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A mobility analysis of the occupational status of the graduates of the University of Palermo in an economic crisis context

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In such a global economic crisis context, our aims are describing the mobility of the Palermitan graduates in the labour market, identifying the variables that influence most their occupational status and finally outlining a transition probability structure among the states: Work, Search for a Job, Study, Other. The availability of a large amount of longitudinal data provided by the surveys carried out by STELLA (Statistics about Graduates and Labour Market) allowed us to analyze the mobility of the graduates of the University of Palermo among the different occupational states in three different times. We analyze data coming from a disproportionate stratified sample of graduates in 2009, interviewed three different times: one year (2010), three years (2012), five years (2014) after the graduation. To achieve our aim, first we provide a brief descriptive analysis of the main characteristics of the graduates gathered by the three different surveys; secondly we fit a time inhomogeneous multi-state Markov model with piecewise constant intensities; eventually implications from the main results are discussed.

keywords: occupational status mobility; Markov model; transition probabilities

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1 Introduction

The complex reform process pertaining to the governance of the Italian University system (such as the progressive financial autonomy of Universities and the review of academic curricula) increased competition between the universities. From recent empirical studies, it emerges that the colleges specific quality and their location has an influence on students and graduates mobility (Giambona et al., 2017) but also on their employment probabilities (Brunello and Cappellari, 2008) and returns (Makovec, 2006). The famous South-North divide is mirrored by the difference attitude and different performance of students and graduates of Northern and Southern universities. Furthermore, the high mobility of Southern students/graduates and more in general youth mobility, is now a central topic of discussion. In particular, outgoing mobility of highly-skilled, commonly referred as "brain drain" (Milio et al., 2012), is one of the criteria used for ranking universities.

In the Italian higher education system the phenomenon of incoming and outgoing mobility of students and graduates In King et al. (2016), the authors investigate the main reasons of youth mobility in Europe and its interaction with the socio-economic mobility. In Italy studies on students mobility (Attanasio and Enea, 2019; Enea, 2016; Giambona et al., 2017) and graduates mobility (Iammarino and Marinelli, 2015; Panichella, 2013), confirm that the "Mezzogiorno" is experiencing a proper brain drain to the Centre-North of Italy. Youth unemployment due to the post-2008 economic crisis is listed as one of the main factor influencing mobility (King et al., 2016).

The Lisbon Strategy stressed the crucial role of the university education system in order to provide more and better quality of employment having as a result the reduction of this brain drain. The information network on education in Europe shows that unemployment and lack of security at the workplace are forcing 50% of young European graduates to seek work outside their chosen fields, as it is shown by key education statistics produced by European-Commission/EACEA/Eurydice 2016. The strategic context for European cooperation in education field, the Europe strategy ET 2020, established the value of graduates employment rate, for young people (20-34 years old) in 2020 will be 82%. The Italian case is often referred as a special case because of its marked difference between North and South in labour markets conditions and universities quality (Lombardo et al., 2012; Pozzoli, 2009). This difference of course has been reflect on the graduates employment and unemployment rates. In Italy, in 2013, the graduates employment rate was 75.5% (Eurostat, 2014) while in EU28 was 81.8%. During the crisis period the employment rate follows a decreasing trend steeper in Italy than in the EU28 area (-14% from 2008 to 2013 AND -6% IN EU28). More, as confirmation of the very large territorial gap between North and South, in 2013 the difference in graduates employment rates between the two macro-areas is around 30 percentage points: namely 41.4% in the South vs. 69.8% in the North[1] (Istat, 2014). The same tendency is observed for the young graduates unemployment rate in 2013: in Southern regions it is around 30% vs. 11.1% in Northern regions. According to Tintori and Romei (2017) Italy's unemployment rate in

[1](http://dati.istat.it)

2015 was the the third largest in the Eurozone after Greece and Spain. The report about Families and Labour Market (Istat, 2019) highlights recovery from pre-crisis levels of unemployment in all Northern regions but not in all the Southern regions. Moreover in 2018 Sicily is one of the regions with the lowest unemployment rates: namely the graduates employment and unemployment rates in Sicily are 38.8% and 27.2 respectively%[2].

Besides the negative aspects that a low employment rate can have in the Italian labour market, its effect seems to influence also the student's enrollment. In fact, since 2012 a significant decrease in students enrollment in Southern universities is registered in favor of Northern and central universities (Attanasio and Enea, 2019). Reaching a higher education does not ensure an easy job finding. This is the conclusion one can draw for the higher unemployment rates for young graduates with respect to their peers without a university title. This is particularly true for the graduates of the Universities of the South of Italy that have to face the strict rigidity of the Southern labour market. In this context, this paper with a different methodological approach can be considered a very first step in the understanding the dynamic of transitions in the Italian youth labour market of graduates from Palermo University for creating new policies act to improve education and to reduce mobility.

The intrinsic relation between mobility and unemployment in Italy is extensively studied in the literature and some examples can be found in Di Pietro et al. (2005), Iammarino and Marinelli (2015), Nifo and Vecchione (2014), Tintori and Romei (2017). In particular in Iammarino and Marinelli (2015) the authors face the problem of education-job (mis)match and correlate it to the interregional migration finding out a positive role of the interregional mobility on increasing the likelihood of finding a job. Moreover, they state that the North does not provide more job opportunities to the Southern moving graduates with respect to the local graduates and hence they are more likely to experience an education job mismatch.

Education is indeed one crucial factor in youth unemployment studies (Biggeri et al., 2001; Lombardo et al., 2012; Losurdo et al., 2013; Pozzoli, 2009; Quintano et al., 2005; Salas-Velasco, 2007; Sciulli and Signorelli, 2011). In particular in Lombardo et al. (2012) the authors model the probability of finding a stable job for graduates of the University of Calabria using an interval-censored discrete time hazard model and a significantly different effect of field of study, gender and age is highlighted. In Losurdo et al. (2013), the probability of being employed three years after the graduation is modeled using a binary logistic model and the authors stress the positive effect of working experience gained during undergraduates studies. In Salas-Velasco (2007), Sciulli and Signorelli (2011) the Cox proportional hazards model is used to model the time to first job or using duration models terminology the duration to first job. In Pozzoli (2009) the author stresses the importance of taking into account individual heterogeneity and how this can explain the positive duration dependence. A multilevel version of the discrete time model is then estimated including random effects both at university and course program level. Also in Biggeri et al. (2001) the authors, remarking as commonly used methods in economics such as simple regression models or discrete time survival models cannot be

[2](http://dati-giovani.istat.it)

applied in the context of transition from university to work, propose the use of multilevel discrete time survival models. In Quintano et al. (2005) a table with the advantages and the limits of the main statistical methods for studying transition from university to work is reported. Discrete choice model and multilevel model are used in cross sectional studies and therefore their main limit is that they describe the transitions structure just at a fixed time t. For longitudinal data or cross-sectional data that contain the date of beginning and the end of the occupational status instead, more dynamic models can be used.

