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Article

The impact of COVID-19 on the level and structure of employment in European Union countries

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The Impact of COVID-19 on the Level and Structure of Employment in European Union Countries

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Abstract

The paper proposes methods that can be used to evaluate the changes in one year of any measurable phenomenon based on how it performed in previous years. The following economic sections are considered: Agriculture, forestry and fishing/Industry/Construction/Wholesale and retail trade, transport, accommodation and food services/Information and communication/Financial and insurance activities/Real estate activities/Professional, scientific and technical activities, including administrative and support services/Public administration, defence, education, human health and social work/Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organisations and bodies. The paper proposes a new method – called The Triple 2 Rule – to identify changes in employment time series. Trends and autoregressive models are estimated for the period 2008–2019, and 2020 forecasts are calculated. The difference between the forecasted and observed values for 2020 is treated as a measure of the impact of COVID-19. Dynamic cluster analysis based on 2008–2020 data is the second approach. The characteristics and changes in the composition of dynamic clusters give a picture of the impact of 2020. These changes can be considered to have been caused – at least partially – by the COVID-19 pandemic.

Keywords: employment, COVID-19, European Union countries, dynamic cluster analysis, triple 2 rule

JEL: C38, E24, F16, O52



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Introduction

The paper proposes methods that can be used to evaluate the changes in one year of any measurable phenomenon based on how it performed in previous years. These methods are used to identify important deviations seen in 2020 from tendencies observed in employment in European Union (EU) countries. 2020 was the year of the COVID-19 pandemic, followed by restrictions, including lockdowns, as well as some helpful measures offered by governments to the economy. The paper proposes a new method – called The Triple 2 Rule – to identify changes in employment time series. We have tried to identify important changes in employment rates in EU countries, i.e. to point out particular countries, answering the question “where?” The answer to “why?” is much more difficult and needs a deeper, country-specific investigation.

Literature review

The COVID-19 pandemic covered the whole world and every aspect of social life. The first wave of the 2020 pandemic impacted not only demographics with rising mortality rates, but also health services, where hospitals and other units were on the brink of collapse. Lockdowns were the means to stop quick transmission of the virus. Online work was widely introduced, and schools and kindergartens were closed, as were some branches of the economy. Generally, enterprises should be prepared to function in a turbulent environment, but this time, the perturbations went far beyond what anyone had expected just a few months before.

Different effects of the pandemic on the economy have been studied in the literature, such as supply chains breaking up (Maital and Barzani 2020), changes in foreign trade (Cardoso and Malloy 2021), and the collapse of tourism due to border closures and other limitations (Rami and Wahba 2021). The influence on the labour market has been discussed for countries with different economies, cultures and sizes, e.g., Canada (Beland, Fakorede, and Mikola 2020; Qian and Fuller 2020; Lamb, Gomez, and Moghaddas 2021), the USA (Lambert 2020; Rojas et al. 2020), Bangladesh (Hossain 2021), Romania (Radulescu et al. 2021), Turkey (Yüksel 2021), the UK (Mayhew and Anand 2020), Vietnam (Le et al. 2021), Australia (Borland 2020a, 2020b; Lim et al. 2021; Lloyd and Dixon 2021; Walkowiak 2021), Spain (Rodríguez-López, Rubio-Valdehita, and Díaz-Ramiro 2021; Rubio-Valdehita, Rodríguez-López, and Marín 2021), Cameroon (Biwolé 2022), India (Roychowdhury, Bose, and De Roy 2022), Poland (Rosak-Szyrocka 2021), and Japan (Fukai, Ichimura, and Kawata, 2021).

The analysis of the effects of the pandemic on the labour market also took place for economic spaces bigger than just one country, e.g., Europe (Lewandowski 2020; Chi-Wei et al. 2021) and Central America (Webster, Khorana, and Pastore 2022), and the whole

world (ILO 2020; OECD 2020). Several aspects were discussed, such as the labour market crisis (junk contracts) (Koebel and Pohler 2020), self-employment (Beland, Fakorede, and Mikola 2020), the employment gap in parents with small children (Qian and Fuller 2020, Fuller and Qian 2021), new forms of parenthood leave (Doucet, Mathieu, and McKay 2020), the employment of youngsters (Svabova and Gabrikova 2021), the mutual effect of labour market development and the progression of the COVID-19 pandemic (Shishkina, Mamistova, and Sabetova 2021), and unemployment (Lambert 2020; Kalkavan et al. 2021; Chi-Wei et al. 2021).

A sectorial approach was also important, e.g., fashion retailing (Rodríguez-López, Rubio-Valdehita, and Díaz-Ramiro 2021), the retail sector (Rubio-Valdehita, Rodríguez-López, and Marín 2021), industries (Slade 2022), and construction and industry (Radzi, Rahman, and Almutairi 2022). Methods used included predictions using time-series mining (Rakha et al. 2021), modelling (Radzi, Rahman, and Almutairi 2022) and surveys (Rubio-Valdehita, Rodríguez-López, and Marín 2021).

