



**A Fuzzy Approach to the Measurement of Employment and Unemployment:
A Comparative Analysis Across European Countries**

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A fuzzy approach to the measurement of employment and unemployment: a comparative analysis across European countries

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The views expressed in this document are those of the authors and do not necessarily reflect the position of the institutions where the authors are employed.

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1. Introduction

The analysis of the labour force is traditionally based on the clear-cut distinction between the two complementary sets of employed and unemployed. However, this classification appears too rigid since it neglects all the nuances between fully employed people and those who work only occasionally while wishing to work more. Furthermore, this way of proceeding involves a significant loss of statistical information that could instead be used to represent and measure employment and unemployment accurately. In our view, employment should not be considered a simple attribute that is present or absent but rather a matter of degree. On a logical level, this implies the passage from a Boolean conception to a “fuzzy” one.

Fuzzy set theory (Zadeh, 1965) has been widely applied in a variety of research fields. In the socio-economic field, the study of poverty has long been the preferred area of application of the fuzzy method. Still, recently, the method has been extended to analyzing other phenomena, including labour force estimation (Betti and Lemmi, 2021). The basic assumption is that workers are employed at a certain degree of intensity, depending on the number of hours actually worked compared to the desired number of hours. The paper aims to propose a method to measure the degree of employment and subsequently arrive at a new estimate (fuzzy estimate) of employment, unemployment and related rates.

The empirical application concerns 29 European countries and it is based on the European Union Labour Force Survey (EU LFS henceforth) data for the year 2019.

The paper is structured as follows. Section 2 recalls the main definitions of the labour force and active population adopted in official statistics. Section 3 describes the fuzzy theory applied to labour force estimates, while section 4 shows the results of the empirical application. Finally, section 5 contains concluding remarks.

2. Employment and unemployment in official statistics

According to the International Labour Organization directives (ILO 1982), working-age population (persons aged 15 and older) can be split into three mutually exclusive groups: the employed, unemployed and inactive population. The first two groups constitute the labour force.

The employed, unemployed and inactive population groups are identified based on information collected by labour force surveys and following a hierarchical process, which first identifies the employed persons, then the unemployed ones and eventually the inactive population.

According to the EU LFS, an employed person is a person aged 15 and over who meets one of the following conditions: i) during the reference week he/she performed some work - even if for just one hour - for pay, profit or family gain; ii) he/she was not at work but had a job or business from which he/she was temporarily absent⁴.

The unemployed population comprises all the persons of working age who: i) were without work during the reference period, ii) are currently available for work, and have taken concrete actions in a specified recent period to seek paid employment or self-employment.

Finally, the inactive population includes persons of working age who are neither employed nor unemployed.

How the employed, unemployed and inactive population groups are identified affects the value assumed by unemployment and employment rates. In fact, the unemployment rate is defined as the proportion of unemployed persons in the total labour force population whereas the employment rate is given by the percentage of employed persons in the population of working age.

3. Methodology

The fuzzy measure of employment intends to overcome the sharp distinction between employed and unemployed persons. Applying the fuzzy set theory (Zadeh, 1965) to the employment concept rejects the binary classification employed/unemployed, which includes among the employed every individual who performed some work during the reference week, regardless of the number of hours worked. Instead, we define a membership function μ_E in the fuzzy subset E of the employed, measured on a scale from 0 to 1, whereby 1 means full membership to the set of the employed persons and 0 full non-membership.

A fuzzy measure of employment can reflect the unmet need for working additional hours among the employed, thus accounting for the labour under-utilization. The concept of labour under-utilization encompasses both time-related underemployment and involuntary part-time. These categories concern persons who share some characteristics with the unemployed even though they are officially included among the employed. In the fuzzy approach that we propose, we treat them as employed to a certain degree: the lesser the time they work, the lower their degree of employment.

Contextually, we define a membership function μ_U in the fuzzy subset U of the unemployed. Among the individuals in the labour force, we assume that the fuzzy set U of the unemployed corresponds to the

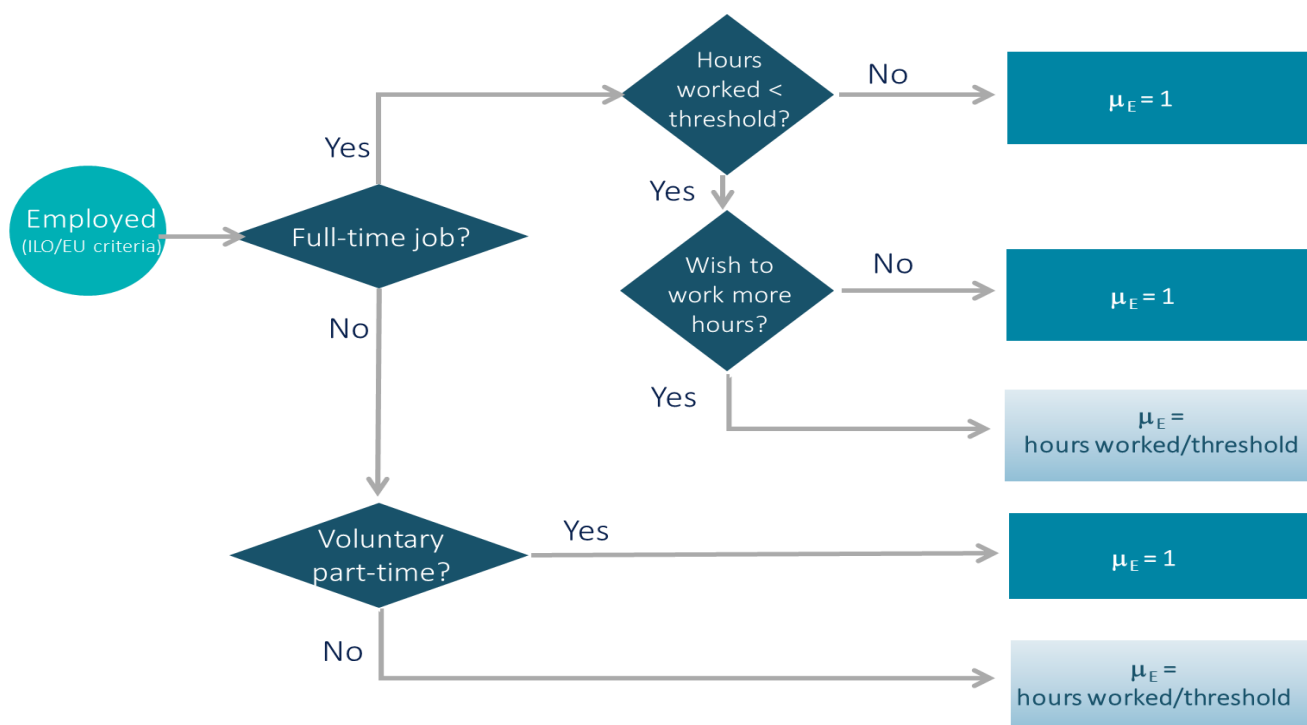
⁴ Criteria for classifying the absences from work (involving, among others, people on parental leave and under Redundancy Fund) have been changed since 2021. In this paper we refer to the definitions that remained in force until 2020.

standard complement of the fuzzy set E of the employed: therefore, the membership function in the fuzzy set U is given by $\mu_U = 1 - \mu_E$.

