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Wage Mobility in Denmark 1980-1990

by

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Determinants of

Wage Mobility in Denmark 1980-1990

1. Introduction

This paper identifies some of the determinants of individual mobility in the wage distribution over time. It is a well proven on the basis of Human Capital theory that individual wage rates increase with experience. The main reason is that people tend to learn by doing, or because they invest in on-the-job training activities. Accordingly, it should be expected that job creation at the lower end of the wage distribution not only produces "bad" (low wage) jobs but makes low rungs on the wage ladder from where most people move upward in the distribution of wage rates relatively quickly.

However, it is not straight forward to see this. Studies of the Danish wage distribution in the 1980's have shown that the distribution of wage rates only changed slightly over this period. The Gini coefficient changed from 0.16 to 0.17 indicating a slightly increased wage dispersion (Asplund et al 1994). The wage differential has grown substantially in some OECD countries, while the growth has been low or negligible in others (OECD, 1993). The UK, US and Sweden are among these countries, whereas Denmark, Finland and Norway are among the 5 countries with little or no growth in wage dispersion. However, the seemingly constant wage distribution in Denmark masks a very high individual wage mobility where less than 20% remain in the lowest deciles of the distribution for more than 4 years.

Part of this mobility is found to be related to normal life cycle mobility where individuals start at some point and move upward until the end of their career. Another part is related to factors that individuals themselves (or policy makers) can influence, including attachment to the labour market, child care, type of work etc. This paper shows that general Human Capital such as education and experience are important determinants of where people are observed in the wage distribution. Upward wage mobility is found to be associated with less unemployment, less experience and the absense of changes in occupation and industry.

These findings have a clear consequence for policies concerning minimum wage setting and job creation schemes. The traditional concern is related to a static perception of those at the low end of the wage distribution and neglects the fact that many actually move upward in the wage distribution if they get started on a work career. We find that people move rather quickly away from the lowest deciles. Thus policy concern should focus on the processes that increase wage mobility. Since a minimum wage limits the number of low wage jobs it is also a constraint on the amount of low paid work that could serve as entry points for the low skilled and low experienced. This exclusion may prevent them from taking part in the general upward wage mobility.

Other studies

Most of the literature on individual income mobility is quite old. Atkinson, Bourguignon and Morrisson (1992) is a very good recent survey. In our discussion we shall select a number of articles to illustrate some of the different approaches which have been used.

Elementary statistical techniques which produce indices of mobility such as rank correlation can be used to evaluate changes in relative positions. This literature will not be discussed. The majority of the literature uses measures of mobility which result from various stochastic specifications of changes in earnings or wages over time.

McCall (1971) estimates a first order Markov model for poverty transitions. Hart (1976) considers a simple Galton-Markov model of regression towards the mean. Schiller (1978) describes a ventile transition matrix. Shorrocks (1978) proposes a mobility index for transition matrics based on the convergence speed of a Markov chain. MaCurdy (1982) estimates a complex autoregressive moving average structure by quasi-maximum likelihood. These are all purely statistical models.

In a number of contributions Lillard (1977), Lillard & Willis (1978), Lillard & Weiss (1979), models are introduced that include some economic structure. An "autocorrelated individual components model" is estimated. This is essentially a variance components model i.e. one with individual random effects, and a first order autoregressive process is included. The estimation framework is GLS.

To show that this literature is not dead, it is important to mention some more recent studies. Gregory & Elias (1993) use UK New Earnings Survey data to estimate the probability of leaving the lowest earnings quintile. Smith and Vavrichek (1992) use US Survey of Income Program and Participation data to estimate poverty transitions.

There are important points to note regarding all these studies. Initial conditions beginning the mobility process are ignored which may lead to possible endogeneity bias. Also the potential sample selection biases associate with panel attrition are ignored.

A relatively small number of recent papers have dealt with individual wage mobility. Elias and Gregory, 1994, estimate transitions of low paid workers in the UK using longitudinal data from the New Earnings Survey covering the period 1976-91. A linear function for the probability moving upward in the wage distribution is estimated by OLS.

Smith and Vavrichek (1992), use longitudinal data from the Survey of Income and Program Participation (USA) to estimate the earnings mobility of workers employed at the minimum wage subsequent to a change in the legal minimum. They find that more than 60% of workers who were at the minimum wage in the mid-1980s were earning higher than minimum wages one year later. Those staying behind tend to have very low levels of education. Two models are estimated. A discrete response model estimated with a logit and a model for the absolute wage increase estimated by a tobit. The models only allow for increases from the minimum wage because it is impossible to fall below this threshold. However, this raises a problem with those who become unemployed or leave the labour force just because they could not obtain the minimum wage. Another problem seems to be that a number of people are "strangers" in the low pay area. For example, the existence of a very high transition rate among high school graduates could be due to those taking a temporary job close to the minimum wage even though could normally expect to employment at a higher wage rate. The lack of unemployment compensation induces them to take these jobs contrary to the case in Europe, where unemployment compensation is higher. Lack of a benefit system with long entitlement durations will undoubtedly mean that mobility is higher, because more people will be forced to take low paid jobs. This is not the case in more generous systems. The present study differs in several respects: First, it addresses the attrition problem together with the problem of temporary placements; second, it deals with upward and downward mobility from all deciles (except for the lowest and highest deciles); third, it uses a relative wage concept, decile-position.

Two other studies deal with reasons for the increased wage dispersion in the 1980s. One of the reasons for the increased wage dispersion in the US is that the wage levels in the lower deciles are falling (Juhn, Murphy and Pierce (1993)). Gosling, Machin and Meghir (1993) find that the UK development is much less dramatic with zero growth at the bottom because - they argue - the UK benefit system effectively bounds hourly wages from below. Instead of moving down as a US worker may do, a UK worker may move to the benefit system. This idea is supported by an overall fall in male participation in the UK and by the result that "there are no experience effects on wages except at the top of the distribution". Gosling, Machin and Meghir (1993) use a set of nine quantiles to estimate the distribution, much like this study.

The present study also uses deciles as the wage concept. The estimation method takes account of the fact that we only observe mobility for those who have a wage in both periods. Similarly, we are dealing with the fact that different people start in different deciles depending on their background. None of the above papers cover both types of selectivity. The probability of moving upward, staying or moving downward is estimated simultaneously with the probabilities of having a wage in both periods and belonging to a specific origin decile.

Organisation of the paper is as follows. A data description is presented in the next section along with a summary of movements over the wage distribution, while the econometric model of wage mobility is outlined in the third section. The results of estimating this model are presented in section four, and further illustrated by a number of simulations in section five. Section seven draws conclusions.

2. Data

The data originate from a longitudinal database which makes it possible to rank individuals according to wage level and to follow the same individual for a number of years. Furthermore, it is possible to identify some of the factors which determine wage mobility. In this section the database and its variables are described and some descriptive statistics presented.

2.1. Sample Design

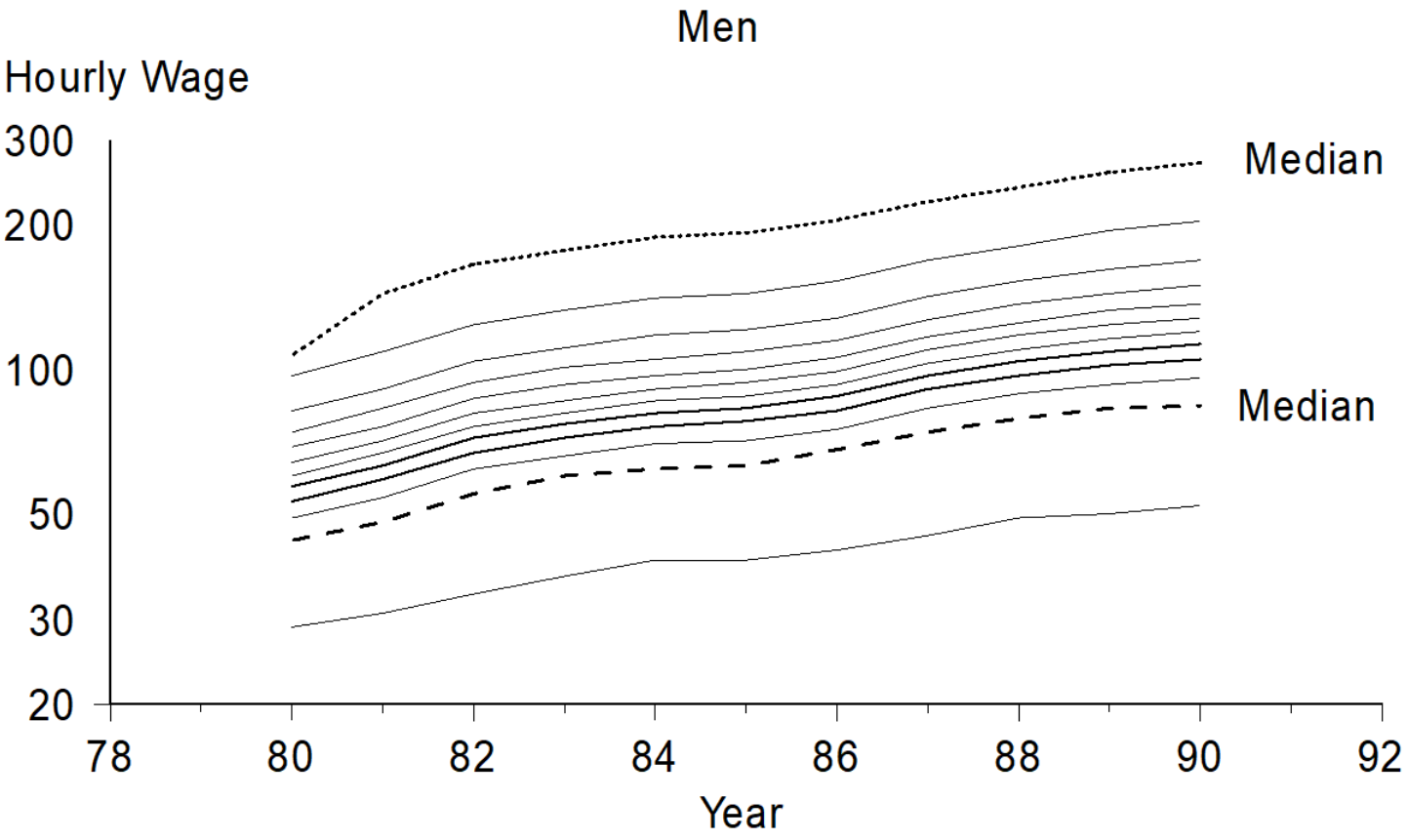
This application uses the Danish Longitudinal Database which contains register data for the years 1976-1990. (For a description, see Westergård-Nielsen, 1984). The present study uses a representative 1% sample of the Danish population for each year from 1980 to 90. Prior to this period information is incomplete for present purposes.

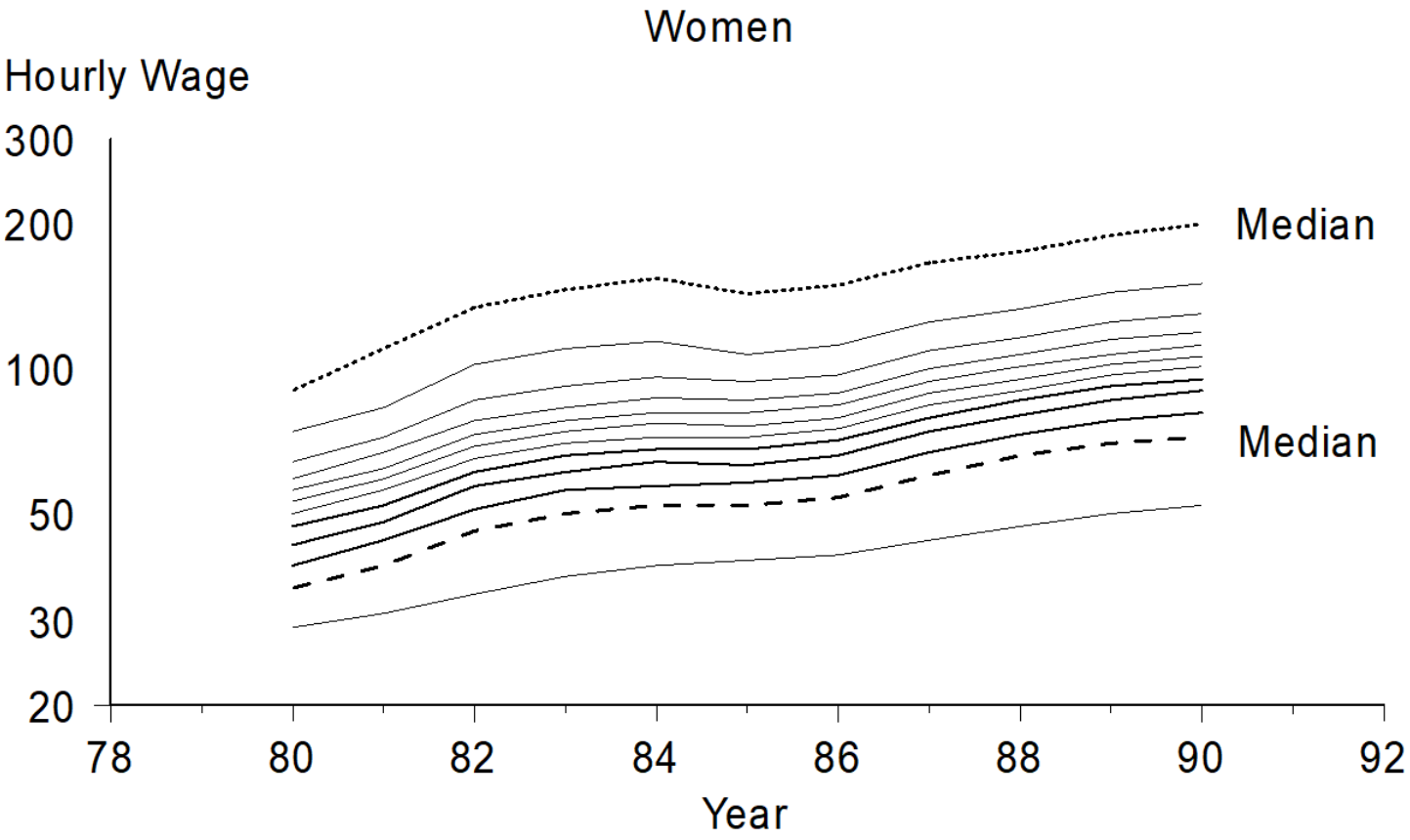
Originating from administrative registers, the dataset contains information on earned income, highest educational qualification obtained, occupation, industry, actual labour market work experience, employment and unemployment history. An hourly wage rate is constructed using annual earned income from tax records (thus including overtime pay, vacation pay etc., but obviously excluding undeclared income) divided by the number of hours worked during the year. The sub-sample used for analysis includes individuals aged 18 to 59 years for whom we can expect to observe a valid wage rate. This means that we are excluding all self-employed, long-term unemployed, pensioners and students. If a person changes status from wage earner to one of these groups we treat the observation as censored for the purposes of wage mobility. Similarly, if a person moves from a status without a salary into one with a salary. Development of the lowest wage in each decile is shown for men and women from 1980 to 1990 in Figure 1. The lowest wage of the lowest decile is determined by the algorithm for the calculation of wage rates as the minimum wage in labour contracts minus

20%. Since this is an "administered minimum" it has been substituted by the median wage for that decile. Likewise, decile ten which is censored by Danish Statistics for confidentiality.

The log wage curves are seen to be almost parallel supporting the initial notion that the distribution has not changed much over the investigated period. The differences between men and women can be seen very clearly, and even though "equal pay for equal jobs" has been law in the Danish labour market for more than 20 years, this has not removed all the differences in remuneration. There are still large differences in the hourly wage rate due to for example educational and occupational differences. (See Smith, 1992).

Figure 1. Minimum hourly wage per decile (log scale) by year for men and women. Medians are indicated for the highest and lowest deciles.





2.2. Decile Descriptives

We are interested in describing relative "performance" over the period 1980-90. The basic wage concept is that of decile. Mobility in this framework is defined as the direction of movement from one decile at time t to another decile at time t+n. This method has several advantages:

First, being an ordered statistic it is robust to outliers. This is important generally when considering hourly wages constructed from earnings over hours because hours are prone to measurement error. In our application this is crucial. For policy purposes those at the bottom of the wage distribution are of greatest interest, and it is obviously at the extremes of the distribution that outliers are grouped. Second, decile grouping uses a degree of precision appropriate to the whole data source. Constructed wages may be grouped in much smaller intervals, but hours are observed weekly or monthly as one of four possible discrete realisations. Temporary and part-time workers receive the lowest wages and measurement error in hours is most likely to occur for these individuals. The imprecise calculated wage for this sample motivates our broad grouping. Third, there will be a large proportion of measurement errors among those (outliers) transiting many deciles in a single period. The weight attached to these observations is greatly reduced when we consider only direction of mobility.

A criticism of the approach whereby the data is discretised is that a small "push" may be sufficient to contribute to the mobility. However, investigation of the distribution of transitions originating around the decile thresholds shows only limited grouping when we consider moves during a single year. No grouping whatsoever is apparent when looking at mobility measured over a 4 year period.

Deciles have been constructed using the rank routine from SAS. Due to the fact that there will always be a number of individuals with the same wage rate, the number of observations belonging to each decile may differ. Men and women were ranked separately as the wage and employment distributions differ between the sexes. If both genders had been included in the same ranking women would have "dominated" the lower end of the distribution.

Descriptive statistics in Table 1 show a positive correlation between a high wage decile and education, age and experience. A number of interesting points may be noted. Firstly, the difference in average age between female low wage earners and high wage earners is just over three years while the difference for men is eight years. This might indicate that it is more likely for men to start their labour market career from one of the bottom deciles and retire at the top. Secondly, men have a higher average employment experience than women due to late entrance into the labour force for many older women and a higher incidence of part-time work among all women. This can also explain some of the difference in the gender composition of different deciles if the sexes were grouped and ranked together. Thirdly, the average length of education for men and women increases neatly with decile, more so for men. Finally, individuals who for various reasons have no registered wage are on average older than the average for the sample. This can be explained by a high average age for the self-employed or those in receipt of various pensions.

Table 1. Mean of selected characteristics by decile.

	Women			Men		
Deciles	Age	Education	Experience	Age	Education	Experience
1.00	36.34	10.10	9.42	33.44	10.24	12.18
2.00	36.71	10.20	10.23	36.33	10.15	15.38
3.00	36.57	10.27	10.31	36.97	10.44	16.00
4.00	36.39	10.34	10.55	37.28	10.65	16.22
5.00	36.66	10.65	11.02	37.83	10.84	16.53
6.00	37.25	10.96	11.49	38.40	11.10	16.88
7.00	37.58	11.33	11.90	38.88	11.37	17.10
8.00	38.60	11.62	12.46	39.32	11.86	17.16
9.00	39.63	11.86	13.04	40.41	12.69	17.54
10.00	39.74	12.18	11.75	41.68	13.43	17.89
No wage	41.10	9.38	6.90	39.70	10.07	10.96
Sum	38.77	10.41	9.88	38.52	10.93	14.88

Figure 2. The "minimum wage" and the lowest deciles for men.

