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Occupational mobility networks of female and male higher education graduates

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Abstract. *We employ a network based approach to explore occupational mobility of the Romanian university graduates in the first years after graduation. This representation of data permits us to use the novel statistical techniques developed in the framework of weighted directed networks in order to extract a set of stylized facts that highlight patterns of occupational mobility: centrality, degree and network density. We find that the gender plays a significant role in shaping the patterns of occupational mobility.*

Keywords: occupational mobility; weighted networks; econophysics.

JEL Classification: E58.
REL Classification: 8J.

1. Introduction

Occupational mobility represents an important feature of the labour markets. While there is a rich literature on the structure and rate of occupational mobility, there are important gaps in understanding career trajectories. Such a challenge should rely on understanding individual histories of transitions among occupations into coherent sequences, if such patterns exist. This paper explores the early career of higher education graduates during the first years after graduation in order to understand their occupational mobility. For understanding paths of occupational mobility, we unify elements from job mobility and human capital theories. By exploiting a unique dataset on working histories of higher education graduates from Romania, we provide novel evidence on the fact that individuals move to similar occupations and that the entrance occupation influence their subsequent career.

We extract a set of stylized facts regarding the occupational mobility of the university graduates by employing a network based approach in which the nodes are represented by occupations and the links by the numbers of individuals moving from one occupational category to another. Such an approach helps us to better visualize paths of mobility and calculate network indicators in order to understand models of connectivity between different occupations. We consider that occupations are related to each other via transferable skills which can be sector-specific or not.

2. Data

The micro-data employed for this study are extracted from a national survey carried out between November 2008 – January 2009. The survey was designed to investigate the labor market entry process and early career of the Romanian university graduates in the first years after graduation. The data were retrospectively recorded and they cover both personal characteristics (e.g. age, sex, place of residence) and information regarding the jobs held by the subjects from graduation until the moment of investigation (e.g. job title, occupation, economic sector, type of contract). There were investigated 2,194 university graduates, the sample being stratified by their field of study according to the structure provided by Romanian National Institute of Statistics.

At the moment of survey, 93.8% of university graduates were employed and around 75% of them declaring that their jobs match their field of study (Pîrciog et al., 2010). This high insertion rate of the university graduates is explained mainly by the moment when the survey was carried out, during that period the Romanian economy was still growing and the labor force demand was high, especially for those highly qualified. Thus, we have to underline that our data were collected in a favorable economic environment characterized by important job mobility.

Scholars distinguish between inter-generational mobility and intra-generational mobility. This article is focused strictly on the second type of occupational mobility. Investigating the employment patterns of university graduates in the first years post-graduation, we noticed two things: they were practically rapidly ”absorbed" by the labour market and they encounter significant job mobility.

Table 1. *Occupational mobility rate, by gender*

	% of graduates that changed their job at least ones	
	Women	*Men*
during the 1st career year	15	13
during the first 3 career years	32	36
during the first 3 career years	47	43

For this study we analyze all the job changes even if they result or not in an occupational change. Originally, the occupations were recorded as string variables, but we coded them according to the International Standard Classification of Occupations ISCO - 88 at 3 digits, in order to keep under control the measurement errors in occupational codes. An occupation change means a modification in the occupational code at 3 digits at the transition from one job to another.