According to the ILO/EU employment status, inactive people do not belong to the labour force, and they are assigned membership functions μ_E and μ_U equal to 0.

For the employed (according to ILO/EU employment status), we compute the values of the membership function μ_E by following the assumptions sketched in Figure 1.

Figure 1. Specification of the membership function μ_E for individuals who are employed according to the ILO/EU criteria



The value assumed by μ_E depends on the amount of hours worked by the person concerned and on her/his satisfaction about it. We define an upper bound (threshold) for the amount of weekly worked hours. This threshold acts as a limit set by statutory or collectively agreed standards and corresponds approximately to the number of hours worked on average by full-time workers. The threshold may assume different values in different countries.

Membership function μ_E is set equal to 1 (and therefore μ_U is set equal to 0) for: i) full-time workers with hours worked not lower than the threshold ii) full-time workers who do not wish to work more, even if employed for less than the specified threshold, iii) voluntary part-time workers.

Values of μ_E membership function are greater than 0 and lower than 1 for underemployed workers. Part of them is composed of involuntary part-time workers, i.e. people who could not find a full-time job. The remaining part consists of full-time workers who work less than the specified threshold and are willing to work additional hours. For both categories of underemployed workers, the membership function has been defined as the ratio of the hours actually worked to the threshold value.

Finally, individuals classified as unemployed based on ILO/EU criteria are assigned membership values $\mu_E=0$ and $\mu_U=1$.

4 Empirical application

We used data from Eurostat, European Union Labour Force Survey (EU-LFS)⁵, reference year 2019, to obtain fuzzy measures of employment, unemployment and related rates, focusing on people between 15 and 64 years old. The analysis covers 29 European countries: 25 EU countries⁶, United Kingdom, Switzerland, Norway and Iceland.

In every country, the threshold of hours worked is set at the median value of the weekly hours usually worked for employees in the public sector, employees in the private sector and self-employed. The category of self-employed also includes the family workers whose size in many countries is very small. Furthermore, we assume that all activities included in the categories O (Public Administration and Defence; Compulsory Social Security), P (Education), and Q (Human Health and Social Work Activities) of NACE Rev.2 classification⁷ belong to the public sector.

Table 1 shows, for every country, the composition of the group of employed according to the five categories described above and referred to in Figure 1.

⁵ The responsibility for all conclusions drawn from the data lies entirely with the authors.

⁶ Slovenia and Lithuania are excluded, the former due to the unavailability of information on the reasons for working part-time whereas the latter because more than 50% of self-employed and family workers declare zero hours usually worked.

⁷ Statistical Classification of Economic Activities in the European Community, NACE Rev. 2

<https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>

Table 1. Percentage composition of employed (from 15 to 64 years) classified in the categories of Figure 1, by country

Country	Full-time workers (hours not less than the threshold)	Full-time workers (hours less than the threshold, not willing to work more)	Voluntary part-time workers	Involuntary part-time workers	Full-time workers (hours less than the threshold, willing to work more)	Total
AT	46.6	25.4	24.8	2.4	0.8	100
BE	57.8	15.6	23.8	1.5	1.3	100
BG	96.8	1.1	1	1.1	0.1	100
CH	41.4	20.5	34.1	3.2	0.8	100
CY	68.6	18.7	4.4	5.8	2.5	100
CZ	76	17.9	5.5	0.4	0.1	100
DE	48.4	23.3	24.5	2.5	1.3	100
DK	66.2	8.7	21.5	2.6	0.9	100
EE	80.7	7.7	10.6	0.7	0.3	100
ES	68.2	15.6	6.7	8	1.5	100
FI	44	37.1	10.9	4.9	3	100
FR	44.6	30.3	10.6	6.5	8.1	100
GR	73.8	15.8	3	5.9	1.5	100
HR	73	21.2	3.4	1.4	1	100
HU	94.5	1	3.5	0.9	0.1	100
IE	43.5	31.9	16.6	3.2	4.9	100
IS	67.9	10.1	18	3.4	0.6	100
IT	60.9	19.8	6.4	12.3	0.5	100
LU	77.2	5.4	14.4	2.1	0.9	100
LV	89.7	2.3	5.9	1.7	0.4	100
MT	80.6	6.6	11.5	0.9	0.4	100
NL	40.3	11.4	45.3	2.6	0.4	100
NO	70.5	9.1	16.1	3.9	0.3	100
PL	90.7	2.8	5.2	0.9	0.4	100
PT	71.8	16.4	4.6	3.5	3.7	100
RO	85.3	7.4	2.7	3.4	1.2	100
SE	61.9	16.1	16.3	4.8	0.8	100
SK	76	19.4	3.3	1.2	0.1	100
UK	47.5	27.1	20.7	3.1	1.5	100

Note: Our elaborations on EU-LFS 2019 data

The composition shows a considerable heterogeneity among countries. The share of full-time workers with hours worked not lower than the corresponding median value ranges from 40.2% in the Netherlands to 96.8% in Bulgaria. It remains below 50% in Austria, Switzerland, Germany, Finland, France, Ireland and the United Kingdom, whereas it is above 90% in Hungary and Poland. Countries where the vast

majority of workers fall into this category show a very low incidence of part-time work and low variability of the distribution of usually worked hours.

The percentage of full-time workers who work fewer hours than the threshold but do not wish to work more hours ranges from approximately 1% in Hungary and Bulgaria to over 30% in France, Ireland and Finland.

The Netherlands rank first for the share of voluntary part-time workers (45.3%), followed by Switzerland (34.1%), whereas the percentage of involuntary part-time workers is by far the highest in Italy (12.3%) and Spain (8.0%).