Data

The data were taken from the Eurostat webpage [lfst_r_lfe2en2] (Eurostat n.d.) or the period 2008–2020. The number of people employed is given as a total, and separately for males and females. The economy is divided into the following sections (numbers given in brackets are used in the tables and text of the paper):

- Agriculture, forestry and fishing (1),
- Industry (2),
- Construction (3),
- Wholesale and retail trade, transport, accommodation and food services (4),
- Information and communication (5),
- Financial and insurance activities (6),
- Real estate activities (7),
- Professional, scientific and technical activities, administrative and support services (8),
- Public administration, defence, education, human health and social work (9),
- Arts, entertainment and recreation, other service activities, activities of household and extra-territorial organisations and bodies (10).

Methods

There are two main approaches used in this paper. The first compares predictions for 2020, calculated from the time series models estimated for 2008–2019, with the actual values observed in 2020.

Method 1

The general assumption is that if there was no extra external influence (such as COVID–19 with all restrictions on the economy it imposed), then the observed values in 2020 should follow the pattern observed in 2008–2019. If there is an important deviation from this pattern, we can assume that an “intervention” (using the language of time series analysis) happened. Following the graphical analysis of the time series, we assume that quadratic trend plus first-order autoregression of residuals and classical autoregression (of the process) of order 2, estimated for 2008–2019, are the models to be used to predict the situation in 2020. Finally, three indexes are used:

$$I_1 = \frac{100 * (y_{2020} - y_{2019})}{y_{2019}}.$$

I_1 is a simple dynamic measure, and y_t are observed values of the number of people employed in a given section (or totals) per 100 eligible population, 15–64 years old.

$$I_2 = \frac{y_{2020} - \hat{y}_{2020}^{(1)}}{S_\varepsilon^{(1)}},$$

where $\hat{y}_t^{(1)} = \widehat{f(t)} + b_3 \varepsilon_{t-1}$

$$\widehat{f(t)} = b_0 + b_1 t + b_2 t^2$$

$$\varepsilon_{t-1} = y_{t-1} - \widehat{f(t-1)}$$

$$S_\varepsilon^{(1)} = \sqrt{\frac{\sum_{t=1}^n (y_t - \hat{y}_t^{(1)})^2}{n - w}}$$

I_2 is the standardised difference between trend model $f(t)$ with autoregression of residuals and real value observed in 2020. The standard error of estimation S_ε is a standardisation factor. Estimates b_0 , b_1 , b_2 , and b_3 are obtained by the OLS (Ordinary Least Squares) method based on data from 2008–2019 ($n = 12$). The number of parameters in the main model is $w = 4$.

$$I_3 = \frac{y_{2020} - \hat{y}_{2020}^{(2)}}{S_\varepsilon^{(2)}},$$

where: $\hat{y}_t^{(2)} = a_0 + a_1 y_{t-1} + a_2 y_{t-2}$

$$S_\varepsilon^{(2)} = \sqrt{\frac{\sum_{t=1}^n (y_t - \hat{y}_t^{(2)})^2}{n - w}}$$

The model used in I_3 is a classical autoregression (CAR) of the process of order 2, with three parameters ($w = 3$).

In order to identify important changes in employment imposed by the intervention, we propose the *Triple 2 Rule*. The first of these *Triple 2's* is used for the three indexes proposed above. They indicate important change if the absolute value is bigger than 2. This choice for I_1 is subjective, but for I_2 and I_3 , it suggests statistical significance at a 0.05 significance level. The second 2 means that the change is considered important if at least 2 of the three indexes (I 's) indicate an important change. Finally, we calculate the geometric average of the modules of the three I 's if at least two of them indicate importance, assigning a minus if all I 's are negative. In the case of different signs of I 's, we take the median instead of the geometric average. The absolute value of this mean should be at least 2 to allow for further interpretation.

For countries characterised by these adjusted (by minuses if necessary) geometric means or medians, we applied Ward's agglomerative cluster analysis method (Ward 1963) to find homogeneous groups of countries where changes in employment sections were similar in 2020. The classification task is $[Y, Zt]$ (Sokołowski 1982; Markowska 2012), where Y (objects) – 27 EU countries, Z (variables) – 10 sections of the economy, t (time) – 2020.

Method 2

Dynamic cluster analysis is the second approach used in the paper. The clustering task is $[YT, Z]$, where Y – 27 countries, T – 13 years (2008–2020), YT – $27 \times 13 = 351$ spatio-temporal “objects”, Z – 10 sections of the economy.

In the results section, we will look for the countries which changed the cluster they were assigned to between 2019 and 2020.

Results – changes in the total employment rate

The application of Method 1 is illustrated in Figure 1. The EU employment rate per 100 eligible population is in blue. The parabolic trend plus first-order autoregression of residuals is shown in green, while the classical autoregression of second-order is in red. The real value in 2020 is represented by the blue square.

