent dispersion is the dominant factor in driving overall wage differentials, the reverse holds for younger cohorts. This evidence is consistent with the presence of heterogeneous earnings growth over the working career, so that the distribution of permanent wages fans out as workers enter later stages of the life cycle.

[6]Increasing permanent inequality up until the first half of the 1990s is consistent with the findings of Cappellari (2004).

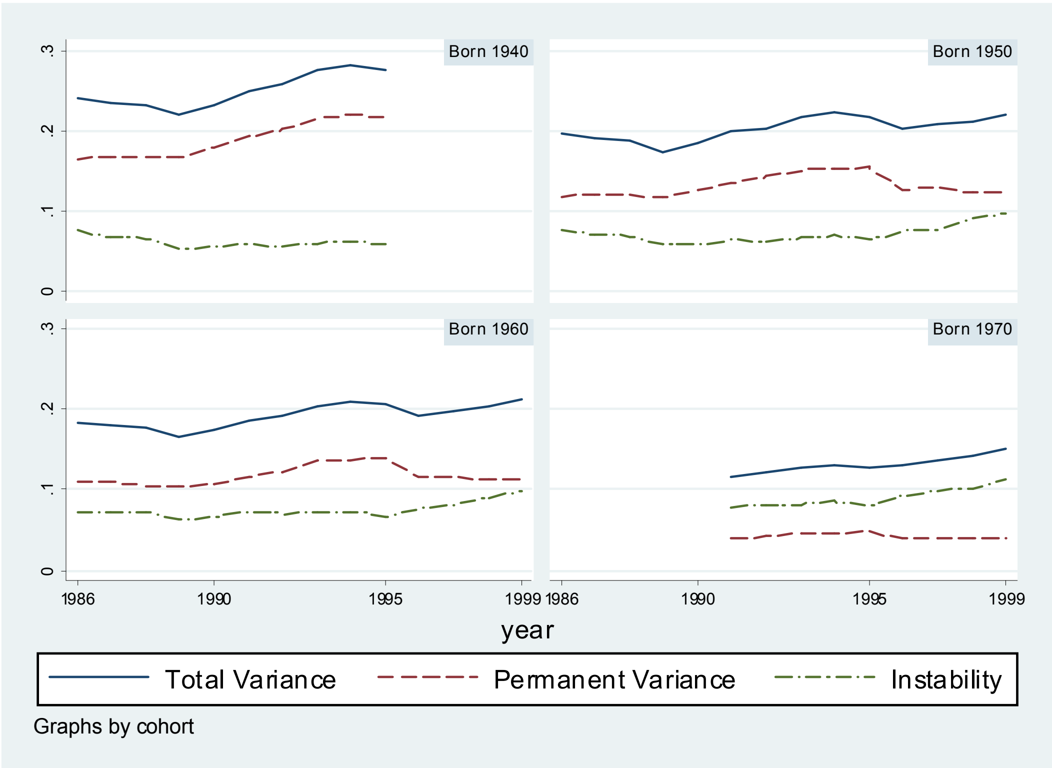

Figure 2: Predicted Variance Components: Multiplicative Model.

Table 3: Variance Components in Models of Tenure

	Linear Model		Multiplicative Model	
	coefficient	std. error	coefficient	std. error
σ_{υ}^2	0.102	0.006	0.111	0.007
σ_{ϕ}^2	0.001	0.000	0.002	0.000
σ_{ε}^2	0.091	0.008	0.095	0.012
β	-0.002	0.000	-0.020	0.006
σ_0^2	0.102	0.008	0.080	0.007
ρ	0.371	0.009	0.321	0.008
SSR	0.526		0.544	
$\chi^2_{(3070)}$	7577.452		6735.669	

Note: Full set of coefficients are in the Appendix Tables. Linear Model in equation 6 and 8, Multiplicative Model in equation 6 and 9.

