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TRANSITION INTENSITIES FROM UNEMPLOYMENT

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ABSTRACT: This paper presents models of transition intensities in the labour market with an application into unemployment duration using Finnish microeconomic data. It is shown that the transition intensities from unemployment to non-participation can be estimated without having information on the state of destination. The models are based on a Gompertz distribution which yields an estimate of the proportion of unemployment persons who will not return back to employment. Allowance for neglected heterogeneity is made assuming that the effect of omitted variables has a gamma distribution across persons.

KEY WORDS: Unemployment duration, non-participation, labour force.

I. Introduction

This paper is concerned with the estimation of transition intensities in the labour market using microeconomic data. This work is motivated by the study of Theeuwes, Kerkhofs and Lindeboom (1990), who estimated the transition intensities between the three basic labour market states: not in the labour force (non-participation), employment and unemployment. Each of these states has two transitions. Theeuwes et al. estimated six models of transitions between these states and one model allowing for transitions between different jobs using Dutch data. The problem with estimating models for all these transitions is that some transitions are observed only a few times or not observed at all.

One way to avoid estimating different models of all transitions is to estimate models of choosing or leaving a state. The choice between non-participation and participation in the labour market are the basis for the studies of supply of labour. The two-state estimation procedure is one way to model the supply of labour. The first stage is discrete choice estimation of the probability of entering labour force, and the second stage is ordinary least square estimation of the working hours (Heckman, 1976, 1979).

There has been a lot of theoretical and empirical research concerning the transitions from employment. The main qualitative predictions of the model for tenure data is given by Jovanovic (1984). One of the implications is that tenure distribution should be defective, i.e. it has a property that the limit of the distribution function as $t \to \infty$ is positive, because some people will not leave the state. This requirement is satisfied by the Inverse Gaussian distribution, which has been applied by Lancaster and Chesher (1985).

The models of leaving unemployment have been widely studied in search theoretical and microeconometric literature. However, there have not been very many studies concerning the well known and important feature of unemployment that some persons will not return back to work. Atkinson and Micklewright (1990) argue that the state of non-participation should be incorporated in models of labour market. Recently van den Berg (1990) has allowed for transitions from unemployment to non-participation. He estimated a model of unemployment duration using information on the state of destination. Such data is not, however, available in this study. This paper shows that information on the state of destination is not necessarily needed and provides alternative models to estimate transition intensities from unemployment to employment and non-participation. The proportions of the persons who will never return back to work are estimated from the data, where the completed spells are not observed for all the observations.

If some persons never return back to work, there are some mathematical requirements for the distribution of unemployment spells. The distribution should allow that the probability of leaving unemployment is low enough for some of the persons that they will never return back to work. It means that the survivor function should allow a possibility of asymptotically decreasing to a positive value instead of zero. These kinds of distributions are called defective. They give estimates for the proportion of persons who will never return back to work. A Gompertz distribution allows for the defectiveness, which is not assumed a priori. A model of unemployment duration is estimated in section II using Finnish microeconomic data.

In an econometric analysis relevant variables will often be omitted, either because they are unmeasurable or because their importance is unsuspected. It is well known that neglected heterogeneity biases the parameter estimates [Lancaster (1979), Nickell (1979)]. In this paper the heterogeneity is taken into account in estimation. A Gompertz model allowing for neglected heterogeneity is derived assuming that the effect of omitted variables has a gamma distribution across individuals.

II. Parametric duration models of unemployment

A general form of the duration model

A general form for the likelihood function of parametric duration models with censored data is presented before the parametrisation of the distribution. Let us consider independent pairs of independent random variables T and Z, where T is the duration variable of primary interest and Z is a censoring variable. The duration of unemployment is defined as the difference between the date of entry into unemployment and the date of returning back to work. A censoring time or a duration time and a censoring indicator are observed as

$$t = \min(T, Z) \tag{1}$$

$$\bar{c} = \begin{cases} 1 \text{ if } T \geq Z \\ 0 \text{ otherwise.} \end{cases} \tag{2}$$

An indicator of a completed spell of unemployment is defined as $c = 1 - \bar{c}$. The survivor function of T is equal to one minus the distribution function of the duration variable, which can be written as

$$S(t) = e^{-I(t)}. \tag{3}$$

It is the probability that an individual has not returned back to work. The density function of the duration of unemployment can be written as

$$f(t) = h(t)\, e^{-I(t)} \tag{4}$$

for $t \geq 0$. $I(t)$ is the integrated hazard

$$I(t) = \int_0^t h(\tau)d\tau. \tag{5}$$

The likelihood contribution of an individual is then

$$\ell(t) = f(t)^{c}\ S(t)^{\bar{c}}, \tag{6}$$

which can be written in view of the above definitions as

$$\ell(t) = h(t)^{c}\ e^{-I(t)}, \tag{7}$$

which is a general form of the likelihood contribution for the duration models with right censored data. The distribution of unemployment duration has to be specified. To estimate the unknown parameters the hazard function and integrated hazard are substituted into (7).