Unlike previous approaches proposed in literature (see also De Iaco et al., 2018) for an extensive report on the main models used in literature) that use as a response variable the time until the first job (Biggeri et al., 2001; Salas-Velasco, 2007) or the probability of being employed after three years (De Iaco et al., 2018; Losurdo et al., 2013) or more in general the probability of being employed vs the probability of being unemployed (Bacci et al., 2008; Ciriaci and Muscio, 2014), in this paper our aim is defining a transition probability structure of the graduates among four different occupational status: Work, Search for a Job, Study, Other. In particular, we refer to the graduates of the University of Palermo in 2009, interviewed at three different times: one year (2010), three years (2012), five years (2014) after the graduation. We choose to look at this interval time given the interest in understanding how graduates deal with the problem of searching for a job in economic crisis period. The analysis is performed using a multi-state Markov model considered as a useful tool for estimating the impact of risk factors on rates of transition between employment states (Fougère and Kamionka, 1992). Some examples of the use of Markovian models can be found in Blasco et al. (2008) for modeling the transition probabilities of a sample of French individuals (17-64) among the states employment, non employment, employment training and unemployment training; Theeuwes et al. (1990), Tasci and Tansel (2005) consider the Dutch and Turkish labour market respectively using a three states (employed, unemployed, not in the labor force) homogeneous time model and more in general Ward-Warmedinger and Macchiarelli (2014) carry out a more general study using data coming from the Eurostat's Labour Force Survey (LFS). Bahia et al. (2011) analyse paths of the vocational training graduates. An application to the Italian labour market is shown in Pastorello (1992). We hereby propose a time inhomogeneous multi-state Markov models for modeling the occupational paths of the graduates of the University of Palermo, one year, three years and five years after the graduation. The advantage of using this kind of model is that it allows to estimate the rate of transition between multiple states taking into account that the transition probabilities depend on a specific time interval. Therefore, it is possible to estimate different transition intensities depending on the considered period (before or after crisis). Although our results cannot be generalized to the national situation, the results could help us to shed some light on the causes of the low employment rate observed in Southern regions and its relation with the mobility trends and the investment in education.

Every year, before the first academic registration of students, the Censis Institute, other research Institutions and organizations (including Media), produce university rankings.

Each of them takes into account several aspects referring to the university's organization, reputation and student benefits, or the actual characteristics of students. Many university rankings now take into account both mobility for studying and mobility for working reasons and the employment rates.

In fact nowadays, it is common to use the word "brain drain", that indicates the necessity of highly educated subjects to leave their place of residence for finding better job opportunities.

In this paper we focus our attention to the occupational states of the graduates of the University of Palermo, because:

- it reaches, every year, a very low position in the university ranking;
- the low position in the ranking is often caused by a low employment rate of the graduates and the outgoing mobility caused by it;
- Palermo is a big city in the South of Italy, and a big university, where the employment is lower than the North.
- it can give us information about the reasons and the dynamic in time of the mobility of the graduates.

The outline of this paper is as follows. Section 2 summarizes the main information gathered from STELLA (Statistics about Graduates and Labour Market) surveys, focusing on the features of the graduates that found a job. Special attention is given to the variables that could be responsible of a so spread unemployment. Section 3 recalls the main results obtained for multi-state Markov model with a special focus on time inhomogeneous Markov models. In section 4 the probabilistic structure for the transition probabilities among different occupational states is presented and the results of the time inhomogeneous Markov model are discussed. Conclusions and future developments follow in Section 5.

2 Data

2.1 STELLA Survey

The data used for this research refer to the graduates in 2009, interviewed one year (2010), three years (2012) and five years (2014) after the graduation. The University of Palermo as part of the initiative STELLA, that gathers data about more than 400000 graduates of different Italian Universities from 2004 until 2014, carries out a disproportionate sampling survey one-year after the graduation. A disproportionate sampling survey is a sampling procedure in which the units of a population are divided into non-overlapping groups also called strata. Simple random samples are drawn from each stratum but the proportion in which the samples are taken is not the same as in the population (Schofield, 1996). Moreover, for the strata with less than 30 graduates per year, a census is conducted. The stratification variables are: Course Type (Bachelor's Degree, Master's Degree (2-years), Master's Degree (5-years)); Degree Class; Degree Course. More details about the sampling methodology are provided in Giambalvo (2010b). The total estimator for the variable y and its variance in this sampling scheme are respectively:

$$\hat{t}_y = \sum_{h=1}^{L} \sum_{j=1}^{n_h} \tilde{w}_h y_{hj} \quad (1)$$

$$V(\hat{t}_y) = \sum_{h=1}^{L} \tilde{w}_h (N_h - n_h) S_h^2 \quad (2)$$

where N_h, n_h and S_h^2, $h = 1, 2, \ldots L$ are respectively the strata size of the target population ($\sum_{h=1}^{L} N_h = N$), the strata size of the sample ($\sum_{h=1}^{L} n_h = n$) and the variances into population strata; $\tilde{w}_h = \frac{N_h}{n_h}$, $h = 1, 2, \ldots L$ are the weights. The target population for the survey three years after the graduation is the population of the Bachelor's Degree graduates (BG) (except the ones that in the survey one year after the graduation were in the status "Study") and all the Master's Degree graduates (2 years Master's Degree graduates (MG2) and 5 years Master's Degree graduates (MG5). The choice of excluding part of the BG population is guided by wanting to avoid interviewing the same individual in the same survey as BG after 3 year and as MG2 after 1 year. This prevents that bias, due to the achievement of a higher title, influences the employment probability. The target population for the interview five years after the graduation is the population of all the graduates interviewed three years after the graduation.

The response rates of STELLA survey are equal to 61.3%, for the first survey (1-yr), 70.6%, for the second (3-yrs), and 70.4%, for the last survey (5-yrs).

2.2 Descriptive Analysis

In this section a descriptive analysis of the graduates in each course type, with respect to their occupational status, in the three different surveys, and given both the gender and the area of study is presented.