Figure 3 plots the incidence of earnings instability on the total variance against tenure for four different cohorts, net of time effects. In this figure we use the exponential model, of transitory shocks, but the results from the linear specification are similar to the ones shown. The Figure shows a declining instability with tenure. The decline appears to be faster at shorter tenures; in a matching model this could be interpreted as a faster release of information on match quality early in the job tenure. The incidence of instability is much higher for the youngest cohort. Using the coefficients of the model we can predict the implied reduction in earnings instability when moving from zero years to a higher tenure. Using the multiplicative model and the estimates in year 1998 for the cohort born in 1940 at zero and at four years of tenure, we can estimate that each year of tenure implies a decrease in instability of (0.1008-0.039)/(4*0.1008)=15%. Zero years of tenure imply a earnings instability between two and three times higher than four years of tenure. The results vary both over time and cohorts, reflecting the variability of the estimated shifters of the earnings process (see Appendix Table 3), but they do not change much.

Figure 3: Earnings Instability (as fraction of total variance) and Tenure: Selected Cohorts

4.2 A model of fixed-term contracts

We now turn to results obtained by estimating the models of Section 3.3, which allow for a relationship between earnings components and contract type by allowing the variance of innovations to each component to be a function of the period- and cohort-specific proportion of temporary workers, using either linear and exponential specifications.

Table 4 shows the results for the main coefficients of interest, while the full set of estimates is reported in Appendix Table 4. Looking at the linear specification first, we notice that the coefficients of contract type on permanent and transitory earnings shocks (γ and η respectively) attract the signs we would expect a priori, indicating that individuals on fixed term contracts have on average a lower permanent variance of earnings and a higher instability relative to permanent workers. The lower permanent variance probably reflects the lower heterogeneity of workers on fixed-term contracts in terms of age, education and of all observed and unobserved permanent characteristics. The higher transitory variance picks up the effect of the lower tenure (among other factors which are associated with a fixed-term contract and affect temporarily the wage).

Parameter estimates from the alternative exponential specification confirm these patterns only partially. Namely, while it is still true that temporary contracts are characterized by lower long-term inequality compared with open-ended ones, the link between type of contract and instability is negative and not statistically different from zero.

On the basis of the coefficients in Table 4 it is possible to predict the average transitory variance of earnings in a given year for somebody on a permanent contract and compare it with the average transitory variance for somebody who is on a temporary contract with a probability given by the share of temporary contracts in his cohort in that year. It is also possible to predict the value of the transitory variance of somebody who is in a temporary contract with probability one i.e. somebody who has always been on temporary contracts all his work life.[7]

We show the results of this counterfactual exercise in Table 5 divided by cohort in two different years at the beginning and at the end of sample, 1988 and 1998. We focus on the linear specification of shocks, i.e. the one that produced a statistically significant estimate of the coefficient on temporary

[7] In technical terms we impose $\eta = 0$ to predict the transitory variance of a permanent contract, we weight η by the second moment of the dummy to predict the variance of a transitory contract and we weight η by one to predict the variance of somebody on a temporary contract for life.

Table 4: Variance Components in Models of Fixed-Term Contracts.

	Additive Model		Multiplicative Model	
	coefficient	std. error	coefficient	std. error
σ^2_μ	0.095	0.006	0.096	0.006
γ	-0.603	0.056	-8.263	0.730
η	0.077	0.018	-0.046	0.174
σ^2_ε	0.072	0.005	0.090	0.006
σ^2_0	0.118	0.007	0.116	0.007
ρ	0.438	0.005	0.459	0.006
SSR	0.491		0.486	
$\chi^2_{(3070)}$	7618.514		7610.595	

Note: Full set of coefficients are in the Appendix Tables. Linear Model in equation 10, Multiplicative Model in equation 11.

contracts in the earnings instability parameters. The predicted value of the transitory variance of earnings on a temporary contract is not very different from the predicted value on a permanent contract for the two oldest cohorts in the Table. However the share of temporary contracts is very low in these cohorts. The results change for the cohorts born in 1960 and 1970, where the share of temporary contracts is on average 10% of the total and up to 20% in certain years.

Somebody born between 1960 or 1970 on a temporary contract can expect on average a earnings instability which is 10% higher than the one for a permanent contract in the years 1988 and 1998 (and in general in the years between). Somebody who is on temporary contracts for his entire working life can expect a earnings instability twice as high as somebody on a permanent contract. This last value changes little across cohorts.

