THE IMPACT OF INDUSTRY 4.0 ON THE EMPLOYMENT STRUCTURE OF EU COUNTRIES

Hana Boháčová – Pavla Jindrová

Abstract

Over the last two hundred and fifty years, mankind has undergone periods of rapid technological development, which has always been reflected in the structure of employment. The fourth industrial revolution, also known as Industry 4.0, has impacted most areas of human activity in recent years. Its main feature is automation, robotization and the emergence of so-called smart factories. This is, of course, also reflected in the structure of employment. In line with expectations, the replacement of human labour by technology has not been smooth. We are currently at the end of the first wave of Industry 4.0. This first wave was expected to result in a reduction in the number of employees in the transport and storage, administration, trade and construction sectors. The aim of this paper is to assess the extent to which these assumptions have been met in the individual Member States of the European Union. Since the beginning of the fourth industrial revolution is dated to 2012-2013, we will work with the number of employees in these sectors from 2011 to 2023.

Key words: Industry 4.0, employment structure, labour market

JEL Code: J21, J29

Introduction

We know from history that technological progress has always had an impact on various areas of people's lives, including, of course, work. Technological progress is not continuous, but rather in leaps and bounds; periods of rapid development of new technologies are called industrial revolutions. The first industrial revolution took place in the 18th century, its typical feature being the use of water and steam power in agriculture and industry. The development of the internal combustion engine and electrification at the turn of the 19th and 20th centuries brought about the second industrial revolution. The Third Industrial Revolution is also known as the Scientific and Technical Revolution, which began in the 1960s with the invention of the transistor and brought about the massive development of computer technology. We are

currently in the era of the fourth industrial revolution, called Industry 4.0 for short. Its main features are digitalisation and automation.

(Branco et al., 2023) identifies three main areas where the advancing Fourth Industrial Revolution is manifesting itself. These are infrastructure, big data processing and custom Industry 4.0 applications. The rate of change varies at country and sector level. Among the main principles of Industry 4.0 is the transformation of manufacturing factories into smart factories that use cyber-physical systems. According to (Sergi et al., 2019): A smart factory is essentially a self-contained unit that is capable of leading, managing and controlling itself. The factory will be able to analyse and configure itself in the event of errors or malfunctions and will also be able to adapt to the conditions imposed on it.

The nature of cyber-physical systems in the context of advancing Industry 4.0 is explained in detail in (Zezulka et al., 2016). The key elements of Industry 4.0 are presented in detail in (Kosacka-Olejnik, Pitakaso, 2019).

Of course, the process of implementing Industry 4.0 is not seamless. The obstacles encountered are clearly summarized in (Zhang et al., 2021). The barriers listed in this paper can be divided into five main categories - technological, organisational, personnel, economic and security barriers. Of course, all these obstacles can also be perceived as challenges. Overcoming them will facilitate the process of implementing Industry 4.0. Dealing with such challenges is of course easier for large stable companies with a good background, medium-sized and small companies will follow. The prerequisites for successful implementation of Industry 4.0 are described by (Sony, Naik, 2019). The readiness of companies to implement Industry 4.0 is assessed, for example, by (Honková, 2018).

With the advent of every industrial revolution, there have always been catastrophic visions that new technologies will largely replace human labour, cause mass unemployment and this will have serious social consequences. In the first, second and third industrial revolutions, it became clear that machines would replace some of the arduous human work, but that this would result in the creation of new professions and a change in the nature of existing professions. How this will be the case in Industry 4.0 is analysed in detail in (Acemoglu, Restrepo, 2019).

According to working paper of the Research Department of the International Labour Office (ILO, 2016) technological change and innovation is a complex, non-linear and non-deterministic process which comes in waves and different phases, and thereby destroys and creates jobs. Similarly, according to the Ministry of Labour and Social Affairs of the Czech Republic (MPSV, 2016), related changes in the structure of employment can be expected to

come in waves. In the first wave, a reduction in the number of employees in transport and logistics, administration, trade and construction are expected. After the first wave, technological decline and a slowdown in replacement is expected. After some time, a second wave is to follow, which will be characterised by the development and introduction of artificial intelligence, self-optimising systems that will be able to replace human work even at the level of decision-making.

