ACTA UNIVERSITATIS LODZIENSIS
FOLIA OECONOMICA 196, 2006

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MULTINOMIAL LOGIT MODEL AND ITS APPLICATION IN LABOR MARKET POSITION ANALYSIS OF INDIVIDUALS IN POLAND

Abstract. In this paper we undertake an attempt to assess an impact which levels of education and vocational skills both have on the individuals' position in the labor market. This position we define on the basis of probability of loosing a job by the employed and odds of finding a job by the unemployed.

The basis of econometric analyses is a so-called multinomial logit model, which allows us to estimate relative probabilities of labor force flows between labor market statuses, depending on demographic, economic and social features of the individuals.

Key words: unemployment, employment, logit model.

1. INTRODUCTION

Labor market performance is of big importance for a position of individuals in the labor market. In times of economic recovery and low unemployment it is easier to maintain jobs and find new places of work. When situation in the labor market gets worse, probability to find new jobs is lower and risk of losing jobs is higher.

Labor market positions of individuals depend not only on general labor market performance but also on personal characteristics of individuals, especially socio-economic characteristics. Socio-economic characteristics of individuals concerning educational attainment levels, skills and occupations are important variables exerting influence upon positions of individuals in the labor market.

In the analysis of relationships between variables one must choose a method of statistical analysis. This method should be dependent on a type and scale of variables analyzed in order to get conclusions drawn properly.

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In statistical analyzes quantitative and qualitative (nominal) variables are used. Logit models are often used if qualitative variables are dependent variables (cf. Domański 1998, p. 67). That is why logit model can be used in order to analyse individual's positions in the labor market.

The goal of the paper is to present a multinomial logit model and its application in labor market position analysis of individuals in the Polish economy. We shall try to describe how socio-economic characteristics of individuals concerning education and occupation influence positions of persons in the labor market measured by probabilities of losing jobs and finding new jobs.

Empirical basis of the paper is based on individual data coming from labor force surveys conducted in Poland in 2000. Since the surveys are conducted quarterly we use three streams of flow data between neighbouring quarters, namely I–II quarters, II–III quarters and III–IV quarters. The flow data refer to transitions of individuals between three labor market states: employment, unemployment and inactivity. These flow data are used to estimate probabilities of losing jobs and finding new jobs.

The structure of the paper is as follows. In Section 2 multinomial logit model is presented. Section 3 is focused on probabilities of losing and finding jobs dependent on socio-economic characteristics of individuals. Section 4 concludes.

2. MULTINOMIAL LOGIT MODEL

In the analysis of factors determining labor force flows between particular categories of labor force status we use a multinomial logit model (cf. Chow 1995, Greene 1993; Kwiatkowski, Steiner 1996). It is a model allowing, similarly like a hazard model, to estimate a risk that a specified event will occur.

The probability that a certain event will occur (e.g. flow from employment to unemployment) can be quantified by estimating the logit function parameters. Parameters of the multinomial logit model are estimated by means of the maximum likelihood method. The probability that event j (e.g. move from employment to unemployment) for *i*-th investigated individual will occur equals to (cf. Chow 1995, p. 316; Greene 1993, p. 666–667):

$$P_{ij} = \frac{e^{\beta' z_{ji}}}{\sum_{k=1}^{J} e^{\beta' z_{ji}}}, \tag{1}$$

where:

P_{ij} – probability of flow, for instance from employment to unemployment,

z_{ij} – is the column vector of characteristics of j-th possibility (every individual can choose move to one of the status of the labor market) and i-th individual. This vector contains characteristics of particular individuals, such as: education or profession exercised in current or previous place of work. In other words, it is a vector of independent variables. Vector $\boldsymbol{\beta}$ on the other hand, is a column vector of estimated parameters.

The likelihood of the sample can be described by the formula:

$$L = \prod_{i=1}^{n} P_{1i}^{f_{1i}} P_{2i}^{f_{2i}} \ldots P_{J_i i}^{f_{J_i i}} \tag{2}$$

where:

L – likelihood of the sample,

$P_{1i}^{f_{1i}}$ – probability that 1 individual chooses j-th possibility (e.g. flow from employment to unemployment).

A dummy variable f_{ji} (in equation 2) takes the value of 1, when i-th individual chooses j-th possibility and 0 otherwise. Using this variable it is possible to observe frequency of i-th individual chooses j-th possibility. Our sample is composed of n individuals. Each of the observed persons can choose from J_i possibilities (namely employment, unemployment or economic inactivity).