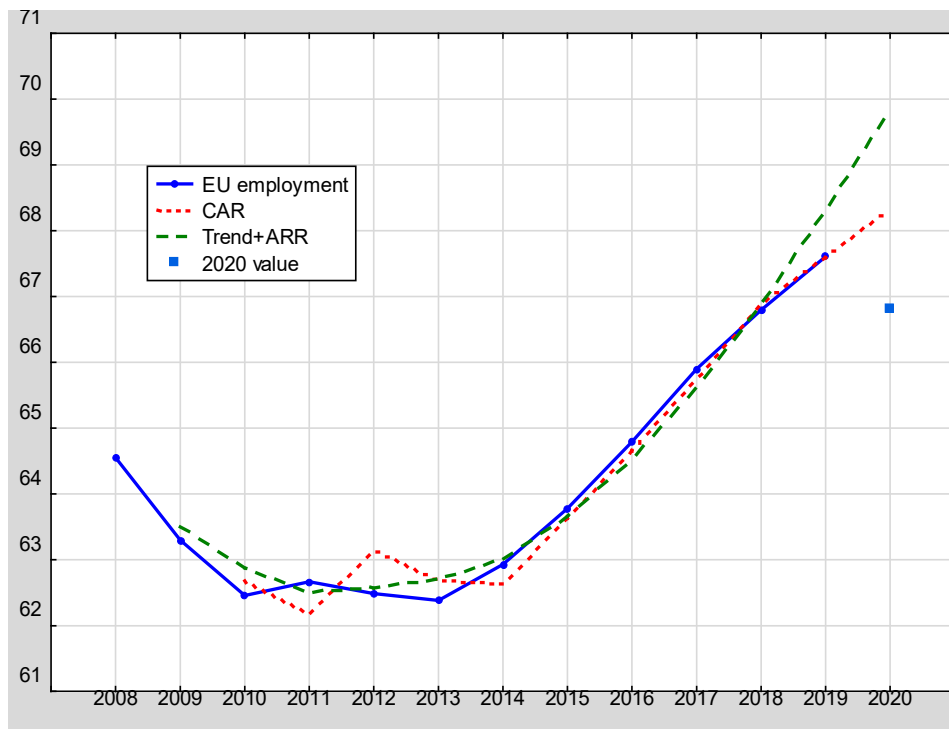


Figure 1. Employment rate in the EU

Source: own calculations.

For this case, we have the following numerical results:

$$I_1 = \frac{66.81 - 67.61}{67.61} = -1.18$$

$$\hat{y}_t^{(1)} = 65.06 - 1.05t + 0.11t^2 + 0.23\varepsilon_{t-1}$$

$$S_\varepsilon^{(1)} = 0.91$$

$$I_2 = -3.18$$

$$\hat{y}_t^{(2)} = 2.79 + 1.68y_{t-1} - 0.72y_{t-2}$$

$$S_\varepsilon^{(2)} = 0.37$$

$$I_3 = -4.04$$

Table 1 presents results for total employment.

Table 1. Predictions vs actual values in 2020 – total employment

Country	I_1 Dynamics: 2020/2019	Difference: Adjusted Trend-Actual	I_2 Standardised difference: Adjusted Trend-Actual	Difference: CAR-Actual	I_3 Standardised difference: CAR-Actual
EU	-1.18	-2.89	-3.18	-1.50	-4.04
Belgium	-0.97	-1.50	-2.02	-2.12	-3.67
Bulgaria	-2.34	-5.85	-2.88	-3.36	-2.01
Czechia	-0.98	-3.65	-2.72	-0.61	-2.24
Denmark	-0.98	-3.01	-2.57	-1.55	-4.05
Germany	-0.89	-1.06	-0.95	-0.99	-1.11
Estonia	-2.01	-5.20	-2.02	-1.56	-0.95
Ireland	-2.67	-6.70	-3.11	-2.44	-5.19
Greece	-0.88	-4.53	-1.64	-0.70	-0.96
Spain	-4.01	-7.34	-3.43	-3.12	-2.64
France	-0.40	-1.18	-2.85	-0.62	-2.65
Croatia	-0.19	-4.33	-2.02	-0.08	-0.07
Italy	-1.54	-2.04	-2.46	-1.37	-2.23
Cyprus	-0.87	-4.07	-1.54	-0.68	-0.43
Latvia	-0.88	-4.68	-1.74	-0.95	-1.08
Lithuania	-1.77	-5.38	-2.41	-1.73	-1.47
Luxembourg	-0.98	-0.73	-0.61	-1.15	-1.39
Hungary	-0.51	-4.15	-2.00	-1.03	-1.15
Malta	-2.14	-5.18	-2.07	-3.15	-4.85
Netherlands	-0.63	-1.98	-2.16	-0.95	-1.50
Austria	-1.53	-1.40	-3.37	-1.56	-4.97
Poland	0.73	-1.77	-1.77	-0.05	-0.06
Portugal	-1.96	-5.97	-2.95	-1.05	-0.88
Romania	-0.52	-3.17	-2.25	0.20	0.13
Slovenia	-0.66	-5.09	-2.80	0.04	0.03
Slovakia	-1.31	-4.32	-2.94	-1.32	-2.74
Finland	-1.25	-2.30	-2.02	-1.52	-2.02
Sweden	-2.34	-3.53	-3.80	-1.85	-3.87

Source: own calculations.

Blue shading indicates important ($I_j < -2$) negative deviations of the values from the prediction (I_2 and I_3), or dynamics lower by at least 2% (I_1). Green indicates growth bigger than expected ($I_j > 2$).

For total employment, all three indices were smaller than -2 in five countries: Bulgaria, Ireland, Spain, Malta, and Sweden. Only I_2 and I_3 are smaller than -2 in Belgium, Czechia, Denmark, France, Italy, Austria, Slovakia, and Finland.

Results – changes in employment rate in sections

The EU economies reacted differently to the perturbations connected with supply chain breaks. In some cases, production had to stop in selected enterprises, in part due to COVID–19 cases among workers. The hotel and restaurant section was generally closed. Schools and universities changed their means of instruction to online education.