Finally, France stands out for the highest percentage (8.1%) of full-time workers who work fewer hours than the threshold and want to work more hours.

Table 2 Workers who fully belong to the fuzzy set of employed ($\mu_E=1$) by work typologies. Italy, France and Spain, percentage values.

Work typologies	France	Italy	Spain
<i>Professional status</i>			
Self-employed	91.2	91.1	96.2
Employee with a permanent job	87.3	88.8	93.1
Employee with a temporary job	75.7	73.9	79.3
<i>Skill level</i>			
High-skilled occupation	91.4	93.4	94.3
Low-skilled occupation	83.3	86.4	91.3
Elementary occupation	70.1	70.3	76.9
<i>Industry</i>			
Agriculture	93.8	90.4	95
Manufacturing & Construction	88.1	94.8	97.4
Trade, transportation and accommodation	84	84.1	89.6
ICT, finance and insurance, real estate	88.1	85.5	89.5
PA, education, health, arts	84.5	83.8	86.5
Total	86	87.3	90.5

Note: our elaborations on EU-LFS 2019 data

In summary, people who have full membership in the employed fuzzy set range from 86% in France to 99.5% in Czechia. We expect minimal differences between fuzzy and traditional employment measures for countries where this percentage is around 99% or above. Conversely, we expect relevant differences for countries where the percentage is lowest, as in France, Italy and Spain. The extent of such differences depends on the distribution of worked hours: the larger the gap between the number of hours worked and the threshold (for workers willing to work more), the larger the expected differences between traditional

and fuzzy measures of employment, unemployment and related rates. Furthermore, there are notable differences across work typologies (Table 2).

Figure 2 and Figure 3 show official and fuzzy employment and unemployment rates by country, while Table 3 and Table 4 present official and fuzzy rates for different categories of workers.

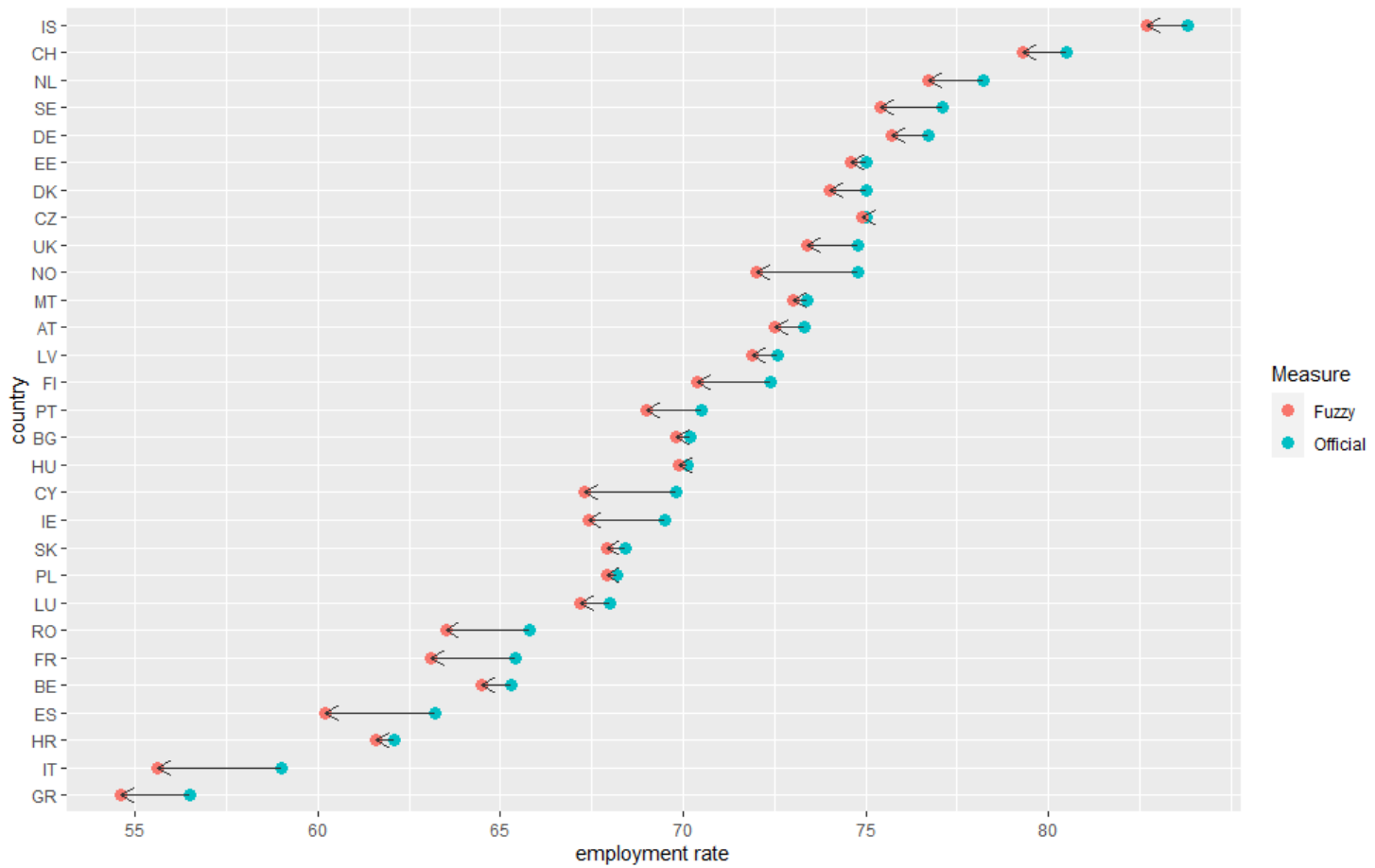
The fuzzy employment rate is the weighted arithmetic mean of the individual membership values μ_E when using survey sample weights. This mean is calculated across all the sample units in working age (aged between 15 and 64). As such, it can be compared with the official employment-to-population ratio. The official rate can be viewed as a particular case of the fuzzy rate, in which every unit gets an individual membership function precisely equal to 1.