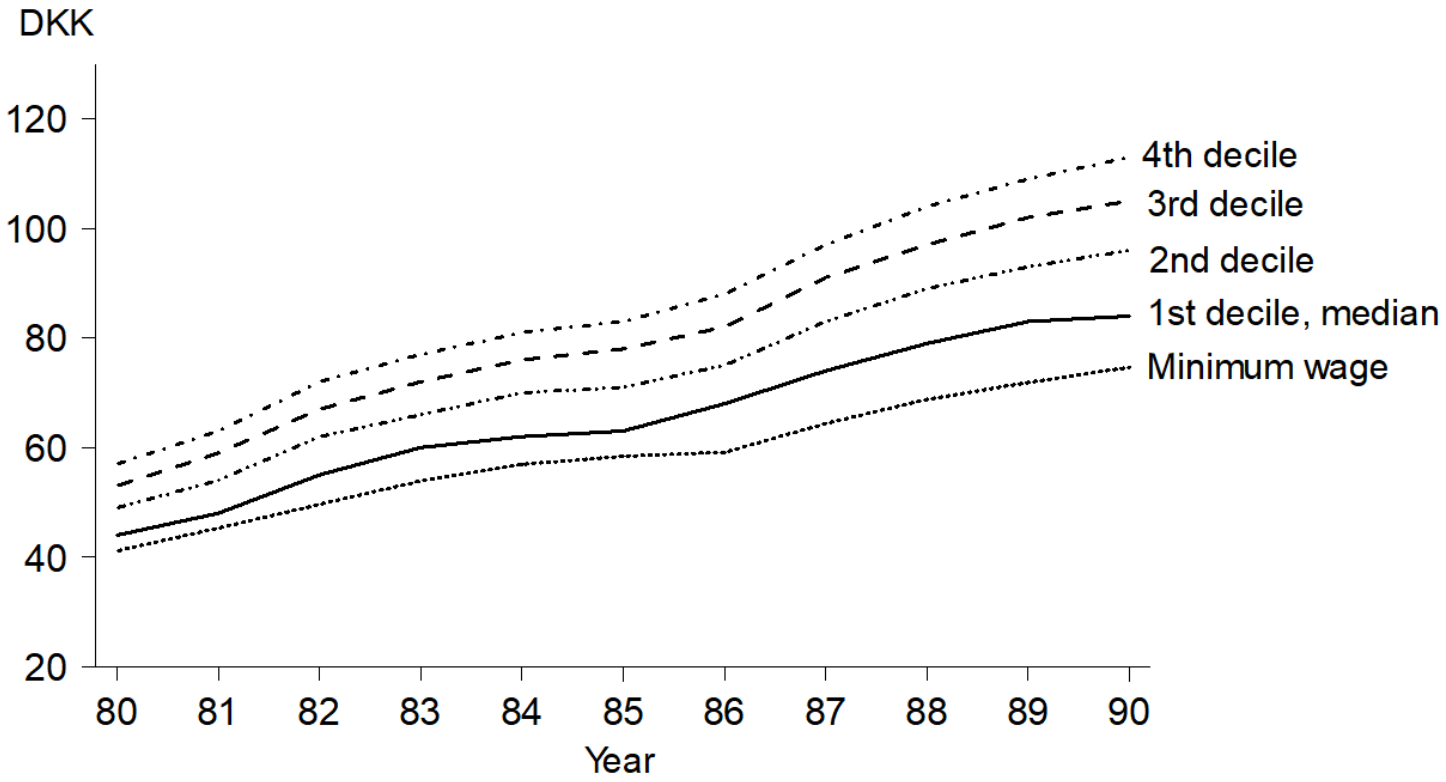


Figure 3. The "minimum wage" and the lowest deciles for women.

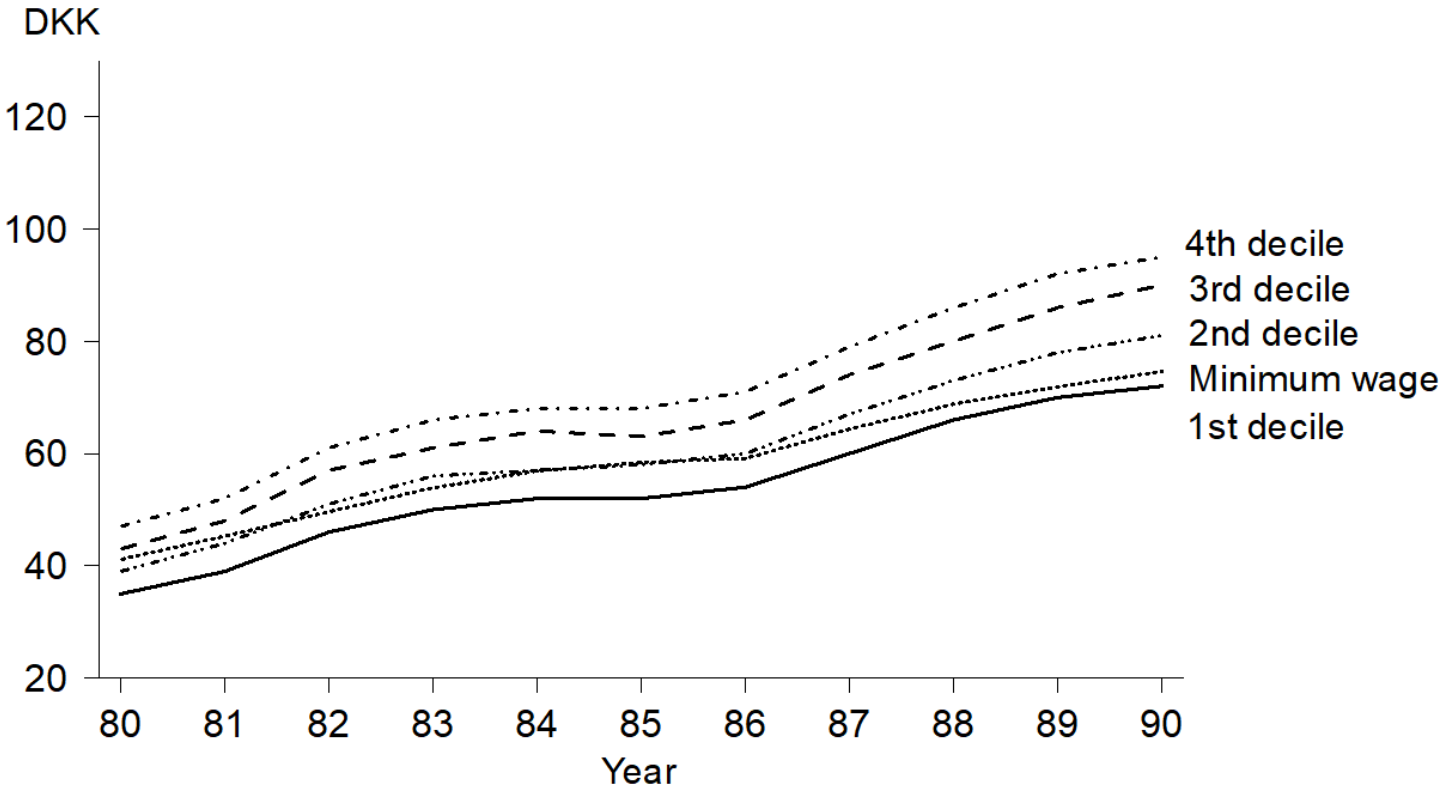


Table 2. Modal selected characteristics by decile.

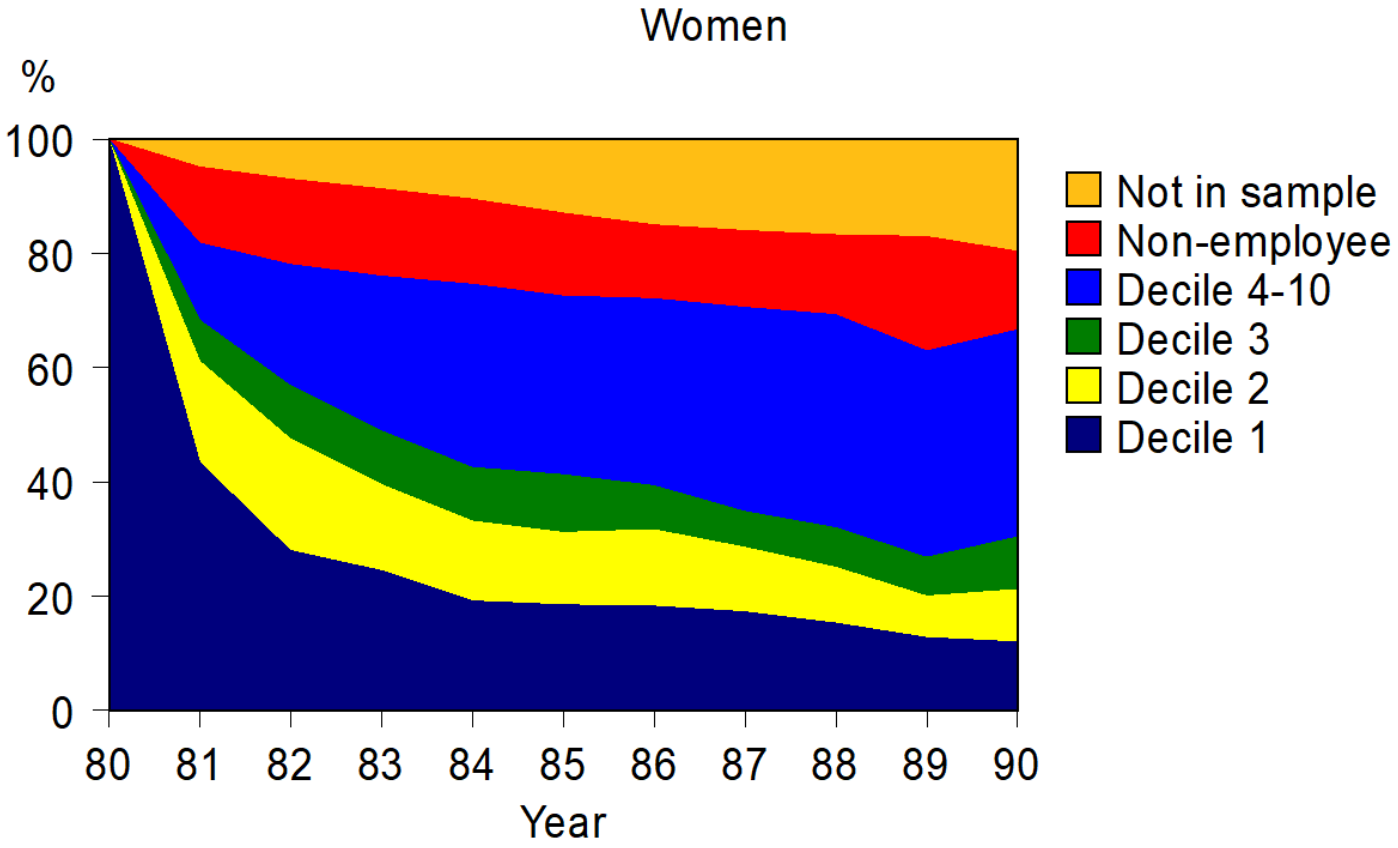
1990 Decile	Women			Men		
	Age	Education	Occupation	Age	Education	Occupation
1.00	23.00	8....10	office clerk	21.00	8....10	unskilled
2.00	23.00	8....10	unskilled	23.00	8....10	unskilled
3.00	25.00	8....10	office clerk	24.00	11..12	unskilled
4.00	24.00	11..12	office clerk	28.00	11..12	unskilled
5.00	28.00	11..12	office clerk	40.00	11..12	skilled
6.00	42.00	11..12	office clerk	26.00	11..12	skilled
7.00	34.00	11..12	office clerk	46.00	11..12	skilled
8.00	39/43	11..12	office clerk	44.00	11..12	skilled
9.00	45.00	14..	office clerk	36.00	11..12	supervisor
10.00	44.00	14..	office clerk	44.00	14..	supervisor

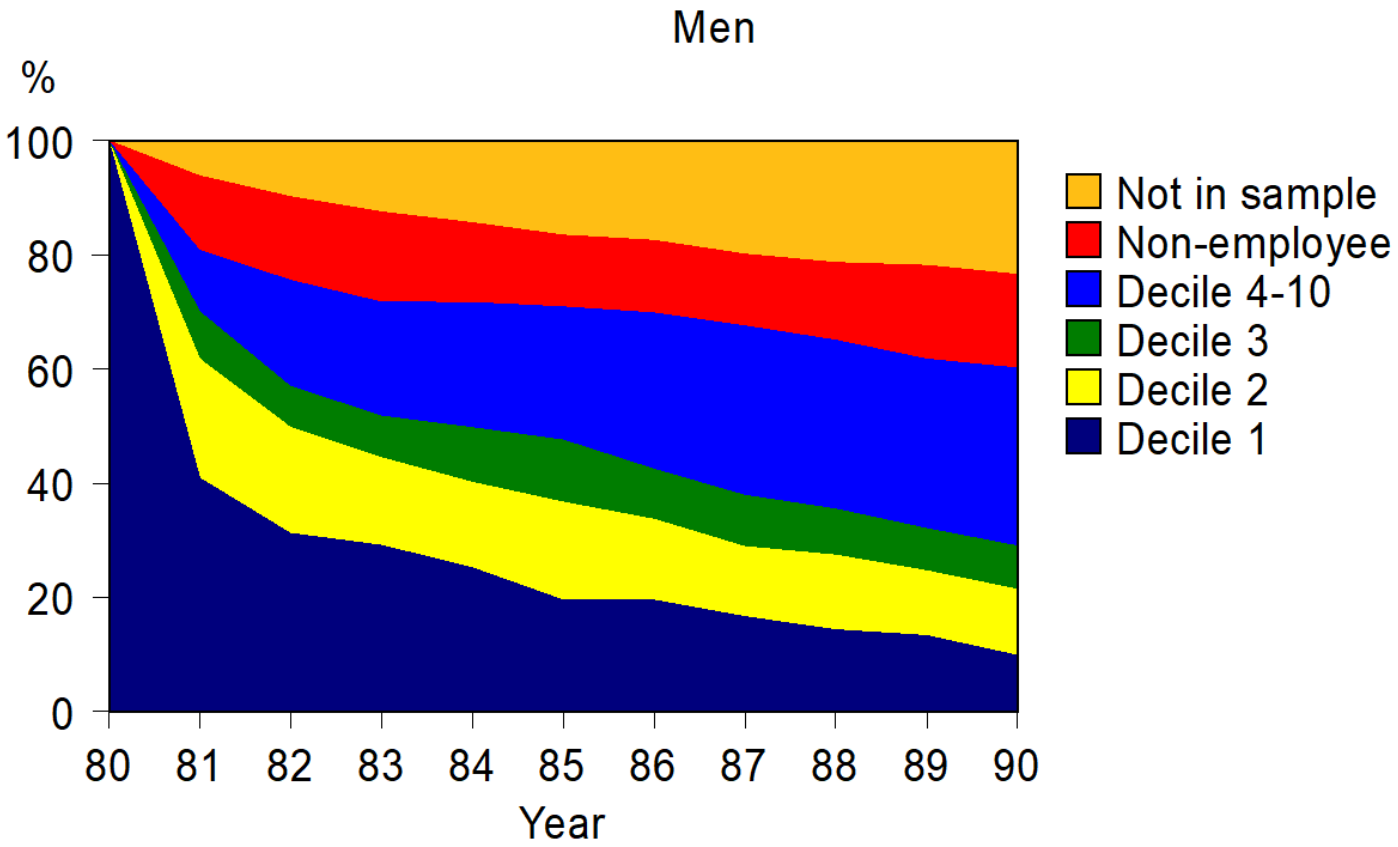
Table 2 describes typical members of each decile: Most frequent age group, length of education and occupation for each decile for men and women. Age is seen to vary over decile, but not in a linear fashion. Education is increasing with decile, as is position in the occupational hierarchy. The latter is somewhat monotonous, due to rather few categories of occupations. The sequential age pattern probably reflects that age is a major determinant of growth, but that upward mobility is constrained at some point because of education and occupation etc. With "better" characteristics, people are able to move higher.

Another important question is how the deciles are placed compared with the Danish minimum wage[1]. Figures 2 and 3 show the lowest deciles for men and women together with the minimum wage, which is the same for men and women. The general finding is that a decreasing number of people are influenced by the "minimum wage", since the median of the lowest decile moves away from the "minimum wage".

For women, it is found that the median of the first decile is below the "minimum wage". The difference between the two diminishes over the period. The centrally administered "minimum wage" has therefore become less binding over the period. This seems hard to explain in a period with high and increasing unemployment. The conjecture discussed in Westergård-Nielsen (1993) is that this is a result of an insider-outsider behaviour, where the actual minimum wage is negotiated at the firm level. A recent tendency to decentralised wage negotiations has probably increased the importance of insider-outsider behaviour.

Figure 4. Percentage remaining in decile 1 as time elapses, women and men.





Mobility in this study is described as movements from one decile to another from year to year or from year t to year t+4. Table 3 shows that the mobility from one year to another is substantial from most origin deciles. Also the number of individuals for whom mobility is unobserved is about 15% each year from the lowest decile, but only 5% from the 5-7th deciles.

Table 3. Male transitions % in 1985-6.

	Decile in 1986															
Decile in 1985	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	Not in lab. for.	Selfem-ployed	Not in sample	Missing	Sum	N
1.00	44.00	18.00	7.00	5.00	5.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	7.00	4.00	1.00	947.00
2.00	16.00	33.00	15.00	11.00	5.00	3.00	3.00	2.00	1.00	0.00	1.00	2.00	6.00	2.00	0.00	960.00
3.00	5.00	22.00	30.00	16.00	8.00	5.00	3.00	2.00	1.00	1.00	1.00	1.00	3.00	2.00	0.00	976.00
4.00	3.00	8.00	23.00	28.00	17.00	9.00	4.00	2.00	1.00	1.00	0.00	1.00	2.00	0.00	0.00	927.00
5.00	2.00	4.00	7.00	21.00	26.00	20.00	9.00	3.00	1.00	1.00	1.00	1.00	2.00	1.00	0.00	1005.00
6.00	2.00	3.00	4.00	8.00	17.00	32.00	17.00	8.00	3.00	1.00	1.00	1.00	2.00	1.00	0.00	924.00
7.00	1.00	1.00	2.00	4.00	8.00	20.00	33.00	16.00	6.00	2.00	1.00	1.00	3.00	0.00	0.00	952.00
8.00	1.00	1.00	1.00	1.00	2.00	7.00	21.00	40.00	16.00	4.00	0.00	2.00	2.00	1.00	1.00	951.00
9.00	1.00	1.00	0.00	1.00	1.00	2.00	3.00	18.00	51.00	16.00	1.00	1.00	3.00	1.00	0.00	954.00
10.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	3.00	13.00	71.00	0.00	3.00	3.00	0.00	2.00	953.00
Not in lab. for.	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	72.00	2.00	15.00	2.00	1.00	1115.00
Self-employed	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	1.00	88.00	4.00	1.00	0.00	1808.00
Not in sample	15.00	7.00	8.00	6.00	5.00	5.00	4.00	3.00	5.00	3.00	31.00	5.00	0.00	2.00	2.00	665.00
LGR>400	20.00	6.00	7.00	3.00	4.00	1.00	1.00	2.00	2.00	1.00	17.00	3.00	7.00	22.00	4.00	281.00
Missing	10.00	2.00	2.00	2.00	1.00	2.00	2.00	1.00	2.00	2.00	12.00	6.00	8.00	4.00	46.00	173.00
Sum	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	9.00	13.00	4.00	2.00	1.00	13591.00

Table 3 shows also that 16% do not have a wage in 1986, due to various resons. It is observed that the number of individuals for whom mobility is unobserved is about 15% for the lowest deciles but only 5% from the 5-7th deciles.