Table 2 presents the final identification of important changes in the labour market as pointed out by the indexes and the Triple 2 Rule. The numbers in brackets are the medians used instead of the geometric averages when not all I_j 's have the same sign. As expected, Wholesale and retail trade, transport, accommodation and food services was the section hurt most by the pandemic. Information and communication and Finance and insurance activities covered more employers than expected.

Germany was a very interesting case – with strong changes in sections, but the overall result in total employment was not important.

There were different effects of the COVID–19 pandemic on employment in various sections of the economy. According to the Triple 2 Rule, there were important changes in the following countries:

- Agriculture, forestry and fishing: Czechia (–), Greece (–), Spain (–), Austria (+), Poland (+),
- Industry: Czechia (–), Greece (–), Spain (–), France (–), Hungary (–), Germany (+),
- Construction: Germany (–), Ireland (–), Lithuania (–), Malta (–), Sweden (–), Austria (–), Finland (–), Czechia (+), Croatia (+), Slovenia (+),
- Wholesale and retail trade, transport, accommodation and food services: all countries suffered a negative change except Denmark, Greece, France, Croatia, Luxembourg and Romania,
- Information and communication: Bulgaria (–), Germany (+), Cyprus (+), Latvia (+), Slovenia (+), Slovakia (+),

- Financial and insurance activities: Bulgaria (-), Estonia (-), Denmark (+), Germany (+), Ireland (+), France (+), Lithuania (+), Malta (+), Austria (+), Slovenia (+), Finland (+),
- Real estate activities: Lithuania (-), Poland (-), Portugal (-), Germany (+), Ireland (+), Luxembourg (+), Hungary (+), Austria (+), Finland (+),
- Professional, scientific and technical activities, administrative and support services: Germany (-), Ireland (-), Spain (-), Italy (-), Slovakia (-),
- Public administration, defence, education, human health and social work: Malta (-), Sweden (-),
- Arts, entertainment and recreation, other service activities, activities of household and extra-territorial organisations and bodies: Czechia (-), Ireland (-), Spain (-), Croatia (-), Italy (-), Slovakia (-), Finland (-), Sweden (-), Germany (+).

Table 2. Final evaluation of the 2020 intervention on the labour market

Country	Total	Section									
		1	2	3	4	5	6	7	8	9	10
EU	-2.47			-3.67	-6.18		+4.23	+4.71	-4.69		
Belgium	-1.93				-5.29						
Bulgaria	-2.38	-1.42			-4.15	-2.14	-2.63				
Czechia	-1.82	-2.29	-2.41	+2.22	-4.17						-3.51
Denmark	-2.16				-1.93		+2.91				
Germany			+3.48	-12.91	-7.20	+9.23	+4.56	+14.95	-8.18		+6.38
Estonia	-1.57	-1.09			-4.20		(-2.35)				
Ireland	-3.51			-3.78	-5.87		+3.97	+5.91	-3.39		-7.72
Greece		-4.38	-2.10								
Spain	-3.31	-3.00	-2.36		-5.58				-2.77		-6.31
France	-1.44		-2.40				+2.71				
Croatia				+2.63							-2.73
Italy	-2.04				-3.58				-2.74		-2.56
Cyprus					-3.78	(+2.28)					
Latvia					-2.41	+3.43					
Lithuania				-2.12	-3.38		+9.13	-3.68			
Luxembourg					+2.95			+4.05			
Hungary			-2.30		-3.15			+4.42			
Malta	-2.78			-6.50	-3.48		+6.44			-2.62	

Country	Total	Section									
		1	2	3	4	5	6	7	8	9	10
Netherlands			- 1.75		- 4.67						
Austria	- 2.95	+2.91		(-2.17)	- 3.59		+2.64	+4.04			
Poland		+2.82			- 2.11			- 3.54			(+2.14)
Portugal					- 3.80			- 5.25			
Romania			- 1.38								- 1.94
Slovenia				(+2.35)	- 3.88	+3.41	+2.86				
Slovakia	- 2.19				- 2.62	+6.30			- 2.71		- 2.93
Finland	- 1.72			(-2.41)	- 5.53			+2.98			- 2.92
Sweden	- 3.25			- 2.82	- 5.82		+4.70			- 3.13	- 4.16

Source: own calculations.

The Triple 2 Rule allows us to identify important changes. Not all were negative (-); in some sections and countries, they were positive. The weakest impact was in the Public administration (and other branches) section.

Results – classification of EU countries based on 2020 employment changes indicators

Full data on averages or medians for the economy section is given in Table 3. It was used as an input for cluster analysis to group countries.