3. Occupational mobility network by gender

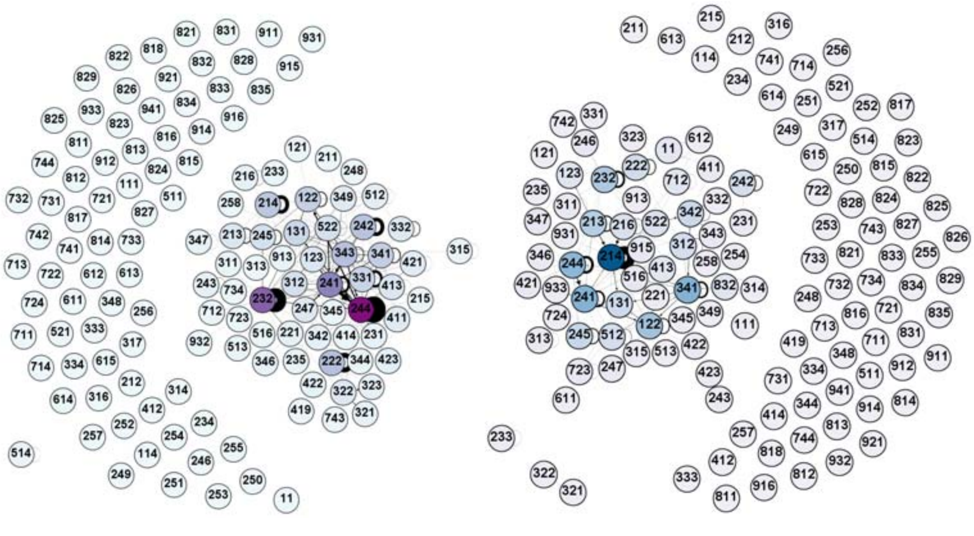
Over the last years, a large body of literatures employing a network-based approach has been emerging in the study of socio-economic systems (Granovetter, 1995, Freeman, 1996, Barabasi et al., 1999). Within this approach, the socio-economic systems such as markets, industries or even the global economy are viewed as networked structures (e.g. international trade (Li et al., 2003), social relations structures (Jackson, Rogers, 2007), internet, peer-to-peer networks, electronic circuits, neural networks, metabolism and protein interactions).

We employ a network approach to analyses the statistical properties of the occupational mobility network (OMN) of the Romanian university graduates, by gender, over five years period (2003-2008). We generate the networks by overlaying the transition matrixes between jobs, without taking into account the unemployment spells. We construct the network as directed and weighted. It is important in this case to consider both the magnitude and the direction of the flow of workers between occupations in order to have a complete view.

Figure 1 shows the empirical occupational network for each gender (a – females and b - males). The nodes represent the occupations coded at 3 digits according to ISCO-88 and the links are weighted with the number of persons moving from one occupation to another. We also counted the people that are changing their jobs in the same occupations as self-loops. A full description of the ISCO-88 Standard Classification of Occupations may be found on International Labour Orgnization (ILO) web page [(1)].

The thickness of the links is proportional with their weights, while the intensity of the color of the nodes reflects their total strength. We can notice that in the case of females, the most central occupation, according to the total strength is 244 (Social science and related professionals), while for males is 214 (Architects, engineers and related professionals). Their central position is highly determined by the amount of graduates that are changing their jobs in the same occupation, represented as self-loops in Figure 1 (a,b).

Both networks have the same number of nodes, n = 130 nodes, representing the total number of occupations at 3 digits according to ISCO-88, while the number of edges is different for each network (m = 224 edges for females and m = 161 edges for males).



(a) Female OMN (b) Male OMN

Figure 1. *Visualization of the empirical occupational mobility network (OMN) for female (a) and males (b). The thickness of the links is proportional to their weights and the color of the nodes reflects their total strenght (light color - isolated node, dark color - highly connected node). The numbers in vertexes represent the occupational codes according to ISCO-88. The networks are realized in Gephi 0.8.- beta using ForceAtlas2 layout (Bastian et al., 2009).*

4. Network statistics

Knowledge of the topological properties of the occupational mobility network is essential in order to have a global perspective over the occupations set and how they interconnect.

The graph density is calculated by dividing the existing number of links at the number of possible ties and it shows how connected or disconnected a network is. Mathematically it is defined as $\rho = \frac{2m}{n(n-1)}$, where m is the number of edges and n is the number of vertexes of the network. The density takes values between [0,1], the closest is its value to 1 the denser is the network.