As the membership function in the fuzzy approach is below 1 for a share of workers (ranging from 0.5% to 14% across countries), the employment rate can only undergo a reduction when computed with the fuzzy approach (Figure 2). For eight countries, most of which are Eastern European countries (namely Czechia, Hungary, Poland, Estonia, Malta, Bulgaria, Slovakia and Croatia), the reduction is lower than 1%. For another group of seven countries, most of which are Mediterranean countries (Italy, Spain, Cyprus and Greece, along with France, Romania and Norway), the fuzzy employment rate is more than 3% lower than the official rate. The latter group includes several countries whose official employment rate is below the EU-27 rate. In particular, Greece and Italy record the lowest official employment rates and, at the same time, they show the largest downward correction when the fuzzy rate is calculated. Therefore, these countries are doubly penalized: on the one hand, the shares of employed people in the population are at the lowest levels, and, on the other hand, the jobs are of poor quality in terms of the inadequacy of the number of hours worked.

In the vast majority of the countries, the fuzzy approach exacerbates the gender gap in the employment rate (Table 3). Indeed, the fuzzy methodology penalizes more women than men, particularly in Italy, Greece, Spain and France, where the female employment rate is well below the EU-27 average value.

When passing from the official to fuzzy measure, the employment rate of the youngest and the least educated workers decreases more than for any other category of workers ranked by age and educational level. For the 15-24 years age class, the most notable changes are observed in Sweden, Italy, Spain and Norway, whereas Romania and Norway record the highest downward correction for the workers with a low educational level.

Figure 2. Employment rates (15-64 years) by country- fuzzy and official measures- year 2019.

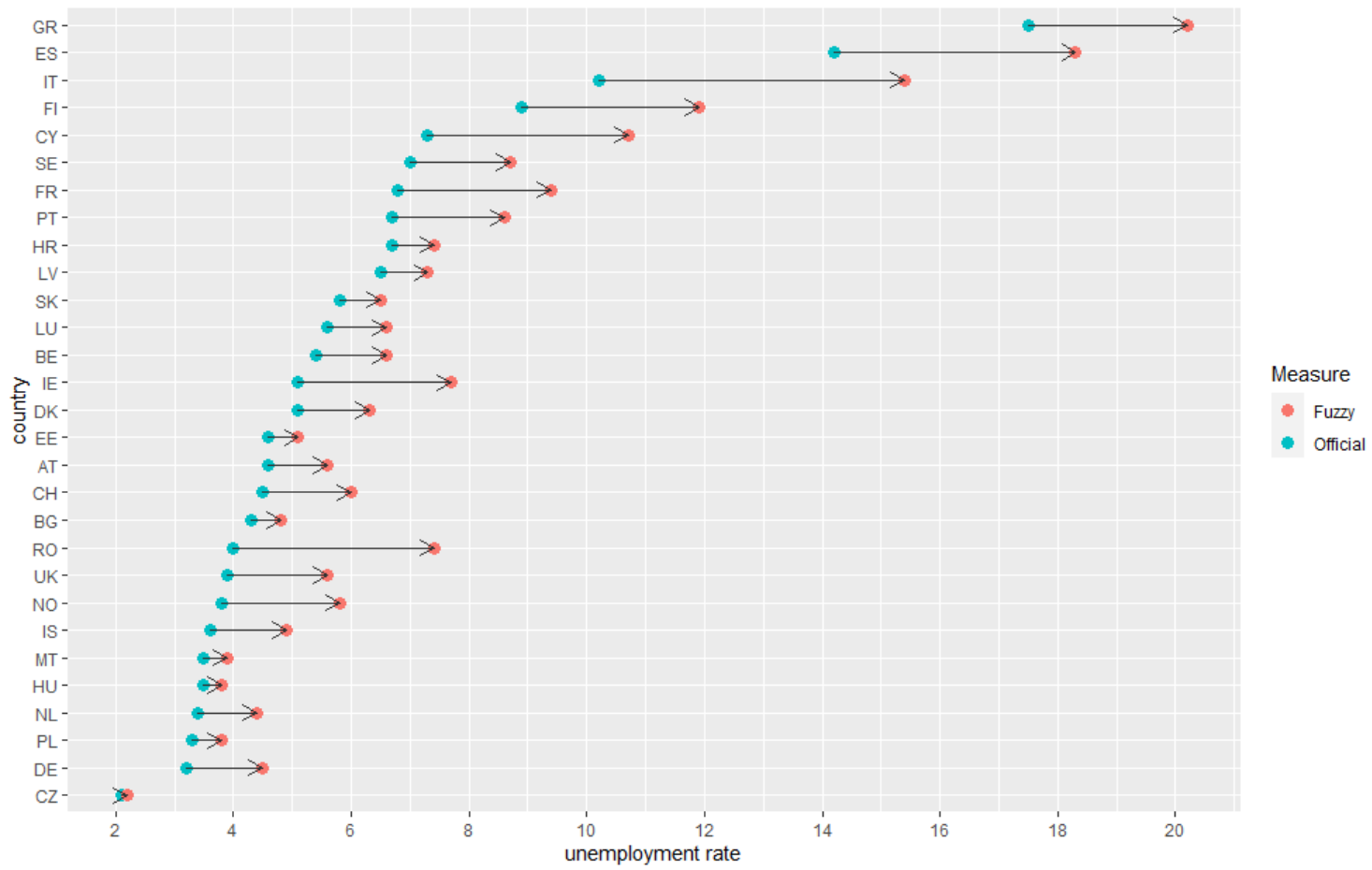


Note: our elaborations on EU-LFS 2019 data

The weighted mean of the μ_U membership function across the individuals in the labour force provides the fuzzy rate of unemployment. The fuzzy measure exceeds the official unemployment rate in all countries: the increase of the fuzzy rate with respect to the official one ranges from 4.8% in Czechia to 85.0% in Romania (Figure 3). Furthermore, Germany, United Kingdom and Ireland show the most relevant increase, together with Italy, Norway and Cyprus.