1 The impact of Industry 4.0 on the structure of employment in the European Union and the Eurozone

Let us first look at whether, or to what extent, the expected impacts of Industry 4.0 on the structure of employment have been felt in the European Union as a whole and in the Eurozone. As mentioned above, in the first wave of Industry 4.0, a reduction in the number of employees in transport and logistics, administration, trade and construction are expected. If we break down the employment sectors according to the NACE classification, then the expected impacts should be reflected in the sections listed in Table 1.

Tab. 1: Sections with an expected decrease in the proportion of employees

F	Construction
G	Wholesale and retail trade; Repair of motor vehicles and motorcycles
H	Transportation and storage
N	Administrative and support service activities

Source: Own elaboration, Eurostat data

In the following, annual time series of the number of employees in the sections listed in Table 1 for the period 2011-2023 from the Eurostat database were used. The year 2011 was chosen as the beginning of the period under consideration because the basic vision of Industry 4.0 was presented at the Hannover-Messe 2011 industrial fair. The latest available data is for 2023. Between 2011 and 2023, there have been two changes in the number of EU Member States: in 2013, Croatia became a member, and in January 2020, the United Kingdom of Great Britain and Northern Ireland leaved the European Union. In order to keep the time series consistent, the numbers of employees from Croatia are included in the time series over the whole period, while the numbers of employees from the UK are not included - in line with Eurostat methodology. During the period under review, the total number of employees in the European Union increased by 18.7 million. The increase occurred in all Member States except

Romania (down by 832 000), Croatia (down by 22 000) and Bulgaria (down by 33 000). For this reason, it seems more accurate to compare not the absolute numbers of employees in the sectors concerned, but rather the percentage share of these sectors in total employment. Changes in the percentages of the four sections under review over the period 2011-2023 for the European Union and the Eurozone are shown in Table 2.

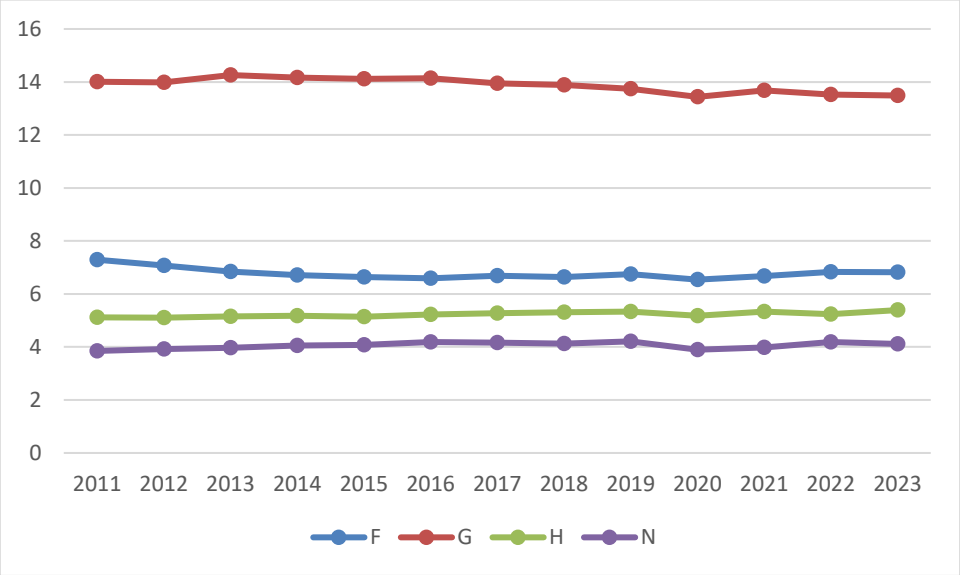
Tab. 2: Percentage share of monitored sections in total employment in 2011, 2023 and difference, European Union, Euro area

	Percentage in 2011				Percentage in 2023				Difference in percentages (2023 - 2011)			
	F	G	H	N	F	G	H	N	F	G	H	N
EU	7.29	14.01	5.11	3.85	6.82	13.49	5.39	4.12	-0.47	-0.52	0.28	0.27
Euro area	7.17	14.04	4.99	4.18	6.48	13.45	5.14	4.42	-0.69	-0.59	0.15	0.24

Source: Own elaboration, Eurostat data

Of particular importance to us are the last four columns of Table 2. They show that the expected decline occurred in both cases (EU as a whole and Euro area) only for sections F - Construction and G - Wholesale and retail trade; Repair of motor vehicles and motorcycles. In sections H - Transportation and storage and N - Administrative and support service activities, on the other hand, there was a slight increase in percentage representation.