A Gompertz model allowing for gamma heterogeneity

Econometric duration models are specified in terms of the hazard function h(t), which is the conditional probability that the person becomes employed at t given that he still is unemployed. A commonly applied specification is the proportional hazard model, where the hazard function factors into the product of a function of duration time t and a function of the regressors x.

$$h(t) = h_0(t)h_1(x), \tag{8}$$

where $h_0(t)$ is called the baseline hazard.

A very often neglected feature of unemployment spells is that some of the unemployed persons will not return back to work. They may leave the labour force before the re-employment. Some of the reasons may be retirement, unemployment pensions or even death. This feature of unemployment spells can be taken into account using defective distributions. Such distributions are by no means worse than others, but it means that there is always mass in the survivor function regardless of how long the duration time is. Therefore it is reasonable to assume a Gompertz distribution, which is an extension of the exponential distribution. The baseline hazard of a Gompertz distribution is $h_0(t) = \exp(t\theta)$.

The hazard function of the two parametric Gompertz distribution may be written as follows

$$h(t) = \phi e^{t\theta}. \qquad (9)$$

The hazard function varies as an exponential function of time starting from ϕ. The explanatory variables x are introduced into the model by a log-linear form $\phi = e^{x\beta}$, where β is a vector of structural parameters.

The integrated hazard of the Gompertz distribution can be written as

$$I(t) = e^{x\beta}(e^{t\theta} - 1)/\theta. \qquad (10)$$

The survivor, density and hazard functions of the Gompertz distribution can then be written as

$$S(t) = e^{-e^{x\beta}(e^{t\theta} - 1)/\theta} \tag{11}$$

$$f(t) = e^{x\beta + t\theta - e^{x\beta}(e^{t\theta} - 1)/\theta} \tag{12}$$

$$h(t) = e^{x\beta + t\theta}. \tag{13}$$

It is inevitable that in an econometric analysis relevant variables will be omitted, either because they are unmeasurable or because their importance is unsuspected. Unobserved heterogeneity is widely discussed in the econometric literature. Lancaster (1979) assumed a parametric functional form for the pattern of heterogeneity. The gamma mixing distribution was chosen because it is analytically simple to use and it provides quite a flexible model for the distribution of the heterogeneity component. Lancaster found that the estimated parameters were biased towards zero if the unobserved heterogeneity was not controlled. Even if the omitted variables are uncorrelated with those which are included in the model, the parameters will be biased towards zero (Nickell, 1979). The method of correcting for gamma heterogeneity has been widely used with exponential and Weibull duration distributions [e.g. Kooreman and Ridder (1983), Newman and McCulloch (1984), Narendranathan, Nickell and Stern (1985), Engström and Löfgren (1987)]. In this paper the assumption of gamma heterogeneity has been extended to the Gompertz distribution.

Suppose the individuals of the sample differ to some degree with respect to some unobservable variable, say, motivation v. Each individual has his own v and hence his own hazard function h(t). Lancaster (1979) using data on a stock of unemployed persons assumed that these hazards have a gamma distribution. It is analytically simple to use and a feasible distribution allowing a wide range of possible distributions for the heterogeneity assumptions.

The conditional hazard in a Weibull model allowing for gamma heterogeneity is

$$h(t|v) = v\ h(t), \tag{14}$$

where v has a gamma density

$$g(v) = \frac{\epsilon^{\mu}}{\Gamma(\mu)} v^{\mu-1} e^{-\epsilon v} \quad \text{with} \quad \Gamma(\mu) = \int_0^{\infty} w^{\mu-1} e^{-w} dw. \tag{15}$$