Table 5: Predicted Earnings Instability by Contract Type.

	Cohort born 1940	Cohort born 1950	Cohort born 1960	Cohort born 1970
Panel A: Additive Model				
Year 1988				
permanent contract	0.092	0.100	0.118	-
temporary contract	0.092	0.100	0.132	-
temporary contract always	0.171	0.186	0.220	-
Year 1998				
permanent contract	-	0.109	0.128	0.132
temporary contract	-	0.113	0.134	0.153
temporary contract always	-	0.203	0.239	0.248
Panel B: Multiplicative Model				
Year 1988				
permanent contract	0.091	0.099	0.120	-
temporary contract	0.092	0.099	0.118	-
temporary contract always	0.088	0.096	0.115	-
Year 1998				
permanent contract	-	0.115	0.138	0.144
temporary contract	-	0.115	0.138	0.144
temporary contract always	-	0.111	0.133	0.139

5 Conclusions

In this paper we have used Italian panel data to estimate the impact of on-the-job tenure on earnings instability. We found that the dispersion of long-term earnings profiles increase with tenure while earnings instability declines with tenure. This result is consistent with a matching model where overall earnings profiles tend to their long-term component as individuals settle down in their job and information on their output is revelead. Models of firm-provided insurance can also account for these findings. We estimate that each year of tenure is associated with a 15% reduction in instability. We also looked explicitly at the effect of fixed-term (short-tenure contracts) and permanent contracts on earnings instability. We found that workers on fixed-term contracts can experience between 10% and 100% more instability than the workers on permanent contracts, depending upon the portion of the career spent on fixed-term contracts.

The exercise of this paper is particularly relevant for Italy, which, starting from the late 1990s, experienced an increasing diffusion of short term contracts and labour market flexibility. Many authors have stressed that the welfare effects of these reforms depend on their impact on employment probability. Here we have provided evidence that, even conditional on being employed, there may be additional channels through which these new type of jobs affect individual welfare, namely through an increased uncertainty surrounding long-term earnings profiles.

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Appendix Tables

Table 1: Base Model (coefficients and standard errors)