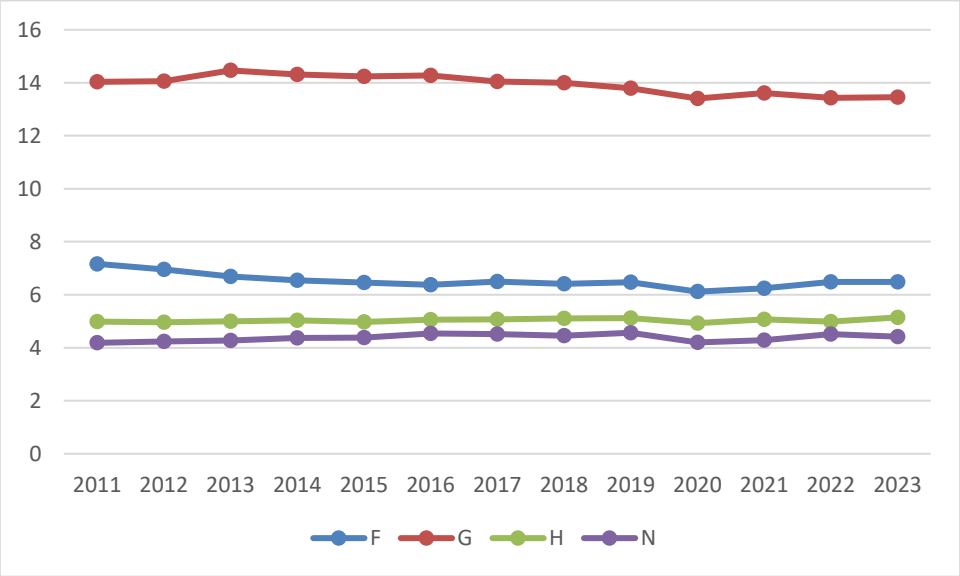
Fig. 1: Time series of the percentage share of selected sectors in total employment, European Union, 2011 - 2023



Source: Own elaboration, Eurostat data

The graph in Figure 1 shows the time series of the percentage share of selected sections in total employment in the European Union. It shows that the percentage of Section F has steadily declined from the beginning of the period under review until 2016. In the following years, the values did not change much. For section G, there is a clear decline between 2013 and 2020. For sections H and N, no downward trend is evident. In contrast, both these series show a weak upward trend between 2011 and 2019.

Fig. 2: Time series of the percentage share of selected sectors in total employment, Euro area, 2011 – 2023



Source: Own elaboration, Eurostat data

If we focus only on euro-denominated countries, the situation is very similar, as can be seen in Figure 2. Only the downward trend for sections F and G is a little more pronounced in this case, and the upward trend for the series showing the evolution of section H is a little weaker.

2 The impact of Industry 4.0 on the structure of employment in the Member States of the European Union

Next the development of the share of construction, transport and logistics, trade and administration in total employment in individual EU Member States is assessed. Time series of the percentage share of sections F, G, H and N for the period 2011-2023 are used here. Panel data models are used for the analysis. One data panel was created for each section under study, covering 27 subjects (EU Member States) and 13 points in time (2011-2023). Gretl statistical

software was used to create the models and select the best model. In the case of all four sections, a fixed effects model incorporating individual time and subject effects emerged as the optimal model best representing the data.