Individuals are followed for several years, but a number do not have the necessary wage information. The reasons for this are retirement, extensive (over 90%) unemployment, undertaking education, self-employment, etc., but the causes could also be emigration, exit from the labour force or death.

Transitions between the different deciles and between deciles and other states show the pattern of a highly dynamic labour market. In the lower deciles only between 25% and 44% remain in the same decile the following year.

The share of men who quit during a boom in the economy is a little higher than the share who leave when the economy is growing slowly, but the difference is small and for women it is negligible. The number who enter extensive unemployment from the first decile is similar to the number who enter the first decile from unemployment, but the number who leave the sample from the lowest decile is less than half of the number who enter the first decile from "out of the sample". Most of those who enter from outside the sample are young people while a large share of those who leave are aged 60 years or more. Those in the middle and at the top of the wage distribution are less mobile. Particularly men at the top of the wage distribution seem to have a more stable relative wage position. Those in the middle often move to the nearest deciles while those at the top stay there. On the other hand it is more common for those in the lowest deciles to enter extensive unemployment and those who leave unemployment are more likely to enter the lowest deciles.

A general impression is that there is a high level of wage mobility in and out of different categories and that a snapshot of the wage distribution gives only an incomplete picture of individual lifetime income distribution. Furthermore, it seems likely that origin decile is important for the chances for mobility.

Figure 4 shows that less than 25% of those who started in the lowest decile are still there 4 years later. Most have moved to higher deciles; some have left the sample; others are unemployed or for other reasons have no recorded wage.

3. Econometric Model

Since we are interested in identifying the effect of various background characteristics on the probability of moving from one decile to another, we have constructed an econometric model that takes into account that people start out from a specific decile and that for some people we do not observe a salary in either or both periods. Here, we will only give a short description of the model, relegating further details to a likelihood appendix.

The approach we use is reduced form. We have two equations controlling for potential sample selection and endogeneity bias. A first equation accounts for those (a selected sample) for whom we do not observe wage mobility, for whatever reason. A second equation determines decile of origin (which is endogenous to subsequent mobility). Finally, we are able to estimate the probability that an individual moves upward, downward, or stays in the decile of origin. Two alternative simultaneous models are estimated. One assumes that factors determine mobility in the same way for all origin deciles, another relaxes this by allowing the mobility functions to differ according to decile of origin. The latter is a switching regresion with selectivity.

4. Estimation

The model is estimated in Gauss. Each estimation is done separately for men and women and for a 4 year lead and a 1 year lead.

Estimates of origin wage decile are basically a Human Capital function, where experience and education are associated with higher decile of origin. Parents of infants starts in a lower decile, while those with older pre-school children are more likely to be observed in a higher decile compared with the reference group (children aged 7+, or no kids).

Estimates of the probability of having unbservable mobility (sample selection) show that the main reason for belonging to this group is the transition into or from severe unemployment, retirement or self-employment.

The headline wage mobility equation is reported in Table 4 below since it gives a general flavour of the determinants of mobility. Towards the end of the current section, we look at how stable these are across different deciles. A positive coefficient indicates that a variable is associated with upward mobility, while a negative coefficient is associated with downward mobility.

The first group of variables represent changes in various background characteristics over the investigated period, i.e. 1 or 4 years. The coefficients on change in occupation and industry all suggest downward mobility, as would be expected due to loss of job-specific capital. Change of residence from Copenhagen to the Province or vice versa is associated with upward mobility. An explanation could be that people only change residence if there is an economic gain. Birth indicates that a member of the household gives birth during the period. It appears that a new born baby is associated with small but significant downward mobility for women, while men are hardly affected.

Human Capital variables, Exper and Exper^2 show that mobility is increasing after a very short initial period. Mobility is also increasing with education. Similarly, higher unemployment means lower mobility. Among occupational groups downward mobility is found for unskilled workers and to a lesser degree for skilled compared to salaried employees. Managers also have a higher tendency to upward mobility than other wage earners.

Coefficients in the "origin decile" equation show that the point of origin is not independent of the possibilities of upward or downward mobility. Origin decile is clearly capturing heterogeneity, that is not otherwise accounted for. Generally, the coefficients represent gravitation towards the median except for the two tails, where it appears people tend to stay other things being equal.

Year of origin shows a pattern that is (weakly) positively related to the business cycle. The general pattern seems to be that upward mobility is relatively lower in years with more job destruction than creation. Thus macro statistics show that employment was not increased in the period 1980-83 while 1984-86 reversed this tendency. After 1987 job destructions were again dominant. The one year lead model seems to track this development better than the 4 year lead model as should be expected.

The ρ—coefficients show that the error term in the mobility equation is negatively correlated with the error term in the relation determining decile of origin and positively correlated with the error term of the "non wage relation". Statistical significance of these correlation coefficients justifies the use of a simultaneous model.

Table 4. Wage Mobility Equation Model Estimates (t ratios)

Variable	4 year lead				1 year lead			
	Men		Women		Men		Women	
Constant	0.688	(18.21)	0.609	(16.66)	0.825	(25.32)	0.801	(27.92)
Occup	-0.522	(34.31)	-0.400	(23.98)	-0.545	(31.95)	-0.374	(20.23)
Industry	-0.230	(19.28)	-0.270	(20.92)	-0.134	(11.50)	-0.145	(11.78)
Location	0.071	(1.98)	-0.023	(0.66)	0.099	(2.17)	0.349	(7.99)
Birth	0.006	(0.57)	-0.060	(5.51)	-0.015	(1.44)	-0.049	(4.13)
Human Capital								
Exper	-0.244	(7.93)	-0.134	(3.77)	-0.099	(4.23)	-0.111	(4.13)
Exper^2	0.127	(1.69)	0.204	(1.56)	0.060	(1.12)	0.266	(2.90)
Ue degree	-0.097	(24.98)	-0.056	(17.44)	-0.049	(17.89)	-0.027	(10.24)
Education (BA)								
7th grade	0.161	(5.68)	0.097	(3.17)	0.001	(0.02)	0.042	(1.50)
8,9th grade	0.318	(6.58)	0.267	(5.38)	0.061	(1.67)	0.050	(1.24)
10th grade	0.111	(4.47)	0.072	(2.96)	-0.010	(0.48)	0.011	(0.57)
College	-0.026	(0.80)	0.164	(5.23)	-0.008	(0.28)	-0.041	(1.69)
Masters	0.302	(6.25)	0.589	(7.58)	0.196	(5.41)	0.420	(6.84)
Occupation								
Manager	0.045	(1.43)	-0.005	(0.18)	0.109	(4.49)	0.047	(2.07)
Skilled	-0.075	(3.81)	-0.080	(1.90)	-0.007	(0.43)	-0.146	(4.55)
Unskilled	-0.135	(7.73)	-0.220	(14.52)	-0.044	(3.22)	-0.107	(9.11)
Origin decile								
1.000	-0.094	(1.51)	-0.555	(8.96)	-0.132	(2.80)	-0.678	(13.22)

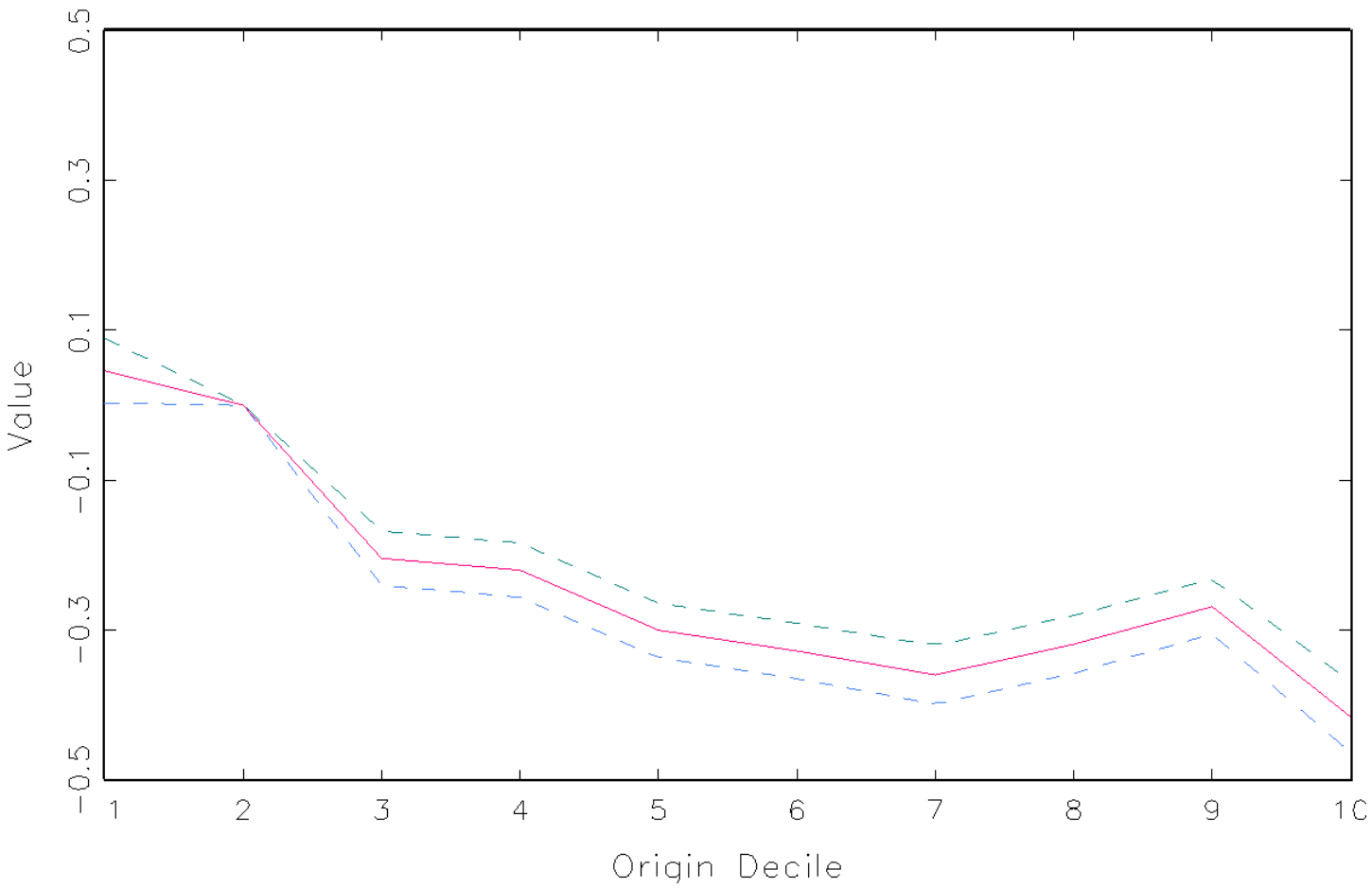
2.000	0.205	(5.27)	-0.069	(1.81)	0.185	(6.24)	-0.075	(2.33)
3.000	0.950	(3.44)	-0.030	(1.08)	0.079	(3.65)	-0.054	(2.29)
4.000	0.076	(3.58)	-0.025	(1.13)	0.041	(2.41)	-0.044	(2.41)
6.000	0.013	(0.63)	-0.034	(1.50)	-0.080	(4.66)	-0.099	(5.28)
7.000	-0.024	(0.90)	-0.057	(2.01)	-0.094	(4.45)	-0.122	(5.06)
8.000	-0.031	(0.91)	-0.091	(2.46)	-0.126	(4.61)	-0.161	(5.03)
9.000	-0.017	(0.37)	-0.139	(2.81)	-0.175	(4.82)	-0.170	(3.99)
10.000	1.086	(15.25)	0.777	(10.71)	0.809	(14.61)	0.650	(10.37)
Origin year								
80.000	0.003	(0.15)	-0.008	(0.42)	0.004	(0.25)	0.054	(2.81)
81.000	0.076	(4.11)	0.113	(5.82)	-0.234	(13.46)	-0.154	(8.32)
82.000	0.118	(6.41)	0.204	(10.61)	-0.019	(1.08)	0.020	(1.08)
83.000	0.114	(6.21)	0.192	(10.06)	-0.009	(0.52)	0.019	(1.00)
84.000	0.094	(5.14)	0.179	(9.37)	0.117	(6.70)	0.226	(12.39)
86.000	0.102	(5.60)	0.058	(3.09)	-0.028	(1.65)	-0.028	(1.53)
87.000	-		-		-0.070	(4.06)	0.025	(1.36)
88.000	-		-		-0.022	(1.27)	-0.123	(6.63)
89.000	-		-		0.066	(3.77)	0.084	(4.46)
Others	-		-					
Province	0.034	(2.31)	-0.006	(0.40)	-0.059	(5.08)	-0.022	(1.69)
	0.640	(79.36)	0.468	(54.11)	1.045	(152.58)	0.882	(90.02)
	-0.343	(10.93)	-0.446	(12.87)	-0.204	(8.45)	-0.327	(11.34)
	0.239	(3.61)	0.312	(5.47)	0.044	(0.90)	0.133	(2.64)
	0.114	(1.34)	0.077	(1.36)	0.220	(3.30)	0.066	(1.27)
Observations	76738.00		73489.00		124619.00		120970.00	
Mean ln lik	-2.28		-2.65		-2.73		-2.60	

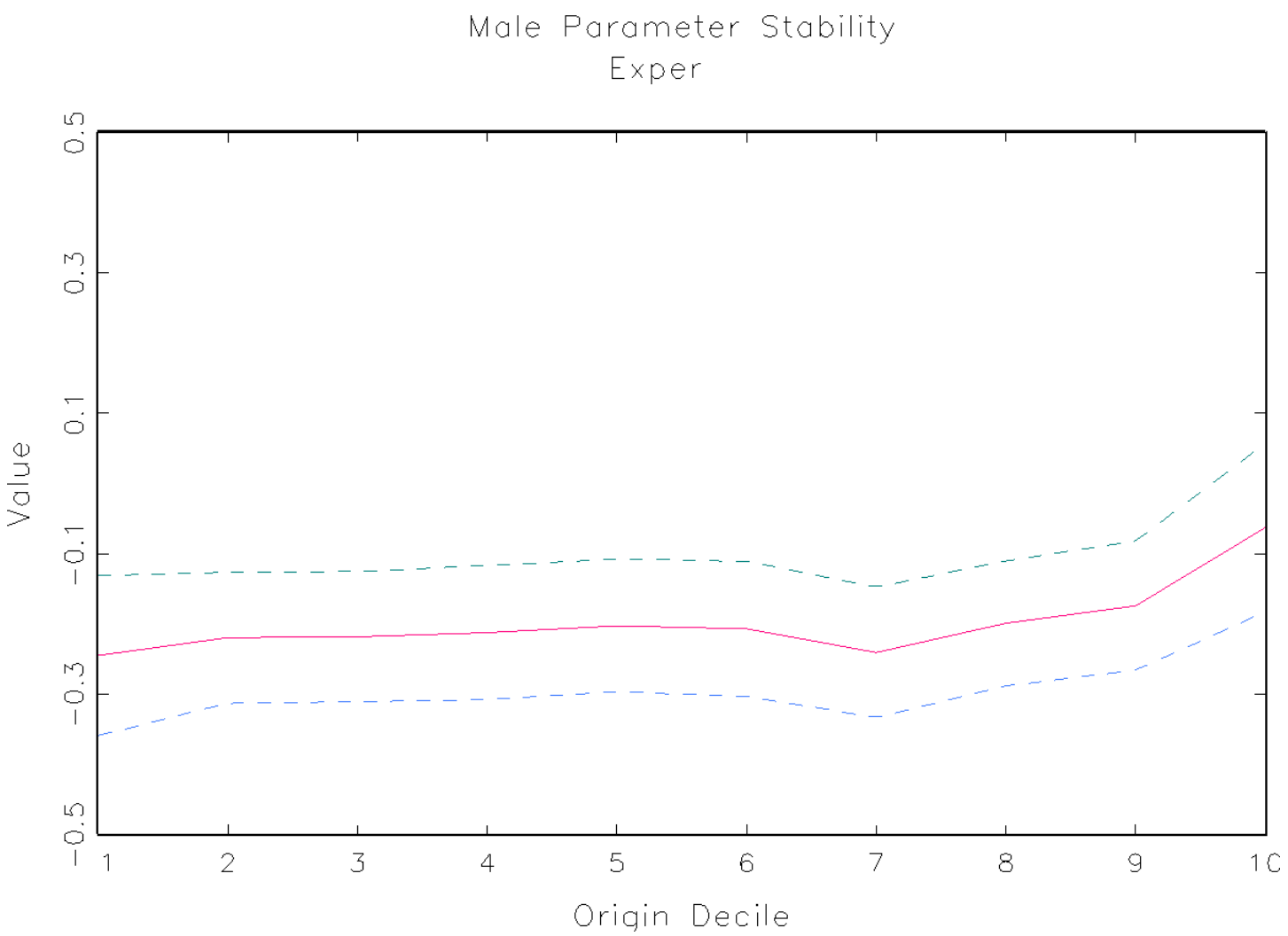
Finally, it should be noted that it does not make very much difference whether we consider the four or the one year lead model.