Log likelihood function (log of formula 2) can be written as (cf. Chow 1995, p. 316):

$$\ln L = \sum_{i=1}^{n} \sum_{J=1}^{J_i} f_{ij} \ln P_{ji} = \sum_{i=1}^{n} \sum_{j=1}^{J_i} \ln \frac{e^{\beta' z_{ji}}}{\sum_{k=1}^{J} e^{\beta' z_{ki}}} = \sum_{i=1}^{n} \sum_{j=1}^{J_i} f_{ji} z_{ji} - \sum_{i=1}^{n} \sum_{j=1}^{J_i} f_{ji} \ln \left(\sum_{k=1}^{J} e^{\beta' z_{ki}} \right) \tag{3}$$

The likelihood function (L) reaches its maximum in relation to the vector $\boldsymbol{\beta}$ then and only then when the function ($\ln(L)$) is achieving its maximum. For the function ($\ln(L)$) to achieve its maximum it is necessary and sufficient, that:

$$\frac{\partial \ln(L)}{\partial \boldsymbol{\beta}} = \sum_i \sum_j f_{ji} \mathbf{z}_{ji} - \sum_i \sum_j f_{ji} \left(\sum_k e^{\beta' z_{ki}} \right)^{-1} \sum_k e^{\beta' z_{ki}} \mathbf{z}_{ki} = \sum_i \sum_j f_{ji} (\mathbf{z}_{ji} - \bar{\mathbf{z}}_i) = 0, \tag{4}$$

where: $\mathbf{z}_i = \sum_j P_{ji}\mathbf{z}_{ji}$

and, Hessian:

$$H = \frac{\partial^2 \ln L(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}\, \partial \boldsymbol{\beta}} \leqslant 0 \tag{5}$$

should be non-positively defined (cf. Greene 1993, p. 643–644). It can be proved that the Hessian from formula (5) is always negatively defined and, thus, the column vector $\boldsymbol{\beta}$ – being the solution for equation (4), will be always determining the logit function estimators, which maximize the likelihood function (described by equations 2 and 3). Equation (4) is solved by using the iterative Newton-Raphson method (this algorithm is explained in details in works of Chow 1995, p. 317 and Greene 1993, p. 347–348, 352–353).

3. THE RESULTS OF ECONOMETRIC ANALYSES

Econometric analyzes of the paper are based on individual data coming from 4 quarters of the Polish Labor Force Surveys.

Before moving on to estimating the multinomial logit model, a sample must be properly prepared. First of all data for each quarter analyzed should be associated with one observation. In the estimation of the multinomial logit model we will use the Stata 7.0 software.

In order to state how independent variables determine the probability of flows from employment to unemployment and economic inactivity, we will be using relative risk ratios. The ratio value greater than 1 means that a given group is characterized by a higher risk of, for instance outflow from employment to unemployment, than individuals belonging to the base category. On the other hand, the ratio value lower than 1 means that individuals in a given group are, to a lesser extent, threatened by unemployment in comparison with the base category.

At this stage we will focus on analyzing differentiation of relative odds to outflow from employment to unemployment and economic inactivity depending on individuals' education. The estimations of relative odds to outflow from employment to unemployment and economic inactivity by education are presented in Table 1. From Table 1, the following conclusions can be drawn. Firstly, threat of outflow from employment to unemployment is connected with the level of education of the employed. In the analyzed period persons with tertiary education had lowest relative "odds" of moving

Table 1. Estimations of relative odds of flows from employment by education in Poland, 1st quarter 2000 – 4th quarter 2000

Independent variable	To unemployment		To economic inactivity	
	RRR	*t*-Student	RRR	*t*-Student
Base category – basic vocational				
Tertiary	0.27	–5.11	0.71	–2.16
Post-secondary	0.72	–1.10	0.94	–0.25
Secondary general	0.99	–0.02	1.45	2.37
Secondary vocational	0.77	–2.10	0.81	–1.77
Primary and less than primary	0.96	–0.29	1.85	5.98

Note: number of observations: 30 372, log likelihood: –5211.76.
Source: data from LFS.

from employment to unemployment in comparison to persons with basic vocational education. A better situation of those with higher education comes from the fact that individuals at this level of education possess (potentially) larger stock of human capital. Secondly, also persons with secondary vocational education were to lesser extent threatened by moving from employment to unemployment in comparison with individuals from the base category. We can say that, despite of drawbacks in vocational education in Poland, persons holding this level of education have significantly higher qualifications than individuals who finished their education on the basic vocational level. Thirdly, persons with tertiary education had lower odds of moving from employment to the economic inactivity than individuals belonging to the base category. On contrary, persons with secondary general, primary and less than primary, had the abovementioned odds higher. Persons with primary and less than primary education probably exercised the possibility to benefit from pre-pension or early retirement schemes. Persons with secondary general education were moving to economic inactivity in order to raise their level of education.

At this point we will try to answer the question, what is an impact of the profession exercised or specialty on odds to remain employed. Estimations of relative odds of flow from employment to unemployment and to economic inactivity by vocational skills are shown in Table 2. From Table 2 it appears, that the persons employed in professions subsumed to 1st, 2nd and 3rd group of the classification of professions and specialties (parliamentary deputies, officers, managers, specialists, technicians and other medium level personnel) were to a lesser extent threatened by loosing their

job and flowing to unemployment, in comparison to the base category (workers and craftsmen). The persons subsumed to the first three groups of the classification are characterized by the highest level of skills. Also individuals working as farmers, gardeners, foresters and fishermen found themselves in a distinctively better situation than workers and craftsmen. It certainly results from the fact that individuals working in these professions work in their own enterprises or farms.

