The Consequences of Unemployment in Wage Determination.*

by

Mette Verner‡

Abstract

This study analyses individual wage effects of unemployment in the Danish case. Effects from different types of unemployment spells help to identify depreciation of firm-specific human capital versus depreciation of general human capital. The findings show evidence of linear depreciation for both men and women but in the case of men, the experience of unemployment produces immediate negative effects. This is interpreted as a combination of depreciation of firm-specific human capital and the use of unemployment as a signalling device. Sector-specific evidence shows that this period of catching up is longer in the public sector than in the private sector.

JEL-Classifications: J24, J31

Keywords: Human capital depreciation, career interruptions, wage effects, panel data sample selection models.

* Financial support from the Danish Research Agency (The FREJA grant) is gratefully acknowledged. I thank Per-Anders Edin, Peter Jensen, Jan C. van Ours, Inga Persson, Nina Smith, Michael Svarer, participants at the EALE Conference 1997, participants at CLS workshops related to this topic and other colleagues from Aarhus for useful comments on earlier versions of this paper.

‡ CIM, CLS and Department of Economics, Aarhus School of Business, Fuglesangs Allé 4, 8210 Aarhus V, Denmark, E-mail: mev@cls.dk, Phone: +45 8948 6416, Fax: +45 8615 5175.

1 Introduction

Since the last part of the seventies and up to the mid-nineties, unemployment has been one of the most serious economic problems in Denmark, as in most other European countries. At the aggregate level, the high unemployment level results in lost aggregate output and a high level of expenses to payment of unemployment benefits. But furthermore, unemployment may have considerable costs at the individual level. There is a direct cost in terms of lost income, because the maximum replacement ratio is 90% of the wage in the previous job, up to a flat level, which is relatively low in Denmark. But also later in the working career a loss may occur, since a loss of human capital during unemployment reduces the earnings potential.

According to human capital theory, this is the result of no human capital accumulation during the interruption and furthermore, depreciation may take place. The magnitude of this depreciation will, among other factors, depend on the amount of firm-specific human capital acquired in the former job. In contrast to general human capital, the firm-specific human capital will be lost in the case of no return to the former employer. After an interruption, it is possible that an earnings loss is only present in the short run but if it is not possible to catch up, the result is lower individual earnings in the long run. In total, the long-run consequences of unemployment may be more serious than what one would expect from examining direct short-run costs.

The purpose of this paper is to investigate whether these effects are present when the interruption is caused by unemployment, and the nature of the data makes it possible to focus on the effects from losses of general versus firm-specific human capital. The human capital hypothesis is, however, rather restrictive in the predictions concerning the depreciation pattern. According to human capital theory, women and men should experience the same wage effects if they are equal in all other matters, i.e. have the same observed and unobserved characteristics. If it turns out that wage effects of unemployment *are* different, an alternative explanation can be found in a signalling framework since it may be the case that unemployed women and unemployed men signal different types of labour to the employers. Furthermore, when predicting the consequences of unemployment on the wage, it should be taken into account that the wage formation process may differ across sectors (e.g. private versus public sectors) and hence the employers' perception of unemployment effects on the quality of labour.

The magnitude of the direct costs affects the incentives and the resulting search behaviour of the individual during the unemployment spell, and these effects have been analysed by means of duration models.[1] The future effects from today's unemployment may be even more severe, for the reasons mentioned above, but they have not been analysed in much detail. The human capital depreciation hypothesis has, however, been tested in the context of women and their career interruptions.[2] Later studies have included unemployment data in wage studies for both males and females. Groot & Ours (1993) include duration of both unemployment and non-participation in wage regressions for Dutch women and men, but find no significant wage effects from

[1] See e.g. Meyer (1990), Narendranathan & Stewart (1993), Jensen & Verner (1996).
[2] E.g. Mincer & Polachek (1974), Mincer & Ofek (1982) and Cox (1984).

unemployment neither in the short run nor in the long run. Rosholm & Smith (1996) include the individual rate of unemployment (lagged once) in wage regressions for Danish workers and here, significant negative wage effects are present for all groups investigated but one, namely for unskilled female workers employed in the public sector. Albrecht *et al*. (1999) estimate wage regressions including durations of various types of non-participation using Swedish data. The conclusion of the study is that unemployment subsequently results in a lower wage for both men and women employed in the public sector, whereas the effects are insignificant for individuals employed in the private sector. However, the hypothesis of depreciation of human capital is questioned, because the effects of all types of non-participation are not equal.

In this paper, the wage effects of unemployment of Danish workers are examined in more detail. The existing Danish data makes it possible to distinguish between the four following types of labour market states: employment, unemployment, out of the labour force and temporary layoffs. Information on the individuals' work histories is available on a weekly basis for the period 1981-90 and both the incidence and the duration of unemployment are investigated in order to focus on the different effects predicted from the human capital model. Employment with a new employer and temporary layoffs are distinguished and hence, it is possible to identify the loss of firm-specific human capital versus general human capital. In addition to the human capital hypothesis, another hypothesis tested in this paper is that unemployment affects public and private sector employees differently. Rosen (1989) predicts that wage growth is lower in the public sector than in the private sector and hence, different effects from interruptions in the two sectors may be present. Earlier studies from Sweden and Denmark confirm this, which is taken into account when choosing the strategy for analysing the effects.

The wage data are analysed by the use of different specifications of empirical models, proposed in the existing literature in the field. First, simple selection models are estimated on a cross section of the data set, where the work histories have been summarised, making the analysis retrospective. Second, panel selection models are estimated in order to analyse the persistence of the effects in greater detail as well as to account for time-invariant unobserved individual characteristics.

The outline of the paper is the following: In section 2, theoretical background dealing with the issue of interruptions is discussed. Section 3 gives a description of the data used in the analysis. The empirical set-up is shown in section 4 and the results from the estimations are outlined in section 5. Section 6 summarises and concludes the paper.

2 Theoretical background

In the following section, four approaches explaining the earnings effects from career interruptions are presented, namely human capital theory, signalling theory, search theory and bargaining theory. These theories of earnings formation are not mutually exclusive, but rather complements that serve to explain the mechanisms of wage formation in the case of interruptions in labour market careers. The purpose of this presentation is to provide theoretical background to be born in mind, when the results are interpreted later in this paper.