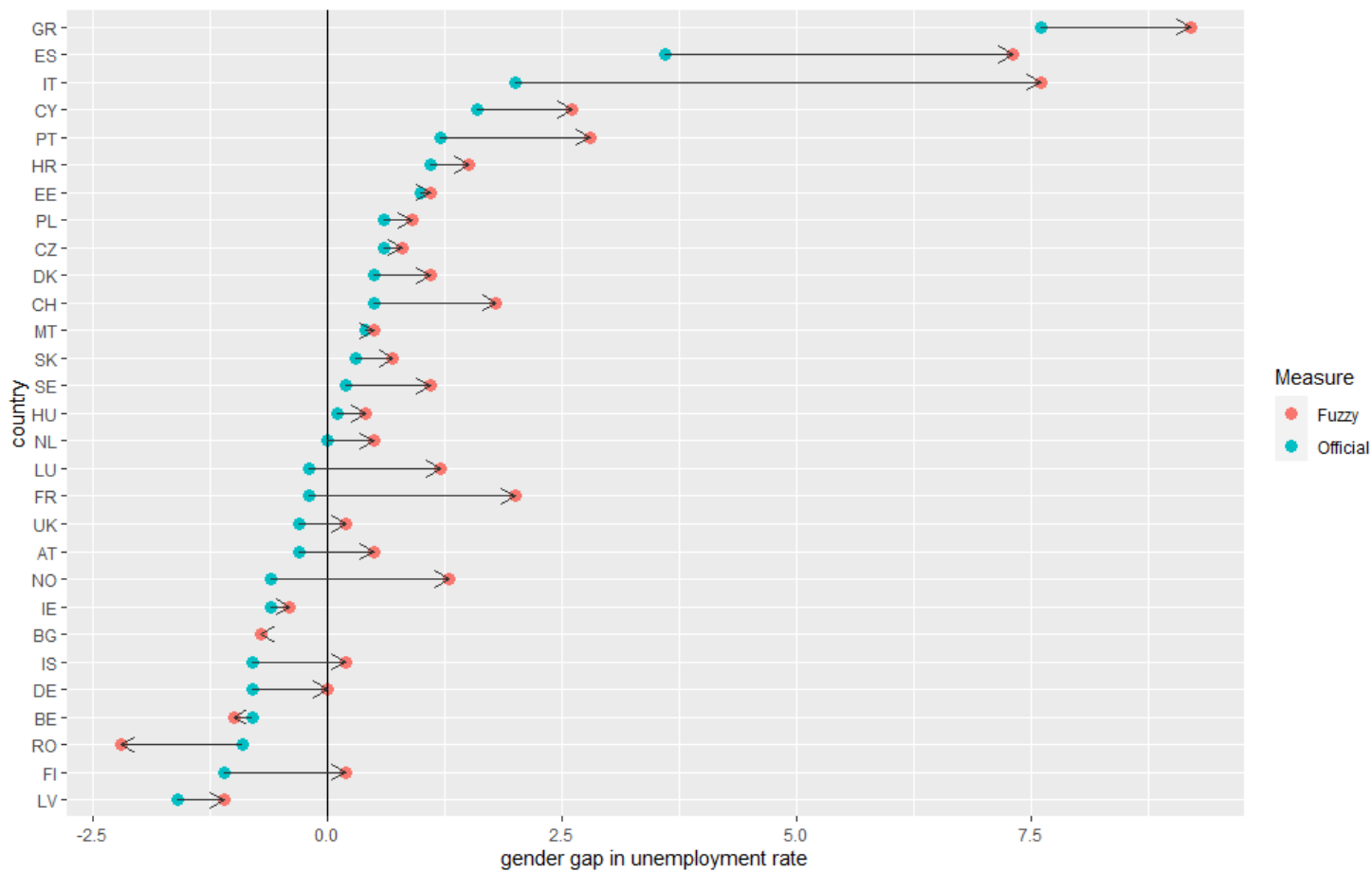
In almost every country, the difference between the fuzzy and official unemployment rate is higher for females than for males, which enlarges the gender gap in the unemployment rate when the fuzzy approach is used (Figure 4). For what concerns the other classifications, we find that the largest upward corrections refer to the categories that are less affected by unemployment, namely the highest age groups and the highly educated individuals (Table 4).

Figure 3. Unemployment rates (15-64 years) by country- fuzzy and official measures- year 2019.



Note: our elaborations on EU-LFS 2019 data

Figure 4. Gender gap in the unemployment rate (15-64 years) by country- fuzzy and official measures- year 2019.



Note: The gender gap is computed as the difference between the female and male unemployment rate

Table 3 Employment rates by categories of work – European countries, year 2019 - Official and fuzzy measures