		Graduates (%)			Area of Study (%)			Gender (%)			Social Class (%)			Age (SD)	Grade (SD)	Delay (SD)
		1-yr	3-yrs	5-yrs	1-yr	3-yrs	5-yrs	1-yr	3-yrs	5-yrs	1-yr	3-yrs	5-yrs	1-yr	1-yr	1-yr
BG	Work	494	275	320	Health	Health	Health	F	F	F	Middle	Middle	Middle	27.6	103.9	17.2
	Search	545 (24.5)	255 (37.5)	130 (27)	Political Science (19.1)	Political Science (21.6)	Language-Political (17.7)	F (70.1)	F (73.3)	F (76.1)	Middle High (29.5)	Middle (26.3)	Middle High (26.9)	26 (3.5)	101.6 (7.1)	22.8 (45.3)
	Study	1035 (46.6)	35 (5.1)	12 (2.5)	Engin. (20)	Humanistic (17.1)	Health (25)	F (57)	F (62.9)	F (66.7)	Middle High (42.1)	Middle High (34.3)	Middle Low (25)	24.4 (2.3)	104 (6.1)	16.2 (15.2)
	Other	148 (6.7)	116 (17)	20 (4.1)	Political Science (23)	Political Science (22.4)	Health (25)	F (68.9)	F (69)	F (90)	Middle High (28.4)	Low (27.6)	Middle Low (35)	27 (4.4)	102 (7.2)	23.2 (17.6)
MG2	Work	272	204	309	Engin.	Engin.	Engin.	F	F	F	Middle	Middle	Middle	28.4	108.6	4.7
	Search	289 (37.5)	236 (40.1)	82 (20)	Humanistic (21.4)	Humanistic (22)	Humanisic (28)	F (70.9)	F (71.2)	F (71.9)	Middle High (42.9)	Middle High (40.3)	Middle High (37.8)	27.1 (2.8)	108.9 (2.9)	4.5 (6.5)
	Study	96 (12.4)	67 (11.4)	12 (2.9)	Humanistic (25)	Humanistic (25.4)	Geo-Biol. (41.7)	F (52.1)	F (53.7)	F (66.7)	Middle High (54.2)	Middle High (50.7)	Middle (25)	26.1 (3)	109 (2.8)	2.9 (5.5)
	Other	114 (14.8)	81 (13.8)	8 (1.9)	Law (22.8)	Law (21)	Geo-Biol. (37.5)	F (64.9)	F (71.6)	F (50)	Middle High (44.7)	Middle High (45.7)	Middle High (62.5)	26.9 (3.5)	108.7 (3.2)	5 (6.7)
MG5	Work	85	60	111	Health	Health	Health	M	M	F	Middle	Middle	Middle	26.9	106.7	10
	Search	48 (18.9)	36 (19)	17 (12.8)	Architect. (54.2)	Architect. (50)	Arch.Law (35.3)	F (60.4)	F (63.9)	F (76.5)	Middle High (43.7)	Middle High (44.4)	Middle High (47.1)	26.9 (2.1)	106.5 (5.1)	11 (11.5)
	Study	52 (20.5)	39 (20.6)	5 (3.8)	Health (71.2)	Health (71.8)	Health (80)	M (51.9)	M (51.3)	M (60)	Middle High (44.2)	Middle High (51.3)	Middle High (100)	26 (2.1)	108.5 (3.8)	21.6 (136.9)
	Other	69 (27.2)	54 (28.6)	0	Law (47.8)	Law (51.8)	-	F (60.9)	F (63)	-	Middle High (46.4)	Middle High (38.9)	-	26.5 (2.1)	107.1 (4.7)	4.5 (9.1)
	Total	3247	1458	1026	Engin. (13.7)	Health (15.2)	Health (15.6)	F (60.3)	F (62.2)	F (61.5)	Middle High (39.7)	Middle High (38.1)	Middle High (39.2)	26.2 (4.2)	104.9 (6.3)	14.6 (28.9)

Table 1: Descriptive statistics for the graduates of the University of Palermo interviewed three times after the graduation

A summary of the main evidences is displayed in Table 1. In the columns labelled as "Graduates (%)" frequencies (percentages values) of graduates for each occupational status, for each survey, and course type are shown. Graduates in Study occupational status are more frequent among the BG cohort, instead those in Work status are more frequent among the MG (MG2 and MG5). The six successive columns show the modal value of the Educational Field and the Gender in all the three surveys.

In this first descriptive analysis we consider the extensive version of the variable Education Field that has 15 different modalities ("Agriculture", "Architecture", "Chemistry", "Economics-Statistics", "Biology and Earth Science", "Law", "Engineering", "Education", "Humanities and Arts", "Languages", "Health", "Political science and Civics", "Psychology", "Scientific"), in the modeling part a narrower version with just 5 macro areas ("Technical", "Law", "Medical", "Humanistic" and "Scientific") is used. The modal value of the Educational Field differs more for BG than for the other two groups. "Female" is the modal value for BG and MG2; more heterogeneity is observed for MG5. Looking at the Social Status classified in "Low", "Middle-Low", "Middle, "Middle-High" and "High" its median value for each group in all the surveys considered "Middle-High". BG interviewed after 3 years are the only exception.

In fact, among the BG interviewed 3 years after the degree in Other occupational status the median value for the Social Status is "Low" suggesting a more disadvantaged condition for graduates in this class. The last three columns show the mean Age at which the students graduated, the mean final Graduation Mark ('Grade') and the mean Delay ('Delay') in obtaining the title expressed in months. Values of the standard deviation for these variables in brackets. The graduates that show the best performance in terms of Age ("the youngest"), Grade ("highest Grade") and Delay ("lowest Delay") occupy the state Study (the only exception is the "high Delay" among the MG5 in the state Study probably due to the extended length of Medicine Degree Course).

STELLA's survey does not provide a homogenous information in the three different surveys about the place in which the graduates are carrying out their declared activities. However, in order to provide information about the mobility of the graduates, being aware of a possible underestimation, in Table 2 the percentages of graduates that declared to be in Sicily according to the different occupational states are reported.

Graduates in Work and Study status are the ones more affected by the outgoing mobility effect; especially after five years the percentages experience a significant decrease (for the BG in Work status from 94.2% 1 year after the degree to 79.8% 5 years after the degree and from 96.1% to 74.1% for the ones that keep studying; for the MG2 and MG5 in Work status from 92% 1 year after the degree to 76.1% 5 years after the degree and from 93% to 85.7% for the graduates that are studying) (Table 2).

In Figure 1 there are six alluvial charts showing the distributions of male and female graduates according to the course type, the area of study and the occupational status in the three different surveys. These categorical variables are assigned to parallel vertical axes and their categories are represented by boxes on each axis. Their frequencies are represented by alluvia spanning across all the axes. The bigger the box is the higher is the frequency of the corresponding category. In the same way, the thicker the alluvia that links two categories of two different variables, the higher is the frequency of graduates

Table 2: Percentages of graduates that declared to be in Sicily according to the different occupational paths and in the three different surveys