The issue of individual earnings can be analysed in a dynamic programming model of human capital formation (see Cox (1984)). The model predicts the individual's earnings profile, depending on the investments in human capital over the life cycle. The main assumption is that earnings depend on the stock of knowledge and skills gained from education and work experience. Usually on-the-job training is not costless and therefore, the individual must choose the optimal level of human capital accumulation depending on the trade-off between current and future earnings, the rate of discount, the depreciation rate and the expected length of the working life. If the individual works without interruptions throughout the working life, it is optimal to invest most in human capital at an early stage of the working career. The resulting earnings profile is continuously upward sloping at a decreasing rate until depreciation eventually is larger than investment in the late part of the working life. However, when the individual faces a discontinuous lifetime labour force participation pattern, the predicted earnings profile differs from this. During unemployment, the individual receives no earnings and furthermore, some depreciation of the stock of human capital may be taking place. The depreciation rate reflects the loss of human capital during the unemployment spell and if it is strictly positive, the earnings potential of the individual will be lower by the end of the unemployment spell. In the case where the individual has invested in general training and not only acquired human capital specific to the firm in which the individual was employed before the interruption, another element of depreciation is present. If this kind of firm-specific human capital is not transferable to a new employer, an immediate drop in the stock of human capital occurs when the employment is terminated. On the other hand, if there is a possibility of returning to the former employer after an unemployment spell (often referred to as recalls or temporary layoffs), this loss is prevented and "only" the general depreciation due to the duration of the spell is taking place. Actually, one should expect the same to hold in the case of e.g. parental leaves, since individuals on leave usually return to their former employer. One implication of the human capital model is that depreciation during different types of interruptions, e.g. unemployment and non-participation spells, are the same. One assumption for this prediction to hold is, of course, that the individual does not acquire any kind of human capital during the interruption. If they are e.g. in education or in military service, some knowledge or skill may be acquired and the stock of human capital increases and hence the depreciation rate is different, eventually positive.

According to the standard human capital model, the optimal investment in the time following the interruption does not depend on past behaviour. But if reconstruction of human capital lost during the recently experienced interruption is more efficient and therefore less costly than construction of new human capital, then the optimal level of investment is higher than it would have been in the case of no interruptions. This results in a steeper earnings profile in the time following the interruption. Therefore, the opportunity costs of investment of the intermittent worker are smaller following re-entry, than they would have been if the individual had not experienced any interruptions. The resulting earnings profile is steeper up to the point in time, when the earnings capacity is restored at the pre-interruption level. Afterwards, the optimal investment strategy coincides with the non-interruption investment strategy.

Figure 1. Earnings profiles.

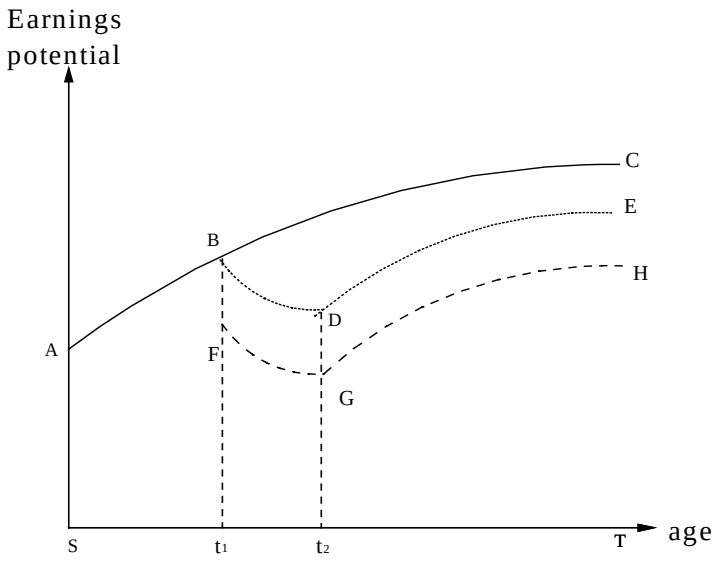


Figure 1 shows the resulting profile of earnings potential. The profile ABC shows the earnings profile given an optimal investment strategy for a working career without interruptions (ignoring the possibility that depreciation may exceed investment in the last part of the working career). ABDE is the resulting potential earnings profile for an individual experiencing an unexpected spell of unemployment from t_1 until t_2 when the following assumptions hold: No firm-specific human capital is lost immediately after the separation from the former employer, the depreciation rate is declining during the interruption and restoration of recently depreciated human capital is less costly than achievement of "new" human capital. The profile ABFGH shows the latter profile with the only moderation that an immediate loss is present due to loss of firm-specific human capital.

These considerations from the human capital theory suggest that in the empirical analysis not only the, eventually non-linear, depreciation rate due to unemployment should be estimated, but also an immediate effect due to loss of firm-specific human capital should be allowed for. Furthermore, identifying the unemployment spells where the individual ends up returning to the previous employer makes it possible to distinct losses of general human capital from losses of firm-specific human capital.

It may, however, be the case that the actual pattern of earnings is different from the previously discussed implications of the human capital model. An alternative interpretation of the loss of earnings after interruptions is given in a signalling framework. From this theory, it is possible to argue that the effects from interruptions vary across different groups of people and different types of interruptions (see e.g. Albrecht *et al*. (1999), Weiss (1995)). If the unemployed/intermittent workers are not a random sample of the population but actually are more unstable in the job and/or less committed to their working careers, the employer will use the knowledge of unemployment and the interruption behaviour of the worker in a screening process. This knowledge can be taken into account in the hiring situation or used in promotion

considerations of raising wages. The workers will take this screening process into account when they decide whether they want to interrupt the careers or in the case of unemployment whether they decide to search more ore less intensively. If the resulting wages differ for the two types of workers, we have a situation of a separating equilibrium, where the intermittent workers are separated from the stable workers and therefore have different earnings profiles. A recent Swedish study (Albrecht *et al*. (1999)) finds that the depreciation rates for men during career interruptions are higher than for women which may be because a man is considered less committed to his working career if he has spent time out of the labour force, simply because there has been no tradition for male workers to do so. On the other hand, women are to a much larger extent expected to interrupt the career during the fertile period of life. If this is initially incorporated in the employers' beliefs and hence the earnings of women, the woman has no reason to pretend to be more productive than she actually is. In the signalling framework, this can be interpreted as a pooling equilibrium situation where all women follow a given earnings path, no matter the type. In the case of unemployment the argument may carry over, especially during periods of the business cycle with a high demand for labour, simply because in that case most unemployment is considered voluntary and therefore may signal less committed labour.

The signalling interpretation of the earnings differential can be viewed as an extension of the human capital theory allowing for productivity differences, and these productivity differences are revealed to employers with the interruption behaviour as the signalling device. That is, the two explanations for lower earnings of intermittent workers are not mutually exclusive but rather good supplements for each other. The implication of the signalling theory for the empirical analysis is that different earnings profiles for different types of individuals e.g. gender should be allowed for. Also, different types of interruptions will, according to this theory, lead to different reactions from the employers and hence, the estimated effects probably differ.