The following notation is needed to describe the resulting models:

i subject index, $i = 1, 2, \dots, 27$

t time index, $t = 1, 2, \dots, 13$

y_{it} percentage share of the examined section in the total employment of the state indexed by i at time t

α_i individual effect of the i-th subject

γ_t individual effect of time t

u_{it} residual component corresponding to y_{it}

Given the need to capture the downward and upward trend of individual time series, a linear function of time $\alpha + \beta t$ was chosen as the basis for the panel models. Intercept α is composed of individual effects: $\alpha = \alpha_i + \gamma_t$. This means the models look like this:

$$y_{it} = \alpha_i + \gamma_t + \beta \cdot t + u_{it} \quad (1)$$
$$i = 1, 2, \dots, 27$$
$$t = 1, 2, \dots, 13$$

The resulting model for section F (according to (1)) is of the form

$$y_{it} = -0.02637t + \alpha_i + \gamma_t + u_{it}. \quad (2)$$

Model for section G:

$$y_{it} = -0.06968t + \alpha_i + \gamma_t + u_{it}. \quad (3)$$

Negative values of the coefficients β indicate a downward trend in the time series for sections F and G. This is consistent with the conclusions of the previous section of the paper.

Model for section H:

$$y_{it} = 0.004324t + \alpha_i + \gamma_t + u_{it} \quad (4)$$

Model for section N:

$$y_{it} = 0.04761t + \alpha_i + \gamma_t + u_{it} \quad (5)$$

The coefficient of β in model (4) is closer to 0 compared to the remaining models, the trend can be assessed as constant. Model (5) suggests a slight increase in section N. These conclusions are also consistent with the EU-wide findings of Chapter 1.

The individual time effects γ_t are summarised for all models in Table 3. The smaller the negative value of the time individual effect, the larger the decline in the variable in that year relative to the previous year. Conversely, positive values of γ_t indicate that there was an

increase in that year. The values of γ_t for section F combined with model (2) show the largest decline in the percentage of section F between 2013 and 2017. Combining the column for section G and model (3), we find that the share of section G in total employment declined the most in 2012, 2019 and 2020. In the other years, there was either a smaller decline (driven by trend) or even a slight increase (where the combination of γ_t and α_i exceeds the decrease given by the trend constant β). Given that the constant β in model (4) is positive but very close to zero, we can infer from the individual time effects for section H that the largest decline in values occurs between 2020 and 2022. Similarly, in section N, a decline can be inferred in 2020 and 2021.

Tab. 3: Individual time effects for resulting model of panel data

t	year	γ_t for section F	γ_t for section G	γ_t for section H	γ_t for section N
2	2012	−0.2719	−0.09387	−0.009329	0.02769
3	2013	−0.4707	0.06600	−0.04358	0.09837
4	2014	−0.6148	0.03436	0.004402	0.1488
5	2015	−0.5531	0.08013	−0.09430	0.1692
6	2016	−0.4839	0.1023	−0.006011	0.2093
7	2017	−0.4837	0.05060	0.05281	0.2096
8	2018	−0.3385	0.06952	0.06990	0.1649
9	2019	−0.1934	−0.01336	0.05418	0.1540
10	2020	−0.1613	−0.09636	−0.09052	−0.05879
11	2021	−0.1388	0.1155	−0.09201	−0.03994
12	2022	−0.07931	0.02599	−0.1417	0.06981

Source: Own elaboration, Eurostat data

Table 4 then presents the individual effects of the countries. Here again, positive values mean that the representation of the corresponding section in a given country is higher than usual in the EU. Negative values indicate that the representation of the section in the country is lower than usual. The column of individual subject effects for Section F - Construction shows that the highest values were found for Slovakia, Estonia, Cyprus, Austria and Romania and the lowest values for Greece, Netherlands, Ireland and Luxembourg. The highest representation of section G - Wholesale and retail trade; Repair of motor vehicles and motorcycles was found for Greece, Cyprus, Bulgaria and Lithuania. The lowest representation is for Luxembourg, Sweden, the Czech Republic and Finland. Section H – Transportation and storage contributes the most to total employment in the Baltic States and the least in Luxembourg, Cyprus, Portugal and Ireland. Within section N - Administrative and support service activities, the percentages are highest in Belgium, Spain and the Netherlands, and lowest in Greece, Romania, Slovakia and Croatia.

The values in Table 4 allow us to compare the percentages of the monitored sections in different EU countries. However, they do not allow us to assess in which countries there has been a decline and to what extent. This is summarised in Table 5.