		Gender		Age (years)					Country of birth		Education			Urbanization			Total
		Male	Female	15-24	25-34	35-44	45-54	55-64	Native-born	Foreign-born	Lower secondary	Upper secondary	Tertiary	Cities	Towns and suburbs	Rural areas	
AT	official	77.5	69.2	50.6	83.1	86.4	86.4	54.5	74.6	68.8	48.1	75.8	84.4	68.2	74.6	76.6	73.3
	fuzzy	76.9	68.1	49.9	82.2	85.6	85.3	53.9	74	67.4	47.2	75	83.6	67	73.9	76	72.5
BE	official	68.9	61.7	26.6	79.7	82.1	80.5	52.1	67.2	57.7	37.7	67.4	84.1	58.1	69.1	68.5	65.3
	fuzzy	67.9	61	26.1	78.5	81	79.7	51.6	66.5	56.4	36.8	66.6	83.3	57	68.5	67.8	64.5
BG	official	74.1	66.1	21.8	76.7	84.7	84.8	64.6	70.2	67.1	38.9	74.5	88.8	74.6	71.1	61.6	70.2
	fuzzy	73.7	65.8	21.5	76.4	84.2	84.4	64.2	69.8	66.4	37.9	74.3	88.7	74.5	70.8	60.6	69.8
CH	official	84.5	76.3	61.2	88.1	87.5	87.1	73	82.2	77.2	61.7	80.3	88	78.9	80.6	82.8	80.5
	fuzzy	83.8	74.6	60.5	87	86.3	85.5	71.6	81.4	75.1	59.8	79	88.9	77.5	79.4	81.6	79.3
CY	official	74.7	65.2	30.5	82	84.9	81	61.1	69.1	71.9	46	69.2	83.3	70.3	70.7	67.3	69.8
	fuzzy	72.3	62.4	29.3	78.5	82.2	78.5	58.6	66.5	69.4	44.4	66.7	80.2	67.8	67.9	64.8	67.3
CZ	official	81.7	68.1	28	78.7	89.6	93.1	66	74.9	77.3	28.5	80.8	83.9	76.7	74.3	74.2	75
	fuzzy	81.6	67.9	27.9	78.5	89.4	92.9	65.9	74.7	77.2	28.2	80.7	83.8	76.5	74.2	74.1	74.9
DE	official	80.5	72.9	48.4	82.1	86.4	87.3	72.9	78.3	70.7	49.4	80.8	88.9	74.3	77.3	79.6	76.7
	fuzzy	79.8	71.5	47.8	81.2	85.4	86.1	71.7	77.4	68.9	48	79.8	88.2	73.2	76.3	78.7	75.7
DK	official	77.9	72	54.9	77	85.6	85.2	71.3	76.3	65.6	53.2	79.9	87.4	74.9	75.6	74.7	75
	fuzzy	77.2	70.8	53.3	75.9	84.9	84.6	70.7	75.4	63.9	52.4	78.8	86.5	73.9	74.7	73.7	74
EE	official	78.1	71.9	39.1	80.5	86.1	86.2	72.1	75	74.6	41	77.7	86.3	79.1	73.3	70.7	75
	fuzzy	77.8	71.4	38.8	80.2	85.7	85.7	71.5	74.6	73.9	40.6	77.3	85.8	78.6	72.9	70.3	74.6
ES	official	68.8	57.6	22.3	72.2	79.2	74.9	53.3	63.2	63	51.6	62	79.8	64.3	62.1	61.4	63.2
	fuzzy	66.9	53.4	20	67.7	76	71.8	51.3	60.6	58.2	48.5	58.8	76.8	60.9	59.4	58.9	60.2
FI	official	73.2	71.7	43.3	78.1	85.3	86.3	66.3	73	65.1	38.8	73.9	86.1	72.8	71.2	73.3	72.4
	fuzzy	71.6	69.2	40.9	75.6	83.6	84.6	64.5	71	62.2	36.8	71.6	84.4	70.7	69.2	71.3	70.4
FR	official	68.3	62.7	29.4	77.8	82.2	82.2	52.9	66.7	58	40.2	65.2	83.5	64.2	64	67.9	65.4
	fuzzy	66.7	59.8	28	75.3	79.6	79.6	50.7	64.6	54.4	37.5	62.7	81.7	61.8	61.7	65.7	63.1
GR	official	65.9	47.3	14.6	65.9	74.5	70.9	43.2	56.8	53.3	39	55.1	75.2	55.3	55.7	59.2	56.5
	fuzzy	64.3	45	13.3	62.6	72.3	69.1	42.2	55	49.7	37.4	53.2	73	53	53.8	57.9	54.6
HR	official	67	57.1	27.7	77.4	83.8	73.4	43.9	62.2	61.1	26.7	65.5	81.9	66.3	61.7	58.9	62.1
	fuzzy	66.7	56.5	27.5	76.7	83.2	72.9	43.6	61.7	60.6	26.2	65.1	81.3	65.9	61.3	58.4	61.6
HU	official	77.3	63	28.5	79.3	85.9	87.4	56.7	69.9	77.4	39.4	74.8	85.2	73	69.8	67.7	70.1
	fuzzy	77.1	62.6	28.4	79.1	85.6	87.1	56.4	69.7	77.1	39.1	74.6	85.1	72.8	69.5	67.4	69.9
IE	official	75	64.2	41.2	80.3	81.5	78.2	61.8	68.9	71.4	37.7	70.3	85.2	71.8	67.3	68.7	69.5
	fuzzy	72.8	62.2	39.1	78	79.8	76	59.6	66.9	69	35.8	67.8	83.5	70.1	64.9	66.4	67.4
IS	official	85.8	81.7	71.4	86.7	89.2	88.6	81	84.1	82	71.6	85.2	91.6	83.8	82.2	86.1	83.8
	fuzzy	85.1	80.2	70	85.4	88.6	87.5	79.7	83	80.9	70.5	84.1	90.5	82.9	80.7	84.9	82.7
IT	official	68	50.1	18.5	62.5	73.5	73.2	54.3	58.7	61.4	44	64.9	78.9	59.5	59.1	58.2	59
	fuzzy	65.9	45.3	16.6	58	69.4	69.4	51.7	55.6	55.9	40.8	61.3	75.4	55.7	55.9	55	55.6
LU	official	72	63.9	28.7	86.1	86.7	80.1	43.2	62.7	72.4	46.1	67.3	84	75.3	66.4	66.1	68
	fuzzy	71.6	62.6	27.6	85.1	85.9	79.4	42.6	62.2	71.2	44.8	66.5	83.5	74.6	65.5	65.3	67.2
LV	official	74.3	70.9	31.8	81.9	85.1	82.4	68.6	72.9	68.9	38	72.1	89.2	76.9	71.3	67.9	72.6
	fuzzy	73.8	70	31.8	81.6	84.4	81.3	67.4	72.2	67.9	37.7	71.3	88.6	76.5	70.4	66.9	71.9
MT	official	82.3	63.6	50.9	87.5	85.5	81.3	51.6	70.9	81.9	62.8	75	88.6	72.5	73.9	78.8	73.4
	fuzzy	81.9	63.2	50.5	87	85.3	80.6	51.4	70.6	81.3	62.4	74.7	88.2	72.2	73.6	78.4	73
NL	official	82.3	74	65.3	85.9	85.6	84.6	69.3	80.4	65.7	61	80.2	88.1	76.5	80.4	80.8	78.2
	fuzzy	81.1	72.2	63.1	84.4	84.6	83.3	67.7	79	63.4	59.1	78.7	86.9	74.8	79.2	79.4	76.7
NO	official	76.9	72.6	49.3	82.6	84.7	83.4	71.3	76.5	68.3	50.6	76.6	88.8	76.2	74.4	74.2	74.8
	fuzzy	75.2	68.5	41.9	79.7	82.6	81.6	69.4	74.1	63.6	45.3	73.6	87.3	73.9	71.4	71	72
PL	official	75.3	61.1	31.7	81.3	85	81.9	49.5	68.2	75	24.7	68.6	87.9	72.2	66.8	65.5	68.2
	fuzzy	75.1	60.7	31.4	81	84.6	81.5	49.3	67.8	74.7	24.4	68.2	87.6	71.8	66.5	65.1	67.9
PT	official	73.6	67.6	28	84.1	88.2	83	60.4	69.8	76.3	61.2	73.3	85.5	70.7	71.5	68.4	70.5
	fuzzy	72.7	65.6	27	82.3	86.7	81.5	59	68.4	74.2	59.9	72	83.7	69.2	70.2	67	69
RO	official	74.6	56.8	24.7	78.7	84.3	80.8	47.8	65.8	61.2	44.4	68.6	89.2	70.2	63.1	63.9	65.8
	fuzzy	71.6	55.3	22.5	76.4	81.7	78.3	46.1	63.5	60.2	39.3	66.9	89	70.1	61	59.6	63.5
SE	official	78.7	75.4	43.9	82	88.6	89	77.7	80.7	65.8	46	82.4	88.8	76.7	77.4	77.3	77.1
	fuzzy	77.5	73.3	39.5	80.1	87.5	88	76.5	79.3	63.2	43.3	80.5	87.8	75	75.7	75.6	75.4
SK	official	74.4	62.4	24.9	75.7	83.8	86.6	57	68.3	78.7	20.7	75	80.6	73.7	67.4	66.8	68.4
	fuzzy	74	61.8	24.6	75.4	83.1	86	56.7	67.9	78.6	19.2	74.6	80.5	73.5	67	66.1	67.9
UK	official	78.9	70.8	49.5	84.6	85.6	84.3	66.3	74.8	74.9	61.9	74.6	85.6	73.3	77.2	76.8	74.8
	fuzzy	77.7	69.2	47.5	83.3	84.4	83	65.1	73.5	73	60	73.1	84.5	71.7	76	75.6	73.4