σ_μ^2	0.096	0.006	φ_{1942}	1.046	0.062	λ_{1940}	1.159	0.055
σ_ε^2	0.100	0.008	φ_{1943}	0.954	0.055	λ_{1941}	1.068	0.049
σ_0^2	0.111	0.007	φ_{1944}	0.953	0.051	λ_{1942}	1.148	0.055
ρ	0.445	0.007	φ_{1945}	0.960	0.046	λ_{1943}	1.095	0.051
π_{1987}	1.037	0.012	φ_{1946}	0.950	0.042	λ_{1944}	1.056	0.047
π_{1988}	1.057	0.014	φ_{1947}	0.932	0.041	λ_{1945}	1.069	0.044
π_{1989}	1.072	0.014	φ_{1948}	0.972	0.046	λ_{1946}	1.052	0.044
π_{1990}	1.123	0.015	φ_{1949}	0.978	0.043	λ_{1947}	1.041	0.045
π_{1991}	1.174	0.017	φ_{1950}	0.982	0.039	λ_{1948}	1.022	0.043
π_{1992}	1.206	0.018	φ_{1951}	1.001	0.044	λ_{1949}	0.941	0.039
π_{1993}	1.257	0.020	φ_{1953}	0.957	0.039	λ_{1950}	0.970	0.038
π_{1994}	1.262	0.020	φ_{1954}	0.992	0.043	λ_{1951}	0.989	0.041
π_{1995}	1.262	0.021	φ_{1955}	0.984	0.041	λ_{1953}	0.968	0.039
π_{1996}	1.127	0.020	φ_{1956}	1.045	0.041	λ_{1954}	0.963	0.043
π_{1997}	1.132	0.020	φ_{1957}	0.971	0.039	λ_{1955}	0.993	0.039
π_{1998}	1.118	0.021	φ_{1958}	0.998	0.040	λ_{1956}	0.959	0.036
π_{1999}	1.131	0.022	φ_{1959}	0.965	0.038	λ_{1957}	0.936	0.038
τ_{1987}	0.897	0.022	φ_{1960}	0.983	0.038	λ_{1958}	0.928	0.036
τ_{1988}	0.859	0.023	φ_{1961}	1.000	0.037	λ_{1959}	0.896	0.034
τ_{1989}	0.768	0.022	φ_{1962}	1.029	0.035	λ_{1960}	0.915	0.038
τ_{1990}	0.766	0.022	φ_{1963}	1.021	0.036	λ_{1961}	0.815	0.030
τ_{1991}	0.786	0.022	φ_{1964}	1.005	0.034	λ_{1962}	0.765	0.027
τ_{1992}	0.777	0.022	φ_{1965}	0.996	0.033	λ_{1963}	0.726	0.027
τ_{1993}	0.789	0.023	φ_{1966}	1.023	0.034	λ_{1964}	0.696	0.026
τ_{1994}	0.811	0.023	φ_{1967}	1.016	0.035	λ_{1965}	0.652	0.024
τ_{1995}	0.789	0.023	φ_{1968}	1.026	0.035	λ_{1966}	0.618	0.024
τ_{1996}	0.856	0.024	φ_{1969}	1.026	0.035	λ_{1967}	0.597	0.022
τ_{1997}	0.879	0.025	φ_{1970}	1.048	0.037	λ_{1968}	0.556	0.021
τ_{1998}	0.905	0.026	φ_{1971}	1.050	0.037	λ_{1969}	0.535	0.022
τ_{1999}	0.943	0.027	φ_{1972}	1.043	0.038	λ_{1970}	0.505	0.023
φ_{1935}	1.006	0.079	φ_{1973}	1.034	0.039	λ_{1971}	0.504	0.024
φ_{1936}	1.005	0.067	φ_{1974}	1.039	0.040	λ_{1972}	0.499	0.028
φ_{1937}	1.062	0.067	λ_{1935}	1.226	0.082	λ_{1973}	0.488	0.031
φ_{1938}	0.942	0.064	λ_{1936}	1.114	0.065	λ_{1974}	0.411	0.033
φ_{1939}	1.036	0.058	λ_{1937}	1.121	0.064			
φ_{1940}	0.980	0.065	λ_{1938}	1.143	0.061	SSR	0.555	
φ_{1941}	0.995	0.057	λ_{1939}	1.051	0.052	$\chi^2_{(3072)}$	8144.4	

Table 2: Linear Model of Tenure (coefficients and standard errors)