Manning (1998) has provided an alternative to the human capital theory in explaining the upward sloping experience-earnings profile. In this type of search model, the wage (and productivity) is assigned to the job rather than the individual, and the factor determining experience-earnings profile is the transition rates between jobs and from non-participation to employment. The expected wage rate of an individual will rise with experience due to search behaviour. The explanation for this is that over the life cycle, the accumulated number of job offers received increases and hence the probability of having received a job offer associated with a high wage. Therefore, the average earnings of more experienced/older workers are higher than for the younger/less experienced workers. If the individual does on-the-job search, a job offer is accepted if the wage associated with the job in question is higher than the current wage. It may, though, be more efficient to search when the individual is unemployed and therefore, the individual may accept to have short spells of unemployment. In that case, if the individual's wage rate is actually higher in the new job than in the former job, the individual will obtain an earnings gain, rather than a loss, from unemployment. The observed spells of unemployment will eventually be rather short in this case (simply because the individual will not be willing to quit the former job if the expected direct loss of unemployment is of a considerable size as in the case of long unemployment spells). In an empirical earnings study, this kind of search behaviour will then result in individuals experiencing

a number of short unemployment spells in order to move up the earnings profile. Hence, the incidence of unemployment will, according to this theory, not always lead to reductions in earnings, but actually the contrary may be the case. Empirically, a simple way to incorporate this potential effect of unemployment is to introduce a variable to correct for the number of unemployment spells. This estimated effect of this variable will indicate whether multiple unemployment spells can result in higher earnings.

As mentioned in the introduction, earlier empirical studies from both Sweden and Denmark have shown that the wage formation process differs between the public and private sectors. Rosen (1989) provides a theoretical explanation of why earnings in the female-dominated public sector may be lower than earnings of the private sector. The paper presents a bargaining theory model where negotiations are not only on wages and employment but also on effort and working conditions in general. If female-dominated unions prefer deals with e.g. flexible working hours and generous maternity leave schemes to deals with high wages, this will result in lower earnings and flatter earnings profiles in the public sector. Actually, this may have been the case in the Danish labour market, where public-sector employees have more flexible hours, more generous leave schemes and the right to be absent from work in order to take care of sick children ("care days"). If this has actually been obtained at the cost of lower wages and lower wage growth over the life cycle, the expected effects of interruptions are smaller for both men and women compared to the private-sector interruption effects. Empirically, this can be investigated by allowing the earnings processes of the two sectors to differ.

3 Data

This analysis is based on a sample of 1% of the Danish population aged 16-67 years. The information comes from registers, and individuals are observed on a yearly basis during the years 1981-1990. Not all individuals are observed in all years, simply because young people are added to the panel every year and old people leave it. The data contains yearly information on demographic variables, income variables, and educational and labour market variables. Furthermore, work histories on a weekly basis exist for these persons, which makes it possible to observe the labour market status of an individual in any given week during the ten-year-interval. Four labour market states can be distinguished: employment, unemployment, temporary layoff[3] and out of the labour force.

Note, that the category "out of the labour force" contains a mix of occupations, since the individuals can be under education, on parental leave, doing their military service, home

[3] Temporary layoffs are defined as unemployment spells, where the employer before and after unemployment is the same. In this analysis, temporary layoffs are included, but the duration of these layoffs are also included in the duration of the surrounding employment spell. Therefore, the duration of a temporary layoff can be interpreted as the part of the employment spell that the worker has not been actually working. Temporary layoffs in general can be regarded as an atypical kind of unemployment, which, presumably, does not affect wage formation in the same manner as "real" unemployment does. Hence, these spells are considered separately in order to be able to test whether these spells in reality affect the earnings formation differently.

Table 1. Average sample values of individual characteristics in the last year of observation.

	Women		Men	
	Mean	Std. dev.	Mean	Std. dev.
Child aged 0-6 (0/1)	0.17	0.37	0.10	0.30
Age	38.86	13.48	37.95	13.27
Region (0/1)	0.64	0.48	0.64	0.48
Education (years)	10.67	2.86	11.07	2.86
Experience * (years)	10.41	8.11	15.41	12.55
Cohabiting (0/1)	0.73	0.44	0.71	0.45
Public sector (0/1)	0.36	0.48	0.19	0.40
Wage (DKK, 1990-prices)	111.10	42.17	134.91	56.79
# Employment spells	1.90	2.52	2.09	2.61
# Unemployment spells	1.39	2.75	1.53	2.98
# Non-employment spells	0.68	1.04	0.58	1.25
Employment (# weeks)	257.92	182.75	292.27	173.45
Temporary layoffs (# weeks)	5.26	19.21	4.39	14.25
Unemployment (# weeks)	26.98	57.29	24.29	52.59
Non-employment (#weeks)	80.26	124.26	46.29	94.12
N	9718		8961	

* Work experience accumulated before the individual is observed in the sample.

workers or retired and hence, the results may reflect that basically it is a residual category. This feature of the "out of the labour force" variable influences the results, since in some of the states, e.g. education and military service, human capital is accumulated resulting in expected positive earnings effects, whereas in states as parental leave and home work the earnings effect is expected to be purely negative.

The following descriptions of the data used for the estimations focus on the central variables of the study, namely wages and durations in the labour market states. In table 1, means and standard deviations of the most important variables used in the empirical analysis are presented. As it is seen, the sample includes 9718 women and 8961 men. Durations of time spent in the various states during the ten-year period are accumulated, and also the number of spells in each state is reported. The durations of ongoing spells observed on January 1st, 1981, and December 31st, 1990, suffer from censoring, since it is not possible to determine for how long a spell has been going on before 1981, and it is unknown for how long spells are continuing after the sampling period.

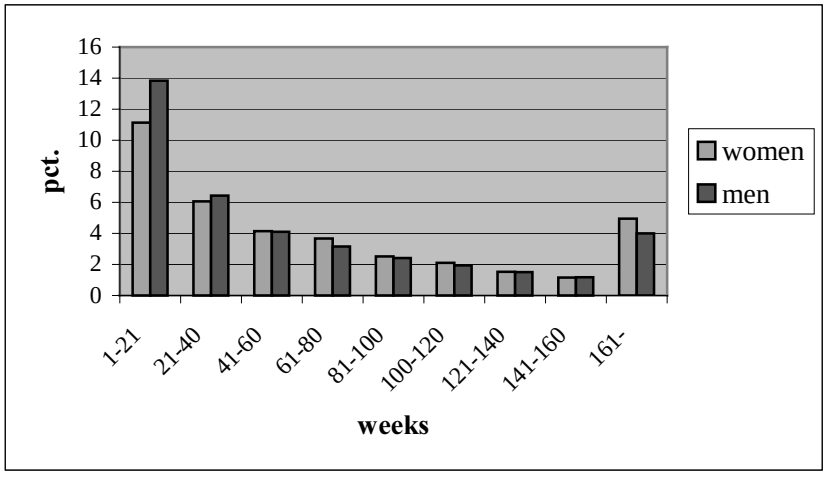
From the table it is seen that on average women earn around DKK 24 (1990 prices) less per hour than males. Women experience fewer spells of employment and unemployment than men do, but more spells out of the labour force. For the corresponding average durations, however, we see that women have been less employed but more unemployed than their male counterparts. Also the durations of time spent out of the labour force are longer for women than for men.