Note: our elaborations on EU-LFS 2019 data

Table 4 Unemployment rates by categories of work – European countries, year 2019 - Official and fuzzy measures

Country	Measure	Gender		Age (years)					Country of birth		Education			Urbanisation			Total
		Male	Female	15-24	25-34	35-44	45-54	55-64	Native-born	Foreign-born	Lower secondary	Upper secondary	Tertiary	Cities	Towns and suburbs	Rural areas	
AT	official	4.7	4.4	8.6	5.1	4.5	3	3.4	3.5	8.3	10.9	4	3	8.1	3.9	2.2	4.6
	fuzzy	5.4	5.9	9.9	6	5.5	4.2	4.4	4.3	10.2	12.5	5	4	9.7	4.8	3	5.6
BE	official	5.8	5	14.2	6.4	4.5	3.5	4.1	4.1	11	11.6	5.7	2.8	9.4	3.5	3.9	5.4
	fuzzy	7.1	6.1	15.9	7.7	5.8	4.5	4.9	5.1	13.1	13.7	6.8	3.7	11.2	4.4	4.9	6.6
BG	official	4.6	3.9	8.9	5.5	3.9	3.1	3.8	4.3	0	12.7	3.5	2	2.5	4.3	7.8	4.3
	fuzzy	5.1	4.4	10.1	5.9	4.4	3.6	4.5	4.8	1	15	3.8	2.1	2.6	4.7	9.2	4.8
CH	official	4.3	4.8	8	4.6	3.7	3.9	3.9	3.2	7.3	8.2	4.5	3.3	5.5	4.3	3.6	4.5
	fuzzy	5.1	6.9	9	5.7	5.1	5.6	5.8	4.1	9.7	10.9	6	4.4	7.1	5.7	5	6
CY	official	6.5	8.1	16.6	7.4	5.6	6.1	6.3	7.4	6.8	8.2	8.1	6.2	7	7.8	7.2	7.3
	fuzzy	9.4	12	19.8	11.4	8.6	9	10.2	10.9	10	11.5	11.5	9.7	10.2	11.5	10.6	10.7
CZ	official	1.8	2.4	5.6	2.6	1.6	1.5	2	2	3.2	10.2	1.8	1	1.9	2.5	1.8	2.1
	fuzzy	1.9	2.7	6	2.8	1.8	1.6	2.1	2.2	3.2	11.1	2	1	2.2	2.6	1.9	2.2
DE	official	3.6	2.8	5.9	3.9	3	2.3	2.7	2.7	5.7	8.1	2.8	1.9	4.3	2.8	2.2	3.2
	fuzzy	4.5	4.5	6.8	5	4.1	3.6	4.2	3.6	8	10.5	4	2.6	5.7	4	3.2	4.5
DK	official	4.9	5.4	10.1	7.3	3.5	3	3.4	4.7	8.5	8.7	4.2	4	6.2	4.9	4.3	5.1
	fuzzy	5.8	6.9	12.7	8.5	4.3	3.8	4.3	5.8	10.9	10.1	5.5	4.9	7.5	6	5.5	6.3
EE	official	4.1	5.1	11.1	4.4	3.8	3.7	4	4.4	6.2	10.3	4.9	2.9	4.3	4.7	4.9	4.6
	fuzzy	4.6	5.7	11.6	4.8	4.3	4.3	4.9	4.9	7.1	11.1	5.4	3.5	4.9	5.2	5.5	5.1
ES	official	12.5	16.1	32.5	16.2	11.5	12	12.7	13.2	18.4	20.6	14.5	8.7	13.9	14.6	14.3	14.2
	fuzzy	14.9	22.2	39.4	21.5	15	15.7	16	16.8	24.6	25.3	18.9	12.2	18.4	18.4	17.8	18.3
FI	official	7.3	6.2	17.2	6.6	4.4	4.3	6.4	6.5	11.7	16.2	7.4	4	7.6	6.9	5.5	6.8
	fuzzy	9.3	9.5	21.7	9.6	6.3	6.1	9	8.9	15.4	20.3	10.2	5.9	10.2	9.5	7.9	9.4
FR	official	9	8.8	22.2	9.5	7.2	6.1	7	8	14.8	15.2	10.1	5.2	10.1	9.6	6.9	8.9
	fuzzy	10.9	12.9	25.6	12.4	10	8.9	10.4	10.7	19.8	20.4	13.3	7.1	13.2	12.7	9.7	11.9
GR	official	14.1	21.7	35.2	23.3	15.3	14.2	13.4	16.3	28.6	21.6	19.7	12.3	18.4	18.1	15.2	17.5
	fuzzy	16.1	25.3	40.4	27.2	17.8	16.3	15.2	18.8	33.4	24.7	22.5	14.7	21.8	20.9	17	20.2
HR	official	6.2	7.3	16.6	9.6	5.6	3.7	3.4	6.8	6.2	9.6	7	5.4	6.1	7.2	6.9	6.7
	fuzzy	6.7	8.2	17.1	10.3	6.3	4.4	4.2	7.5	6.9	11.4	7.5	6	6.7	7.8	7.7	7.4
HU	official	3.4	3.5	11.4	3.7	2.9	2.5	2.2	3.5	2.7	9.8	3	1.6	2.6	3.6	4.1	3.5
	fuzzy	3.6	4	11.8	3.9	3.3	2.8	2.7	3.8	3.2	10.6	3.4	1.7	3	4	4.5	3.8
IE	official	5.4	4.8	12.5	5.2	3.7	3.6	3.6	4.8	5.9	9.7	6.1	3.2	4.8	6.2	4.7	5.1
	fuzzy	7.9	7.5	16.4	7.7	5.7	6.2	6.8	7.4	8.9	13.8	9.2	5.2	6.9	9.3	7.7	7.7
IS	official	4	3.2	8.7	4.4	2.5	1.6	1.7	3.5	4.7	6	3.4	2.4	4	4.2	1.3	3.6
	fuzzy	4.8	5	10.5	5.8	3.1	2.8	3.2	4.7	6	7.4	4.8	3.5	5	6	2.7	4.9
IT	official	9.3	11.3	29.2	14.8	9.1	7.3	5.4	9.6	13.1	14.1	9.6	5.9	11.1	9.6	9.9	10.2
	fuzzy	12.1	19.7	36.2	21	14.1	12.1	9.9	14.4	21	20.4	14.6	10	16.7	14.6	14.9	15.4
LU	official	5.7	5.5	17	5.5	4.8	3.7	4.1	4	6.7	8.2	6.2	4	6.6	6	4.6	5.6
	fuzzy	6	7.2	18.7	6.5	5.7	4.5	4.9	4.3	8.1	10.1	7.2	4.6	7.3	7.1	5.4	6.6
LV	official	7.3	5.7	12.4	6.6	5.5	5.6	6.5	6.3	8.6	13.2	7.1	4.2	6.2	5.1	7.8	6.5
	fuzzy	7.9	6.8	12.4	7	6.3	6.8	8	7.1	9.8	13.8	8.1	4.9	6.7	6.2	9	7.3
MT	official	3.3	3.7	9.2	3.8	2.4	2.1	1.5	3.4	3.6	4.8	3.2	2.2	4.8	2.3	1.2	3.5
	fuzzy	3.7	4.2	9.7	4.2	2.6	2.9	1.9	3.7	4.4	5.3	3.6	2.7	5.2	2.7	1.7	3.9
NL	official	3.4	3.4	6.7	2.9	2.7	2.2	3.4	3	5.9	6	3.2	2.3	4	2.7	2.3	3.4
	fuzzy	4.2	4.7	8.1	4.1	3.4	3.1	4.5	4	7.6	7.3	4.3	3.2	5.2	3.6	3.3	4.4
NO	official	4.1	3.5	10	3.7	3.3	2.4	1.5	3	7.2	8.7	3.4	2.2	4.1	3.8	3.6	3.8
	fuzzy	5.2	6.5	15.3	6.4	4.9	3.7	2.5	4.5	11.4	12.8	5.7	3.3	5.6	6	5.8	5.8
PL	official	3.1	3.7	9.9	3.7	2.6	2.4	2.4	3.3	5.7	8.6	3.7	2	2.9	3.5	3.7	3.3
	fuzzy	3.4	4.3	10.7	4.1	3.1	2.8	2.9	3.8	6	9.7	4.2	2.4	3.3	4	4.2	3.8
PT	official	6.1	7.3	18.3	7	4.9	5.3	6.2	6.5	8.4	7.2	7.3	5.4	7.2	6.3	6.3	6.7
	fuzzy	7.2	10	21.2	9	6.5	7.2	8.4	8.3	10.9	9.3	8.9	7.4	9.2	8.1	8.2	8.6
RO	official	4.4	3.5	16.8	4.5	2.6	2.7	2.4	4	3.6	7	4	1.6	2.7	4.6	4.9	4
	fuzzy	8.3	6.1	24	7.2	5.7	5.8	5.8	7.4	5.1	17.6	6.4	1.8	2.9	7.8	11.3	7.4
SE	official	6.9	7.1	20.1	6.3	5.1	4.7	4.7	4.5	15.5	21.6	5.1	3.8	7.5	6.9	6.4	7
	fuzzy	8.2	9.3	25.6	8.2	6.2	5.7	6	6	18.3	24.9	7.1	4.8	9.2	8.6	8.3	8.7
SK	official	5.7	6	16.1	6.7	4.9	4.3	4.7	5.9	3.6	31.3	4.9	2.5	3.5	6	6.9	5.8
	fuzzy	6.2	6.9	17.3	7	5.7	4.9	5.2	6.5	3.7	36.1	5.3	2.7	3.8	6.6	7.7	6.5
UK	official	4	3.7	11.3	3.2	2.4	2.5	2.9	3.8	4	6.4	3.9	2.8	4.6	2.8	2.6	3.9
	fuzzy	5.5	5.7	14.6	4.7	3.7	4	4.5	5.4	6.3	9.1	5.8	4	6.6	4.3	4.1	5.6