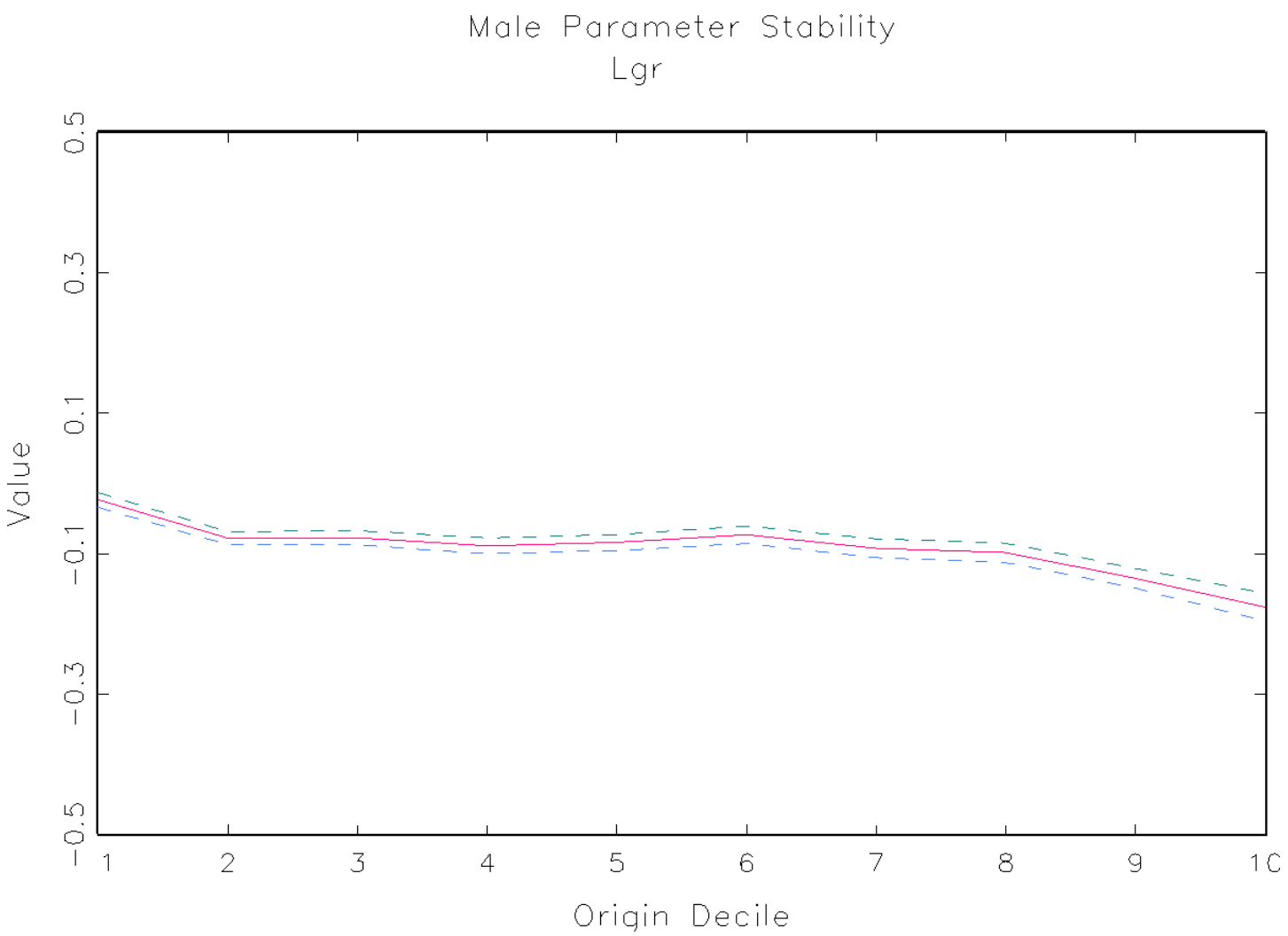
In order to investigate the stability of the coefficients we have also estimated a switching regression model, where all coefficients in the mobility function are estimated unconstrained for each decile. Below, for selected variables in the mobility function we have shown the value of the coefficient across decile of origin.

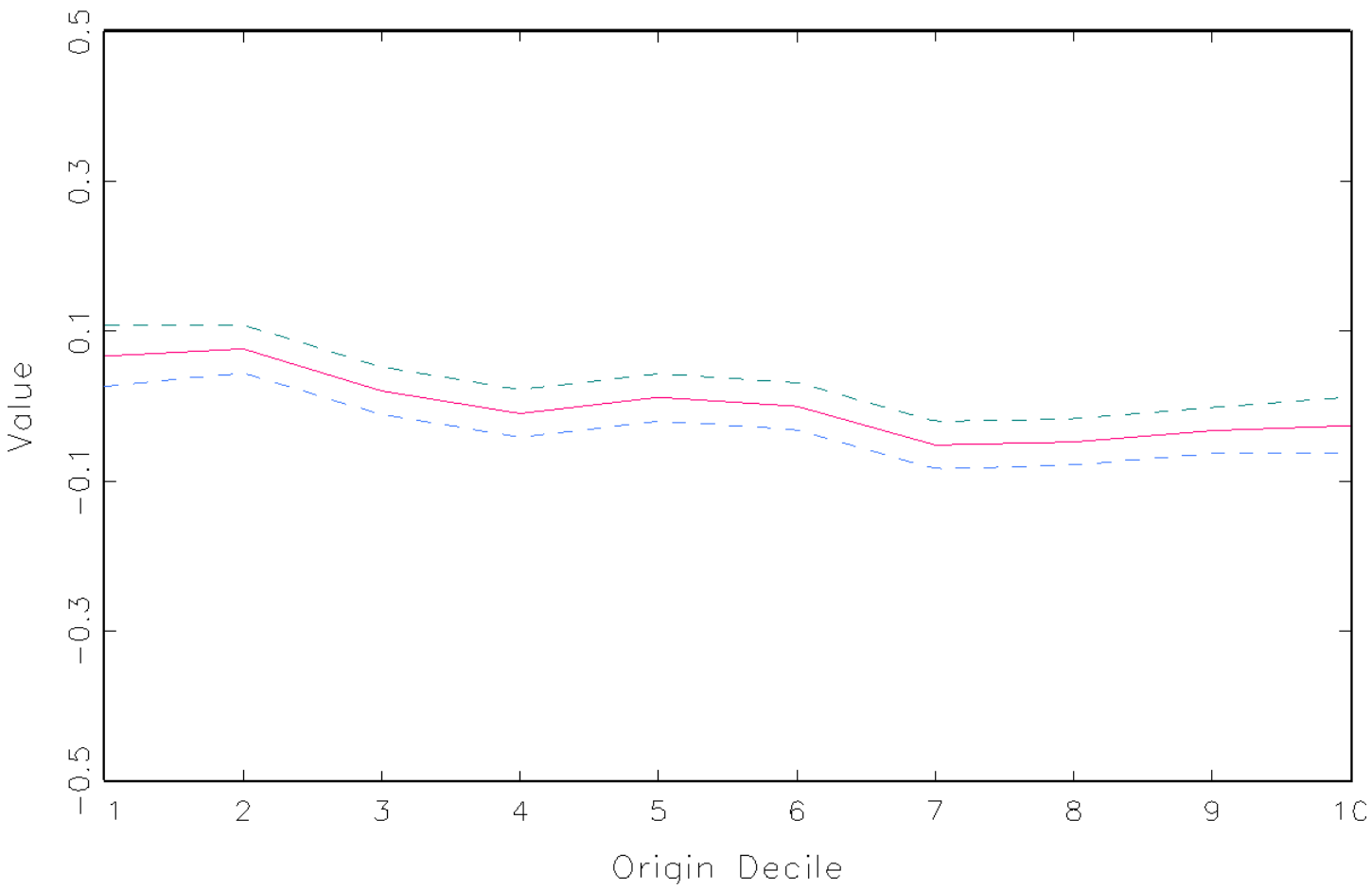
For males we see that the downward mobility contribution of experience (EXP) is less negative for deciles 8 and up, while experience squared is constant. Individual unemployment degree (LGR) appears to give a more and more negative contribution the higher we move up the wage distribution. Birth (New_kids) is found to be associated with upward mobility for the lowest deciles, while it becomes slightly negative for higher deciles. Skilled occupations are associated with an upward mobility for the first 4 deciles, then they become a liability. Unskilled occupations on the other hand are negative all the way up. The rho-parameter is the correlation between the unobserved factors (the error term) in the "no-observed-wage function" and the unobserved factors in the mobility function. It is first positive and becomes negative from the second decile.

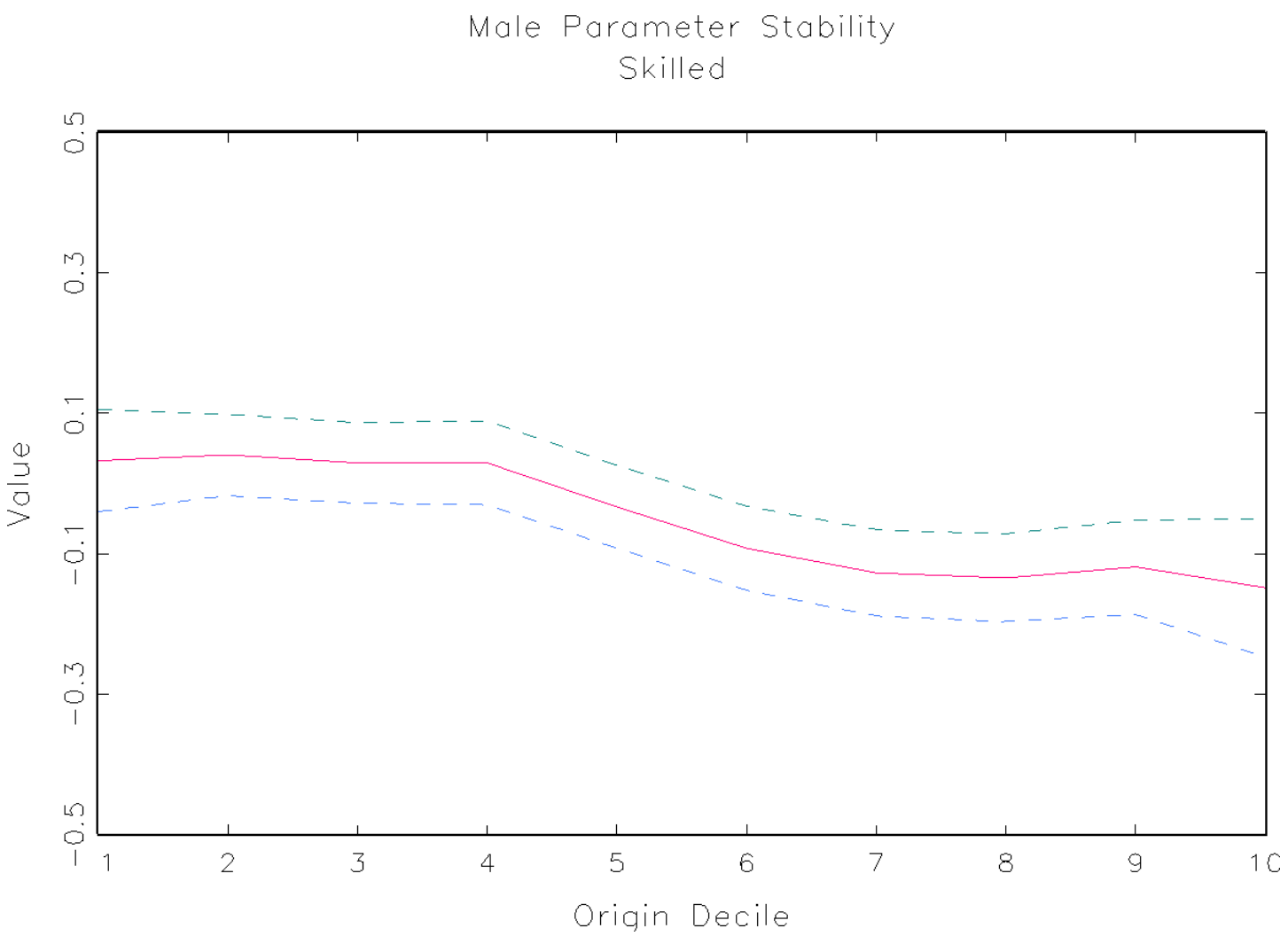
Figure 5. Selected Mobility Equation Coefficients across Male Switching Regressions.

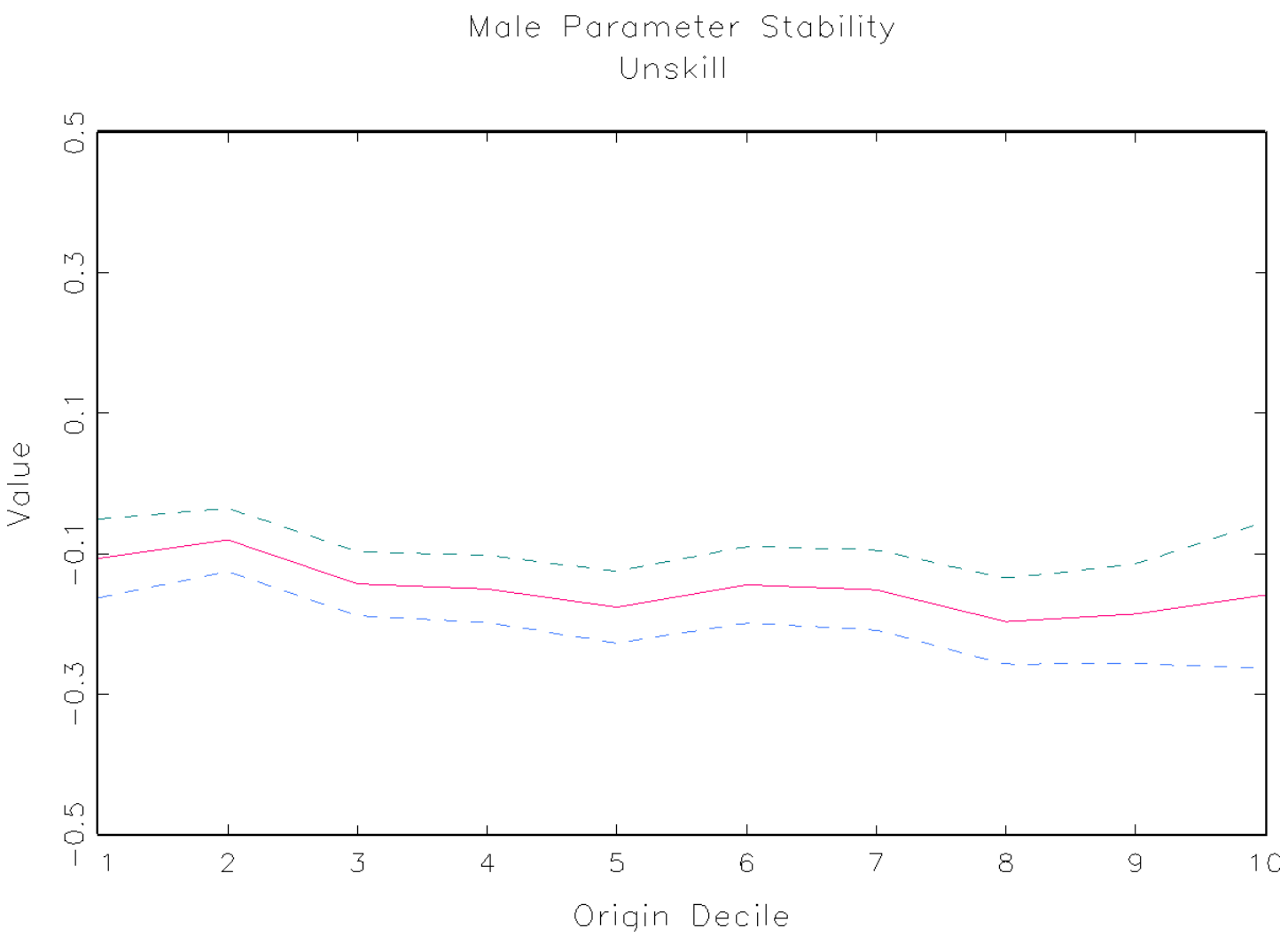

Male Parameter Stability
D_indust
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Male Parameter Stability
Exper
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Male Parameter Stability
Lgr
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Male Parameter Stability
New Kids
Value
0.5
0.3
0.1
-0.1
-0.3
-0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Male Parameter Stability
Skilled
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Male Parameter Stability
Unskill
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile

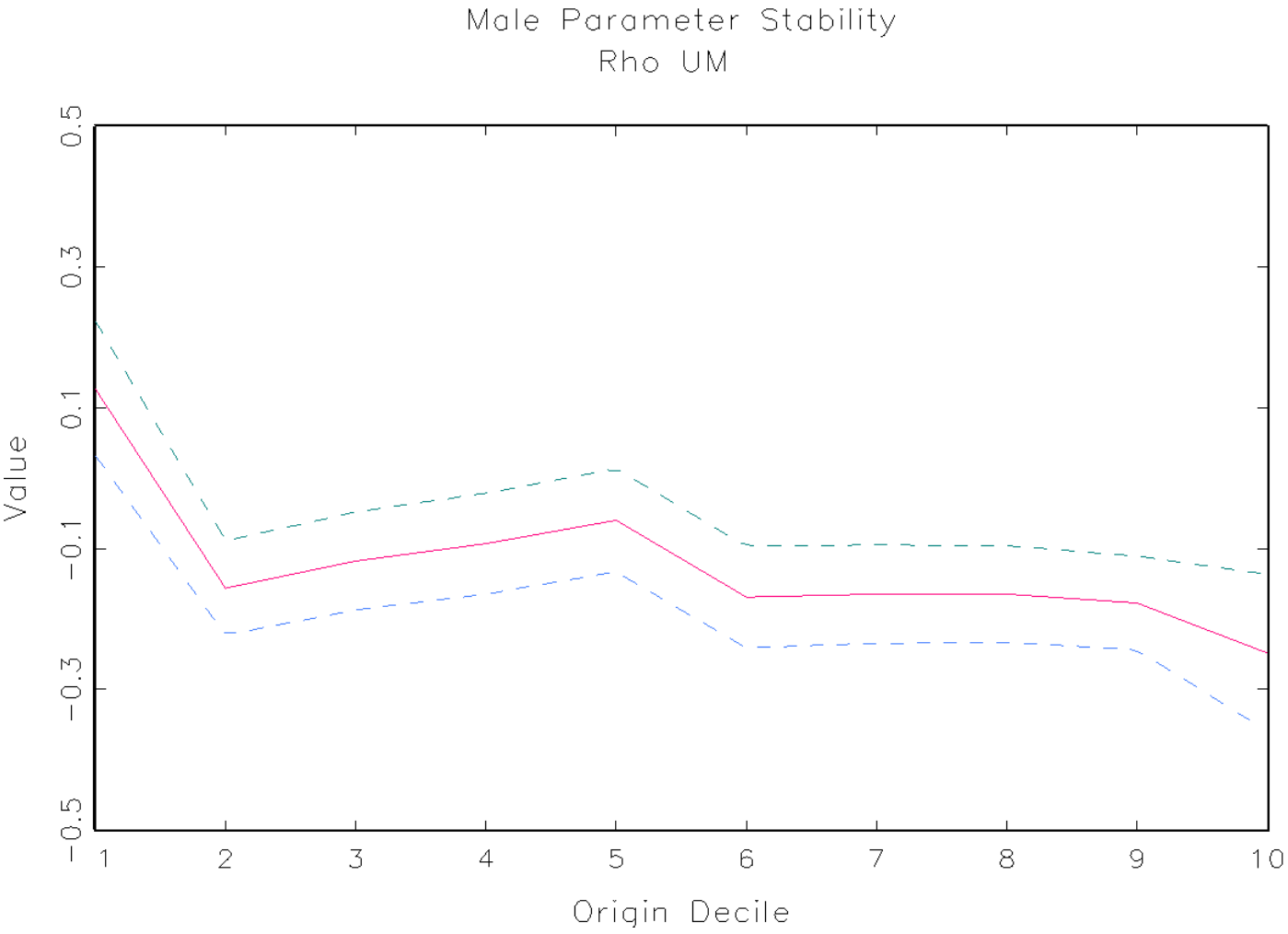
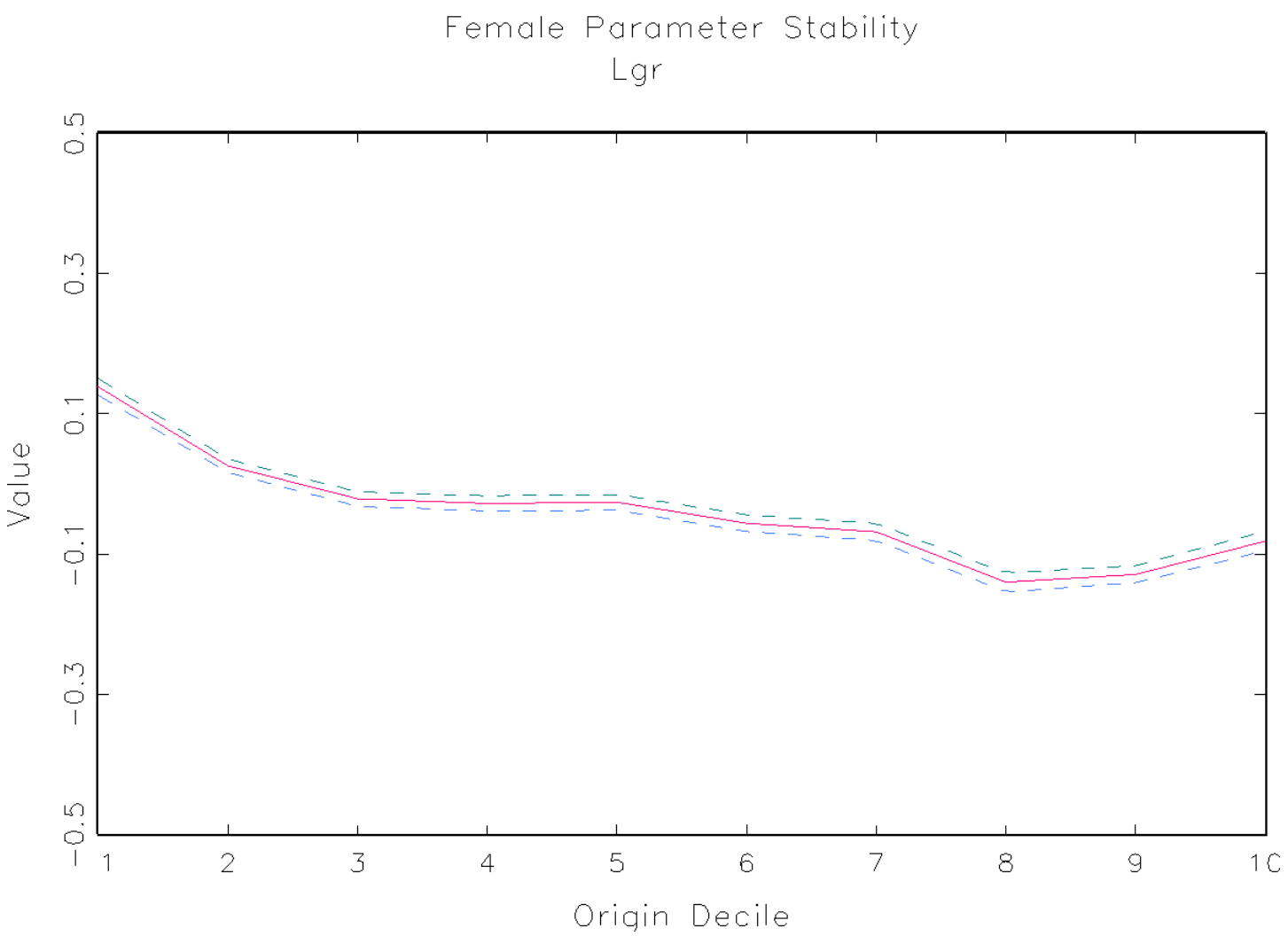
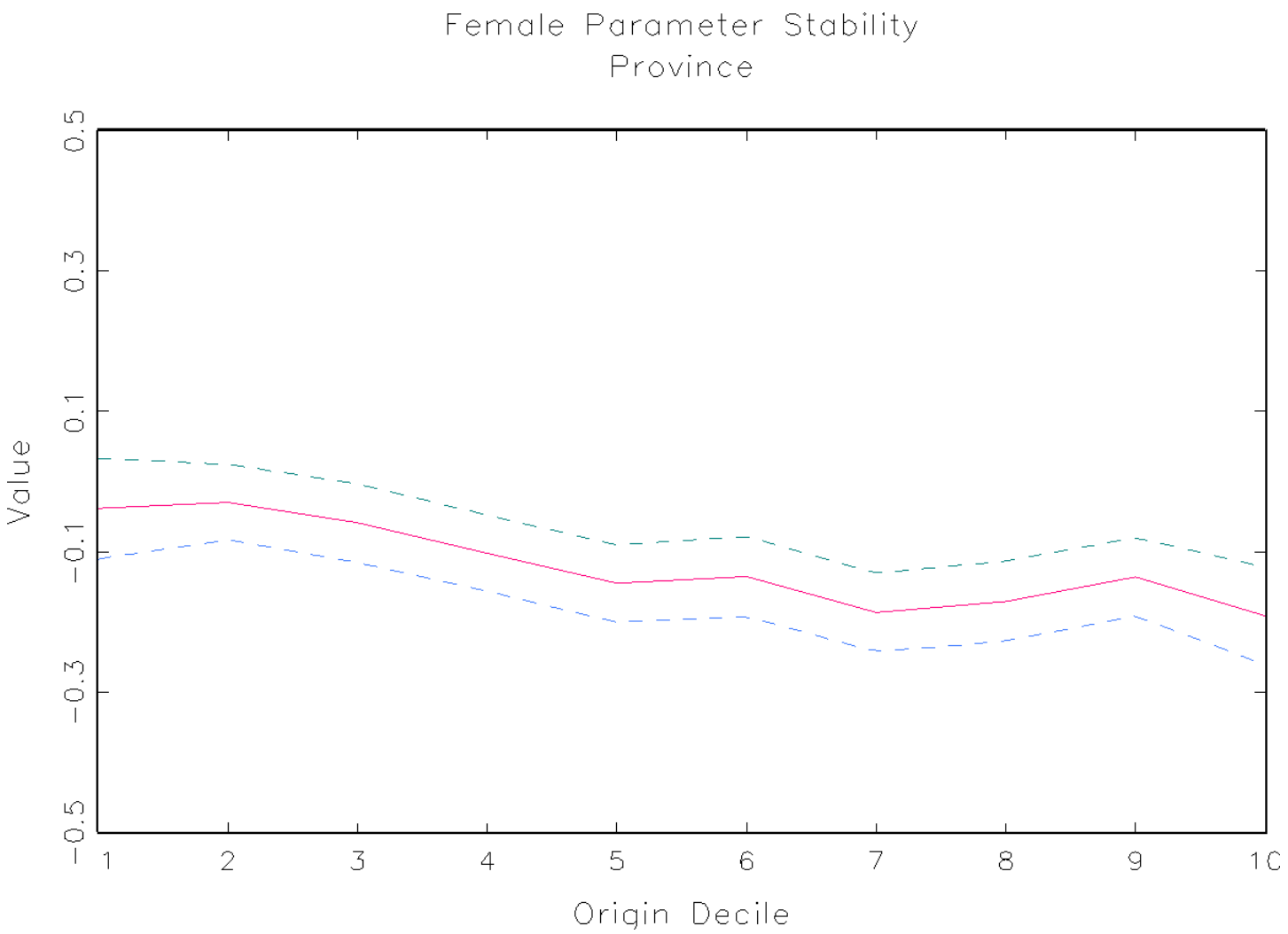
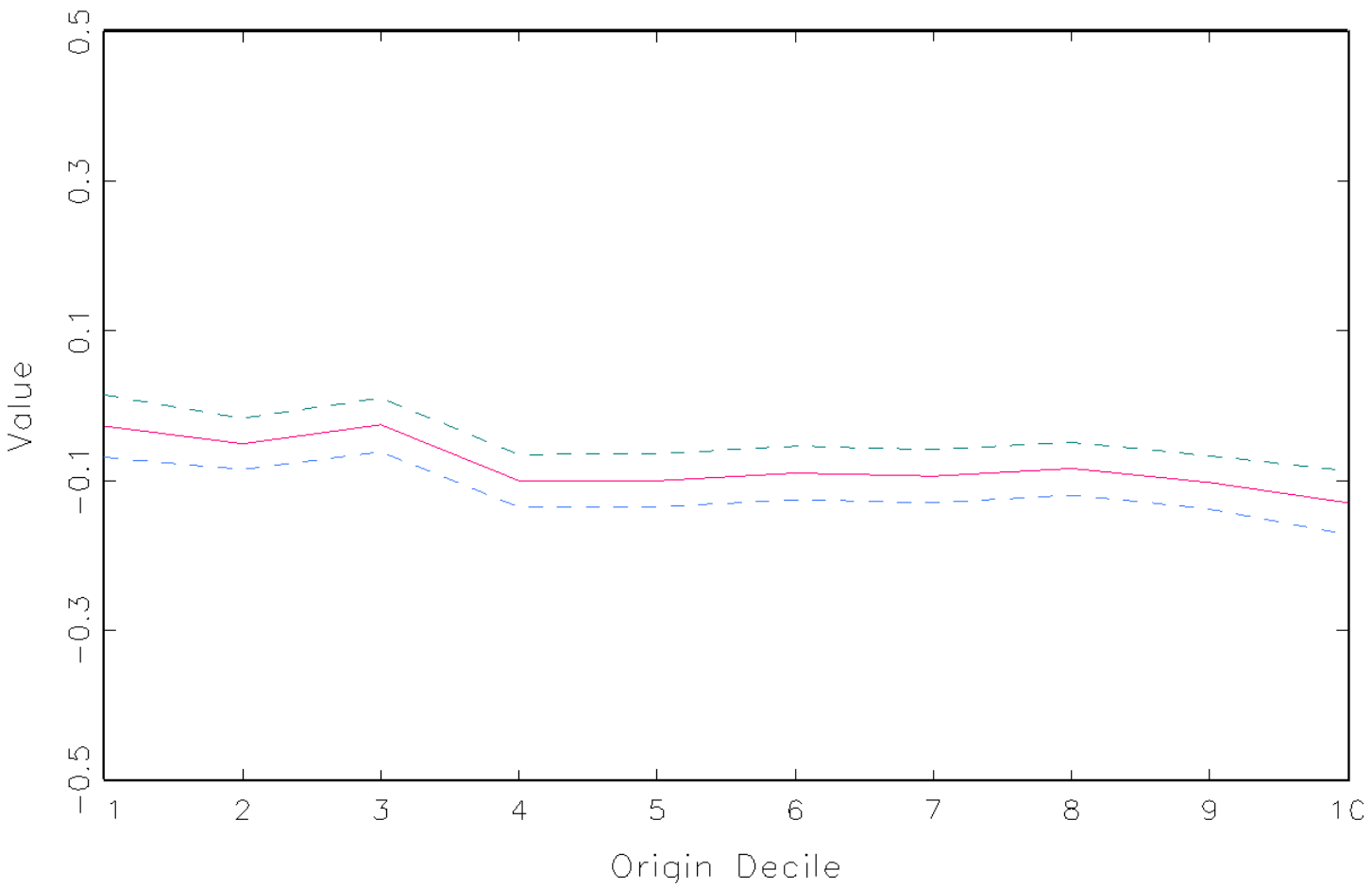
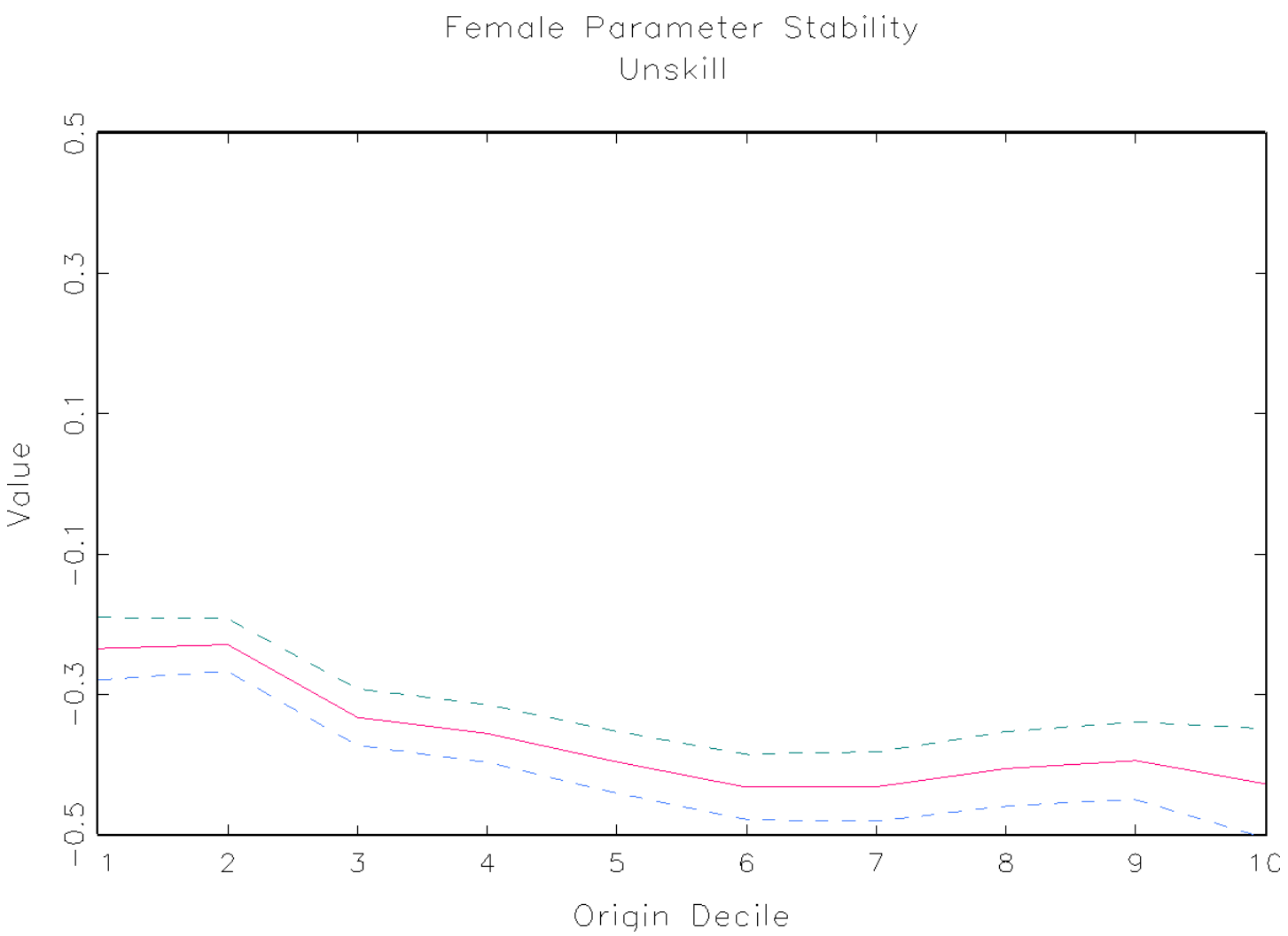


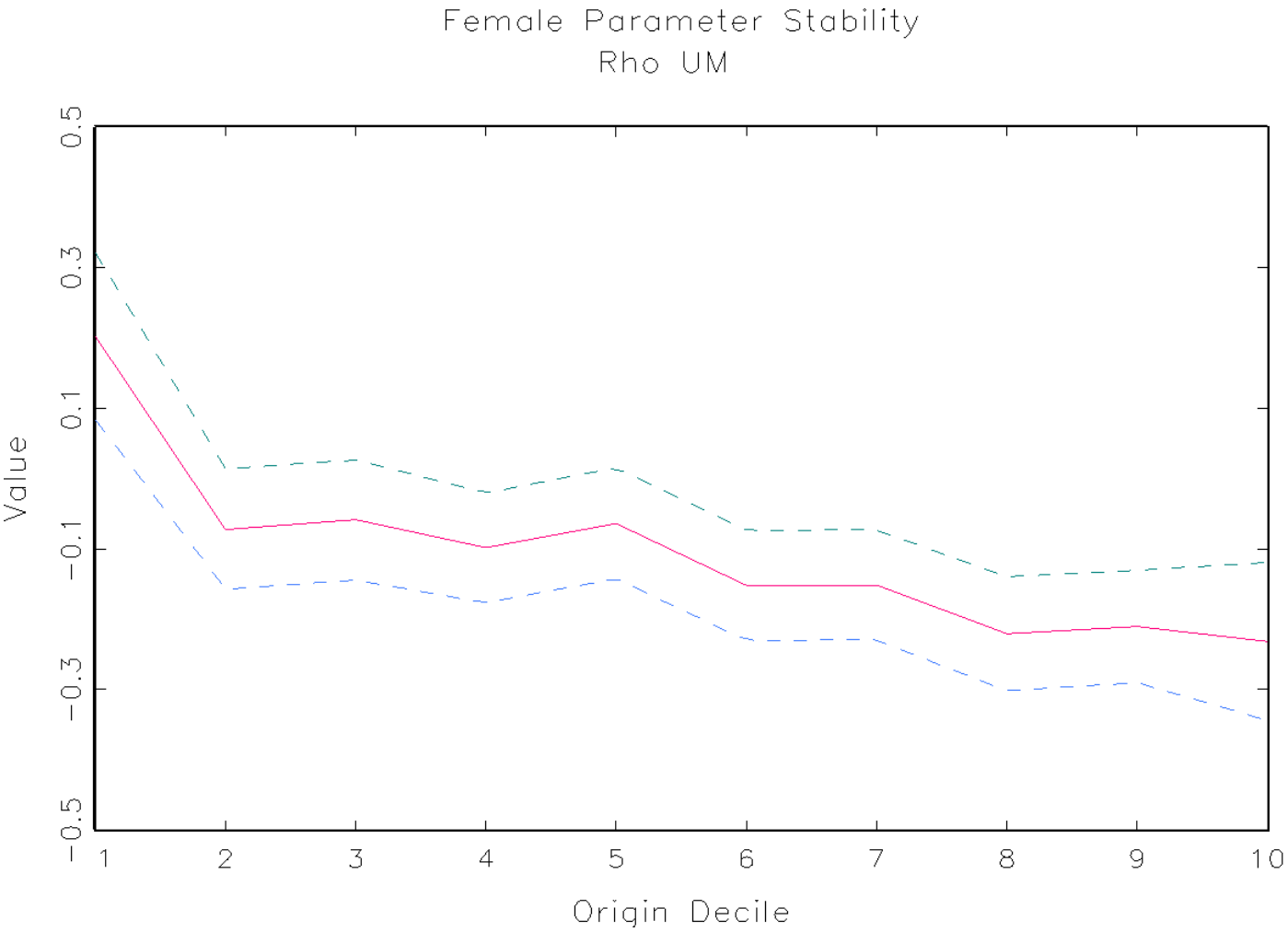
Figure 6. Selected Mobility Equation Coefficients across Female Switching Regressions.