In the following section, the distributions of spells and unemployment durations across individuals are analysed. It is also investigated in a rather descriptive manner whether there seems to be any evidence of the hypothesis that individuals having career interruptions tend to have lower wages than the non-intermittent workers do. The magnitude of the aggregate loss from unemployment may depend on what causes the loss: incidence or duration of unemployment. Hence, it is useful to see how unemployment is distributed across the population.

Figure 2 presents the distribution of accumulated durations of time spent in unemployment in the observed period.[4] Around 62% of the sampled individuals have not experienced any unemployment at all during the ten-year period and slightly more women than men were not unemployed.[5] Around 14% of the men have experienced l-21 weeks of accumulated unemployment and no individuals have been unemployed for more than 350 weeks. The latter may reflect the attempts to activate the long-term unemployed.

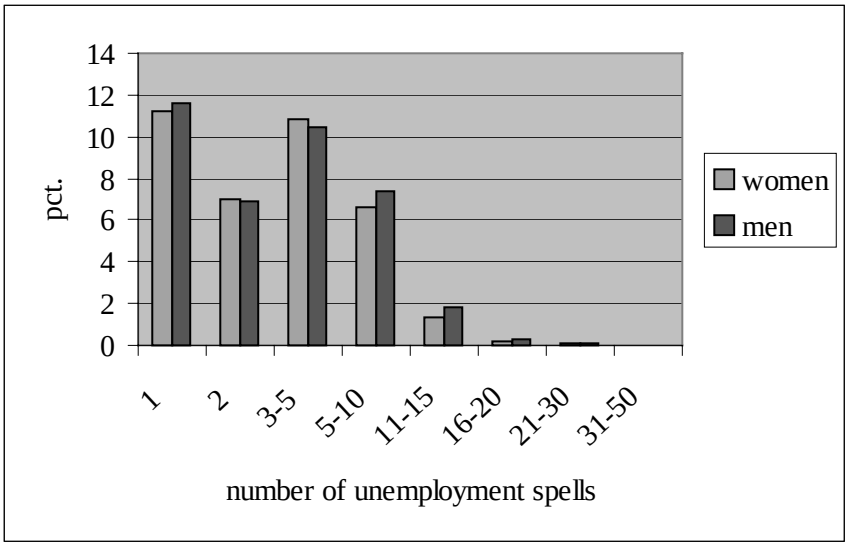
The distribution of the number of spells of unemployment experienced by the individual is shown in figure 3. As before, around 62% of the sample do not experience any unemployment at all, but actually around 20% of the individuals do have three unemployment spells or more. This fraction is rather high, meaning that if incidence of unemployment is the cause of a possible loss, then it may be a serious problem at the individual level. On the other hand, if duration determines the loss, the problem may not be so severe, since only around 10% of the individuals have been unemployed for more than two years out of nine.

Figure 2. Distribution of the duration of unemployment, years 1981-89.



[4] The sample was reduced for the construction of these figures, so that it only includes persons observed throughout the whole ten-year period.
[5] For illustrational purposes these individuals are left out in figure 2 and 3.

Figure 3. The distribution of number of unemployment spells, years 1981-89



In tables 2 and 3, mean hourly wages in the last observational year are shown by different observed durations in the various labour market states. It turns out that there seems to be a quite strong correlation between mean wages and durations of employment and unemployment. The longer durations of employment, the higher mean wages of the individuals, and for unemployment the opposite is the case. Both for women and men, this trend is present but one should note that the magnitude of the dispersion of the wage is much higher for men than it is for women. For durations out of the labour force, it is not so easy to see what the relationship might be and for the long durations, there are very few observations so one should be cautious when interpreting these results.

Table 2. Mean hourly wages in 1990 and accumulated durations in different states, women.

	Mean hourly wages		
Duration	Unemployment	Employment	Out of the labour force
0	116.17	105.70	114.67
1-50	108.96	92.80	118.99
51-100	108.82	104.46	104.60
101-150	106.42	100.27	109.80
151-200	102.90	104.25	106.37
201-250	98.30	105.89	107.00
251-300	98.97	107.47	117.86
301-350	94.65	107.72	133.80
351-400		115.19	109.30
401-450		113.36	98.79
451-500		120.86	157.72
N	9718	9718	9718

Table 3. Mean hourly wages in 1990 and accumulated durations in different states, men.

	Mean hourly wages		
Duration of spell	Unemployment	Employment	Out of the labour force
0	144.96	107.18	144.42
1-50	134.70	112.03	131.38
51-100	125.92	107.45	117.67
101-150	118.69	116.19	120.43
151-200	114.86	124.18	119.65
201-250	127.87	126.07	141.05
251-300	116.27	132.21	131.08
301-350	107.93	133.00	129.90
351-400		141.19	158.86
401-450		135.28	
451-500		157.15	116.58
N	8961	8961	8961

4 Estimation

The models estimated in the following section are linear regression models, where the hourly wage is modelled according to human capital theory. The models can be divided into two categories: First, simple linear cross-section selection models are estimated by use of cross-sectional data from the last observed year including summarised retrospective information on the working history. Second, we estimate panel data sample selection models on the basis of yearly observations where the panel feature of the data is exploited. The former makes it possible to estimate depreciation rates, and the latter produces estimates of the persistence of the unemployment effects. The panel data sample selection model of interest is the following:

$$y_{it}^{*} = x_{it}' \beta + \alpha_i + \varepsilon_{it}$$
$$d_{it}^{*} = w_{it}' \gamma + \eta_i + u_{it}$$
$$d_{it} = 1 \; if \; d_{it}^{*} > 0, 0 \; otherwise$$
$$y_{it} = y_{it}^{*} \cdot d_{it},$$

where i (i=1,...,N) denotes the individual and t (t=1,...,T) denotes the time period. The equation of interest (in this context the wage equation) is the first one and the selection process is the second one.

The dependent variable of the equation of interest, y_{it}, is the mean hourly wage of the individual during a year. It is transformed to ln(wage) as proposed in standard human capital theory. The dependent variable of the selection equation is simply an indicator of whether the dependent variable of the equation of interest, namely the wage, is observed in a given year. In the cross-sectional case, the incidental parameters are absorbed into the error term, and it is rather simple to take into account the sample selection process

by simultaneous maximum likelihood. This is how the cross-sectional models of this paper are estimated.