σ_{υ}^2	0.102	0.006	φ_{1942}	1.059	0.071	λ_{1942}	1.144	0.054
σ_{ϕ}^2	0.001	0.000	φ_{1943}	0.949	0.060	λ_{1943}	1.089	0.050
σ_{ε}^2	0.091	0.008	φ_{1944}	0.982	0.060	λ_{1944}	1.049	0.046
β	-0.002	0.000	φ_{1945}	0.983	0.053	λ_{1945}	1.062	0.043
σ_0^2	0.102	0.008	φ_{1946}	1.033	0.052	λ_{1946}	1.041	0.044
ρ	0.371	0.009	φ_{1947}	0.980	0.050	λ_{1947}	1.035	0.044
π_{1987}	1.003	0.015	φ_{1948}	1.007	0.053	λ_{1948}	1.016	0.043
π_{1988}	0.993	0.021	φ_{1949}	1.055	0.053	λ_{1949}	0.935	0.039
π_{1989}	0.984	0.026	φ_{1950}	0.973	0.042	λ_{1950}	0.969	0.038
π_{1990}	1.011	0.031	φ_{1951}	1.014	0.050	λ_{1951}	0.986	0.040
π_{1991}	1.047	0.034	φ_{1953}	0.933	0.042	λ_{1953}	0.969	0.038
π_{1992}	1.062	0.039	φ_{1954}	0.946	0.046	λ_{1954}	0.967	0.042
π_{1993}	1.102	0.042	φ_{1955}	0.935	0.043	λ_{1955}	0.997	0.038
π_{1994}	1.101	0.043	φ_{1956}	1.008	0.044	λ_{1956}	0.963	0.036
π_{1995}	1.097	0.045	φ_{1957}	0.928	0.041	λ_{1957}	0.941	0.038
π_{1996}	0.984	0.042	φ_{1958}	0.909	0.040	λ_{1958}	0.937	0.036
π_{1997}	0.993	0.043	φ_{1959}	0.876	0.038	λ_{1959}	0.906	0.034
π_{1998}	0.974	0.043	φ_{1960}	0.873	0.038	λ_{1960}	0.928	0.038
π_{1999}	0.984	0.045	φ_{1961}	0.914	0.038	λ_{1961}	0.828	0.030
τ_{1987}	1.063	0.031	φ_{1962}	0.923	0.036	λ_{1962}	0.779	0.028
τ_{1988}	1.126	0.037	φ_{1963}	0.923	0.036	λ_{1963}	0.741	0.028
τ_{1989}	1.091	0.038	φ_{1964}	0.912	0.035	λ_{1964}	0.710	0.026
τ_{1990}	1.179	0.043	φ_{1965}	0.902	0.034	λ_{1965}	0.666	0.024
τ_{1991}	1.279	0.047	φ_{1966}	0.847	0.034	λ_{1966}	0.643	0.025
τ_{1992}	1.379	0.054	φ_{1967}	0.773	0.032	λ_{1967}	0.631	0.024
τ_{1993}	1.470	0.061	φ_{1968}	0.732	0.032	λ_{1968}	0.597	0.023
τ_{1994}	1.593	0.071	φ_{1969}	0.683	0.031	λ_{1969}	0.582	0.024
τ_{1995}	1.647	0.078	φ_{1970}	0.661	0.032	λ_{1970}	0.558	0.025
τ_{1996}	1.929	0.097	φ_{1971}	0.631	0.031	λ_{1971}	0.560	0.026
τ_{1997}	2.139	0.118	φ_{1972}	0.589	0.031	λ_{1972}	0.560	0.030
τ_{1998}	2.242	0.125	φ_{1973}	0.554	0.030	λ_{1973}	0.551	0.034
τ_{1999}	2.406	0.139	φ_{1974}	0.537	0.030	λ_{1974}	0.469	0.036
φ_{1935}	0.978	0.088	λ_{1935}	1.218	0.080			
φ_{1936}	0.994	0.076	λ_{1936}	1.110	0.064			
φ_{1937}	1.049	0.075	λ_{1937}	1.120	0.062	SSR	0.526	
φ_{1938}	0.932	0.074	λ_{1938}	1.138	0.060	$\chi^2_{(3070)}$	7577.4	
φ_{1939}	1.045	0.065	λ_{1939}	1.049	0.051			
φ_{1940}	0.981	0.074	λ_{1940}	1.155	0.054			
φ_{1941}	0.998	0.064	λ_{1941}	1.065	0.048			

Table 3: Multiplicative Model of Tenure (coefficients and standard errors)