Table 3. Averages or medians for the 2020 change in employment

Country	Section									
	1	2	3	4	5	6	7	8	9	10
EU	0.50	- 0.84	- 3.67	- 6.18	2.18	4.23	4.71	- 4.69	- 0.42	- 1.43
Belgium	- 0.84	- 0.85	- 2.15	- 5.29	2.25	2.22	- 0.10	- 1.30	1.33	0.13
Bulgaria	- 1.42	- 1.75	0.46	- 4.15	- 2.14	- 2.63	- 1.67	- 1.41	- 0.08	- 0.42
Czechia	- 2.29	- 2.41	2.22	- 4.17	0.99	- 0.66	0.07	- 0.41	0.54	- 3.51
Denmark	- 1.94	0.38	1.20	- 1.93	- 0.39	2.91	- 1.28	- 2.14	0.99	- 1.58
Germany	0.32	3.48	- 12.91	- 7.20	9.23	4.56	14.95	- 8.18	1.11	6.38
Estonia	- 1.09	- 1.18	1.29	- 4.20	- 2.11	- 2.35	- 0.34	- 0.21	1.03	0.43
Ireland	- 0.49	0.32	- 3.78	- 5.87	1.30	3.97	5.91	- 3.39	- 0.68	- 7.72
Greece	- 4.38	- 2.10	- 1.59	- 0.96	- 1.35	0.57	0.30	0.62	1.60	0.53

Country	Section									
	1	2	3	4	5	6	7	8	9	10
Spain	-3.00	-2.36	-1.56	-5.58	-0.56	0.10	-1.32	-2.77	-0.30	-6.31
France	-1.11	-2.40	-0.07	-0.67	1.74	2.71	-0.01	-0.40	0.79	-1.63
Croatia	2.02	-1.51	2.73	-1.75	-1.96	1.03	1.79	-1.25	-0.84	-2.73
Italy	0.17	-0.30	0.89	-3.58	-0.17	-0.80	-1.58	-2.74	0.27	-2.56
Cyprus	0.86	1.05	0.56	-3.78	2.28	1.81	-1.19	-0.72	1.05	-0.94
Latvia	0.11	0.54	-1.74	-2.41	3.43	-0.22	-0.48	0.51	-0.33	1.03
Lithuania	-3.38	-0.56	-2.12	-3.38	0.37	9.13	-3.68	1.37	-1.11	-1.58
Luxembourg	-0.03	-0.52	-1.34	2.95	-0.48	1.00	4.05	-0.18	1.06	-2.82
Hungary	-0.07	-2.30	1.66	-3.15	2.86	0.94	4.42	2.17	-1.42	-0.21
Malta	0.85	-0.34	-6.50	-3.48	-2.07	6.44	0.50	0.48	-2.62	0.09
Netherlands	-0.65	-1.75	-0.97	-4.67	0.68	-0.35	1.61	-0.65	1.42	1.54
Austria	2.91	-1.33	-2.17	-3.59	-0.54	2.64	4.04	-1.26	-0.57	0.13
Poland	2.82	-1.51	1.17	-2.11	-0.19	0.78	-3.54	0.91	0.11	2.14
Portugal	-0.01	-1.05	-0.90	-3.80	1.23	-0.88	-5.25	-1.31	-0.95	-0.02
Romania	-0.24	-1.38	0.84	-0.39	0.47	-1.68	0.09	-1.13	0.88	-1.94
Slovenia	-0.20	-1.98	2.35	-3.88	3.41	2.86	1.75	1.15	1.62	-1.99
Slovakia	-2.11	0.36	-1.04	-2.62	6.30	-0.14	1.64	-2.71	-1.27	-2.93
Finland	-2.09	0.84	-2.41	-5.53	0.86	0.44	2.98	1.56	-0.38	-2.92
Sweden	-0.66	-1.32	-2.82	-5.82	0.28	4.70	0.14	-0.49	-3.13	-4.16

Source: own calculations.

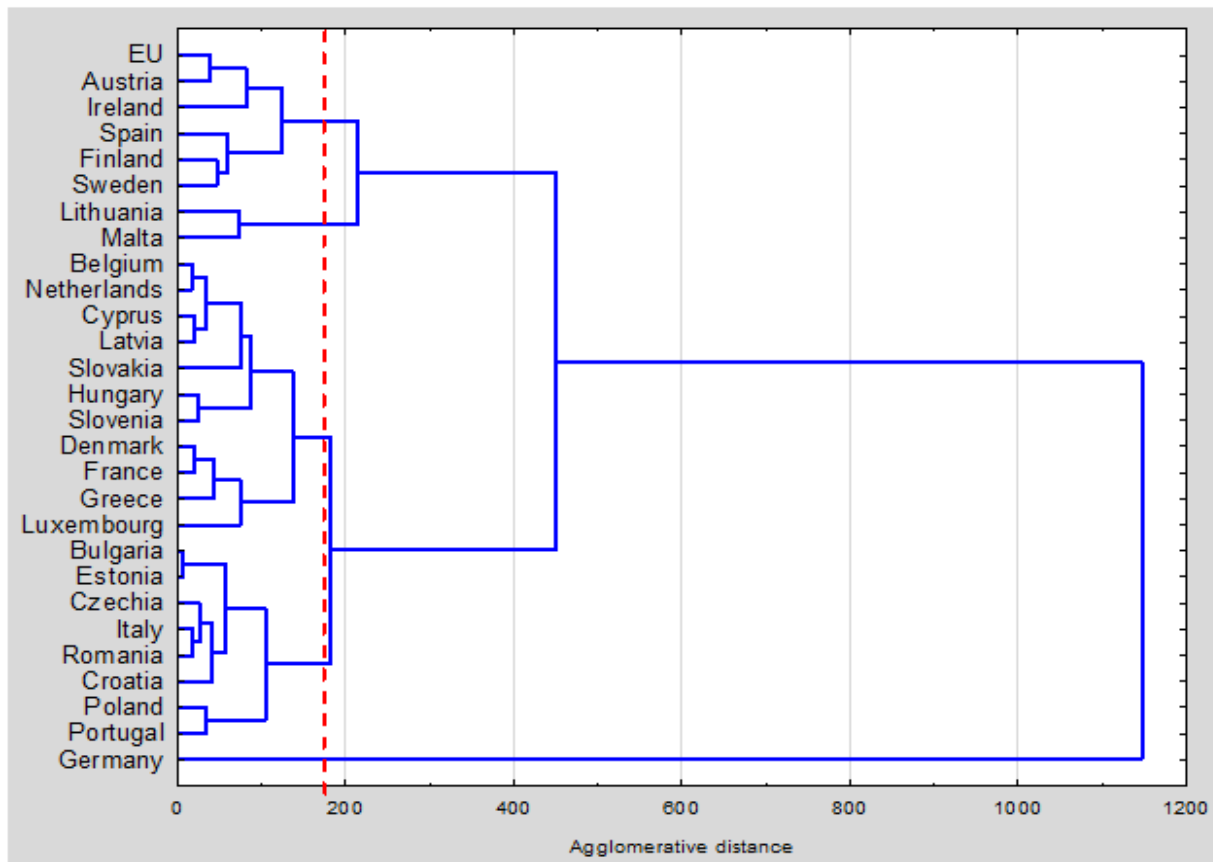
The resulting dendrogram from Ward's agglomerative method is shown in Figure 2. The partition (cutting dendrogram) into five groups is justified.