In the applied literature, various more or less suitable methods have been used for estimation of the panel data version of the sample selection model, and it is not obvious which of the suggested specifications to choose. In Jensen, Rosholm and Verner (2001), on the basis of Monte Carlo estimations, a comparison between various panel data estimators, for various data generating processes, is made.[6] The specification chosen for the panel part of the estimations in this paper is a parametric panel data random effects model where the two equations are estimated simultaneously by maximum likelihood. In this estimation procedure, unobserved heterogeneity is treated as random effects. For this purpose, it is necessary to specify the joint distribution of the random effects in the selection equation and the equation of interest.

The assumptions for the model are: The idiosyncratic error terms, each having zero mean, are assumed to follow a bivariate normal distribution

$$E[\varepsilon_{it}] = E[u_{it}] = 0$$
$$(\varepsilon_{it}, u_{it}) \sim N(0, \Sigma),$$

where

$$\Sigma = \begin{bmatrix} \sigma_\varepsilon^2 & \rho\sigma_\varepsilon \\ \rho\sigma_\varepsilon & 1 \end{bmatrix}$$

Furthermore, we make the following assumptions on the random effects and their interactions with the idiosyncratic errors:

$$E[\alpha_i] = E[\eta_i] = 0$$
$$E[\varepsilon_{it}\alpha_i] = E[u_{it}\eta_i] = 0$$

Thus, the individual-specific effects of the two equations may be correlated but are assumed to be uncorrelated with the idiosyncratic error terms.

The likelihood of a single observation, conditional on the random effects, is then

$$\begin{aligned} L_{it}(\gamma, \beta, \Sigma \mid \alpha_i, \eta_i) &= f(\varepsilon_{it}, u \mid \alpha_i, \eta_i) \\ &= \left[\int_{-w_{it}'\gamma-\eta_i}^{\infty} \phi_{\varepsilon u}\left(y_{it} - x_{it}'\beta - \alpha_i, u_{it}\right) du \right]^{d_{it}} \\ &\times \left[\int_{-\infty}^{-w_{it}'\gamma-\eta_i} \int_{-\infty}^{\infty} \phi_{\varepsilon u}(\varepsilon, u)\, d\varepsilon du \right]^{1-d_{it}} \\ &= \left[\left(1 - \Phi_{u|\varepsilon}\left(-w_{it}'\gamma - \eta_i \mid y_{it} - x_{it}'\beta - \alpha_i\right)\right) \cdot \phi_\varepsilon\left(y_{it} - x_{it}'\beta - \alpha_i\right) \right]^{d_{it}} \\ &\times \left[\Phi_u\left(-w_{it}'\gamma - \eta_i\right) \right]^{1-d_{it}}, \end{aligned}$$

[6] The results show that the computationally demanding simultaneous random effects models, including the Mundlak correction, perform quite well, whereas e.g. simple fixed effects models, in the case of time-varying selection effect, results in substantial bias of the estimates.

where the conditional distribution is

$$u \mid \varepsilon \sim N\left(\frac{\rho\varepsilon}{\sigma_\varepsilon}, (1-\rho^2)\right)$$

When a distribution of the random effects is specified, they can be integrated out of the likelihood function. If (α_{it}, η_i) is distributed according to G(.), the likelihood function is:

$$L_i(\psi) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left[\prod_{t=1}^{T_i} f\left(\varepsilon_{it}, u_{it} \mid \alpha_i, \eta_i\right)\right] dG(\alpha_i, \eta_i)$$

T_i is the number of observations for the individual. In the estimations of this paper, G(.) is specified as a bivariate discrete distribution with 2×2 points of support.

However, the random effects formulation can be criticised on the grounds that it neglects the correlation that may exist between the random effects and the explanatory variables. If this correlation is ignored, the estimates of the parameters of interest (here γ and β) are biased. Mundlak (1978) proposes a way to correct for this correlation. Basically, what he does in the linear model, is to approximate $E(\alpha_i|x_i)$ by a linear function and to include the individual means of the explanatory variables in the two equations. In the models of this paper, the individual means of the main variables of interest are included. A simple joint F-test of these correction terms then makes it possible to determine whether the correlation is actually present in the random effects model and hence, whether it makes a difference to make the Mundlak correction.

5 Results

5.1 Cross-section models

In this part of the analysis, the cross-sectional version of the sample is the basis of the estimations. In order to estimate the effects of interruptions for each of the observed interruption states (note, the employment state is used as the reference category), the following variables for the three kinds of interruptions are included in the cross-section models: An indicator for having observed any interruption of a given kind, the accumulated duration of the interruption, the duration squared and observed number of spells. Furthermore, as proposed in the human capital theory, other control variables are included in the regressions, though not reported here.[7]

[7] A potential problem in the application of this paper is that the experience of unemployment and other interruptions is endogeneous to the wage formation. This may be the case if the individual voluntarily chooses to stay outside the labour market because the wage to be obtained is below the reservation wage. In the Danish case, this may be a relevant issue due to incentive problems caused by the extensive coverage of the unemployment benefit system, especially for individuals belonging to the lower end of the wage distribution. One standard way to deal with potential endogeneity is to instrument the duration of the interruptions. In the models of this paper, modelling the selection process is of major interest and instrumentation of both the selection process and the interruptions is not possible due to lack of sufficient valid instruments.

Table 4. Results from the cross-sectional models, by sectors, women.

	All		Public sector		Private sector	
Variable	coef.	std. dev.	coef.	std. dev.	coef.	std. dev.
Dur. of unemployment >0 (0/1)	-0.013	0.011	0.003	0.015	-0.030	0.017
Dur. of unemployment (weeks)	**-0.001**	**0.000**	**-0.001**	**0.000**	0.000	0.000
Dur. of unemployment squared/1000	0.000	0.001	0.001	0.001	-0.001	0.002
Dur. of non-participation >0 (0/1)	0.021	0.019	0.003	0.028	0.040	0.027
Dur. of non-participation (weeks)	0.000	0.000	0.000	0.000	0.000	0.000
Dur. of non-participation squared/1000	0.000	0.001	0.000	0.001	0.001	0.001
Dur. of temporary layoffs >0 (0/1)	-0.001	0.011	-0.001	0.013	0.007	0.017
Dur. of temporary layoffs (weeks)	0.000	0.000	0.001	0.000	**-0.001**	**0.001**
Dur. of temporary layoffs squared/1000	0.001	0.002	-0.003	0.002	**0.009**	**0.004**
# unemployment spells	0.012	0.007	0.003	0.009	**0.021**	**0.009**
# non-employment spells	-0.010	0.008	0.015	0.011	**-0.029**	**0.011**
# employment spells	-0.007	0.006	0.001	0.009	-0.014	0.009
log likelihood	-6091.61		-462.13		-4579.25	

Note: Bold letters indicate significance at a 5% level.