Female Parameter Stability
Lgr
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Female Parameter Stability
Province
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Female Parameter Stability
New Kids
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile


Female Parameter Stability
Unskill
Value
0.5
0.3
0.1
−0.1
−0.3
−0.5
1
2
3
4
5
6
7
8
9
10
Origin Decile



A similar pattern is found for women, with some remarkable differences. Unemployment degree has a small positive coefficient for the first decile. Living outside Copenhagen (Province) means an increasing downward mobility. New_kids seem to have a negative impact on wage mobility only from the 4th decile. Being Unskilled has a negative and increasing impact. Finally ρ_{UM} shows that the correlation between the error terms in the "no-observable-wage" equation and the mobility equation is positive for the first five deciles and then turns negative.

It is apparent from these figures for men and women that the null hypothesis of equal coefficients across all deciles may be rejected. However, the differences are not big enough to lead us to reject the single equation model out of hand. It is much easier to interpret (being roughly the average of switching estimates) and it is suggested that the stability diagnostics should be considered as a caveat to conclusions drawn from individual mobility coefficients. Formal diagnostics and goodness-of-fit tests are relegated to an appendix

5. Simulation

Interpretation of the above results is difficult because mobility depends on the simultaneous determination of three relations. If a certain characteristic makes it more likely that a person starts out from decile three but he or she actually starts from decile four, it is not direct to infer expected mobility.

Table 5 summarises the effects of different levels of unemployment and experience for representative individuals. These are driven by estimates from the switching regression model with a four year lead. Experience is measured at the origin, while unemployment is measured as the average unemployment over the three intervening years. The advantage with this strategy is that we get "clean" effects not influenced by factors such as the business cycle.

First, it can be seen that upward mobility decreases with experience for men and women. At the same time, downward mobility increases but with a small increase in the probability of staying in the same decile. Occupation has little affect on these results.

Next we have simulated what happens if the representative individual becomes unemployed (average unemployment is 10% instead of zero[2]). For men and women upward mobility is reduced, while downward mobility is increased and fewer tend to stay in the same decile. These effects are much stronger for men than for women, but there is not much difference across occupations. Downward mobility is somewhat stronger for individuals with higher experience than for individuals with less. As well as the gender difference, the experience trend could be explained by the reduction of specific human capital due to unemployment. Usually, men have longer job tenure and are considered to have more specific human capital and therefore more to loose. An explanation for the lower amount of specific training is that more women hold part time jobs or have longer spells of absence from the

labour market due to child care responsibilities. The coefficient on the birth variable in Table 4 supports this view. At the same time the amount of specific training is usually associated with more experience.

Finally, we have simulated what are the effects of 50% unemployment over a three year period. This extensive unemployment will most probably be associated with long term unemployment. It is evident that this really increases downward mobility and makes it less likely that a person stays in the same decile than an individual without the severe unemployment.

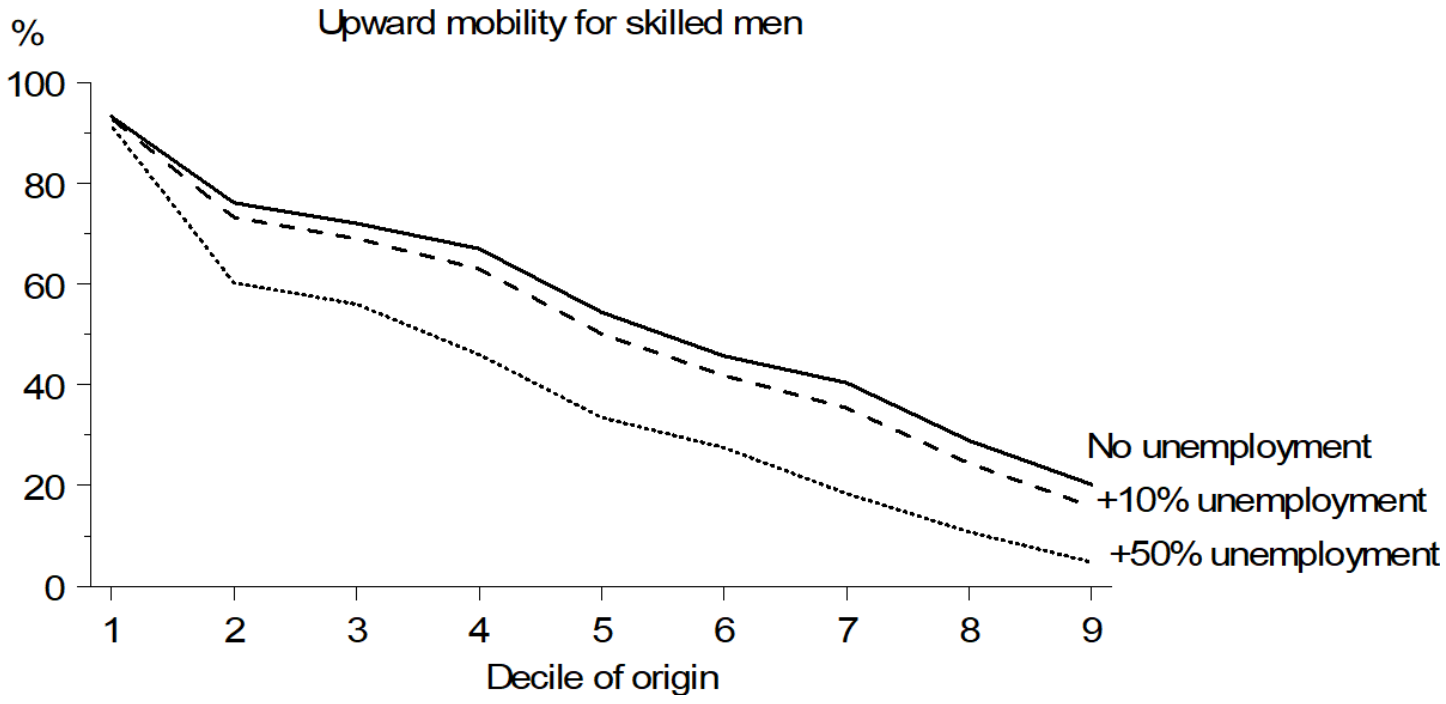
On the other hand, it is worth remarking that even 50% unemployment is not able to completely offset upward mobility even for people who start their working careers and have no experience. The offsetting effect is smallest for women and largest for men. For extensively unemployed men, downward mobility is almost doubled and the upward mobility is halved. The lack of a complete offset may be due to the existence of wage contracts that actually regulate wages according to age and not according to individual productivity. If age regulation is too strong, it will result in increasing difficulties in finding a job.

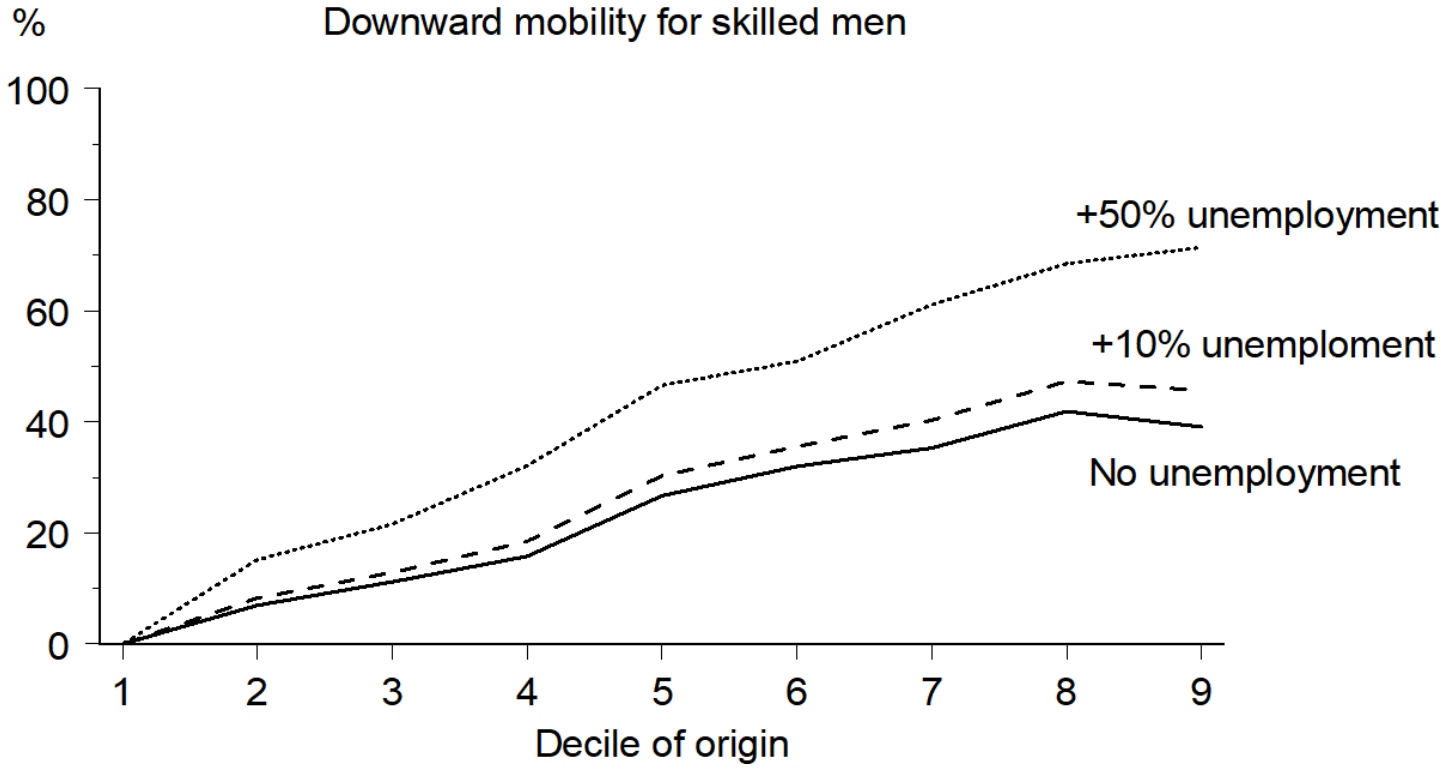
Table 5: Representative Individual Mobility by Unemployment Degree Expected % moving down staying or moving up.

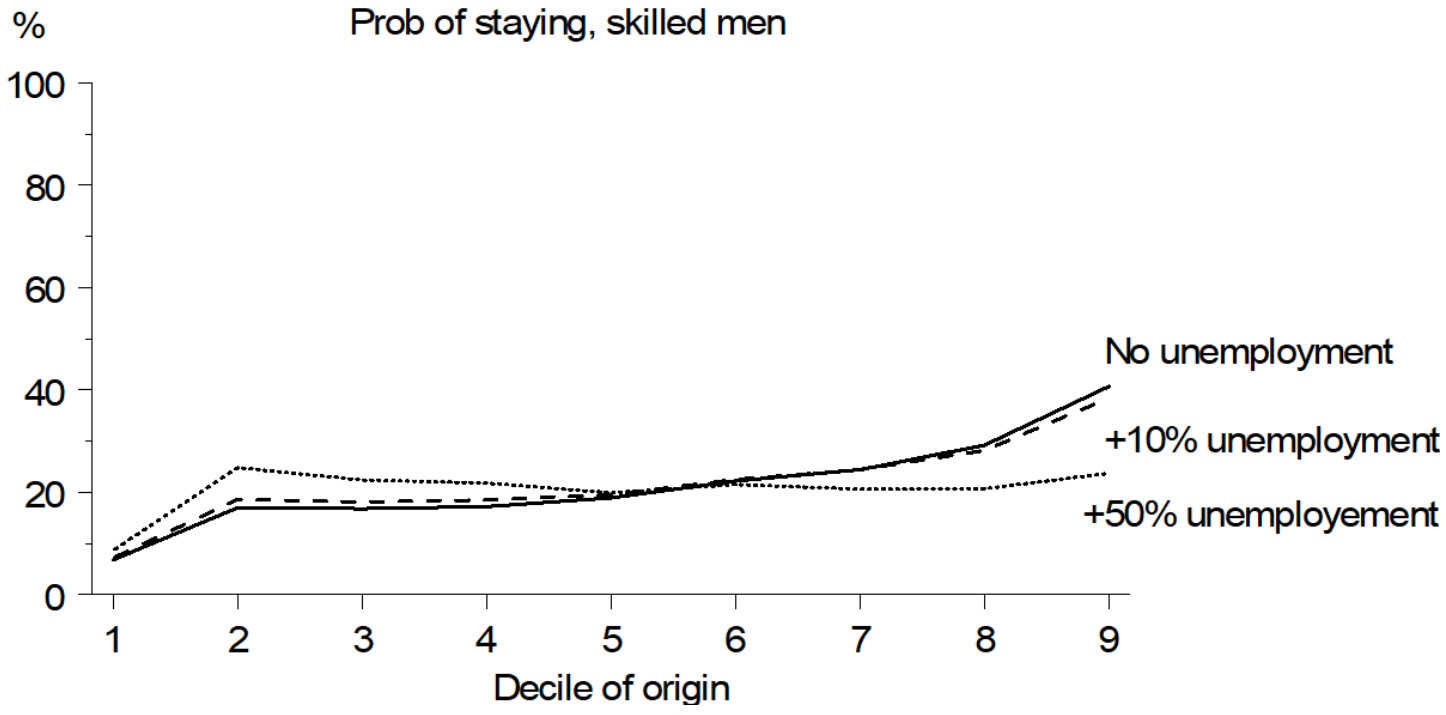
Sample	Occupation	Experience	Base			Change resulting from change in unemployment					
			None			+10%			+50%		
women	skilled	0.00	15.3	34.8	49.90	1.4	0.10	-1.50	7.8	0.10	-7.90
		5.00	18.3	37.90	43.80	1.6	-0.10	-1.50	8.7	-1.0	-7.60
		10.00	20.5	41.10	38.30	1.7	-0.30	-1.40	9.3	-2.0	-7.20
	unskilled	0.00	21.4	32.80	45.80	1.7	0.0	-1.70	9.0	-0.60	-8.40
		5.00	25.1	34.60	40.30	1.8	-0.20	-1.60	9.7	-1.80	-7.90
		10.00	28.0	36.60	35.50	2.0	-0.40	-1.50	10.3	-2.80	-7.40
men	skilled	0.00	20.5	31.10	48.40	5.0	-0.80	-4.20	26.7	-8.80	-17.90
		5.00	25.9	33.90	40.20	6.5	-1.90	-4.70	32.6	-14.20	-18.30
		10.00	30.3	37.10	32.60	7.9	-3.20	-4.70	37.8	-20.30	-17.50
	unskilled	0.00	21.2	30.20	48.60	4.6	-0.80	-3.90	24.2	-8.0	-16.20
		5.00	26.9	32.40	40.70	6.0	-1.70	-4.30	29.8	-12.70	-17.0
		10.00	31.7	34.80	33.50	7.4	-2.90	-4.50	34.8	-18.10	-16.70

The separate effect of unemployment has been investigated across origin deciles and for skilled men, unskilled men and unskilled women. For the sake of exposition we shall consider a reference individual who has no labour market experience at all. (Giving the person more experience does not change the arguments qualitatively) The results are illustrated in Figure 7.

Figure 7. Simulated 4-year mobility across deciles for different levels of unemployment .





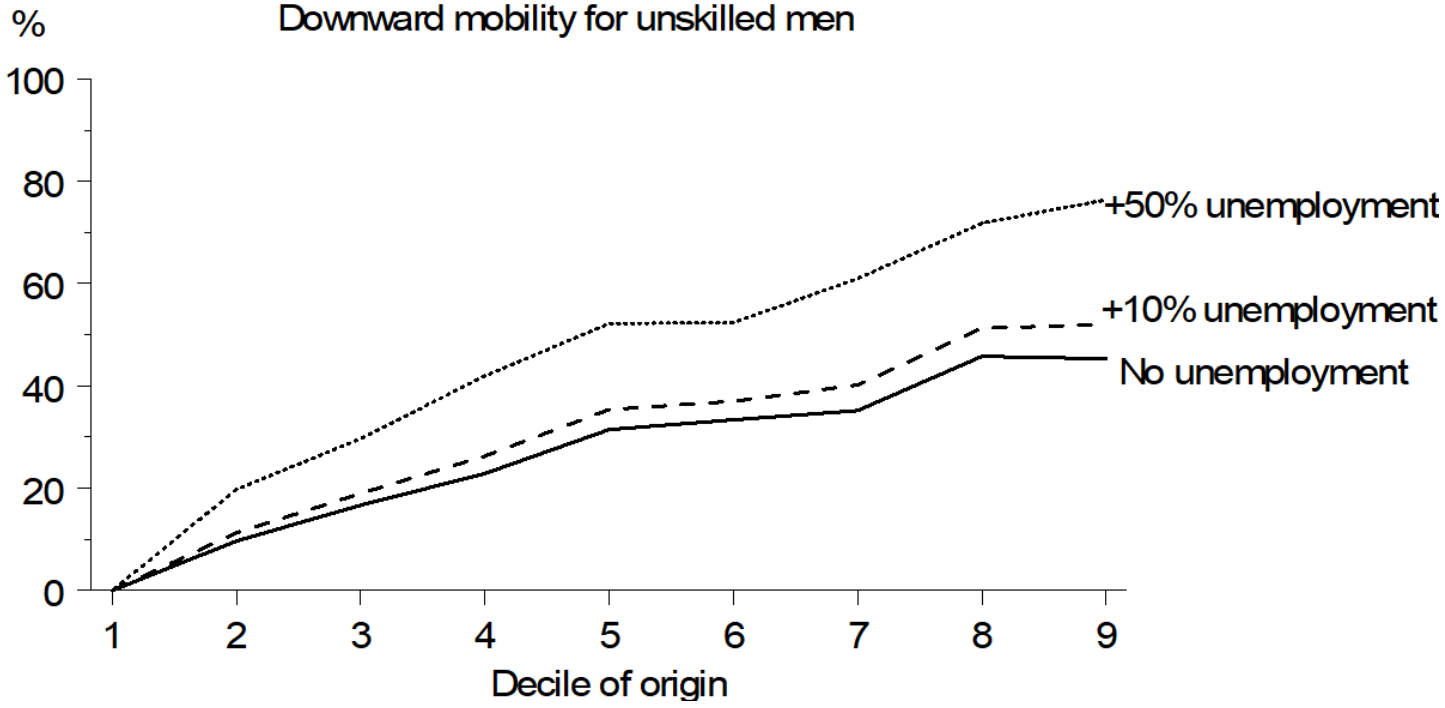


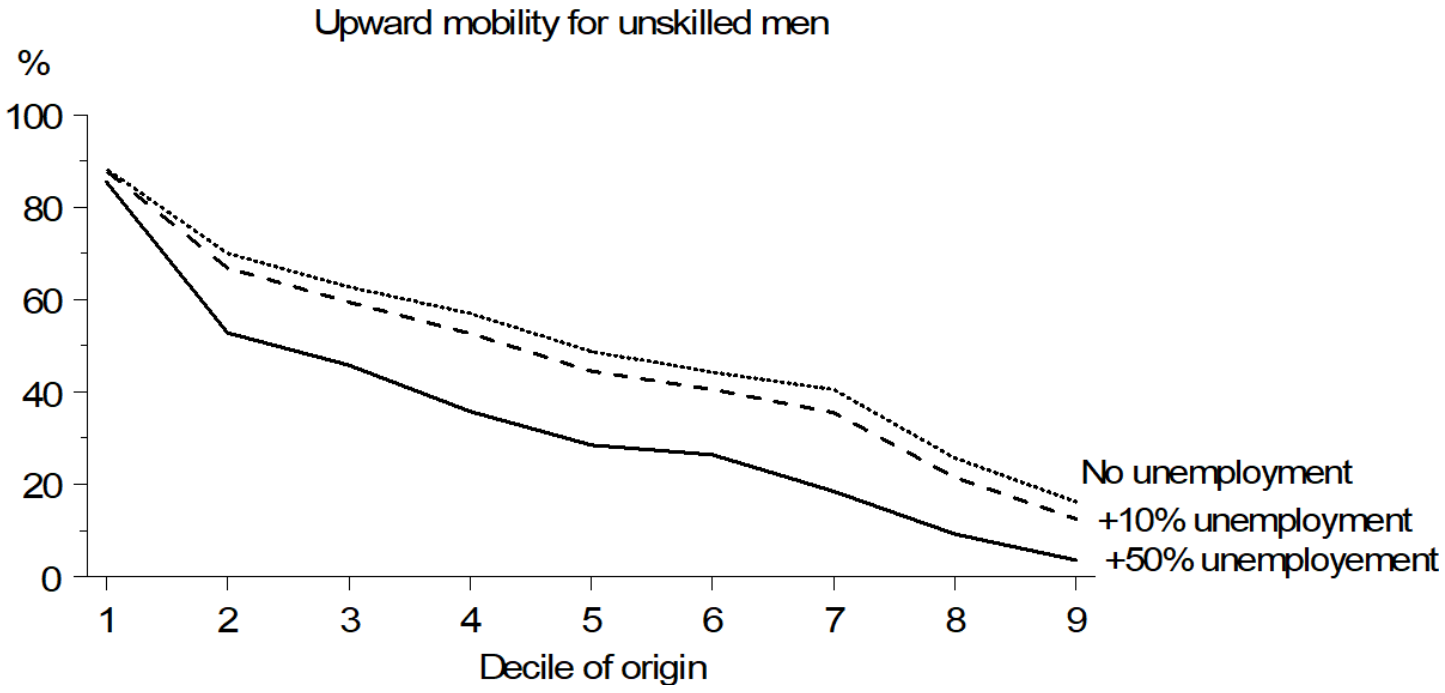
As expected, downward mobility increases with decile. 10% unemployment increases the downward mobility slightly, but increasing with deciles. The same though much stronger pattern is observed for the case with high unemployment. This is probably because the loss of human capital due to unemployment is more severe the higher decile position.