		Work	**Search**	**Study**	**Other**
BG	1-yr	94.2	97.3	96.1	95.7
	3-yrs	94.2	98.0	94.3	98.0
	5-yrs	79.8	90.6	74.1	84.8
MG2&MG5	1-yr	92.0	97.1	93	99.1
	3-yrs	94.2	94.5	100	100
	5-yrs	76.1	90.7	85.7	70.6

conjointly in these two categories. The distributions of male (left) and female (right) graduates (Fig.1) exhibit some remarkable differences, in the three times of the survey: the percentage of BG in Work status grows over time, more for males than for females, passing from the 24.3% in 2010 to 79% in 2014 (51.7% in 2012), and from the 20.9% in 2010 to 59.2% in 2014 (34.2% in 2012), respectively. Considering the area of study, graduates in "Medical" area (both males and females) present the highest percentages in Work status in 2010 (67.8% and 52.1%) and in 2012 (75% and 56.7%), whereas in 2014 "Law" graduates show the highest percentages (83.8%). The percentages of graduates in Search status vary in a seesawing way, passing from the 18.9% in 2010 to 17.6% in 2014 with a peak of 28.1% in 2012 for males, and from 28.1% in 2010 to 32.3% in 2014 with a peak of 42.6% in 2012 for females. In 2010 and 2012, "Law" and "Technical" graduates show the highest percentages in the searching occupational condition (for males graduates in "Technical" area 25.7% and 36.3% and for females graduates in "Law" area 34% and 49.2% respectively). In 2014 the percentages of graduates in "Humanistic" area in Search status are the highest (35.3% and 43.2% for males and females respectively). As expected, the percentages of graduates in Study status decrease significantly over time, varying from the 51.5% and 43.5% in 2010, for males and females respectively, to just over 2% in 2014, for both. Finally, also the percentages of graduates in Other status exhibit a seesawing pattern, passing from the 5.3% in 2010 to 1.1% in 2014 (14.9% in 2012) for males and from 7.5% in 2010 to 5.9% in 2014 (18.2% in 2012) for females. In 2012, the graduates in this occupational status belong mainly to "Law" area probably because for graduates in this area a mandatory internship period is needed before obtaining a job (23.4%) for males, and to Scientific area (31.3%) for females; the same growing trend observed for BG is observed for MG2 in Work status. The percentages of MG2 in Work status grows over time, passing from the 44.4% in 2010 to 80.9% in 2014 (45.5% in 2012) for males, and from the 29.3% in 2010 to 71.5% in 2014 (28% in 2012) for females. Considering the Area of Study, the highest percentage of male graduates in Work status is in "Medical" area (100% in 2014); whereas the highest percentage of female graduates is in "Technical" area (88.9% in 2014).

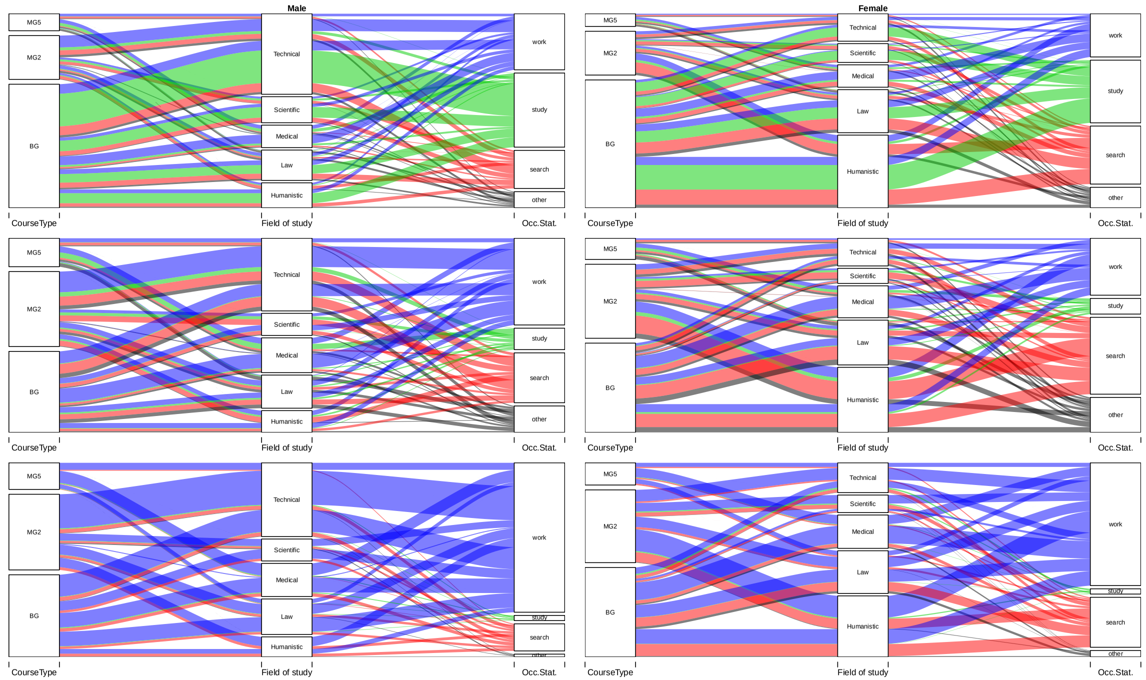

Figure 1: Distributions of graduates by Course Type (Course), Area of Study (Area), and occupational status (Occup.). From top to bottom (Surveys: 1-yr, 3-yrs, 5-yrs), from left to right (Gender: Male, Female).

Also for MG2, the percentages in Search status exhibit a seesawing pattern, passing from 27.5% in 2010 to 14.2% in 2014 (30.4% in 2012) for males, and from 44.9% in 2010 to 23.7% in 2014 (46.2% in 2012) for females. The highest percentages in this occupational status are those registered in 2012 for graduates in “Scientific” area (48.6% and 53.4%, for males and females respectively). The percentages of graduates in Study status exhibit overall a decreasing pattern, reaching their minimum values in 2014 for both males and females (2.5% and 3.2% respectively); among the areas of study, the lowest percentages are observed for “Scientific” area in 2014 (4.6% and 8.5% for males and females respectively). The percentages of graduates in Other status decrease dramatically over time, with the maximum values, in 2010 and 2012, among the graduates in “Medical” area (66.7% and 50%,for males and females); as observed for BG and MG2, the percentage of MG5 in Work status grows over time, especially between the second and the third survey, when the percentages undergo a big jump passing from about 38% to almost 88% for males, and from about 28% to 80% for females. “Medical” area graduates, both males and females, have the highest percentages in Work status (in 2014 89.7% and 83.8% respectively). Instead, in the first and second survey the areas with the highest percentage of graduates that declare to Work are “Technical” for males (around 50%) and “Medical” for females (39%).

Contrary to what observed for BG and MG2, for MG5, the percentages of male and female graduates in Search status exhibit a decreasing trend over time, passing from 16% in 2010 to 7% in 2014 (15.3% in 2012) for males, and from 21.5% in 2010 to 22.1% in 2014 (17.1% in 2012) for females. In the first two surveys, the highest percentages in this occupational status are registered for graduates in “Technical” area, with percentages between 30%-40%, while in the last survey the highest percentages are registered for male graduates in “Technical” area (11.8%) and for female graduates in “Law” area (23.8%). The percentages of graduates in Study status exhibit, as in the other two groups of graduates, a decreasing pattern over the time, reaching their minimum values in 2014 for both males and females (5.3% and 2.6% respectively). One year and three years after the graduation there are still consistent percentages of graduates in this condition, especially within “Medical” area, instead, in 2014 there are strictly positive percentages only within the group of graduates in “Law ”(9.1%) and “Medical” (5.4%) areas, for males and females respectively. The percentages of graduates in Other status for each area of study decrease dramatically in the first two surveys and become absent in 2014.