Note: our elaborations on EU-LFS 2019 data

5. Conclusions

The classification of the working-age population into the three mutually exclusive and exhaustive categories of employed, unemployed and economically inactive persons may conceal relevant grey areas among them, such as underemployment and marginal labour force attachment, which deserve special attention.

In this paper, we focused on people on the margin between employment and unemployment. Using a fuzzy approach, we introduced the idea of “employed to a certain degree”. Our methodological proposal accounts for both the number of hours actually worked and the will to work more.

The results of the empirical application to EU Labour Force Survey 2019 data show that the adoption of a fuzzy approach increases the heterogeneity of the employment and unemployment rates across countries. The extent of the effect depends on the share of underemployed workers and the distribution of worked hours: the lower the percentage of underemployed workers and the less concentrated the distribution of worked hours, the more negligible the difference between official and fuzzy rates.

For several Eastern European countries, the fuzzy approach reduces the employment rate by less than 1%. In contrast, for many Southern European countries, the differences exceed 3%: specifically, Italy records a reduction of over 5%.

For almost all countries, we observe the most remarkable downward corrections for the employment rate of typically disadvantaged segments of the labour market, such as females, young people and those with the lowest educational attainment. In fact, these workers are the most severely affected by underemployment.

In countries such as Italy, Spain, Greece and France, the female component not only is penalized in terms of employment but also presents an unmet need for working more hours stronger than male workers. The consequence is that the fuzzy approach widens the gender gap in the employment rate, particularly in the countries mentioned above.

As for the unemployment rate, the fuzzy measure is higher than the official rate in all countries. As we commented on for the employment rate, the differences are homogeneous neither across countries nor across workers' categories. With very few exceptions, in those countries where the gender gap in the official unemployment rate favoured women, the fuzzy approach reduces or even reverses the gap. Conversely, in all those countries where the gender gap was to the advantage of male workers, the fuzzy method enlarges the difference.

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