The expected value of the heterogeneity component $E(v) = \mu/\epsilon$ is normalized to one by setting $\epsilon = \mu$ and its variance, i.e. $\sigma^2 = 1/\mu$, is estimated. The marginal survivor function, not conditional on v, is obtained by integrating over the assumed mixing distribution. The density function is obtained from the survivor function by differentiating $f(t) = - \delta S/\delta t$ and the hazard function is obtained as a ratio $h(t) = f(t)/S(t)$. The Gompertz distribution allowing for unobserved gamma heterogeneity across individuals gives the following survivor, density and hazard functions

$$S_g(t) = [1 + \sigma^2 I(t)]^{-1/\sigma^2} \tag{16}$$

$$f_g(t) = h(t)[1 + \sigma^2 I(t)]^{-1/\sigma^2 - 1} \tag{17}$$

$$h_g(t) = h(t)[1 + \sigma^2 I(t)]^{-1}, \tag{18}$$

where $I(t)$ is the integrated hazard of the original Gompertz distribution (10). The integrated hazard with gamma heterogeneity can be written as $I_g(t) = -\log[S_g(t)]$, which is in an other form as follows

$$I_g(t) = 1/\sigma^2 \log[1 + \sigma^2 I(t)]. \tag{19}$$

The integrated hazards $I(t)$ and $I_g(t)$ are the generalized residuals of these models in the sense of Cox and Snell (1968).

To write the likelihood functions and estimate the unknown parameters, the hazard functions and the integrated hazards of the two models presented are substituted into the log likelihood contribution (7). For completeness the log likelihood functions which are maximized are presented. The likelihood function of the Gompertz model can be written as

$$L(\theta,\beta) = \sum_{i=1}^{n} c(x\beta + t\theta) - e^{x\beta}(e^{t\theta} - 1)/\theta \qquad (20)$$

and the log likelihood function of the Gompertz model with gamma heterogeneity can be written as

$$L(\theta,\beta) = \sum_{i=1}^{n} c(x\beta + t\theta) - (c + 1/\sigma^2)\log[1 + \sigma^2 e^{x\beta}(e^{t\theta} - 1)/\theta]. \qquad (21)$$

To see the shape of the survivor function of the Gompertz model consider their limits:

If $\theta < 0$, then $\lim_{t\to\infty} S(t) = e^{e^{x\beta}/\theta}$.

If $\theta > 0$, then $\lim_{t\to\infty} S(t) = 0$.

The limits of survivor functions after allowing for gamma heterogeneity can be written as follows:

If $\theta < 0$, then $\lim_{t\to\infty} S_g(t) = [1 - \sigma^2 e^{x\beta}/\theta]^{-1/\sigma^2}$.

If $\theta > 0$, then $\lim_{t\to\infty} S_g(t) = 0$.

These limits give estimates for the proportion of individuals who will never return back to work. No person remains unemployed for ever. Therefore the transition intensities from unemployment to non-participation can be estimated without having information on the state of destination.

Retrospective data can be misleading because people forget and make mistakes. Therefore the data on 2077 Finnish unemployed persons used in this study has been taken from the register of the Ministry of Labour. It is more reliable than the data from surveys. 40 % of the observations are right censored, i.e. the completed spells of unemployment were not observed. In order to guarantee that the sample would be randomly generated, every hundredth individual was picked from the flow into unemployment during 1985. The individuals were then followed until the end of their unemployment spells but at most until the end of 1986. The data set is fairly rich in individual and market specific information. The description of the variables of the models are in Appendix and reference for further details regarding the data should be made to Kettunen (1989, 1990).

The results of estimations are in Table 1. The parameter estimate of duration dependence θ is negative indicating that the hazard function is decreasing and that the survivor function is asymptotically decreasing to a positive value. Hence some persons will never return back to work. When gamma heterogeneity is introduced into the model, the negative duration dependence decreases, as was expected. Another implication of the negativeness of θ is that the expected value of the duration for the sample is not defined, because some persons do not become employed again. This fact can be seen e.g. in Broadbent (1958) and Lee

(1980). The constant of the model, where the effect of omitted variables is captured, decreases and the absolute values of the statistically significant parameter estimates increase when gamma heterogeneity is introduced into the model, as was expected.

Many of the explanatory variables have significant effects on the re-employment probability. Married persons seem to return back to work earlier than single persons. Age is a very significant factor. Older people are more apt to incur problems in finding jobs. Training for further employment has a significant and positive effect on the re-employment probability. Members of the UI funds, i.e. members of the labour unions, are often skilled workers and therefore they become employed earlier than the non-members. The persons leaving school or the army have usually not very big problems, since they find acceptable jobs clearly earlier than the others. The persons who have come from house work find it very difficult to find a job. The effects of unemployment benefits are measured using the benefit replacement ratio. The benefits decrease significantly the re-employment probability as is expected by the search theoretical models. The number of children, gender, level of education, demand variables and taxable assets do not have statistically significant effects on the re-employment probability.