In table 4, the estimation results of the cross-section models for women are presented.[8] In the first column, the cross-section model for all women shows that the estimated immediate effects from having experienced unemployment (the indicator variable) are negative but insignificant, whereas the duration variable is significantly negative. Since the coefficient to the squared duration of unemployment term appears to be insignificant, the conclusion is that the depreciation rate is constant and negative. In relation to this, it is remarkable that having experienced temporary layoffs does not reduce earnings. This difference may be due to the fact that in contrast to "real" unemployment, the individual does not loose firm-specific human capital during spells of temporary unemployment. Actually, no evidence of losses is found at all in the case of temporary layoffs. In this simple model, no other interruption term comes out significantly different from zero.

To test the hypothesis of the bargaining model, the estimations have been made for the public- and private-sector employees separately, and the results are shown in the second and third columns of table 4.[9] As in the case of all women, the coefficients of the interruption variables show that the only significant effect in the model for the public sector is the effect of the duration of unemployment, namely the depreciation rate which is estimated to be significantly negative and around 0.1%. For private-sector employees,

[8] In the cross-section models, the unreported control variables are: Age, education, province-indicator, accumulated experience before the sampling period, public-sector indicator, occupational indicators, ongoing education indicator and yearly indicators.

[9] When the models are estimated for the two sectors seperately, individuals are assigned to a given sector according to the employment status in the year of which the wage is measured. The result of this procedure is that, in the panel version of the model, the same individuals can be present in both the public-sector and the private-sector sample in different years. Mobility between sectors is not modelled explicitly, and this may be a problem if there are systematic differences in the mobility patterns, depending on expected wages. Pedersen *et al.* (1988), for the years 1977-85, find only weak evidence of wage gains from mobility between sectors for the case of Danish men, and for Danish women no mobility gains are encountered at all.

there is no significant effect of unemployment. Concerning the temporary layoffs, it is seen that the private-sector employees loose from these layoffs (since the minimum of the parabolic form is at 55 weeks). The prediction from the theoretical bargaining model is that interruptions will have smaller impact on the earnings profile in the public sector than in the private sector. However, the results of these models show that, in the case of unemployment, the opposite is the case. Furthermore, in the private-sector models, the number of observed unemployment spells has a positive effect, whereas the number of observed non-employment spells has a negative effect. This may support the hypothesis of Manning (1998), saying that individuals search for better paid jobs during unemployment and hence "climb the ladder". On the other hand, the sign of the number of non-participation spells variable is negative. One interpretation of this is that non-participation spells serve as signalling device of less committed labour. These effects are not present in the public sector.

An alternative hypothesis is that interruptions affect differently aged people in different manners. This may especially be the case for women, because women in their childbearing years are expected to leave their job or even the labour market for shorter or longer periods. Therefore, the model is estimated for two subsamples consisting of women of different ages.

For the unemployment variables of table 5, the only case of a significant effect is for the age group of 40-54. In that case, a negative, declining depreciation rate reaching zero at167 weeks is estimated. The conclusion from this table is that again we see very few

Table 5. Results from the cross sectional models, by age intervals, women.

	Age			
	25-39		40-54	
Variable	coef.	std. dev.	coef.	std. dev.
Dur. of unemployment >0 (0/1)	-0.026	0.016	0.016	0.019
Dur. of unemployment (weeks)	0.000	0.000	**-0.001**	**0.000**
Dur. of unemployment squared/1000	0.000	0.001	**0.003**	**0.001**
Dur. of non-participation >0 (0/1)	0.028	0.026	0.000	0.045
Dur. of non-participation (weeks)	-0.001	0.000	-0.001	0.000
Dur. of non-participation squared/1000	0.001	0.001	0.000	0.000
Dur. of temporary layoffs >0 (0/1)	0.023	0.014	-0.008	0.016
Dur. of temporary layoffs (weeks)	-0.001	0.001	0.000	0.000
Dur. of temporary layoffs squared/1000	0.008	0.004	0.000	0.000
# unemployment spells	0.003	0.009	0.010	0.015
# non-employment spells	-0.003	0.010	-0.004	0.026
# employment spells	0.000	0.009	-0.006	0.014
log likelihood	-1612.07		-1299.44	

Note: Bold letters indicate significance at a 5% level.

significant effects from interruptions for women and especially, it is interesting that *none* of the interruption variables is significant for the women of 25-39 years of age. The explanation for this result may simply be that the interruptive behaviour of women

belonging to this age interval is expected and already incorporated in the earnings profile.[10]

Table 6 presents estimation results for men. The results for all men show that the incidence of unemployment, as measured by the indicator variable, decreases the earnings by 3%. Furthermore, there is a linear negative effect of the duration of unemployment, which can be interpreted as a depreciation rate of 0.1%. The immediate effect of unemployment is not present in the case of temporary layoffs but the duration of temporary layoffs has a negative effect on earnings. The variables for number of spells show that increasing the number of unemployment spells increases earnings significantly confirming the hypothesis from the search framework, that eventually job search during multiple spells of unemployment can increase wages (or at least offset some of the depreciation effect).

In both models estimated for the public- and private-sector male employees separately, there is a negative unemployment depreciation rate of 0.1% but only in the private sector there is an immediate negative effect of unemployment of 3.1%. Furthermore, there is a negative effect for private-sector employees of 6.5% of having experienced any non-participation spells. There are no significant effects of temporary layoffs and this is a strong indication of substantial losses of firm-specific human capital in the case of no return to the former employer. The interpretation of these results is that for men in the private sector, a lot of job-specific human capital is lost when the man becomes unemployed or leaves work for some other reason. Another explanation of this loss

Table 6. Results from the cross-sectional models, by sectors, men.

	All		Public sector		Private sector	
Variable	coef.	std. dev.	coef.	std. dev.	coef.	std. dev.
Dur. of unemployment >0 (0/1)	**-0.030**	**0.011**	-0.038	0.021	**-0.031**	**0.013**
Dur. of unemployment (weeks)	**-0.001**	**0.000**	**-0.001**	**0.000**	**-0.001**	**0.000**
Dur. of unemployment squared/1000	0.002	0.001	0.003	0.001	0.002	0.001
Dur. of non-participation >0 (0/1)	**-0.050**	**0.023**	-0.008	0.040	**-0.065**	**0.028**
Dur. of non-participation (weeks)	0.000	0.000	0.000	0.001	0.000	0.000
Dur. of non-participation squared/1000	-0.001	0.001	-0.001	0.001	-0.002	0.001
Dur. of temporary layoffs >0 (0/1)	0.001	0.011	0.003	0.022	-0.001	0.013
Dur. of temporary layoffs (weeks)	**-0.001**	**0.001**	-0.001	0.001	-0.001	0.001
Dur. of temporary layoffs squared/1000	**0.013**	**0.006**	0.012	0.009	0.013	0.007
# unemployment spells	**0.031**	**0.007**	**0.034**	**0.012**	**0.028**	**0.008**
# non-employment spells	**-0.015**	**0.008**	-0.012	0.014	-0.015	0.010
# employment spells	**-0.017**	**0.007**	**-0.029**	**0.012**	-0.011	0.008
log likelihood	-5162.18		-122.72		-4660.31	

Note: Bold letters indicate significance at a 5% level.