The evidences, coming from the detailed descriptive analysis presented in this Section, guide the choice of the model discussed in the next Section 3.

3 Methodology

The aim of the paper is building a probabilistic structure for evaluating the mobility of the graduates among the different occupational status. Labor status mobility can be viewed more realistically as a process in which states changes occur at random time points and the probabilities of moving among the different states are governed by Markov transition matrices. In this light, Multistate Markov model represent a valid option.

For readers that aim to a formal definition of Markov Process more details can be found in **?**. Generally, given $\mathcal{S} = 1, \dots R$ a discrete set of states governed by a continuous time stochastic process $X(t)$ which takes values in $\mathcal{S}$ and a filtration F_t, it is possible to define a Multistate model by its transition intensity matrix $Q(t, \mathcal{F}_t)$, with generic element

$$q_{rs}(t, \mathcal{F}_t) = \lim_{\delta t \to 0} \frac{\mathbb{P}(X(t + \delta t) = s | X(t) = r, \mathcal{F}_t)}{\delta t}, \tag{3}$$

where $\delta_t, t > 0$ and s and r are possible states for the given model.

The transition intensities in case of survival model can be interpreted as "state changing" hazards (Hougaard, 2012). But in Multistate models, as a type of multivariate survival models, the quantities of interest are often expressed in terms of the state occupation probabilities as functions of time (Lan and Datta, 2010). Therefore, it is possible to describe the process in terms of transition probabilities as

$$p_{rs}(t_1, t_2, \mathcal{F}_{t_1}) = \mathbb{P}(X(t_2) = s | X(t_1) = r, \mathcal{F}_{t_1}), \tag{4}$$

where $t_2 > t_1 > 0$.

The peculiarity of a general Multistate Markov model is that the process evolution just depends on the actual status of the process and not from its past history. This means that we can express the transition intensities in 3, as:

$$q_{rs}(t, \mathcal{F}_t) = q_{rs}(t) = \lim_{\delta t \to 0} \frac{\mathbb{P}(X(t + \delta t) = s | X(t) = r)}{\delta t}. \tag{5}$$

The transition probabilities matrix satisfies the so called Kolmogorov forward equation:

$$\frac{dP(t_2, t_1)}{dt} = P(t_2, t_1) Q(t_1), \tag{6}$$

under the initial condition $P(t_1, t_1) = I$. Hence, for finding the transition probabilities, this system of differential equation has to be solved.

Another common assumption is the time homogeneity. In this scenario the transition probabilities just depend on the interval length t_1 and t_2 and not from t_1 itself. Therefore,

$$Q(t) = Q_0, \quad \forall t. \tag{7}$$

But this assumption is often not realistic. A time homogeneous Markov Multistate model is an oversimplified model, because it implies that all the transition intensities, or using survival terminology all the hazards are constant. A more general option is to use piecewise constant transition intensities, which retains most of the simplicity associated to Markov assumption, but allows to model the changes in hazard. Hence, time inhomogeneous Multistate Markov models with piecewise constant intensities are a valid and more flexible alternative. The main advantage of this approach is the possibility of relaxing the time homogeneity hypothesis but at the same time maintaining a closed algebraic expression for the transition probabilities. In this framework given a serie of times $b_1, b_2, \dots, b_M$ which specify the intervals of constant hazard, the transition intensity matrix is defined as:

$$Q(t) = \begin{cases} Q_0 & t < b_1 \\ Q_i & b_i \leq t < b_{i+1}, \ \ i = 1, \dots, M-1 \\ Q_M & t \geq b_M. \end{cases} \tag{8}$$

In the same way it is possible to express the transition probabilities according to two different cases:

- between two times t_a and t_b in the same hazard interval, $b_k < t_a < t_b < b_{k+1}$

$$P(t_a, t_b) = \exp(Q_k(t_b - t_a)) \tag{9}$$

- between two times t_a and t_b in different hazard intervals, $b_i < t_a < b_{i+1}$ and $b_j < t_b < b_{j+1}$, $j > i$:

$$P(t_a, t_b) = P(t_a, b_{i+1})P(b_{i+1}, b_{i+2}) \dots P(b_{j-1}, b_j)P(b_j, t_b). \tag{10}$$

Another advantage of using Markov Multistate models is the possibility of including explanatory variables. It is common to assume that the variables related to the transition intensities have a multiplicative effect such that:

$$q_{rs} = q_{rs}^{(0)}(t)\exp(\beta_{rs}^T \mathrm{z}(t)), \tag{11}$$

where $q_{rs}^{(0)}(t)$ is the baseline intensity at time t, β_{rs} is the regression coefficient vector and z is the explanatory variables matrix.

The available data in this study can be thought as a collection of individual histories represented as a sequence of realizations of a continuous time stochastic process $Y_i(t)$, $i = \{1, \dots, n\}$, with n the population size, taking its values in a discrete-state space $\mathcal{S} = 1, \dots 4$. Y_{it} indicate the state occupied by the individual i at time t. Then,

$$y_{it} = \begin{cases} 1 & \text{if the individual is in the state Work at time t} \\ 2 & \text{if the individual is in the state Search at time t} \\ 3 & \text{if the individual is in the state Study at time t} \\ 4 & \text{if the individual is in the state Other at time t} \end{cases} \tag{12}$$

with $1 \leq i \leq n$ and $n = 5865$ graduates in the considered survey. The first step for Multistate model is identifying the transition structure. Looking at the observed transition in Table 3 given that all the entries are not zero, it is reasonable to assume that there are not absorbing states and transitions among all the states are allowed (Figure 2).

The last column of Table 3 is relative to censored observations. The highest number of censored observations is observed for the graduates in the Study status. This is the case because, as said in Section 2, BG that declare to study one year after the

Table 3: Observed transitions matrix

	Final State				
Initial State	Work	Search	Study	Other	Censored
Work	581	69	15	8	348
Search	219	209	25	14	300
Study	87	28	28	5	646
Other	91	52	28	12	54

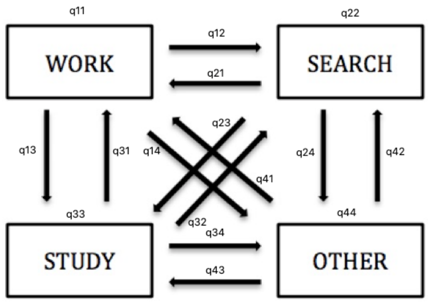

Figure 2: States and transitions of the Markov multistate model

graduation are excluded from the survey. Multistate Markov models allow to split the maximum likelihood contribution of censored observations from the contribution of all the other observations. Therefore, a probability of moving to another state of the model is computed also for censored observations. However, this approach can sometimes be too conservative because of its tendency in assigning higher probability to remain in the last state observed before the drop out.
The absence of absorbing states makes our analysis different from the classical survival analysis. Indeed, classical comparison methods such as survival curves cannot be applied in this context.