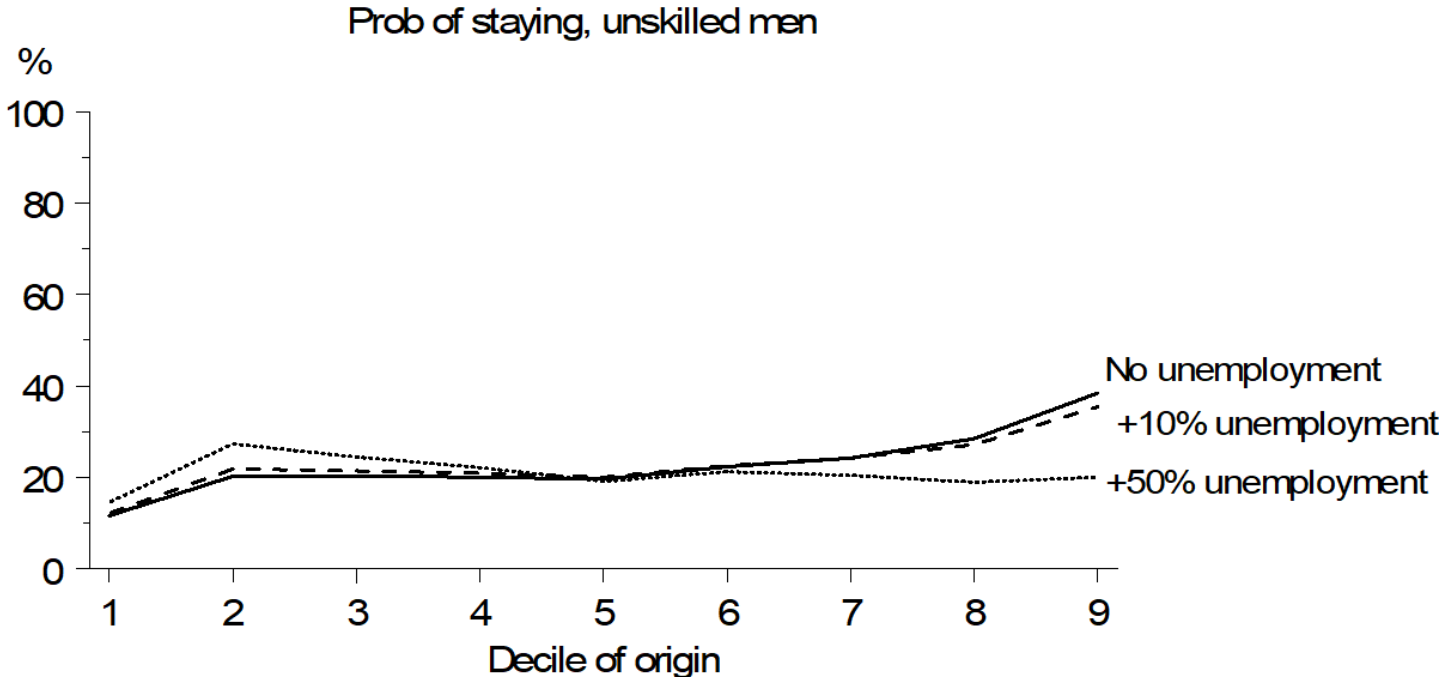
The graph for the simulated upward mobility shows that unemployment becomes important from the 2nd decile from which point the impact is fairly constant.

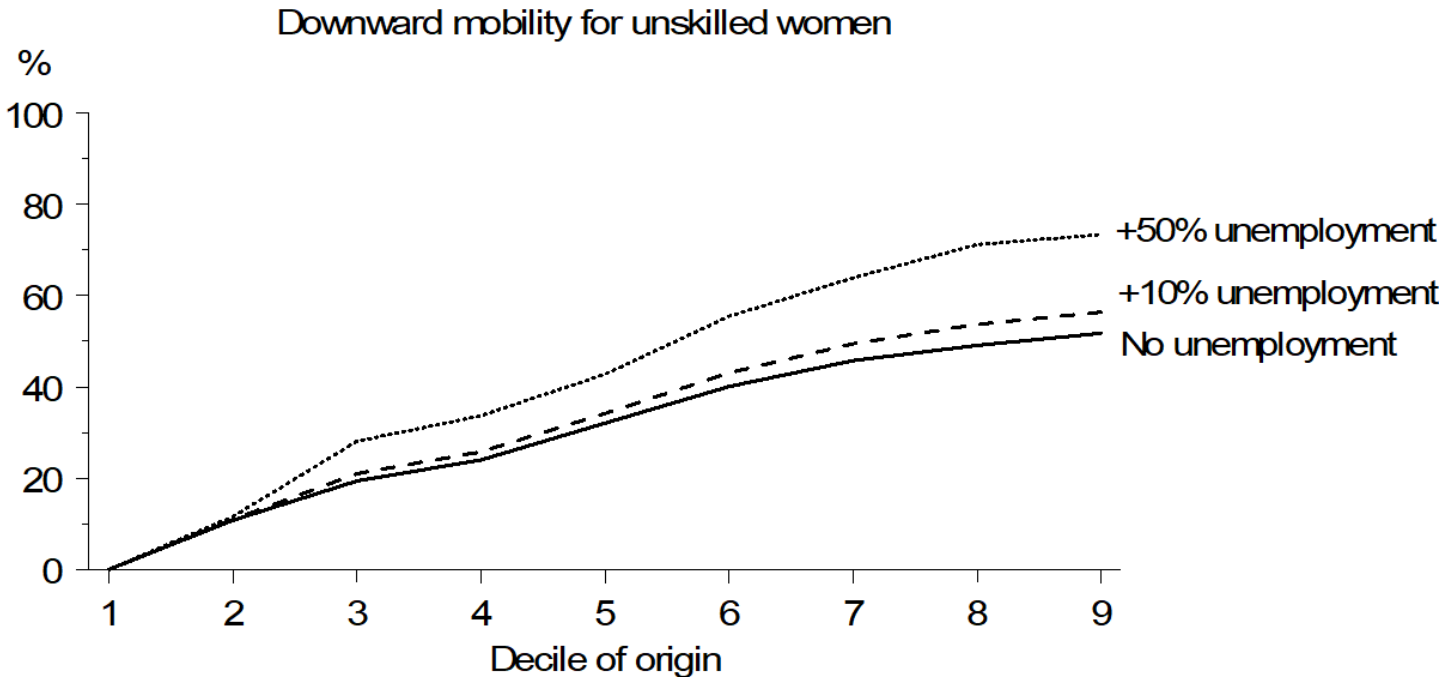
Finally, the stayer probability shows that unemployment makes it more likely that people in the lower deciles stay, while unemployment in the higher deciles makes it less likely to stay. Similar figures below consider the two unskilled groups.

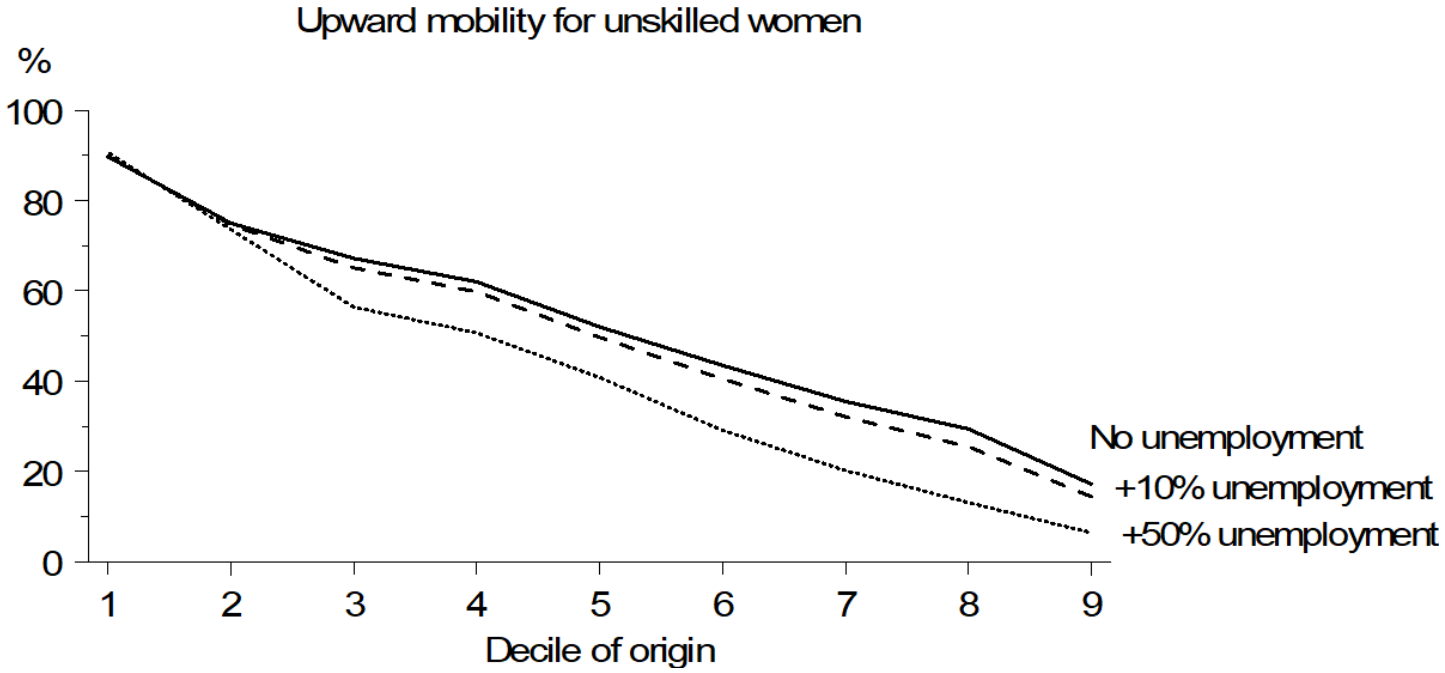
Figure 8. Simulated 4-year mobility across deciles for different levels of unemploymt

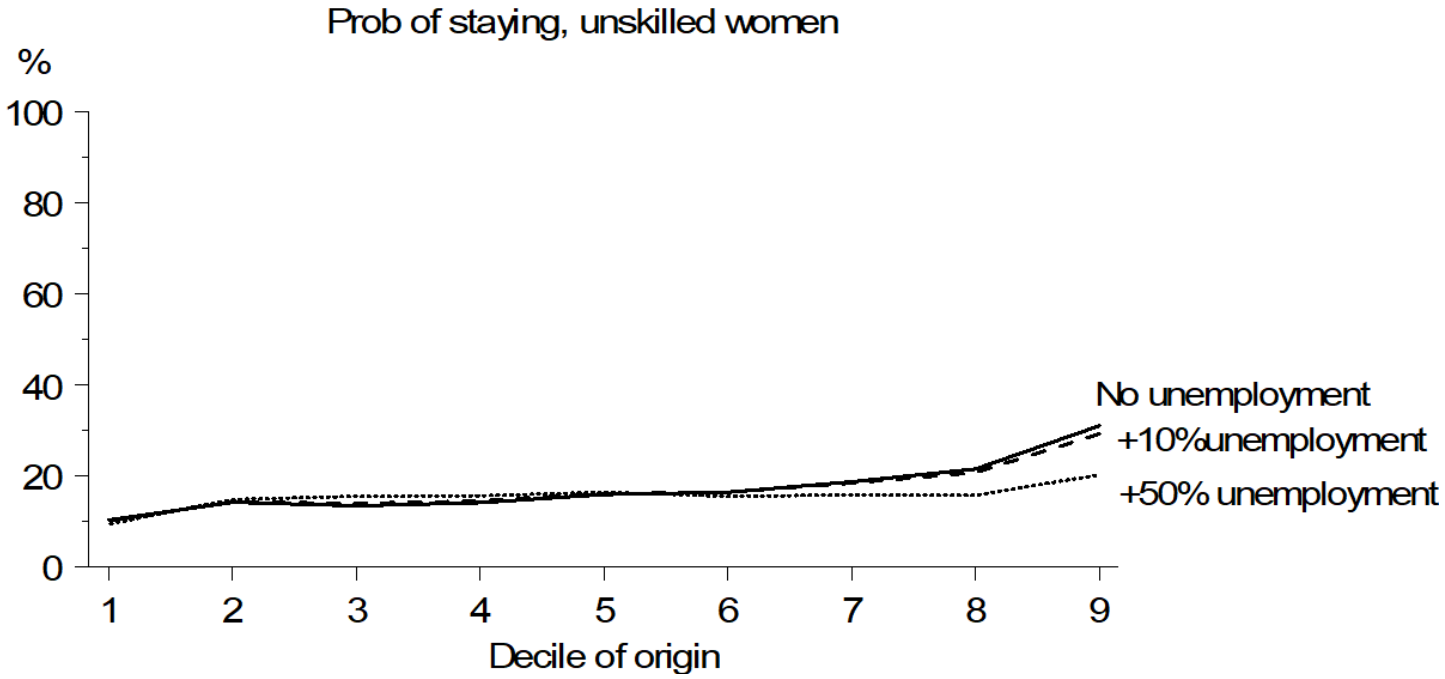

Downward mobility for unskilled men
%
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
Decile of origin
+50% unemployment
+10% unemployment
No unemployment


Upward mobility for unskilled men
%
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
Decile of origin
No unemployment
+10% unemployment
+50% unemployement


Prob of staying, unskilled men
%
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
Decile of origin
No unemployment
+10% unemployment
+50% unemployment


Downward mobility for unskilled women
%
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
Decile of origin
+50% unemployment
+10% unemployment
No unemployment





6. Conclusion

Unlike other contributions in the area this paper estimates the determinants of upward and downward wage mobility accounting for selectivity due to initial wage position and unobserved wages. This is accomplished by estimating a simultaneous nonlinear model on administrative panel data. First, we estimate a model such that the coefficients on the mobility function are constrained to be identical for different origin deciles. Second, these coefficients are estimated freely in a switching regression. Finally, we use the switching regression model to simulate the effects on wage mobility of different occupations, levels of experience and degrees of unemployment.

These simulations clearly support the conclusion that unemployment is the single most important obstacle for upward mobility. At the same time it is found to have a much stronger effect among men than among women.

The aggregate income/wage distribution covers a myriad of individual upward and downward mobility, which may be highly affected by macroeconomic policy. However, analyses of such policy rarely consider the effects on the individual dynamics.

People starting work in a job with a low salary move very quickly up the distribution of wage rates. The policy implication of this result is that attention should be paid to the creation of new jobs even if at low wages. Furthermore, policies should address the processes influencing individual relative wage growth. These are identified as on-the-job training and education.

7. References

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8. Goodness of Fit Appendix

Likelihood decompositions for the 3 marginal female equations are presented in appendix tables A3-5. Elements on the principal diagonal are the expected number of individuals correctly predicted. The wage observability equation expects 57.9% correct. Conditional upon observing a wage, the origin decile equation expects 12.5% correct. Conditional upon observing a wage and origin decile 32.0% are expected correct. While the latter fits no better than random assignment, it should be borne in mind that we are considering a model with 29 regimes, none of which collapses. No similar decomposition exists in the literature for comparison.

Table A6 compares 1 year lead predictive performance of single mobility equation estimators. The switching model estimates a mobility equation for each origin, and so fits each origin better overall. In fact, with 3 exceptions the switch dominates the single equation for all contributions by an average of 2%. Female fit is improved by the increased flexibility more so than male fit, suggesting more heterogeneity in mobility determinants for women.

Table A7 shows a similar comparison for a 4 year lead. The single mobility equation better fits downward mobility than a switch for men 6 out of 9 times. Comparing tables A6 and A7 we find the 4 year lead sample producing a better mobility fit at the expense of immobility. This is to be expected since more people are mobile over this period. The net effect is that a 4 year lead fits no better than a 1 year lead.