(which is not present for women!) can be that previous unemployment and especially non-participation is a signal of bad labour and hence, these individuals are less well paid.

[10] Estimation of models for different age intervals of males does not show any systematic differences across ages.

5.2 Panel data models

This section presents the results of the estimated sample selection random effects models. In the wage equation, indicators for the incidence of the various interruption types for the past five years are included. Hence, it is possible to determine whether there are any effects in the longer run of having experienced any interruptions or whether the effects, if any, are rather short-term effects. The tables only report the results of the interruption variables in the wage equation and in the lower part of the tables, ρ, the correlation of the idiosyncratic error terms of the two equations, is included.[11]

The results for models estimated for all women in column 1 of table 7 shows that the effects of the unemployment indicators are significant for all 5 included lags, but one. There is a slight decline in the magnitude of the coefficients of the three first lag variables, indicating that there is a tendency towards catching up the lost earnings in the

Table 7. Results for random effects models, by sectors, women.

	All		Public sector		Private sector	
Variable	coef.	std. dev.	coef.	std. dev.	coef.	std. dev.
Unemployment(t-1) (0/1)	**-0.022**	**0.006**	**-0.023**	**0.008**	**-0.027**	**0.009**
Unemployment(t-2) (0/1)	**-0.020**	**0.006**	-0.014	0.008	**-0.022**	**0.008**
Unemployment(t-3) (0/1)	**-0.012**	**0.006**	**-0.021**	**0.008**	0.000	0.008
Unemployment(t-4) (0/1)	-0.008	0.006	**-0.025**	**0.008**	0.010	0.008
Unemployment(t-5) (0/1)	**-0.016**	**0.006**	**-0.019**	**0.008**	-0.004	0.008
Non-participation(t-1) (0/1)	**0.021**	**0.009**	**0.035**	**0.014**	0.010	0.013
Non-participation(t-2) (0/1)	-0.010	0.009	-0.012	0.012	-0.019	0.013
Non-participation(t-3) (0/1)	**-0.031**	**0.006**	**-0.033**	**0.011**	**-0.024**	**0.011**
Non-participation(t-4) (0/1)	**-0.024**	**0.006**	**-0.024**	**0.010**	**-0.027**	**0.010**
Non-participation(t-5) (0/1)	**-0.017**	**0.006**	**-0.021**	**0.008**	-0.007	0.009
Temporary layoff(t-1) (0/1)	**0.020**	**0.005**	**0.040**	**0.007**	0.004	0.008
Temporary layoff(t-2) (0/1)	0.007	0.006	0.003	0.007	0.010	0.008
Temporary layoff(t-3) (0/1)	0.004	0.006	0.000	0.007	0.005	0.008
Temporary layoff(t-4) (0/1)	-0.004	0.006	-0.005	0.008	-0.003	0.008
Temporary layoff(t-5) (0/1)	0.003	0.006	0.002	0.007	0.005	0.008
σ_ε	**0.049**	**0.000**	**0.041**	**0.001**	**0.054**	**0.001**
ρ	**-0.139**	**0.022**	0.071	0.112	**-0.227**	**0.029**
log likelihood	-13038.445		320.786		-9923.065	

Note: Bold letters indicate significance at a 5% level.

long run. The effect of shortest lag of the temporary layoffs is positive and for the longer lags, we see no significant effects. This indicates that in contrast to individuals that are recalled, the unemployed returning to new employers suffer significant losses of job-specific human capital. Columns 2 and 3 show estimation results for women employed in the public and private sector, respectively. The results for unemployment

[11] In the panel models, the unreported control variables are: Age, education, province indicator, accumulated experience before the sampling period, public-sector indicator, occupational indicators, ongoing education indicator and yearly indicators. Furthermore, individual means of the interruption variables are included (Mundlak correction).

confirm and make it clear what is going on in the cross-sectional models. In the public sector, four out of five coefficients are significantly negative, whereas in the private sector only the first two lags come out significantly negative indicating that catching up losses from unemployment is easier in the private sector than in the public sector. As in the cross-sectional models, there is no loss from temporary layoffs and actually, there are positive effects from the first lag in the public sector. Hence, the loss of firm-specific human capital is non-negligible both for public- and private-sector female employees. The profile of the non-participation variables is peculiar, since only the longest lags are significantly negative indicating that long-run effects are present.

When we turn to the results for all males in column 1 of table 8, we see that the first three lags of the unemployment indicators are negative and significantly different from zero and approach zero with the lag length. This indicates that there are losses from unemployment in the short run, but that they fade away after three years. Temporary layoff has no negative impact on wages, which confirms that also in this case, firm-specific human capital depreciation takes place. The results of the models estimated for the public- and private-sector males separately show that in the public sector only one of the unemployment indicators is significant, whereas the private-sector results show that during the three subsequent years after unemployment there is a diminishing negative

Table 8. Results for random effects models, by sector, men.

	All		Public sector		Private sector	
Variable	coef.	std. dev.	coef.	std. dev.	coef.	std. dev.
Unemployment(t-1) (0/1)	**-0.026**	**0.005**	-0.020	0.012	**-0.029**	**0.006**
Unemployment(t-2) (0/1)	**-0.015**	**0.005**	**-0.025**	**0.012**	**-0.012**	**0.006**
Unemployment(t-3) (0/1)	**-0.013**	**0.005**	-0.016	0.012	**-0.012**	**0.006**
Unemployment(t-4) (0/1)	-0.006	0.005	-0.004	0.012	-0.007	0.006
Unemployment(t-5) (0/1)	0.001	0.005	0.005	0.011	0.002	0.006
Non-participation(t-1) (0/1)	0.008	0.009	0.027	0.018	-0.003	0.013
Non-participation(t-2) (0/1)	**-0.026**	**0.007**	-0.006	0.017	**-0.042**	**0.012**
Non-participation(t-3) (0/1)	**-0.027**	**0.008**	**-0.061**	**0.015**	-0.016	0.011
Non-participation(t-4) (0/1)	**-0.019**	**0.008**	0.011	0.013	**-0.031**	**0.010**
Non-participation(t-5) (0/1)	**-0.062**	**0.007**	-0.014	0.011	**-0.080**	**0.008**
Temporary layoff(t-1) (0/1)	**0.015**	**0.005**	0.015	0.012	**0.015**	**0.006**
Temporary layoff(t-2) (0/1)	-0.005	0.005	**-0.027**	**0.012**	0.000	0.006
Temporary layoff(t-3) (0/1)	-0.003	0.005	-0.019	0.011	-0.001	0.006
Temporary layoff(t-4) (0/1)	-0.003	0.005	-0.010	0.011	-0.001	0.006
Temporary layoff(t-5) (0/1)	-0.002	0.005	**-0.023**	**0.010**	0.000	0.006
σ_ε	**0.044**	**0.000**	**0.033**	**0.001**	**0.046**	**0.000**
ρ	**-0.095**	**0.027**	-0.006	0.074	**-0.125**	**0.029**
log likelihood	-9861.732		148.430		-9273.381	