Tab. 4: Individual subject effects for resulting model of panel data

i	country	α_i for section F	α_i for section G	α_i for section H	α_i for section N
1	Belgium	0.1397	-0.8690	0.0621	2.1623
2	Bulgaria	0.7491	3.4732	0.8173	-0.0310
3	Czechia	0.8989	-2.4182	0.6650	-1.1402
4	Denmark	-0.8495	0.7201	-1.0251	0.0655
5	Germany	-0.5082	-0.3486	-0.6908	1.2706
6	Estonia	2.1059	-0.8431	2.0925	-0.2415
7	Ireland	-1.4727	-0.3290	-1.1574	0.5566
8	Greece	-2.8192	3.9199	-0.4777	-1.4215
9	Spain	-0.6923	1.8504	-0.4888	1.5785
10	France	-0.3457	-1.2821	-0.2879	0.4140
11	Croatia	0.0305	0.1046	0.9168	-1.1055
12	Italy	-0.4716	0.2915	-0.7078	0.5891
13	Cyprus	1.9506	3.9811	-1.5059	-0.8804
14	Latvia	0.7376	1.0784	3.0121	-0.4846
15	Lithuania	0.4605	2.6759	1,8751	0.2293
16	Luxembourg	-1.3640	-5.8274	-1.5882	-0.5268
17	Hungary	0.1561	-0.9018	0.9087	-0.2124
18	Malta	-0.5750	-0.0255	-0.2749	0.7318
19	Netherlands	-2.2672	0.6014	-1.0220	1.2742
20	Austria	1.2735	0.5678	-0.5569	-0.1694
21	Poland	0.7223	0.2324	0.6473	-0.8926
22	Portugal	-0.2770	0.8672	-1.3699	-0.,2182
23	Romania	1.2730	0.6665	0.2941	-1.2290
24	Slovenia	-1.2045	-1.6510	-0.3776	-0.9939
25	Slovakia	2.5688	-1.5974	0.9260	-1.1913
26	Finland	0.1331	-2.2895	0.0677	0.8767
27	Sweden	-0.3299	-2.6463	-0.7526	0.9904

Source: Own elaboration, Eurostat data

Tab. 5: Individual subject effects for resulting model of panel data

Section	Countries with the biggest drop in percentage
F	Cyprus (-3.04 %), Greece (-1.89 %), Portugal (-1.50 %), Italy (-1.43 %), Luxembourg (-1.37 %)
G	Lithuania (-3.22 %), Ireland (-2.59 %), Malta (-2.38 %), Bulgaria (-2.23 %), Sweden (-2.16 %)
H	Malta (-1.03 %), Estonia (-0.88 %), Slovenia (-0.87 %), Sweden (-0.83 %)
N	Slovakia (-0.59 %), Germany (-0.54 %), Latvia (-0.48 %)

Source: Own elaboration, Eurostat data

Conclusion

So how is the fourth industrial revolution manifesting itself in the European Union and its countries? The first changes have already occurred. Particularly in large manufacturing companies, there is a tendency to automate production and gradually replace monotonous and arduous human work with the work of machines. Industry 4.0 was predicted to result in a decline in the number of employees in construction, transport and logistics, trade and administration in the first phase. The aim of this paper is to assess the extent to which this prediction has come true. At EU level, only construction and trade (according to CZ NACE sections F and G) have declined. The share of administration (section N) and transport and logistics (section H) has slightly increased. Only two Member States - Sweden and Slovakia - saw a decline in the share of all four sections in total employment during the period under review. In nine countries, there was a decrease in the share of three of the sections studied, and in the other nine countries there was a decrease in two sections. In five countries there was a decrease in only one section and in Croatia and Romania there was even an increase in the percentage in all sections monitored. During the period 2011-2023, the share of Section F in total employment decreased in 16 Member States, the share of Section G decreased in 23 Member States, the share of Section H decreased in 15 Member States and the share of Section N decreased in only 6 Member States of the European Union. Further changes can be expected to follow. Not only in the structure of employment, but also in the job descriptions of individual occupations. It is therefore desirable for society to be prepared for these developments.

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Contact

Hana Boháčová

University of Pardubice

Faculty of Economics and Administration

Studentská 84, 532 10 Pardubice

Hana.Bohacova@upce.cz

Pavla Jindrová

University of Pardubice

Faculty of Economics and Administration

Studentská 84, 532 10 Pardubice

Pavla.Jindrova@upce.cz