Table A3. Origin Wage Decile Likelihood Decomposition for Women +1 year lead 12.5% correct

Expected	Observed										
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	All
1.00	824	805	755	762	716	678	626	568	488	350	6572
2.00	823	830	793	812	775	745	699	646	569	429	7121
3.00	795	813	782	807	775	749	708	661	590	459	7138
4.00	791	828	807	842	818	800	765	724	658	529	7563
5.00	726	784	779	826	816	811	790	763	715	607	7617
6.00	663	741	753	815	820	833	830	824	800	727	7804
7.00	601	693	720	795	816	846	864	883	891	877	7985
8.00	541	637	672	754	788	834	871	917	967	1070	8051
9.00	488	578	615	697	738	794	846	917	1014	1316	8003

10.00	445	513	540	607	641	690	742	823	966	1749	7716
All	6696	7222	7215	7717	7703	7780	7742	7725	7657	8114	75570

Table A4. Wage Mobility Likelihood Decomposition for Women +1 year lead 32.9% correct

Expected	Observed			
	↓	~	↑	All
↓	6309.00	7272.00	7650.00	21230.00
~	8792.00	10297.00	10486.00	29575.00
↑	7978.00	8547.00	8239.00	24764.00
All	23079.00	26116.00	26375.00	75570.00

Table A5. Unemployment Likelihood Decomposition for Women +1 year lead 57.9% correct

Expected	Observed		
	No-wage	Wage	All
No-wage	19945.00	25455.00	45400.00
Wage	25443.00	50127.00	75570.00
All	45388.00	75582.00	120970.00

Table A6. Wage Mobility (1 Year Lead) Predictive Performance by Origin % Expected correct across estimators & samples

Origin	Wage Mobility Estimator & Sample											
	Women						Men					
	Single			Switch			Single			Switch		
	↓	~	↑	↓	~	↑	↓	~	↑	↓	~	↑
1.00	-	34.9	33.6	-	36.9	35.6	-	36.8	33.4	-	39.5	34.8
2.00	28.0	35.2	32.6	30.5	36.4	34.9	31.1	38.0	32.0	30.9	38.4	33.1
3.00	28.1	35.7	32.1	30.8	36.7	34.5	31.1	38.6	31.1	30.6	39.1	32.3
4.00	28.1	36.3	31.7	31.6	37.0	34.1	31.0	39.4	30.2	30.4	40.0	31.6
5.00	28.1	36.8	31.2	30.6	37.7	34.0	30.8	40.3	29.2	30.8	41.2	30.7
6.00	28.0	37.5	30.7	31.0	38.5	33.4	30.5	41.4	28.0	29.9	42.4	29.7
7.00	27.9	38.3	30.0	30.5	39.4	33.0	30.0	42.8	26.5	30.1	44.4	28.6
8.00	27.7	39.3	28.9	30.0	40.8	32.4	29.2	44.7	24.6	29.8	47.0	26.9
9.00	27.3	40.9	27.2	29.5	43.1	31.1	27.9	47.8	21.8	29.1	51.1	24.8
10.00	25.1	52.4	-	28.7	51.1	-	22.7	61.8	-	27.8	60.7	-

Table A7. Wage Mobility (4 Year Lead) Predictive Performance by Origin % Expected correct across estimators & samples

Origin	Wage Mobility Estimator & Sample											
	Women						Men					
	Single			Switch			Single			Switch		
	↓	~	↑	↓	~	↑	↓	~	↑	↓	~	↑
1.00	-	17.1	39.6	-	19.4	40.4	-	21.5	41.0	-	23.6	41.6
2.00	42.7	18.2	39.5	44.4	18.8	41.1	42.5	23.1	40.2	43.0	23.4	40.8
3.00	42.5	18.6	39.5	44.2	19.5	41.7	42.5	23.7	39.2	42.0	24.3	40.0
4.00	42.3	19.1	39.4	44.1	20.0	42.0	42.3	24.4	38.2	41.5	25.2	39.3
5.00	41.9	19.7	39.3	43.8	20.6	42.1	42.1	25.1	37.2	41.3	26.3	38.5
6.00	41.5	20.2	39.1	43.6	21.3	42.5	41.8	26.0	36.1	41.1	27.5	37.9
7.00	41.0	21.0	38.7	43.0	22.3	42.6	41.3	27.1	34.6	40.8	29.3	37.3
8.00	40.4	21.9	37.9	42.8	23.9	42.7	40.5	28.7	32.7	40.3	31.5	35.9
9.00	39.4	23.4	36.4	42.0	26.0	41.6	39.1	31.2	29.9	39.6	35.1	34.5
10.00	34.4	39.9	-	38.7	36.7	-	32.1	48.1	-	37.0	45.1	-

Table A8. Equation Stability Test for Men +1 year lead Substituting all estimated equations Test Statistics

Original	Substitute

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	0.00	5.90	9.40	10.72	12.51	20.53	4.97	8.42	10.00	5.90
2.00	5.90	0.00	11.52	9.85	15.47	13.37	19.00	22.65	30.01	39.94
3.00	9.40	11.52	0.00	9.08	14.23	12.71	17.51	20.64	27.21	35.31
4.00	10.72	9.85	9.08	0.00	12.58	11.52	15.60	18.11	23.20	31.05
5.00	12.51	15.47	14.23	12.58	0.00	11.24	14.27	16.56	20.97	27.99
6.00	20.53	13.37	12.71	11.52	11.24	0.00	14.94	17.14	21.70	29.47
7.00	4.97	19.00	17.51	15.60	14.27	14.94	0.00	15.85	20.15	27.08
8.00	8.42	22.65	20.64	18.11	16.56	17.14	15.85	0.00	19.86	25.58
9.00	10.00	30.01	27.21	23.20	20.97	21.70	20.15	19.86	0.00	23.64
10.00	5.90	39.94	35.31	31.05	27.99	29.47	27.08	25.58	23.64	0.00

9. Likelihood Appendix

9.1. Introduction

Suppose each member of a population is characterised by *X, Y, Z, V*. X is a vector describing a person, Z, V are binary indicators, *Y* is a vector of outcomes. All realisations of X, V are observed, but Y, Z are only observed when V=1. We are interested in the expectation of Y conditional on X:

$$\begin{aligned} E(Y|X) \quad &= E(Y|X,Z=0,V=1)P(Z=0|X,V=1)P(V=1|X) \\ &+E(Y|X,Z=1,V=1)P(Z=1|X,V=1)P(V=1|X) \\ &+E(Y|X,Z=0,V=0)P(Z=0|X,V=0)P(V=0|X) \\ &+E(Y|X,Z=1,V=0)P(Z=1|X,V=0)P(V=0|X) \end{aligned}$$

Clearly we have an identification problem where the censored sampling process reveals only some features of the population under study. Thus E(Y|X,Z=0,V=0), E(Y|X,Z=1,V=0), P(Z=0|X,V=0), P(Z=1|X,V=0) cannot be identified.

In the general (non-censored) case where *Y, Z, V* are simultaneously determined, in order to estimate E(Y|X) we must focus on the stochastic dependence between *Z, V, u*:

$$Y = X\beta + Z\gamma + V\alpha + u$$

If individuals were randomly assigned to *V, Z*, then it would be appropriate to assume that (conditional on X), *Y* are independent of *V, Z*. Otherwise, the coefficients γ, α cannot be assumed exogenous. Bias may occur if endogeneity truncates the disturbance term *u*. This can be addressed by imposing identifying restrictions in the form of parametric latent models for *V, Z*.

Our set up can be summarised as a 3-variable simultaneity problem with censored sampling (or partial observability) of 2 variables. This may be characterised as a 3-equation system: *V* determines sample selection; *Y* is the dependent variable of interest; *Z* is endogenous to *Y*. In the current application: sample selection (*V=1*) if a wage is observed in both periods; dependent variable of interest (*Y*) is mobility among deciles of a wage distribution; origin decile (*Z*) is endogenous to *Y*. Note that an N-chotomous (discrete) Z, is a straight forward generalisation of the binary case.

In the more general endogenous switching equation case, the relationship between simultaneity and censored sampling becomes more apparent (the latter being a subset of the former). Suppose, as before, each member of a population is characterised by *X, Y, Z, V*. Also *Y* could be one of two outcomes Y_0 and Y_1, according to the realisation of *Z* being 0 or 1 respectively.

$$\begin{aligned} E(Y_0|X) \quad &= E(Y_0|X,Z=0,V=1)P(Z=0|X,V=1)P(V=1|X) \\ &+E(Y_0|X,Z=1,V=1)P(Z=1|X,V=1)P(V=1|X) \\ &+E(Y_0|X,Z=0,V=0)P(Z=0|X,V=0)P(V=0|X) \\ &+E(Y_0|X,Z=1,V=0)P(Z=1|X,V=0)P(V=0|X) \end{aligned}$$

Now additionally $E(Y_0|X,Z=1,V=1)$ cannot be identified. So in the general (non-censored) case, we have 2 such equations (one for each possible realisation of *Z*):

$$Y_Z = X_Z\beta_Z + V_Z\alpha_Z + u_Z$$

Hence the latent models for *V, Z* determine respectively whether we estimate an equation for *Y* and which equation for Y we estimate. So allowing each different realisation of *Y* to be determined differently gives a censored sampling problem for Y_0, Y_1.

9.2. Econometric Framework

At any point of time the individual wage level is assumed to be determined by the observed Human Capital factors as education, experience, occupational level, seniority, industry, gender, number of children, marital status etc, all included in *Z*, and past unemployment.

The wage distribution at any time can be described by a set of deciles. Distribution over deciles is captured by an index D^* which is determined by an exogenous (human capital and controls) matrix Z and coefficient vector $\boldsymbol{\gamma}$ with disturbance $\boldsymbol{v}$. $\boldsymbol{\mu_{D?}}$ are free parameters to be estimated which split the error distribution according to *D*. $\boldsymbol{\mu_{D0}}$ is normalised to 0 for identification.

$$\boldsymbol{D^* = Z\gamma + v}$$

$$D = \begin{cases} 1 & if \quad D^* \le \mu_{D0} \\ 2 & if \quad \mu_{D0} < D^* \le \mu_{D1} \\ 3 & if \quad \mu_{D1} < D^* \le \mu_{D2} \\ . & . \\ 10 & if \quad \mu_{D8} < D^* \end{cases}$$

The lack of a wage rate, *U* is assumed to be a discrete realisation of index U*, which is determined by an exogenous characteristics matrix *Y* and a coefficient vector $\boldsymbol{\psi}$ with disturbance $\boldsymbol{v}$.

$$\boldsymbol{U^* = Y\psi + v}$$

$$U = \begin{cases} 0 & if \quad U^* \le 0 \\ 1 & if \quad 0 < U^* \end{cases}$$

Mobility M^* in the wage distribution is discretized according to *M* which indicates transition to a higher decile, nowhere, or to a lower decile. Subscript *K* denotes the origin decile. Mobility is determined by exogenous characteristics matrix *X* and coefficient vector $\boldsymbol{\beta}$ with disturbance $\boldsymbol{\epsilon}$.

$$\boldsymbol{M_K^* = X_K\beta_K + \epsilon_K}$$

$$M_K = \begin{cases} \downarrow & if \quad M_K^* \le \mu_{MK_0} \\ \sim & if \quad \mu_{MK_0} < M_K^* \le \mu_{MK_1} \\ \uparrow & if \quad \mu_{MK_1} < M_K^* \end{cases}$$

$$\forall K = 2, 3, \ldots, 9$$

Clearly it is imposible to transit down from the lowest decile or up from the highest. In a pure selectivity framework, where $\boldsymbol{\beta_K}$ and $\boldsymbol{\mu_{MK_1}}$ are fixed across origin decile these two likelihood contributions are degenerate. In other words we have a couple of three state ordered probits with only two feasible regimes each.

$$\boldsymbol{M_1^* = X_1\beta_1 + \epsilon_1}$$

$$M_1 = \begin{cases} \sim & if \quad \mu_{M1_0} < M_1^* \le \mu_{M1_1} \\ \uparrow & if \quad \mu_{M1_1} < M_1^* \end{cases}$$

$$\boldsymbol{M_{10}^* = X_{10}\beta_{10} + \epsilon_{10}}$$

$$M_{10} = \begin{cases} \downarrow & if \quad M_{10}^* \le \mu_{M10_0} \\ \sim & if \quad \mu_{M10_0} < M_{10}^* \le \mu_{M10_1} \end{cases}$$

More generally, we can allow $\boldsymbol{\beta_K}$ and $\boldsymbol{\mu_{MK_1}}$ to vary according to origin decile. This is denoted by superscript *SW* for switching and selectivity and the two degenerate ordered probit marginals are substituted for regular binomial probits.

$$\boldsymbol{M_1^{SW*} = X_1\beta_1 + \epsilon_1}$$

$$M_1 = \begin{cases} \sim & if \quad M_1^{SW*} \le 0 \\ \uparrow & if \quad 0 < M_1^{SW*} \end{cases}$$

$$\boldsymbol{M_{10}^{SW*} = X_{10}\beta_{10} + \epsilon_{10}}$$

$$M_{10} = \begin{cases} \downarrow & if \quad M_{10}^{SW^*} \leq 0 \\ \sim & if \quad 0 < M_{10}^{SW^*} \end{cases}$$

Stochastic specification is assumed multivariate normal with mean zero vector and variance covariance matrix.

$$V \begin{pmatrix} \upsilon \\ v \\ \epsilon_1 \\ \epsilon_2 \\ . \\ \epsilon_{10} \end{pmatrix} = \begin{pmatrix} 1 & \rho_{DU} & \rho_{DM1} & \rho_{DM2} & \cdots & \rho_{DM10} \\ \rho_{DU} & 1 & \rho_{UM1} & \rho_{UM2} & \cdots & \rho_{UM10} \\ \rho_{DM1} & \rho_{UM1} & 1 & 0 & \ldots & 0 \\ \rho_{DM2} & \rho_{UM2} & 0 & 1 & \ldots & 0 \\ . & . & . & . & . & . \\ \rho_{DM10} & \rho_{UM10} & 0 & 0 & \ldots & 1 \end{pmatrix}$$

In the pure selectivity model the variance covariance becomes the upper left triangle trivariate normal since we only have one mobility equation. With switching equations it is difficult to imagine characteristics which determine mobility from some origins and not others. This motivates assuming mobility equation errors are independent. For identification of the selectivity process we require appropriate exclusion restrictions. Age is assumed to exclusively affect unemployment, which is consistent with a human capital wage function. Industry and number of children are assumed to exclusively determine origin decile as well as normal human capital. Mobility includes human capital and controls together with changes in characteristics during the period.

Let us consider one of the 24 intermediate likelihood contributions which is invariant in functional form to the choice of model.

$$L_{D=5,U=0,M\sim} = \prod \begin{pmatrix} \Phi_3\left(\mu_{D4} - Z\gamma, \mu_{M5_1} - X_5\beta_5, -Y\psi, \rho_{DM5}, \rho_{UM5}, \rho_{DU}\right) - \\ \Phi_3\left(\mu_{D3} - Z\gamma, \mu_{M5_1} - X_5\beta_5, -Y\psi, \rho_{DM5}, \rho_{UM5}, \rho_{DU}\right) - \\ \Phi_3\left(\mu_{D4} - Z\gamma, \mu_{M5_0} - X_5\beta_5, -Y\psi, \rho_{DM5}, \rho_{UM5}, \rho_{DU}\right) + \\ \Phi_3\left(\mu_{D3} - Z\gamma, \mu_{M5_0} - X_5\beta_5, -Y\psi, \rho_{DM5}, \rho_{UM5}, \rho_{DU}\right) \end{pmatrix}$$

The contribution for a non-wage holder is similarly invariant.

$L_{U=1} = \prod \Phi_1\left(Y\psi\right)$

For the pure selectivity model, highest and lowest origin decile contributions have to be weighted so that probabilities sum to one. Let us consider only the case of the lowest decile, and denote simple unweighted contribution with superscript *X*. A similar expression can be obtained for decile 10.

$L_{D=1,U=0} = \prod \Phi_2\left(-Z\gamma, -Y\psi, \rho_{DU}\right)$

$$L^X_{D=1,U=0,M\sim\uparrow} = \prod \left(\Phi_2\left(-Z\gamma, -Y\psi, \rho_{DU}\right) - \Phi_3\left(-Z\gamma, -X\beta, -Y\psi, \rho_{DM1}, \rho_{UM1}, \rho_{DU}\right)\right)$$

$L_{D=1,U=0,M\uparrow} = L^X_{D=1,U=0,W\uparrow} \frac{L_{D=1,U=0}}{L^X_{D=1,U=0,W\sim\uparrow}}$

$$L_{D=1,U=0,M\sim} = L^X_{D=1,U=0,W\sim} \frac{L_{D=1,U=0}}{L_{D=1,U=0,W\sim\uparrow}}$$

In the switching case such weighting is unnecessary and we have the four contributions for marginal mobility binomial probits complicated by bivariate selectivity.

$$L_{D=1,U=0,M\uparrow} = \prod \left(\Phi_2\left(-Z\gamma, -Y\psi, \rho_{DU}\right) - \Phi_3\left(-Z\gamma, -X\beta, -Y\psi, \rho_{DM1}, \rho_{UM1}, \rho_{DU}\right)\right)$$

$$L_{D=1,U=0,M\sim} = \prod \Phi_3\left(-Z\gamma, -X\beta, -Y\psi, \rho_{DM1}, \rho_{UM1}, \rho_{DU}\right)$$

$$L_{D=10,U=0,M\downarrow} = \prod \left(\Phi_2\left(-X\beta, -Y\psi, \rho_{UM10}\right) - \Phi_3\left(\mu_{D8} - Z\gamma, -X\beta, -Y\psi, \rho_{DM10}, \rho_{UM10}, \rho_{DU}\right)\right)$$

$$L_{D=10,U=0,M\sim} = \prod \begin{pmatrix} \Phi_1\left(-Y\psi\right) - \Phi_2\left(-X\beta, -Y\psi, \rho_{UM10}\right) - \\ \Phi_2\left(\mu_{D8} - Z\gamma, -Y\psi, \rho_{DU}\right) + \Phi_3\left(\mu_{D8} - Z\gamma, -X\beta, -Y\psi, \rho_{DM10}, \rho_{UM10}, \rho_{DU}\right) \end{pmatrix}$$

>

Notes

1. The minimum wage in Denmark is a result of the collective bargaining process and is defined as the lowest wage that any member of the Employers Federation is allowed to give a member of the Trade Unions. This serves in practice as a minimum wage. However, it is not a legal minimum, and one may observe lower wages for certain non-unionised groups. ↩
2. This can cover one long spell or many shorter spells of unemployment. ↩

Frames placed on the page in the original

These frames (figures, captions, numbered equations, table labels) sat at fixed positions on a page and have no anchor in the text, so they are gathered here by page, top to bottom. Page numbers are those of the Ami Pro layout.

Page 12

$$M_1^{SW*} = X_1\beta_1 + \epsilon_1$$

Page 15

$\Delta\ \mu_1\ \rho_{Mob-Origin}\ \rho_{Mob-Unemp}\ \rho_{Origin-Unemp}$

Page 17

$\Delta\ \rho_{Mob-Origin}\ \rho_{Mob-U|e}\ \rho_{Origin-U|e}$

Page 18

$\mu_1\ \rho_{Mob-Origin}\ \rho_{Mob-U|e}\ \rho_{Origin-U|e}$

Page 20

$\downarrow \sim \uparrow \downarrow \sim \uparrow \downarrow \sim \uparrow$

Page 40

$$M_1^{SW*} = X_1\beta_1 + \epsilon_1$$

Page 45

$\Delta\ \rho_{Mob-Origin}\ \rho_{Mob-U|e}\ \rho_{Origin-U|e}$

Page 46

$\mu_1\ \rho_{Mob-Origin}\ \rho_{Mob-U|e}\ \rho_{Origin-U|e}$