The graph density of the two OMN is statistically different (H_0: independent samples, t-test: 3.4743^{**}); the occupational mobility network of females being denser than the ones of males (Table 1 and Figure 1). An important part of the occupational mobility is explained by the job mobility in the same occupation, 18% for women and 13% for men (see self-loops in Figure 1). However, one should notice that women mobility on the labour market is more ample than men's as they cover a higher share of the occupational space.

Due to the fact that we are investigating the ISCED5 graduates, they don't move in all the occupational set, but just in 45% of it, around 59 occupational categories being connected into the giant component. Taking into account that the occupations classified in the first two groups which require higher education represent around 29% of the total occupational categories, we can conclude that the movement of ISCED5 graduates, during the first years after receiving their degree, is quite diverse, part of them transiting in inadequate occupational groups.

Both the network diameter and the average path length are lower in the case of OMN for females, proving that the nodes in the occupational mobility network of women are better connected. The first network metric shows the longest distance between any two nodes in a network and the second one the average distance between any two nodes.

Table 2. *Occupational mobility networks (OMN) statistics, by gender*

Network metric	OMN	
	Female	*Male*
Graph Density	0.018	0.011
Self-loops (%)	18%	13%
Giant Component (%)	46%	44%
Average Degree	1.723	1.238
Degree Variance	6.999	4.858
Average Weighted Degree	3.946	2.577
Weighted Degree Variance	23.020	15.107
Network Diameter	6	8
Average Path Length	2.584	3.093

The degree of a node i denotes the number of links connected to it. In the case of directed networks, there are defined also the in-degree as the number of links that point to node i and the out-degree as the number of links that leave from node i (Chinazii et al., 2012). In the context of OMN, the in-degree could be interpreted as the number of occupations from where an occupation i attracts labour force, the out-degree as the number of occupations where the labour force from node i flows and the total degree the total number of occupations a specific node has connections with.

$$ND_{in} = \sum_{j=1}^{n} A_{ij} \quad ND_{out} = \sum_{i=1}^{n} A_{ij} \quad ND = ND_{in} + ND_{out} \tag{1}$$

where A_{ij} is the adjacency matrix.

In the same manner is defined the total strength, in-strength and out-strength for the weighted directed network:

$$SD_{in} = \sum_{j=1}^{n} W_{ij} \quad SD_{out} = \sum_{i=1}^{n} W_{ij} \quad SD = SD_{in} + SD_{out} \tag{2}$$

The average degree and average weighted degree are calculated as averages over the node´s total degree/strength. On average, the nodes from the occupational mobility network of females are better connected than the ones of males.

Even thou degree is a local measure of a specific node i, the degree distribution provides us information about the global topology of the network. If the degree distribution is narrow, with a well-defined mean and small variance it suggests that all the nodes are similar in terms of structural importance. This is not out case, since both the degree and weighted degree present high variances (Table 1). So, there is high probability to observe nodes with a large degree relative to the rest of the network.

Since a lot of empirical networks that have high variance are characterized by a distribution which decays as a power law: $p(k) \sim k^{-\alpha}$, with the exponent α taking values between 2 and 3, we test this hypothesis for the two occupational mobility networks.

We analyze the tails of the degree and strength distributions of the OMN for females and males as power laws, described by the probability density function p(x):

$$p(x) = \Pr(X = x) = Cx^{-\alpha} \tag{3}$$

where X is the observed integer value, C is normalization constant and α the scaling parameter.

In order to estimate the exponent α, we use the maximum likelihood method (MLE) or Hill estimator. The likelihood function in the case of integers has the following form:

$$p(x \mid \alpha) = \frac{x^{-\alpha}}{\zeta(\alpha, x_{\min})} \tag{4}$$

where $\zeta(\alpha, x_{\min})$ is the generalized of Hurwitz zeta function. Further we calculate the log-likelihood function and set $\partial L / \partial \alpha = 0$ in order to obtain the approximate solution for α.

$$\hat{\alpha} \simeq 1 + n \left[\sum_{i=1}^{n} \ln \frac{x_i}{x_{\min} - \frac{1}{2}} \right]^{-1} \tag{5}$$

Further details regarding the calculations may be consulted at Clauset et al. (2009).

