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Comparative Analysis of the Relationship Between Workforce Demand and Digitalization at Company Level in Romania and Germany

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ABSTRACT

The impact of technology on the workforce demand at the company level can result in job loss due to automation, but it can also create new jobs through the development of new technologies and increased demand for products and services. We use correlation statistical analysis of the data collected in 2018 by Eurofound through the European Company Survey (ECS 2019) to analyze the effects of technology on workforce demand in Romania and Germany and to compare the two countries in terms of digitalization and employment evolution. Although at first glance the substitution effect suggests a significant risk of job loss due to digitalization, the analysis of data obtained from the ECS 2019 survey at the company level in Romania highlights the opposite. Thus, we observe an upward trend in employment growth in Romanian companies with various levels of digitalization, but a weak correlation between the two suggesting there are other factors involved. We find that usage of personalized software and data analysis are positively correlated with employment growth in both countries. Likewise, robots adoption in Romania do not have a clear effect on employment, compared to the positive employment trends in Germany during 2016-2018.

1. Introduction

Beginning with the Fourth Industrial Revolution (2015-2016) characterized by an exponential pace of technological change the discussion over the effects of digitalization and automation on employment become prevalent over the last 10 years (Autor D, 2022). As Romania has been placed on the last places in the EU regarding technological uptake over the last 10 years (COM, 2022), the current analysis aims to shed light over the relationship between employment and digitalization at company level before the Covid-19 pandemic, a period that was largely unexplored. This is particularly useful for decision-makers involved in designing digital and employment strategies, who need to understand the relationship between the two, against a prevalent fear of job loss. Therefore, considering the ECS 2019 microdata available at the company level for both Romania and Germany, the research aimed to identify the correlations between the digitalization of companies and the evolution of employment at the firm level over a six-year period time through a comparative analysis between the two countries.

2. Literature review

Over the last years one of the hottest topics when discussing the labor market trends was the impact of technologies on the evolution of workforce demand.

Nevertheless, the topic is not new, as humankind already transitioned several technological revolutions. Therefore, when discussing about the impact of technology, specifically digitalization, on employment, several effects are documented. One of the most discussed effects, from the perspective of workforce demand, is the disappearance/loss of jobs when machines replace humans in the production process (the substitution effect) (Douglas, 1934). On the other hand, another effect of technological advancement on the labor market is the creation of new jobs (the compensation effect) (Schumpeter, 1942). Further research showed that this can be determined by: (i) the creation of new occupational profiles with the development of new technologies (Autor and all., 2022), and (ii) the increase in production and demand for technology products and services, resulting from the reduction in their prices across regions, customer types, or new markets. For example, digitalization or robotization can lead to lower prices, thus in return leading to increased

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demand for products, which can further on create more jobs in other areas of the economy (Acemoglu and Restrepo, 2017).

Recent analyses showcase that organization that have a higher level of technology update have a greater capacity to increase productivity and adopt innovation, which in turn leads to higher employment (Mastrostefano and Pianta, 2019). What was noticed was that indeed digitalization has a great capacity to positively influence trends in employment. For instance, when analyzing the German economy, it has been noticed that digitalization had a small but positive employment results (Arntz all., 2016). Likewise, it was observed that the non-machine based digital technologies such as e-commerce has the capacity to have a better influence on employment as it leads to increased efficiency, which in return leads to the creation of additional jobs, (Alubert - Tarby at all., 2018). However, the increase in e-commerce does not appear to contribute to GDP in Romania (Pantelimon et al., 2020).

There is an important relationship between innovation and technology adoption as they synergically influence each other with the net positive effect on employment, as it leads to the creation of new job opportunities, (Blanchflower and Burgess 1999). Garcia Ramos and Martinez – Ros (2024) also analyzed and concluded that digitalization has a marginally positive overall impact on employment indicating that it can create jobs when combined with research and development, therefore policy makers and corporate executive should consider this aspect in order to guarantee positive employment outcomes.