After having identified the model transition structure, an initial transition matrix is required for finding the solution in terms of transition probabilities. Defining an initial transition matrix is often referred as initial condition problem. Numerical methods that require an initial condition value for the transition intensity matrix are used for likelihood maximization of the transition probability matrix. In this work we apply the methodology explained in Jackson (2007), for which the $(r; s)$ element of the initial transition matrix $Q^{(0)}$ is

$$q_{rs}^{(0)} = \frac{n_{rs}}{T_r}, \tag{13}$$

where n_{rs} is the number of transitions from the state r to the state s and T_r is the total time spent in the state r. In the piecewise constant intensities, it is possible to define different initial transition matrices, according to the period in which the transition intensity is assumed to be different.

On the basis of previous literature results (Allegro and Giambalvo, 2011; Giambalvo, 2010a) and of what descriptive analysis suggests, the model chosen describes the mobility among the occupational status according to the Gender, the Course Type, the Area of Study and the final Graduation Mark.

$$q_{r,s}^{(t)} = q_{rs}^{(1)} \exp(\beta_{rs}^{GENDER} \times GENDER + \beta_{rs}^{COURSE\_TYPE} \times COURSE\_TYPE + \\ + \beta_{rs}^{AREA} \times AREA + \beta_{rs}^{MARK} \times MARK) \exp(z_{rs}^{(t)}), \tag{14}$$

where $z_{rs}^{(t)}$ represents the effect of time in the $t-$th period for the $r \to s$ transition intensity.

The parameter estimation procedure is based on the BFGS (Broyden, Fletcher, Goldfarb and Shanno) method, a Quasi-Newton method for loglikelihood minimization.[3]

Finally for evaluating the goodness of fit of the model and comparing it with nested or non nested models, the common Likelihood Ratio Test is used. For identifying what are the causes of a possible poor goodness of fit, score residuals also called influence residuals,

$$U_j(\hat{\boldsymbol{\beta}})^T I(\hat{\boldsymbol{\beta}})^{-1} U_j(\hat{\boldsymbol{\beta}}), \tag{15}$$

where $U_j(\hat{\boldsymbol{\beta}})$ is the vector of first derivatives of the loglikelihood for a subject j at maximum likelihood estimates vector $\hat{\boldsymbol{\beta}}$, and $I(\hat{\boldsymbol{\beta}})$ is the observed Fisher information matrix evaluated at the maximum likelihood estimates, are used (Titman and Sharples, 2010).

Subjects with a higher influence on the maximum likelihood estimates will have higher score residuals.

4 Results

In this work a time inhomogeneous Markov model with piecewise constant intensities and explanatory variables Gender, Course Type, Disciplinary Area and final Graduation Mark is used. The estimated model parameters and their corresponding confidence intervals are reported in Tables 4-5 (in bold the statistically significant coefficients). The choice of this model is motivated by the will to capture the different crisis effect over the years and to include individual heterogeneity. A model containing as explanatory variable also the Age at the graduation moment has been considered but the effect of the covariate is found to be not significant. This might be due to the high correlation with the variable Course Type that already takes into account part of the difference in age. The variable related to the mobility is not included in the model because as said in Section 2, it is not gathered homogeneously in the three different surveys. The categories of the variable Course Type MD2 graduates and MD5 graduates are merged for reducing the complexity of the model. The plausibility of using this kind of models is confirmed by comparing two models with

[3]The function *msm* of the homonymous R package allows to specify this option.

and without piecewise constant intensities via likelihood ratio test ($LRT = 1.71 \times 10^{-12}$). The estimated coefficients of the variable Time Period that describes the time intervals with piecewise constant intensities show a significant difference in the transitions from state Work to state Study (z_{13}), from state Search to state Work (z_{21}) and from state Other to state Work (z_{41}). This means that the transition probabilities among these states between 2012-2014 (3 years to 5 years after the degree) are significantly lower than the same probabilities between 2010-2012 (1 year to 3 years after the degree). The parameter β_{42} associated to the variable Gender is significantly less than 1 meaning that female graduates (baseline) have a higher hazard ratio of experience a transition from the state Other to the state Search with respect to male graduates.

The major differences are in the transition probabilities of the BG with respect to the MG2 (baseline in the model). It is indeed less probable for BG to pass from the state Search to the state Work (β_{21}), from the state Search to the state Study (β_{23}), from the state Study to the state Work (β_{31}), from the state Study to the state Search (β_{32}). More, the final grade influences positively the transition from the state Search to the state Work (β_{21}): the hazard ratio of experiencing this transition is higher for graduates with a higher final grade. Finally, graduates in "Medical" area have higher probability to find a job with respect to their peers graduated in "Scientific area" (β_{21}>1).

This justifies our choice of showing just the transition probability matrices for these two categories of the variable Course Type.

Table 4: Parameters estimates of the chosen Multi-state Inhomogeneous Markov Model- Baseline and piecewise constant intensities variable (Time Period)

	Log Baseline Estimates		**Time Period** Estimates
q_{12}	0.002 (0.002;0.003)	$z12$	0.781 (0.486;1.256)
q_{13}	0.000 (0.000;0.001)	$z13$	**0.211** (0.066;0.671)
q_{14}	0.000 (0.000;0.001)	$z14$	0.707 (0.176;2.824)
q_{21}	0.007 (0.006;0.009)	$z21$	**0.484** (0.356;0.653)
q_{23}	0.001 (0.000;0.001	$z23$	0.427 (0.169;1.077)
q_{24}	0.000 (0.000;0.032)	$z24$	1.207 (0.421;3.452)
q_{31}	0.001 (0.001;0.002)	$z31$	1.049 (0.687;1.601)
q_{32}	0.001 (0.001;0.001)	$z32$	0.846 (0.399;1.797)
q_{34}	0.000 (0.000;0.037)	$z34$	0.296 (0.028;3.109)
q_{41}	0.006 (0.004;0.011)	$z41$	**0.251** (0.116;0.542)
q_{42}	0.006 (0.003;0.009)	$z42$	0.569 (0.266;1.213)
q_{43}	0.000 (0.000;0.607)	$z43$	0.002 (0.000;6690.4)

It is in principle possible to show the transition probability matrix for each graduate within specific categories of the covariates[4]. We hereby present the two years transition probabilities matrices for BG and MG2 (MG5 don't show a different behavior with respect

[4]Values of transition probabilities for all the categories of the other explanatory variables included in the model are omitted but they are available on request