Note: Bold letters indicate significance at a 5% level.

effect. It is somewhat surprising to see that in the public sector, the effects during temporary layoffs correspond to the pattern of unemployment effects, whereas there is no negative effect from temporary layoffs in the private sector. In the case of non-participation, the tendency is the same, namely that the effects in the public sector are moderate whereas there seems to be a "longer memory" in the private sector.

5.3 Summary of the results

The results of the estimations presented in the last two sections can be summarised in the following way: With respect to the hypothesis posed on the basis of Rosen's model that publicly employed workers face smaller losses from interruptions than the privately employed, the results of this paper do not confirm this prior. In contrast to women in the private sector, the human capital of publicly employed women depreciates during unemployment, and these effects appear to be present in the long run. In the case of men, depreciation takes place both in the public and private sectors and these effects are mainly short-run effects, indicating that men are more able to catch up with the non-intermittent earnings profile. When negative effects from unemployment are present, the general picture is that a substantial part of this loss of the earnings potential is due to a loss of firm-specific human capital, which is not present when the employee returns to the former employer after unemployment. Furthermore, it is remarkable that only the males in the private sector face an immediate effect from the incidence of unemployment in addition to the linear depreciation, which indicates that losses of firm-specific human capital are most pronounced for this group of individuals. Part of the reason for this may also be that private employers use unemployment as a signalling device in the case of males. However, a high number of (short) unemployment spells may partly counteract these effects for women in the private sector and men in both sectors as explained from search theory.

Concerning the non-participation variables, the general result is that all individuals face losses from non-participation, especially in the long run. As in the case of unemployment, it is remarkable that only for males in the private sector, a negative effect of the incidence is found. Again, this may be explained partly by loss of firm-specific human capital and partly by the signalling hypothesis.

6 Conclusion.

In this paper, the wage effects of labour market career interruptions have been analysed with a special focus on the unemployment effects. In the section of theoretical considerations, four complementary predictions of the consequences of unemployment on earnings were given, namely the human capital theory, the signalling framework, the search model and the bargaining model.

In the empirical section, the Danish case has been studied by the use of Danish register-based information covering the period 1981-90. It is possible to distinguish the following states: Employment, unemployment, non-participation and temporary layoffs and hence the losses of general versus specific human capital. The earnings models estimated in the paper have been twofold: The relatively simple sample selection cross-sectional models, with cumulative measures of the work histories included as explanatory variables, and panel data sample selection models.

The empirical analysis shows evidence of linear depreciation for both men and women both in the public and private sector, of which a considerable part is attributed to the loss of job-specific human capital. Furthermore, in the case of men, the experience of unemployment produces additional immediate negative effects. This is interpreted as a

combination of depreciation of firm-specific human capital and the use of unemployment as a signalling device. The dynamic analysis shows that in the years following the unemployment spell, effects are still present though declining, indicating that in the long run there is a possibility of catching up what has been lost. The sector-specific evidence shows that this period of catching up is longer in the public sector than in the private sector. Regarding non-participation spells there is also quite clear evidence that earnings are reduced when the individuals have left the labour market for a period and especially for men, this effect seems to be long lasting.

References

Albrecht, J. W., Edin, P., Sundström, M., & Vroman, S. B. (1999): Career Interruptions and Subsequent Earning: A Reexamination Using Swedish Data, *The Journal of Human Resources*, 34, 294-311.

Becker, G. S. (1975): *Human Capital*, University of Chicago Press for the National Bureau of Economic Research.

Cox, D. (1984): Panel Estimates of the Effects of Career Interruptions on the Earnings of Women, *Economic Inquiry*, 22, 386-403.

Groot, W. & Ours, J.V. (1993): Career Interruptions and the Depreciation of Human Capital, *Unpublished paper*.

Jensen, A. M. & Verner, M. (1996): Dagpengenes betydning for omfanget af arbejdsløshed i Danmark, (In Danish, The Effect of UI-benefits on Unemployment in Denmark), *Nationaløkonomisk Tidsskrift*, 134, 238-256.

Jensen, P., Rosholm, M. & Verner, M. (2001): A comparison of different estimators for panel data sample selection models, *Unpublished paper*.

Kim, M.K. & Polachek, S. (1994): Panel Estimates of Male-Female Earnings Functions, *The Journal of Human Resources*, 29, 406-428.

Manning, A. (1998): Movin' on up: Interpreting the Earnings-Experience Profile, Centre of Economic Performance, London School of Economics, *Discussion paper* 380.

Meyer, B. D. (1990): Unemployment Insurance and Unemployment Spells, *Econometrica*, 58, 757-782.

Mincer, J. & Polachek, S. (1974): Family Investments in Human Capital: Earnings of Women, *Journal of Political Economy*, S76-S108.

Mincer, J. & Ofek, H. (1982): Interrupted Work Careers: Depreciation and Restoration of Human Capital, *The Journal of Human Resources*, 17, 3-24.

Mundlak, Y., 1978. On the Pooling of Time Series and Cross-Sectional Data. *Econometrica*, 46, 69-86.

Narendranathan, W. & Stewart, M.B. (1993): How Does the Benefit Effect Vary as Unemployment Spells Lengthen? *Journal of Applied Econometrics*, 8, 361-381.

Pedersen, P.J., J.B. Schmidt-Soerensen, N. Smith & N. Westergaard-Nielsen (1988): Wage Differentials Between the Public and Private Sector, Studies in Labour Market Dynamics, *Working Paper 88-5*, Aarhus School of Business.

Rosen, Å. (1989): Bargaining Over Effort, Centre for Labour Economics, London School of Economics, *Discussion paper* 351.

Rosholm, M. & N. Smith (1996): The Danish Gender Wage Gap in the 1980s: A Panel Data Study, *Oxford Economic Papers*, 48, 254-279.

Sandell, S. H. & Shapiro, D. (1978): The Theory of Human Capital and the Earnings of Women, *The Journal of Human Resources*, 13, 103-117.

Weiss, A. (1995): Human Capital vs. Signalling Explanations of Wages, *Journal of Economic Perspectives*, 9, 133-154.