σ_{υ}^2	0.111	0.007	φ_{1942}	1.073	0.078	λ_{1942}	1.126	0.052
σ_{ϕ}^2	0.002	0.000	φ_{1943}	0.974	0.067	λ_{1943}	1.075	0.049
σ_{ε}^2	0.095	0.012	φ_{1944}	0.986	0.063	λ_{1944}	1.030	0.044
β	-0.020	0.006	φ_{1945}	0.971	0.056	λ_{1945}	1.050	0.042
σ_0^2	0.080	0.007	φ_{1946}	0.956	0.052	λ_{1946}	1.031	0.042
ρ	0.321	0.008	φ_{1947}	0.938	0.052	λ_{1947}	1.022	0.043
π_{1987}	0.963	0.014	φ_{1948}	0.965	0.054	λ_{1948}	1.011	0.041
π_{1988}	0.924	0.019	φ_{1949}	1.001	0.052	λ_{1949}	0.930	0.038
π_{1989}	0.891	0.022	φ_{1950}	0.984	0.046	λ_{1950}	0.965	0.037
π_{1990}	0.895	0.026	φ_{1951}	1.015	0.053	λ_{1951}	0.982	0.039
π_{1991}	0.915	0.028	φ_{1953}	0.951	0.046	λ_{1953}	0.968	0.037
π_{1992}	0.912	0.031	φ_{1954}	0.978	0.051	λ_{1954}	0.970	0.041
π_{1993}	0.945	0.033	φ_{1955}	0.969	0.048	λ_{1955}	0.998	0.038
π_{1994}	0.940	0.034	φ_{1956}	1.045	0.048	λ_{1956}	0.966	0.035
π_{1995}	0.932	0.035	φ_{1957}	0.962	0.046	λ_{1957}	0.944	0.037
π_{1996}	0.834	0.032	φ_{1958}	0.986	0.047	λ_{1958}	0.941	0.036
π_{1997}	0.832	0.033	φ_{1959}	0.950	0.044	λ_{1959}	0.910	0.033
π_{1998}	0.816	0.033	φ_{1960}	0.957	0.046	λ_{1960}	0.938	0.038
π_{1999}	0.819	0.034	φ_{1961}	0.991	0.044	λ_{1961}	0.840	0.030
τ_{1987}	0.972	0.034	φ_{1962}	1.023	0.044	λ_{1962}	0.793	0.028
τ_{1988}	1.012	0.044	φ_{1963}	1.017	0.044	λ_{1963}	0.755	0.028
τ_{1989}	0.968	0.052	φ_{1964}	1.002	0.042	λ_{1964}	0.725	0.026
τ_{1990}	1.036	0.065	φ_{1965}	0.999	0.042	λ_{1965}	0.681	0.024
τ_{1991}	1.107	0.079	φ_{1966}	0.976	0.046	λ_{1966}	0.668	0.025
τ_{1992}	1.144	0.095	φ_{1967}	0.931	0.051	λ_{1967}	0.662	0.025
τ_{1993}	1.183	0.110	φ_{1968}	0.918	0.056	λ_{1968}	0.630	0.024
τ_{1994}	1.235	0.126	φ_{1969}	0.898	0.062	λ_{1969}	0.614	0.025
τ_{1995}	1.219	0.133	φ_{1970}	0.889	0.069	λ_{1970}	0.597	0.026
τ_{1996}	1.358	0.159	φ_{1971}	0.877	0.074	λ_{1971}	0.598	0.027
τ_{1997}	1.427	0.178	φ_{1972}	0.840	0.080	λ_{1972}	0.606	0.031
τ_{1998}	1.500	0.192	φ_{1973}	0.805	0.086	λ_{1973}	0.609	0.035
τ_{1999}	1.577	0.207	φ_{1974}	0.789	0.089	λ_{1974}	0.546	0.035
φ_{1935}	0.975	0.104	λ_{1935}	1.196	0.076			
φ_{1936}	1.006	0.088	λ_{1936}	1.089	0.060			
φ_{1937}	1.070	0.084	λ_{1937}	1.103	0.060	SSR	0.544	
φ_{1938}	0.928	0.087	λ_{1938}	1.117	0.057	$\chi^2_{(3070)}$	6735.6	
φ_{1939}	1.061	0.072	λ_{1939}	1.032	0.049			
φ_{1940}	0.966	0.083	λ_{1940}	1.135	0.052			
φ_{1941}	1.003	0.069	λ_{1941}	1.051	0.047			

Table 4: Linear Model of Fixed-Term Contracts (coefficients and standard errors)