Table 5: Parameters estimates of the chosen Multi-state Inhomogeneous Markov Model for covariates Gender, Course Type, Disciplinary Area and Graduation Mark

	Males	**BG**	**MG5**	**Final Mark**
	Estimates	Estimates	Estimates	Estimates
β_{12}	0.693 (0.409;1.176)	2.173 (0.967;4.883)	2.200(0.786;6.161)	0.987 (0.951;1.024)
β_{13}	2.290 (0.766;6.844)	0.414 (0.096;1.782)	0.966 (0.118;7.894)	1.333 (0.987;1.802)
β_{14}	0.665 (0.145;3.054)	1.069 (0.098;16.31)	0.006 (0.000;5977.8)	0.948 (0.859;1.047)
β_{21}	1.186 (0.876;1.607)	**0.549** (0.381;0.792)	0.878 (0.542;1.422)	**1.026** (1.002;1.050)
β_{23}	0.835 (0.326;2.138)	**0.316** (0.128;0.884)	0.398 (0.066;2.420)	1.017 (0.945;1.094)
β_{24}	0.313 (0.063;1.551)	216.9 (0.000;1.15×10^{10})	0.215 (0.000;1.35×10^{19})	0.999 (0.924;1.079)
β_{31}	1.116 (0.711;1.751)	**0.041** (0.021;0.080)	0.885 (0.437;1.794)	1.003 (0.959;1.049)
β_{32}	0.802 (0.348;1.845)	**0.096** (0.037;0.244)	0.249 (0.056;1.095)	1.003 (0.933;1.078)
β_{34}	0.503 (0.050;5.057)	0.000 (0.000;71.68)	0.263 (0.019;3.584)	0.875 (0.724;1.056)
β_{41}	1.234 (0.799;1.903)	1.294 (0.709;2.360)	0.856 (0.465;1.578)	1.035 (0.996;1.077)
β_{42}	**0.477** (0.237;0.957)	0.978 (0.423;2.261)	0.864 (0.319;2.338)	0.969 (0.926;1.015)
β_{43}	0.835 (0.379;1.838)	0.872 (0.200;3.794)	2.261 (0.622;8.207)	0.945 (0.891;1.003)

((a)) ***Gender*** ((b)) ***Course Type*** ((c)) ***Mark***

Technical	**Medical**	**Law**	**Humanistic**
Estimates	Estimates	Estimates	Estimates
0.476 (0.195;1.159)	0.567 (0.212;1.520)	0.571 (0.233;1.399)	0.792 (0.332;1.886)
0.092 (0.007;1.222)	1.003 (0.100;10.01)	0.006 (0.000;13664)	1.404 (0.262;7.524)
0.396 (0.023;6.933)	3.337 (0.268;41.63)	0.862 (0.065;11.36)	0.431 (0.022;8.244)
1.491 (0.910;2.444)	**2.215** (1.217;4.030)	1.508 (0.910;2.499)	0.921 (0.556;1.522)
0.319 (0.077;1.334)	1.093 (0.216;5.519)	0.556 (0.163;1.911)	0.420 (0.139;1.267)
1.527 (0.166;14.10)	2.299 (0.203;25.91)	1.259 (0.150;10.55)	0.549 (0.058;5.198)
0.620 (0.267;1.439)	1.252 (0.509;3.087)	1.469 (0.684;3.151)	1.004 (0.434;2.323)
0.889 (0.245;3.220)	1.409 (0.231;8.613)	2.355 (0.749;7.402)	1.071 (0.306;3.750)
0.027 (0.000;10796)	0.034 (0.000;17285)	3.441 (0.332;35.70)	1.984 (0.108;36.28)
0.767 (0.323;1.820)	0.943 (0.366;2.431)	0.868 (0.373;2.016)	0.505(0.200;1.273)
1.438 (0.318;6.507)	0.982 (0.164;5.889)	1.078 (0.235;4.945)	2.646 (0.621;11.27)
0.997 (0.112;8.835)	1.274 (0.130;12.50)	1.785 (0.215;14.82)	0.274 (0.016;4.466)

((d)) ***Area of Study***

to MG2 as it is shown in Table 5) between one year and three years after the degree (2010-2012) and between three years and five years after the degree (2012-2014), (Table 6).

Table 6: Two year Transition Probabilities for BG and MG (observed transition probabilities)

	Work	**Search**	**Study**	**Other**
Work	0.879(0.811)	0.093(0.148)	0.014(0.018)	0.014(0.024)
Search	0.250(0.474)	0.702(0.443)	0.029(0.047)	0.019(0.037)
Study	0.025(0.579)	0.018(0.263)	0.957(0.158)	0.000(0.000)
Other	0.338(0.500)	0.165(0.341)	0.074(0.122)	0.042(0.037)

((a)) ***(2010-2012) - BG***

	Work	**Search**	**Study**	**Other**
Work	0.847(0.858)	0.125(0.122)	0.008(0.005)	0.020(0.015)
Search	0.239(0.337)	0.701(0.564)	0.024(0.030)	0.036(0.069)
Study	0.040(0.353)	0.026(0.529)	0.932(0.118)	0.001(0.000)
Other	0.227(0.273)	0.196(0.455)	0.004(0.000)	0.573(0.272)

((b)) ***(2012-2014) - BG***

	Work	**Search**	**Study**	**Other**
Work	0.910(0.884)	0.045(0.044)	0.036(0.073)	0.009(0.000)
Search	0.451(0.506)	0.490(0.402)	0.054(0.092)	0.005(0.000)
Study	0.379(0.500)	0.098(0.281)	0.493(0.125)	0.030(0.094)
Other	0.386(0.594)	0.114(0.250)	0.041(0.094)	0.460(0.063)

((c)) ***(2010-2012) - MG***

	Work	**Search**	**Study**	**Other**
Work	0.912(0.927)	0.059(0.052)	0.018(0.010)	0.012(0.010)
Search	0.449(0.417)	0.507(0.500)	0.038(0.083)	0.006(0.000)
Study	0.516(0.867)	0.117(0.067)	0.346(0.000)	0.022(0.067)
Other	0.258(0.333)	0.133(0.667)	0.007(0.000)	0.601(0.000)

((d)) ***(2012-2014) - MG***

In Tables 7 the four years transition probabilities matrices between 2010 and 2014 (one year and five years after the degree) for BG and MG between and are shown.

Tables 6 suggest that it is easier to pass from the state Work to the state Search from one year to three years after the degree (2010-2012) than from three years to five years after the degree (2012-2014): namely for BG 0.09 vs 0.12 whereas for MG 0.05 vs 0.06.