There are five groups of countries:

- Group 1: Austria, Ireland, Spain, Finland, Sweden;
- Group 2: Lithuania, Malta;
- Group 3: Belgium, the Netherlands, Cyprus, Latvia, Slovakia, Hungary, Slovenia, Denmark, France, Greece, Luxembourg;
- Group 4: Bulgaria, Estonia, Czechia, Italy, Romania, Croatia, Poland, Portugal;
- Group 5: Germany.

Differences between mean values were tested by one-way analysis of variance (ANOVA). Only Agriculture, forestry and fishing did not show statistical significance, so it

is not included in Table 4, where average indicators are marked if the absolute value is bigger than 1.



Dendrogram of countries clustered on the basis of 2020 employment changes indicators

Figure 2. Dendrogram of countries clustered based on the 2020 employment changes indicators

Source: own calculations.

Employment in Wholesale and retail trade, transport, accommodation and food services was severely affected by the situation in 2020 in all groups. Most of the EU countries are in groups 3 and 4. The difference between these groups is that in group 3, there was a slight increase in Information and communication, and in Finance and insurance.

In group 4, there was an increase in Construction, while there was an average decrease in Industry, Real estate activities, and in the Arts, entertainment and recreation, other service activities, activities of household and extra-territorial organisations and bodies. The difference between groups 1 and 2 lies mainly in changes observed in Real estate activities and in Professional, scientific and technical activities, including administrative and support services.

Table 4. Arithmetic averages in groups (agriculture shows no statistical difference between groups)

Country	Number of countries	Industry	Construction	Trade	Information	Finance	Real Estate	Science	Administration	Arts
Group 1	5	-0.77	-2.55	-5.28	0.27	2.37	2.35	-1.27	-1.01	-4.20
Group 2	2	-0.45	-4.31	-3.43	-0.85	7.79	-1.59	0.93	-1.86	-0.74
Group 3	11	-0.87	-0.28	-2.40	1.88	1.30	0.97	-0.33	0.62	-0.81
Group 4	8	-1.39	1.09	-3.02	-0.48	-0.90	-1.30	-0.94	0.12	-1.08
Group 5	1	3.48	-12.91	-7.20	9.23	4.56	14.95	-8.18	1.11	6.38

Source: own calculations.

Germany is a very special case. There was an important increase in some sectors but an important decrease in others. All sectors were involved in these unexpected changes.