σ^2_μ	0.095	0.006	φ_{1941}	0.959	0.054	λ_{1940}	1.165	0.055
γ	-0.603	0.056	φ_{1942}	1.006	0.057	λ_{1941}	1.071	0.049
η	0.077	0.018	φ_{1943}	0.954	0.048	λ_{1942}	1.154	0.055
σ^2_ε	0.072	0.005	φ_{1944}	0.963	0.045	λ_{1943}	1.096	0.051
σ^2_0	0.118	0.007	φ_{1945}	0.981	0.041	λ_{1944}	1.053	0.046
ρ	0.438	0.005	φ_{1946}	0.956	0.037	λ_{1945}	1.066	0.043
π_{1987}	1.041	0.012	φ_{1947}	0.942	0.036	λ_{1946}	1.050	0.044
π_{1988}	1.056	0.014	φ_{1948}	0.974	0.041	λ_{1947}	1.039	0.044
π_{1989}	1.064	0.014	φ_{1949}	0.973	0.038	λ_{1948}	1.020	0.043
π_{1990}	1.114	0.015	φ_{1950}	0.986	0.035	λ_{1949}	0.942	0.039
π_{1991}	1.169	0.016	φ_{1951}	1.000	0.039	λ_{1950}	0.968	0.038
π_{1992}	1.208	0.018	φ_{1953}	0.968	0.034	λ_{1951}	0.986	0.041
π_{1993}	1.266	0.020	φ_{1954}	0.993	0.037	λ_{1953}	0.964	0.038
π_{1994}	1.274	0.020	φ_{1955}	0.987	0.036	λ_{1954}	0.962	0.042
π_{1995}	1.273	0.020	φ_{1956}	1.043	0.037	λ_{1955}	0.991	0.039
π_{1996}	1.142	0.019	φ_{1957}	0.988	0.034	λ_{1956}	0.958	0.036
π_{1997}	1.147	0.020	φ_{1958}	1.031	0.035	λ_{1957}	0.933	0.037
π_{1998}	1.144	0.021	φ_{1959}	1.026	0.033	λ_{1958}	0.925	0.036
π_{1999}	1.162	0.022	φ_{1960}	1.068	0.033	λ_{1959}	0.891	0.033
τ_{1987}	1.062	0.024	φ_{1961}	1.087	0.034	λ_{1960}	0.914	0.038
τ_{1988}	1.070	0.026	φ_{1962}	1.114	0.033	λ_{1961}	0.815	0.029
τ_{1989}	0.996	0.025	φ_{1963}	1.105	0.033	λ_{1962}	0.769	0.027
τ_{1990}	0.988	0.026	φ_{1964}	1.095	0.033	λ_{1963}	0.737	0.027
τ_{1991}	0.983	0.027	φ_{1965}	1.079	0.032	λ_{1964}	0.713	0.026
τ_{1992}	0.948	0.027	φ_{1966}	1.090	0.034	λ_{1965}	0.674	0.024
τ_{1993}	0.945	0.029	φ_{1967}	1.094	0.034	λ_{1966}	0.651	0.025
τ_{1994}	0.973	0.030	φ_{1968}	1.093	0.034	λ_{1967}	0.625	0.023
τ_{1995}	0.966	0.030	φ_{1969}	1.090	0.035	λ_{1968}	0.587	0.022
τ_{1996}	1.014	0.031	φ_{1970}	1.084	0.036	λ_{1969}	0.551	0.023
τ_{1997}	1.035	0.032	φ_{1971}	1.087	0.037	λ_{1970}	0.539	0.024
τ_{1998}	1.121	0.033	φ_{1972}	1.081	0.039	λ_{1971}	0.533	0.025
τ_{1999}	1.170	0.033	φ_{1973}	1.069	0.040	λ_{1972}	0.534	0.028
φ_{1935}	0.961	0.074	φ_{1974}	1.021	0.040	λ_{1973}	0.521	0.033
φ_{1936}	0.949	0.062	λ_{1935}	1.229	0.084	λ_{1974}	0.451	0.034
φ_{1937}	1.001	0.062	λ_{1936}	1.121	0.066			
φ_{1938}	0.897	0.059	λ_{1937}	1.130	0.064	SSR	0.491	
φ_{1939}	0.998	0.053	λ_{1938}	1.151	0.061	$\chi^2_{(3070)}$	7618.5	
φ_{1940}	0.946	0.060	λ_{1939}	1.056	0.052			

Table 5: Multiplicative Model of Fixed-Term Contracts (coefficients and standard errors)