Table 2. Estimations of relative odds of flows from employment by vocational skills in Poland, 1st quarter 2000 – 4th quarter 2000

Independent variable	To unemployment		To economic inactivity	
	RRR	*t*-Student	RRR	*t*-Student
Base category – workmen and craftsmen				
Parliamentary deputies, officials, managers, specialists, technicians and other medium level personnel	0.26	–7.45	0.86	–1.10
Office workers, personal service personnel and salespersons	1.02	0.16	1.22	1.36
Farmers, gardeners, foresters and fishermen	0.34	–6.07	1.52	3.20
Operators and assemblers of machinery and equipment, unskilled workers	1.14	0.99	1.51	2.96

Note: number of observations: 30 372, log likelihood: –5180.56.
Source: as Table 1.

Table 3. Estimations of relative odds of flows from unemployment by education in Poland, 1st quarter 2000 – 4th quarter 2000

Independent variable	To employment		To economic inactivity	
	RRR	*t*-Student	RRR	*t*-Student
Base category – basic vocational				
Tertiary	1.73	2.86	2.16	3.03
Post-secondary	1.36	1.28	1.17	0.42
Secondary general	0.90	–0.67	1.15	0.64
Secondary vocational	1.15	1.36	1.13	0.80
Primary and less than primary	0.78	–2.19	1.29	1.81

Note: number of observations: 6010, log likelihood: –3508.93.
Source: as Table 1.

Table 4. Estimations of relative odds of flows from unemployment by vocational skills in Poland, 1st quarter 2000 – 4th quarter 2000

Independent variable	To unemployment		To economic inactivity	
	RRR	*t*-Student	RRR	*t*-Student
Base category – workmen and craftsmen				
Parliamentary deputies, officials, managers, specialists, technicians and other medium level personnel	0.91	–0.60	1.23	0.83
Office workers, personal service personnel and salespersons	0.70	–2.70	0.84	–0.85
Farmers, gardeners, foresters and fishermen	0.63	–1.45	2.10	2.29
Operators and assemblers of machinery and equipment, unskilled workers	0.94	–0.50	1.08	0.42
Persons with no professional experience	0.70	–3.28	1.50	2.52

Note: number of observations: 6010, log likelihood: –3505.01.
Source: as Table 1.

Lets as have an insight now on how level of education and vocational skills influences odds of outflows from unemployment to employment. Estimations of relative odds of outflows from unemployment to employment and economic inactivity by education and vocational skills are presented in Tables 3 and 4. From the analysis of data in Tables 3 and 4, the following conclusions can be drawn:

1. During the whole period persons with tertiary education had significantly better odds of outflows from unemployment to employment in comparison to people holding basic vocational education. This stands in accordance with the theory of human capital, which claims that persons possessing higher level of human capital have better odds to find a job.

2. Persons with primary and less than primary education had poorer odds to find a job, compared to individuals from the base category. These individuals have a very low level of skills.

3. Office workers as well as personal service personnel and salespersons had, in the analyzed period, poorer odds for moving from unemployment to employment in comparison to persons belonging to the base category. A worse situation of these profession groups results probably from the type of their skills. These persons possess rather peculiar qualifications and, what appears from the human capital theory, individuals with this kind of skills have little odds for finding a job.

4. Persons with no professional experience (mostly graduates) had poorer odds to outflow from unemployment to employment and bigger odds for moving into economic inactivity, than individuals from the base category.

4. CONCLUSIONS

Multinomial logit model is a useful tool of analyzing labor market position s of individuals. It allows to describe how socio-economic characteristics of individuals impact their probabilities of transitions from employment to unemployment and from unemployment to employment. Due to the estimations of parameters of the multinomial logit model one can identify problem groups of labour force in the labour market, i.e. the groups characterized by the highest probability of losing jobs and by the lowest probability of finding jobs. This knowledge can be used by policy makers while addressing active labor market policy programmes.

The results of econometric analyzes confirm a big role human capital in the present Polish economy. The stock of human capital embodied in educational attainments and occupational skills results in labor market status of individuals. People with tertiary education and specialists have the best position in the labor market: both in terms of probabilities of losing jobs and the chances of finding jobs. The worst position have the persons with primary and basic vocational education as well as unskilled workers and persons with no professional experience.

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WIELOMIANOWY MODEL LOGITOWY I JEGO ZASTOSOWANIE W ANALIZIE POZYCJI OSÓB NA RYNKU PRACY W POLSCE

(Streszczenie)

Celem artykułu jest uchwycenie wpływu poziomu wykształcenia i kwalifikacji zawodowych na pozycję jednostek na rynku pracy. Pozycję tę określamy w oparciu o prawdopodobieństwo utraty pracy przez osoby pracujące oraz szanse znalezienia pracy przez osoby bezrobotne.

Podstawą analiz empirycznych, podjętych w artykule, są dane jednostkowe, pochodzące z badań aktywności ekonomicznej ludności (BAEL) z roku 2002.