Results – dynamic classification of EU countries

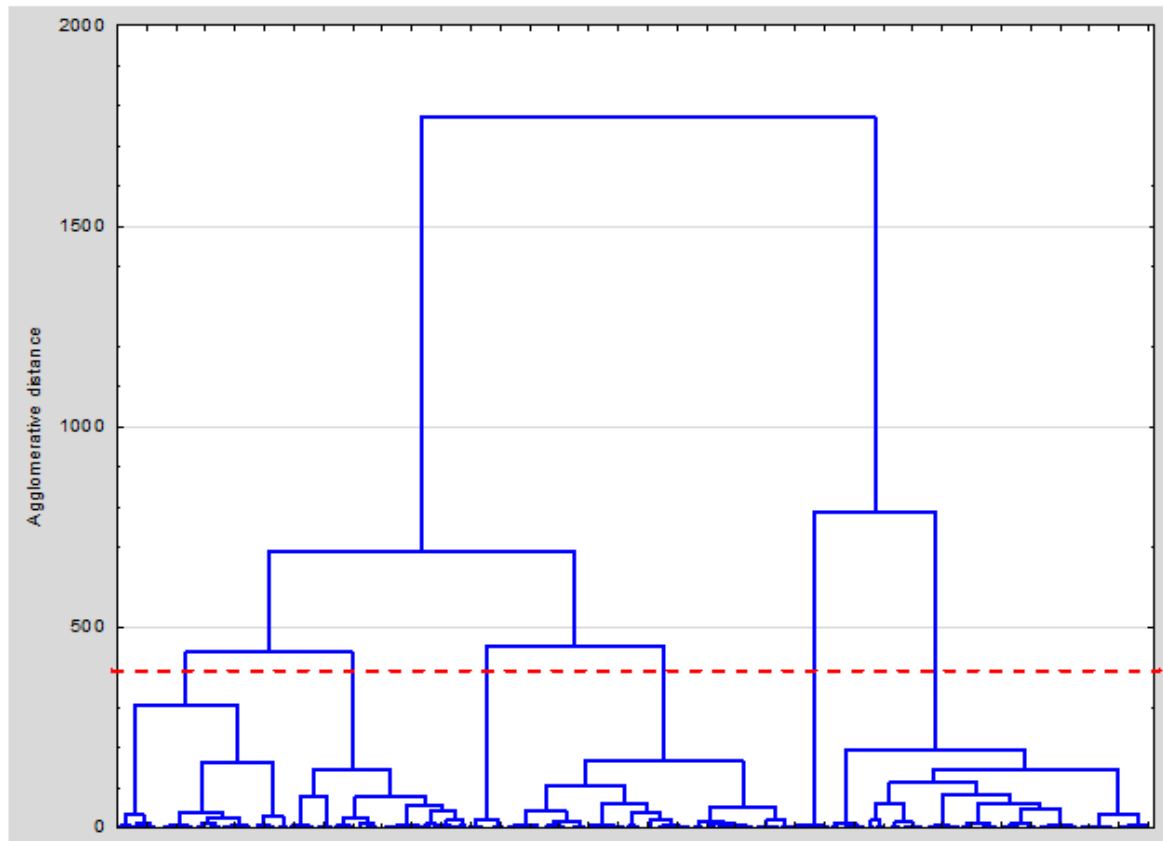
In the dynamic cluster analysis approach, the number of objects (sometimes called OTUs – operational taxonomic units) is 351. Each country in each year is a separate OTU. The number of clusters was identified with Ward's method – see Figure 3. The final partition was obtained by the k-means method. We start the presentation of results with the table with mean values of employment rates per 100 eligible population in groups. Groups are named with capital letters, and there is no order in them. Means were compared with ANOVA, and for each variable, the hypothesis of no differences between expected values was rejected (all p-values were equal to 0.0000). The biggest values in columns are marked in green and the smallest in pink.

Values in Table 5 can be quantified into three classes, high/medium/low, using differences in ordered means. The procedure is illustrated in Table 6 for means in the Arts section. Means are ordered from the biggest to the smallest (column 1), and then differences between consecutive ordered means are calculated (column 2).

Using the procedure described above, we found the qualitative characteristics of clusters (Table 7).

The two biggest differences defined the “borders” (marked in yellow) between the three qualitative classes.

Now we can analyse the dynamic composition of groups and their characteristics. The short names are used for sections, but you must bear in mind the full coverage defined at the beginning of the paper.



Dendrogram for [YT,Z] clustering task

Figure 3. Dendrogram for [YT,Z] clustering task

Source: own calculations.

Table 5. Mean values in dynamic clusters

Group	Section									
	1	2	3	4	5	6	7	8	9	10
A	8.81	11.05	4.15	14.8	1.21	1.21	0.21	3.36	10.80	2.02
B	1.62	10.02	4.47	15.57	2.65	2.17	0.63	7.22	20.50	3.58
C	2.04	9.00	4.67	17.02	1.73	2.24	0.38	5.77	13.39	4.84
D	3.19	16.02	4.95	15.58	1.8	1.49	0.35	4.22	13.55	2.33
E	0.71	3.67	3.79	10.18	2.43	7.45	0.41	6.66	18.85	6.67
F	3.77	12.47	5.99	17.93	2.02	1.59	0.87	5.24	15.17	3.28

Source: own calculations.

Table 6. Quantification of means into three classes – Arts

Means	Differences	Class
6.76		High
	1.91	
4.84		Medium
	1.26	
3.58		Low
	0.31	
3.28		Low
	0.94	
2.33		Low
	0.32	
2.02		Low

Source: own calculations.

The biggest group, B, consists of 108 operational taxonomic units. Then we have groups D (85), F (55), C (47), and A (43). Group membership with changes in time is illustrated in Table 8.

Table 7. Qualitative characteristics of clusters

Group	Section									
	1	2	3	4	5	6	7	8	9	10
A	H	M	M	M	L	L	L	L	L	L
B	L	M	M	M	H	M	M	H	H	L
C	L	M	M	H	M	M	L	M	M	M
D	M	H	M	M	M	L	L	L	M	L
E	L	L	L	L	H	H	L	H	H	H
F	M	M	H	H	M	L	H	M	M	L

Abbreviations: H – high, M – medium, L – low.

Source: own calculations.