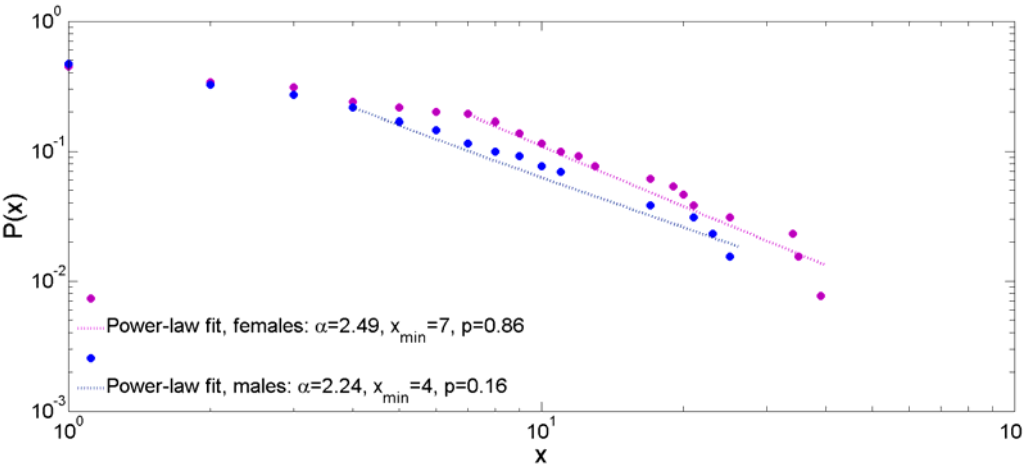


Figure 2. *The cumulative density function P(x) of degree for females (pink dots) and males (blue dots). The dotted lines are the power-law fits for the distributions tails*

In Figure 2, we plotted the cumulative density function of degrees for female's and male's occupational mobility network and the fitted power-laws. According to Clauset et al. (2009), we accept the power law hypothesis if the goodness-of-fit test (p) is higher than 0.1. The p-value (p) quantifies the plausibility of the hypothesis by measuring the distance between the distribution of the hypothetical power law model and the empirical data. We can see from Figure 2, that both of our distributions pass this test. These networks that exhibit power law behaviour are called scale-free networks, because there is not a characteristic scale for the degree of the vertexes.

5. Node centrality

Node centrality is a key issue of the social networks. The relevance of this measure emerges from the fact that job mobility defines a certain degree of dependency of an occupation to another. In this case the vertex/occupation centrality denotes the likelihood of a given occupation to appear along a randomly selected mobility flow within the OMN. The higher is their likelihood the more influential is the occupation in the network. Consequently shocks affecting central occupation are more likely to be transmitted in the whole network, to all the occupations. We consider three measures to quantify the centrality of a node: degree centrality, closeness and betwenness.

Betweenness centrality is calculated as the average number of short paths between pairs of the nodes that pass a certain node.

$$C_B(i) = \frac{g_{jk}(i)}{g_{ji}} \tag{6}$$

where g_{ij} is the number of shortest path between two nodes and $g_{jk}(i)$ is the number of shortest paths that pass node i.

Closeness centrality is defined as the inverse sum of the shortest distance to all other nodes from a specific node.

$$C_C(i) = \left[\sum_{j}^{N} d(i,j) \right]^{-1} \tag{7}$$

where d(i,j) is the length of shortest path between two nodes.

Table 3 presents the first three occupations according to different node centrality measures. In the case of females the most central occupations are social science and related professionals (244), secondary education teaching professionals (232) while in the case of males are architects, engineers and related professionals (214), business professionals (241).