Table 7: Four years Transition Probabilities (2010-2014) (observed transition probabilities)

	Work	**Search**	**Study**	**Other**
Work	0.829(0.813)	0.133(0.146)	0.018(0.016)	0.020(0.024)
Search	0.311(0.507)	0.622(0.440)	0.037(0.007)	0.030(0.045)
Study	0.041(0.667)	0.027(0.250)	0.931(0.083)	0.001(0.000)
Other	0.376(0.632)	0.206(0.263)	0.075(0.035)	0.344(0.070)

((a)) ***(2010-2014) - BG***

	Work	**Search**	**Study**	**Other**
Work	0.892(0.941)	0.063(0.039)	0.032(0.020)	0.013(0.000)
Search	0.549(0.661)	0.394(0.321)	0.048(0.000)	0.009(0.018)
Study	0.510(0.739)	0.117(0.174)	0.342(0.087)	0.031(0.000)
Other	0.453(0.800)	0.135(0.100)	0.033(0.050)	0.378(0.050)

((b)) ***(2010-2014) - MG***

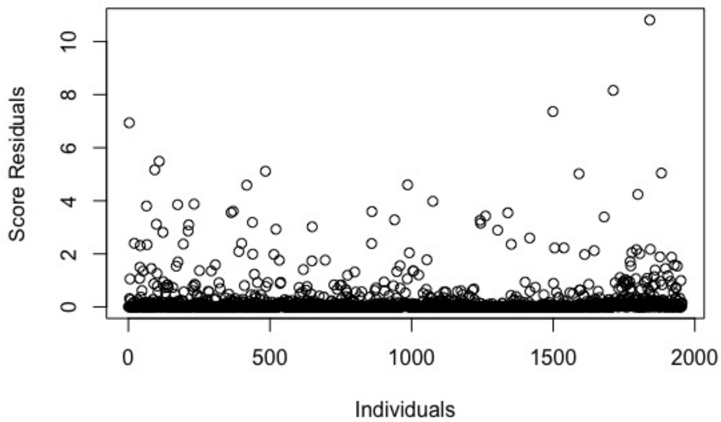

Figure 3: Score residuals for all the graduates

This confirms that the crisis effect lasts at least until 2014. Before the crisis and also during the crisis, data suggest that "The more you study the better it is". The probability of moving from state Search to state Work is indeed higher for master graduates (≈ 0.45, Tables 6 (c) and 6 (d)) than bachelor graduates (0.25 and 0.24, Tables 6 (a) and 6 (b)) in both periods 2010-2012 and 2012-2014. Moreover, in such a complicated moment investing in higher education seems to be a priority for bachelor graduates. In fact, the probability of remaining in the state Study is higher than 0.9 in all the cases considered

(Tables 6 (a) and (b), 7 (a)).

For assessing the goodness of fit of the model the score residuals (equation 15) for each individual are considered in Figure 3.

Given the presence of some highly influencing observations, a deeper analysis of outlier detection might be needed. However in this context their effect is not particularly strong considering the high number of observations.

5 Conclusions

In this work the occupational paths of the graduates of the University of Palermo are analyzed with the aim of drawing a mobility structure among the occupational status in a very delicate moment of crisis. Multistate models given their flexibility in modeling panel data with more than two transition states, proofs to be a valid alternative in analyzing the transition dynamic of the labour market of the graduates of the University of Palermo.

From the descriptive analysis of the occupational status 1 year after the graduation it emerges that the percentages of employed graduates is quite low, and different with respect to the course type, around 22% for BG against around 35% for MG2 and MG5. This result if from one side confirms the previous findings in literature, showing that the investment in education reduces the risk of being trapped in the unemployment area (Manitiu and Galeazzi, 2016) from the other side it can be explained by the high percentages of BG that keep studying one year after the degree (46.6%).

Three years after the graduation, in 2012, the effect of the economic crisis dramatically influence the youth employment rate in Italy (Rostan and Stan, 2017). In Istat (2014) the authors say that in 2008-2012 the graduates employment looses 6 percentage points in Europe and 14 in Italy. Also for the graduates of the University of Palermo a similar trend is observed: decreasing percentages among MG2 and MG5 in the status Work are registered in 2012.

Improvements in the employment probabilities are finally registered for all the graduates in the last survey (2014), five years after the graduation, confirming that the slow school to work transition for Southern Italian universities (Pastore, 2019) is happening.

The gender gap, highlighted in other studies (De Iaco et al., 2018; Pozzoli, 2009), is visible from the higher percentages of male graduates in the status Work with respect to female graduates.

The discipline of study is one of the aspects that matter most on finding a job (Quintano et al., 2005; Pozzoli, 2009). The discipline studied can have either a positive or negative impact on employment rates. The greatest difficulty in finding a job is experienced by graduates of "Humanistic" area while "Medical" and "Technical" graduates have higher chances of transitioning into Work status. Similar results can be found in Pozzoli (2009) where the worst performance in terms of employability are registered for female graduates in "Humanistic" area. As in Bacci et al. (2008), Quintano et al. (2005) good results are registered also for graduates of "Scientific" and "Economic" area.

Contrasting conclusions are drawn in relation to the final Graduation Mark. In Quintano et al. (2005), Santoro and Pisati (1996) the authors find a negative correlation of the final grade with the probability of being employed, concluding that the most brilliant students are "choosy" about proposed job opportunities. On the other hand in Losurdo et al. (2013) the authors don't find a clear relation between Graduation Mark and employment. In this study as in Biggeri et al. (2001) a higher grade facilitate the transition from Search status to Work status.

Given the descriptive analysis results and the previous literature findings, the chosen model includes as explanatory variables Gender, Course Type, Area of Study and Graduation Mark confirming the evidences of the descriptive analysis. The model does not include the variable Age that usually shows a negative correlation with the probability of being employed, suggesting that younger students (that are more likely to be "better" students (Pozzoli, 2009)) have better chances to be employed with respect to the older peers. The choice of not including this variable in the model is guided by its non significant contribution in explaining the transition probability dynamic of the graduates of the University of Palermo. A possible justification can be found in the high correlation between the Age and the Course Type variable.

Moreover, the model presents an extra explanatory variable (Time Period) that takes into account the effect of the economic crisis in a piecewise constant way and it allows us to distinguish what happened before and during the crisis.

In fact, releasing the time homogeneity hypothesis, a Time Inhomogeneous Markov model with piecewise constant intensities is fitted to the data.

From the results interpretation, it emerges that: males graduates in "Medical" Area have higher transition probabilities towards the state Work; females graduates in "Humanistic" Area have lower transition probabilities from state Search to state Work and the highest from state Work to state Search. One of the downside of the model is that it seems to overestimate the sojourn time in the same state. This can be attribute to the considerable number of drops out in the study. Therefore, developments for dealing with censored observations are needed. Finally, the results show a trend in the relationship between the occupational paths of the graduates and the mobility, noticing that as the probability of finding a job increases over the years the percentages of graduates that remain in Sicily decrease. However, future developments for describing more accurately the relation between occupational paths and mobility are ongoing. In fact, using the same model but with data not related to a crisis period could lead to discover new insights in the dynamic and in the factors influencing the mobility of graduates and their employment rate.

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