σ^2_μ	0.096	0.006	φ_{1941}	0.953	0.053	λ_{1940}	1.165	0.056
γ	-8.263	0.730	φ_{1942}	1.007	0.057	λ_{1941}	1.071	0.049
η	-0.046	0.174	φ_{1943}	0.955	0.048	λ_{1942}	1.154	0.056
σ^2_ε	0.090	0.006	φ_{1944}	0.963	0.044	λ_{1943}	1.097	0.051
σ^2_0	0.116	0.007	φ_{1945}	0.980	0.040	λ_{1944}	1.053	0.047
ρ	0.459	0.006	φ_{1946}	0.950	0.036	λ_{1945}	1.067	0.044
π_{1987}	1.037	0.012	φ_{1947}	0.941	0.035	λ_{1946}	1.051	0.044
π_{1988}	1.051	0.014	φ_{1948}	0.969	0.040	λ_{1947}	1.040	0.045
π_{1989}	1.059	0.014	φ_{1949}	0.968	0.037	λ_{1948}	1.021	0.043
π_{1990}	1.106	0.015	φ_{1950}	0.982	0.034	λ_{1949}	0.942	0.040
π_{1991}	1.155	0.016	φ_{1951}	0.995	0.039	λ_{1950}	0.968	0.038
π_{1992}	1.191	0.018	φ_{1953}	0.963	0.034	λ_{1951}	0.987	0.041
π_{1993}	1.248	0.020	φ_{1954}	0.990	0.037	λ_{1953}	0.965	0.039
π_{1994}	1.257	0.020	φ_{1955}	0.985	0.036	λ_{1954}	0.962	0.043
π_{1995}	1.258	0.020	φ_{1956}	1.039	0.036	λ_{1955}	0.991	0.039
π_{1996}	1.126	0.020	φ_{1957}	0.989	0.034	λ_{1956}	0.958	0.036
π_{1997}	1.132	0.020	φ_{1958}	1.035	0.035	λ_{1957}	0.933	0.038
π_{1998}	1.131	0.021	φ_{1959}	1.030	0.033	λ_{1958}	0.924	0.037
π_{1999}	1.150	0.022	φ_{1960}	1.074	0.033	λ_{1959}	0.890	0.034
τ_{1987}	0.972	0.020	φ_{1961}	1.089	0.033	λ_{1960}	0.915	0.038
τ_{1988}	0.953	0.021	φ_{1962}	1.117	0.033	λ_{1961}	0.817	0.030
τ_{1989}	0.877	0.020	φ_{1963}	1.111	0.033	λ_{1962}	0.772	0.028
τ_{1990}	0.875	0.021	φ_{1964}	1.096	0.032	λ_{1963}	0.739	0.028
τ_{1991}	0.884	0.022	φ_{1965}	1.084	0.032	λ_{1964}	0.718	0.027
τ_{1992}	0.860	0.022	φ_{1966}	1.094	0.033	λ_{1965}	0.679	0.025
τ_{1993}	0.861	0.024	φ_{1967}	1.090	0.034	λ_{1966}	0.657	0.025
τ_{1994}	0.885	0.025	φ_{1968}	1.090	0.034	λ_{1967}	0.637	0.024
τ_{1995}	0.874	0.025	φ_{1969}	1.088	0.034	λ_{1968}	0.603	0.023
τ_{1996}	0.920	0.026	φ_{1970}	1.099	0.036	λ_{1969}	0.573	0.024
τ_{1997}	0.938	0.027	φ_{1971}	1.105	0.037	λ_{1970}	0.546	0.025
τ_{1998}	1.027	0.028	φ_{1972}	1.098	0.039	λ_{1971}	0.542	0.026
τ_{1999}	1.076	0.029	φ_{1973}	1.086	0.040	λ_{1972}	0.547	0.030
φ_{1935}	0.965	0.074	φ_{1974}	1.053	0.041	λ_{1973}	0.537	0.035
φ_{1936}	0.953	0.062	λ_{1935}	1.224	0.084	λ_{1974}	0.452	0.039
φ_{1937}	1.003	0.062	λ_{1936}	1.116	0.066			
φ_{1938}	0.894	0.059	λ_{1937}	1.127	0.065	SSR	0.486	
φ_{1939}	0.995	0.052	λ_{1938}	1.150	0.062	$\chi^2_{(3070)}$	7610.5	
φ_{1940}	0.943	0.060	λ_{1939}	1.055	0.053			