Table 3. *Top three occupations by node centrality measures, for females and males occupational mobility network*

Centrality measure	Occupational mobility network (OMN)	
	Female	*Male*
Degree	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Secondary education teaching professionals (232)	Finance and sales associate professionals (341)
	Business professionals (241)	Business professionals (241)
In-degree	Social science and related professionals (244)	Production and operations manager (122)
	Business professionals (241)	Architects, engineers and related professionals (214)
	Secondary education teaching professionals (232)	Business professionals (241)
Out-degree	Secondary education teaching professionals (232)	Finance and sales associate professionals (341)
	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Administrative associate professionals (343)	Business professionals (241)
Strength	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Secondary education teaching professionals (232)	Finance and sales associate professionals (341)
	Business professionals (241)	Business professionals (241)
In-strength	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Secondary education teaching professionals (232)	Business professionals (241)
	Business professionals (241)	Finance and sales associate professionals (341)
Out-strength	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Secondary education teaching professionals (232)	Finance and sales associate professionals (341)
	Business professionals (241)	Social science and related professionals (244)
Betweenness	Secondary education teaching professionals (232)	Finance and sales associate professionals (341)
	Social science and related professionals (244)	Architects, engineers and related professionals (214)
	Business professionals (241)	Business professionals (241)
Closeness	Optical and electronic equipment operators (313)	Secretaries and keyboard-operating clerks (411)
	Protective services workers (516)	Legal professionals (242)
	Textile, garment and related trades workers (743)	Primary education teaching associate professionals (331)

Conclusions

This new approach to study of occupational mobility provides interesting insights in the movement of the employees between jobs and occupations. Creating a different network for each gender, we could observe the occupational segregation that exists on the Romanian labour market, and highlight specific features of the job mobility of females and males. We find that women and men not only enter, but also move in different occupations along their career.

Both occupational mobility networks present scale-free properties. The degree distribution takes the form $p(k) \sim k^{-\alpha}$, where α=2.49 for the OMN of females and α=2.24 for the OMN of males.

Note

(1) International Standard Classification of Occupations (ISCO-88) on International Labour Organization web page, http://www.ilo.org/public/english/bureau/stat/isco/isco88/index.htm

References

Barabasi, A.L., Albert R., Jeong, H. (1999). "Mean-field theory for scale-free random networks", *Physica A,* 272, pp. 173-187

Bastian, M., Heymann, S., Jacomy, M. (2009). "Gephi: an open source software for exploring and manipulating networks", *International AAAI Conference on Weblogs and Social Media*

Chinazzi, M., Fagiolo G., Reyes, J.A., Schiavo, S. (2012). "Post-Mortem Examination of the International Financial Network", *Working Papers,* No. 1202, Department of Economics, University of Trento, Italia, http://EconPapers.repec.org/RePEc:trn:utwpde:1202

Clauset, A., Shalizi, C.R., Newman, M.E.J. (2009). "Power-Law Distributions in Empirical Data", *SIAM Review* 51.4, p. 661

Estrada, E. (2012). *The Structure of Complex Networks*, Oxford University Press

Freeman, L. (1996). "Some antecedents of social network analysis", *Connections*, 19, pp. 39-42

Granovetter, M. (1995). *Getting a Job: A Study of Contacts and Careers,* University Of Chicago Press

Jackson, M.O., Rogers, B.W. (2007), "Meeting Strangers and Friends of Friends: How Random Are Social Networks?", *American Economic Review,* 97, 3, pp. 890-915

Li, X., Jin, Y.Y., Chen G. (2003). "Complexity and synchronization of the World trade Web", *Physica A: Statistical Mechanics and its Applications,* 328.1-2, pp. 287-296

Pîrciog, S., Lungu, E.O., Mocanu, C. (2010). "Education-Job Match among Romanian University Graduates. A Gender approach", *11th WSEAS International Conference on Mathematics and Computers in Business and Economics,* pp. 205-2010