Table 8. Composition of groups in 2008–2020

Country	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
Greece	A	A	A	A	A	A	A	A	A	A	A	A	A
Romania	A	A	A	A	A	A	A	A	A	A	A	A	A
Croatia	A	A	A	A	A	A	A	A	D	D	D	D	D
Poland	A	A	A	A	A	A	A	A	D	D	D	D	D
Lithuania	F	D	A	D	D	F	F	F	F	F	F	F	F
Belgium	B	B	B	B	B	B	B	B	B	B	B	B	B
Denmark	B	B	B	B	B	B	B	B	B	B	B	B	B
Germany	B	B	B	B	B	B	B	B	B	B	B	B	B
France	B	B	B	B	B	B	B	B	B	B	B	B	B
Netherlands	B	B	B	B	B	B	B	B	B	B	B	B	B
Finland	B	B	B	B	B	B	B	B	B	B	B	B	B
Sweden	B	B	B	B	B	B	B	B	B	B	B	B	B
Ireland	F	B	B	B	B	B	B	B	B	B	B	B	B
Malta	D	D	D	D	C	C	C	B	C	B	B	B	C
Portugal	F	F	F	D	D	C	C	C	C	C	F	F	B
Cyprus	C	C	C	C	C	C	C	C	C	C	C	C	C
Spain	F	C	C	C	C	C	C	C	C	C	C	C	C
Italy	D	C	C	C	C	C	C	C	C	C	C	C	C
Bulgaria	D	D	D	D	D	D	D	D	D	D	D	D	D
Czechia	D	D	D	D	D	D	D	D	D	D	D	D	D
Hungary	D	D	D	D	D	D	D	D	D	D	D	D	D
Slovenia	D	D	D	D	D	D	D	D	D	D	D	D	D
Slovakia	D	D	D	D	D	D	D	D	D	D	D	D	D
Estonia	F	F	F	F	F	F	F	F	F	F	F	F	F
Latvia	F	F	F	F	F	F	F	F	F	F	F	F	F
Austria	F	F	F	F	F	F	F	F	F	F	F	F	F
Luxemburg	E	E	E	E	E	E	E	E	E	E	E	E	E

Source: own calculations.

Cluster A is characterised mainly by the highest (compared to other clusters) employment in agriculture, forestry and fishing. Greece and Romania stayed for the whole period, and Croatia and Poland left in 2016.

Seven countries constitute Group B for the whole period (Belgium, Denmark, Germany, France, the Netherlands, Finland and Sweden), plus Ireland, which has been there

since 2009. Two countries changed their assignment in 2020: Malta (leaving the group) and Portugal (joining).

Group B has high employment in Information and communication, professional, scientific and technical activities, administrative and support services, and in Public administration, defence, education, human health and social work.

The core of Group C is Spain, Italy and Cyprus, with the partial presence of Malta and Portugal – all Mediterranean countries. It is natural that they have high employment in Wholesale and retail trade, transport, accommodation and food services.

Group D consists of post-communist countries with high employment in industry.

Group E has just one country throughout the 2008–2020 period – Luxembourg, with high employment in five services sections and low in the other five.

Baltic countries plus Austria are in Group F. They have high employment in Construction, Wholesale and retail trade, transport, accommodation and food services, and Real estate activities.

Conclusions

Two methods were proposed in the paper to identify the effects of intervention in yearly time series: one-dimensional and multidimensional. The first method – based on trend and autoregressive models – identifies changes in volume, while the dynamic cluster analysis shows changes in volume and structure.

The proposed Triple 2 Rule made it possible to identify the interventions in the employment index time series for individual sections of economic activity. These changes in already observed employment dynamics were likely due to the COVID-19 pandemic.

Generally, employment in all EU countries (except Romania) was affected by the COVID-19 crisis in 2020 – most severely in Sweden, Ireland and Spain. The biggest changes were observed in Germany, in all sections.

As expected, Wholesale and retail trade, transport, accommodation and food services, and Real estate activities showed the biggest decline in employment.

2020 did not change the structural employment picture of differences between EU countries. Only two countries changed their cluster membership, Malta and Portugal.

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Wpływ pandemii COVID-19 na poziom i strukturę zatrudnienia w krajach Unii Europejskiej

Celem artykułu jest zaproponowanie i zastosowanie metod, które można wykorzystać do oceny zmian w ciągu jednego roku dowolnego mierzalnego zjawiska z punktu widzenia tego, w jaki sposób podążają one za schematem procesu obserwowanego w latach poprzednich. Badania przeprowadzono dla zatrudnienia ogółem oraz zatrudnienia w następujących sekcjach: Rolnictwo, leśnictwo i rybołówstwo; Przemysł; Budownictwo; Handel hurtowy i detaliczny, transport, usługi hotelowe i restauracyjne; Informacja i komunikacja; Działalność finansowa i ubezpieczeniowa; Nieruchomości; Działalność naukowa, fachowa i techniczna, usługi administracyjne i pomocnicze; Administracja publiczna, obrona narodowa, edukacja, ochrona zdrowia i opieka społeczna; Sztuka, rozrywka, rekreacja, inne usługi, działalność gospodarstw domowych i organizacji pozarządowych. Zastosowano dwa podejścia metodologiczne. W ramach pierwszego oszacowano modele trendu i autoregresji na podstawie danych z lat 2008–2019 oraz wyznaczono prognozy na rok 2020. Następnie porównano je z wartościami rzeczywistymi w roku 2020. Zaproponowano tzw. Regułę trzech dwójek. Drugie podejście to dynamiczna analiza skupień. Zmiany w składzie wyodrębnionych grup pozwoliły na ocenę wpływu pandemii COVID 19 na stopy zatrudnienia w roku 2020.

Słowa kluczowe: zatrudnienie, COVID-19, państwa Unii Europejskiej, dynamiczna, analiza skupień, reguła trzech dwójek