Table 1. Gompertz models of unemployment duration

Dependent variable: The length of the spell of unemployment

(A) A Gompertz model
(B) A Gompertz model with gamma heterogeneity

	(A)	(B)
	Sdt.errors in parentheses	
θ	-0.023	-0.010
	(0.002)	(0.005)
σ^2		0.332
		(0.127)
Constant	-1.639	-1.363
	(0.132)	(0.181)
Number of children	-0.001	-0.005
	(0.054	(0.063)
Married	0.147	0.148
	(0.069)	(0.082)
Sex	-0.011	-0.031
	(0.060)	(0.072)
Age	-0.039	-0.046
	(0.003)	(0.005)
Level of education	0.044	0.051
	(0.062)	(0.075)
Training for employment	0.183	0.226
	(0.077)	(0.094)
Member of UI fund	0.208	0.258
	(0.064)	(0.078)
Came from schooling	0.278	0.300
	(0.082)	(0.101)
Came from house work	-0.649	-0.742
	(0.135)	(0.154)
Regional demand	0.113	0.155
	(0.242)	(0.278)
Occupational demand	0.563	-0.352
	(0.627)	(0.761)
Taxable assets	0.765	0.791
	(1.115)	(1.240)
Replacement ratio	-1.232	-1.533
	(0.157)	(0.197)
Log likelihood	-4931.8	-4927.4

The model specification was examined using a graphical procedure suggested by Lancaster and Chesher (1985). The product limit procedure allowing for censored data was applied to the integrated hazards (10) and (19) in order to estimate the residual survivor functions $\hat{S}(\hat{I})$ and $\hat{S}(\hat{I}_g)$. The plot of the opposite of the logarithm of the residual survivor function should give a 45° line through the origin in large samples, when the model is right. The residual plots are in the Figure 1. They are fairly precisely on the 45° line except for the last few observations. The Gompertz models seem to be clearly better specified than the corresponding Weibull models (see Kettunen, 1991).

Fig. 1. Residual plots of duration models

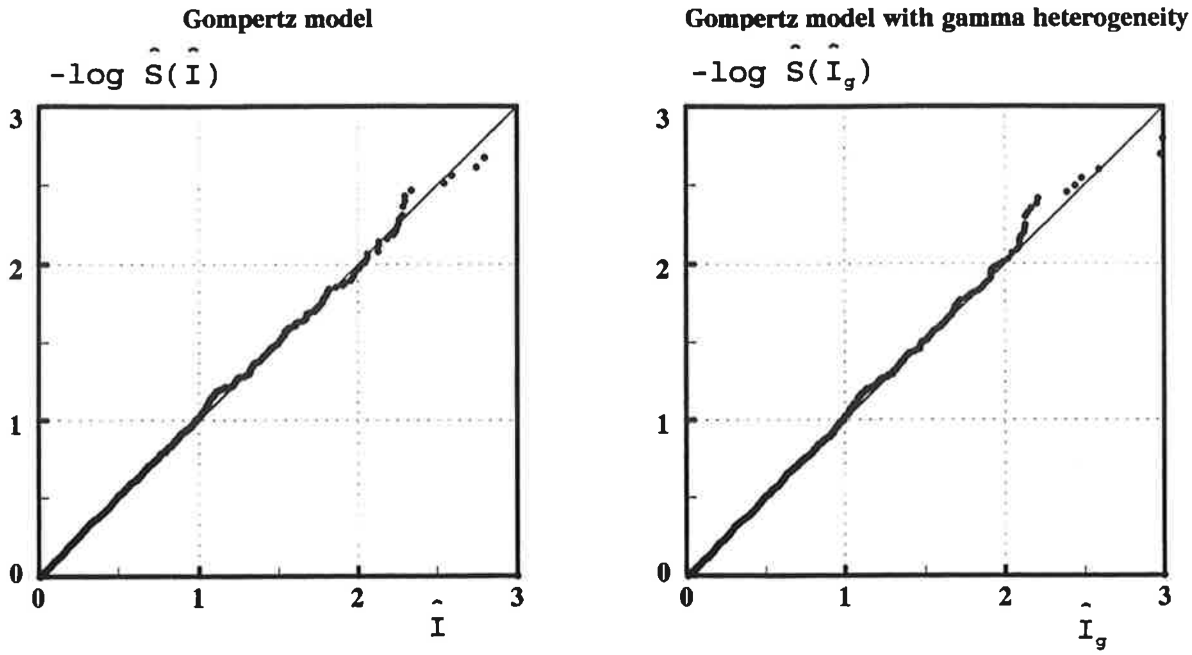

Table 2 includes the estimates of proportions of the unemployed persons who do not return back to work. The figures have been calculated for an average person in the sample. The limits of the survivor function as the duration of unemployment approaches to infinity give the lowest estimates of the proportion of the persons who will never return back to work. However, instead of infinity it may be more reasonable to calculate the proportions for a number of years, say, 2 and 5 years.

It is well known that uncontrolled unobservables bias the estimated hazards towards negative duration dependence (Heckman and Singer, 1984, 1986). Consequently, it could be expected that after allowing for gamma heterogeneity the estimates of survivor functions would be lower. The estimates of the survivor function of the Gompertz model at 2 and 5 years unemployment are 0.088 and 0.069 respectively and the survivor function is decreasing to a value 0.062 showing that more than 6 % of the individuals will not return back to work according to the model. After allowing for gamma heterogeneity the corresponding estimates are 0.076, 0.038 and 0.032 respectively. The estimates of the survivor functions are lower after taking into account the effects of omitted variables as was expected. As a final estimate it can be said that more than 3 % of the persons who became unemployed during 1985 will never return to work again.

Table 2. The proportion of unemployed persons who will not return to work

	Years		
	2	5	∞
A Gompertz model	0.088	0.069	0.062
A Gompertz model with gamma heterogeneity	0.076	0.038	0.032

III. Conclusions

A Gompertz model of unemployment duration was estimated using Finnish microeconomic data collected from various registers. Completed spells are not observed for all the observations in the data. The model takes into account the censored observations and the feature of unemployment spells that for some of the persons the re-employment probability is very low so that they will never become employed again. The model gives an estimate of the proportion of persons who will never find a job. The estimated proportion given by a Gompertz model is slightly more than 6 %.

Even though the data are rich of explanatory variables and more reliable than the data from surveys, there is reason to assume that relevant variables have been omitted from the model. Neglected heterogeneity across individuals was taken into account in estimation. A Gompertz model allowing for gamma heterogeneity was derived and estimated assuming that the effect of omitted variables has a gamma distribution across individuals.

Comparing the results of the two models shows that the model without correcting for heterogeneity gives lower estimates of parameters. The absolute values of parameters increase when heterogeneity is introduced in to the model. Furthermore, the Gompertz model gives estimates for the hazard function that are too low. Consequently, the survivor function of the model with gamma heterogeneity is lower and the estimate of the proportion of persons who will never return back to work is slightly more than 3 %.

Many of the explanatory variables have significant effects on the re-employment probability. Married persons, members of labour unions, school graduates and persons with training for employment return back to work earlier than other persons. Old people, persons who have come from house work and those who get high unemployment benefits have longer unemployment spells than the others.

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Appendix. Variables of the data

Duration of unemployment is calculated in weeks and it is the difference between the date of entry into unemployment and the date of returning back to work. Mean = 15.03.

Number of children is the number of unemployed person's children who are younger than 18 years old. Mean = 0.23.

Married is a dummy variable, 1=yes. Mean = 0.37.

Sex is a dummy variable, 1=male. Mean = 0.54.

Age is measured in years. Mean = 31.2.

Level of education is a dummy variable, 1 = at least 12 years education. The level of education is based on the education code of the Central Statistical Office of Finland. Mean = 0.45.

Training for employment is a dummy variable, 1 = The person has got training for further employment. Mean = 0.15.

Member of UI fund is a dummy variable, 1 = yes. Mean = 0.42.

Came from schooling is a dummy variable, 1 = The person has come from schooling or from the army. Mean = 0.13.

Came from house work is a dummy variable, 1 = The person has come from home or elsewhere outside the labour force. Mean = 0.07.

Regional demand describes the regional rate of jobs available. It is the number of vacancies divided by the number of job seekers in the area. Mean = 0.10.

Occupational demand describes the occupational rate of jobs available in the whole country. It is the number of vacancies divided by the number of job seekers in the occupation group. Mean = 0.12.

Taxable assets has been compiled from the tax register and it is measured in millions of marks. Mean = 0.011.

Replacement ratio is unemployed persons average replacement ratio of unemployment benefits during the unemployment period after tax. Weekly unemployment benefits after tax have been divided by the weekly income after tax. Mean = 0.17.

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