Within the framework of global value chains, there are findings that confirm that several digital technologies such as computerization, software automation, robots and artificial intelligence have an impact on worker well-being (Parteka at all., 2024), which in turn can lead to better employment outcomes.

Digitalization uptake is similarly influenced by other aspect related to companies' characteristics, such as size, industry sector, and education level of the employees. It was observed that larger firms and firms that are activating in highly intensive, technological industries lead the change in digitalization. Therefore, larger companies have a larger propensity to adopt new digital technologies, such as Switzerland, where it was observed that companies with more than 20 employees have higher adoption rates of technology (Balsmeier, 2019). On the other hand, technology has negative influence on employment when we are looking at less technological, and intensive manufacturing sectors such as traditional sectors (Obadic, 2020).

Advancements in robotics and artificial intelligence have generated global fears regarding the disappearance of jobs. Studies (PwC, 2019) show that Romania has one of the highest risks of automation in the EU, affecting over 60% of jobs. Against this context, the current analysis aims to better understand the correlation between digitalization and employment.

3. Research methodology

The analysis uses the correlation analysis of the data obtained through the questionnaire method. The data source is the European Company Survey (ECS) from 2019, conducted by Eurofound (The European Foundation for the Improvement of Living and Working Conditions) in collaboration with Cedefop (European Centre for the Development of Vocational Training), before the pandemic. The aim of the 2019 ECS edition was to assess workplace organization and innovation, as well as companies' approaches to skills and digitalization. ECS 2019 collected data from over 20,000 companies across Europe (27 EU Member States plus the United Kingdom). ECS is a company survey based on a questionnaire administered to companies with more than ten employees, through interviews with HR managers and, wherever possible, employee representatives. The data collection methods used were the self-administered questionnaire: web-based (CAWI)and the phone interview: computer-assisted (CATI).

Regarding sampling, a multi-stage stratified random sample method was used. The procedures varied from country to country, and a high-quality representative sample was used. Sampling was stratified according to company size and general sector of activity (production, construction, and services).

At the European level, 21,869 interviews were conducted with management personnel, which we will use for the purpose of this analysis. Additionally, 3,073 interviews with employee representatives were conducted. For 1,835 units at the company level, interviews were organized with both management representatives and employee representatives. In Romania, 815 interviews were conducted with management personnel, 76 interviews with employee representatives, and interviews were organized with both categories of personnel in 44 companies.

The results obtained were weighted by Eurofound to make the survey results representative of the target population concerning distribution at the country level, sectors of activity, and company size.

For the comparative statistical analysis between Romania and Germany the following statistical methods have been used:

- Application of cross-tabulation function and chi-square test in Stata;
- Application of Spearman correlation method in Stata;
- Application of the analysis method;

The variables used for the analysis fall under two categories, that is employment evolution and digitalization.

For the company-level employment analysis we use:

- the variable regarding employment trends starting from 2016 (practically 3 years before the survey), that is how the total number of employees in the company has evolved since the beginning of 2016 (CHEMP),
- the variable regarding the employers' estimation of employment growth in the next 3 years, that is the evolution of the total number of employees in the company in the next three years (CHEMPFUT).

For the digitalization analysis we used all the variables highlighted in the ECS questionnaire relevant to the digitalization of companies, respectively:

- e-commerce, meaning the company buys or sells goods or services online (for example, through business-to-business portals, e-commerce, etc.) (ECOMMERCE),
- the use of computers/laptops by employees in daily activities, meaning the company's employees use computers or laptops to perform daily tasks (ICTCOMP),
- the use of customized software for the company, meaning if since the beginning of 2016, the company has acquired software designed or customized specifically for its needs (ICTAPP),
- the use of robots, meaning the company uses robots (robots are programmable machines that can perform a series of complex actions automatically, including interactions with people) (ICTROB),
- the use of data analysis to improve production processes or service delivery, meaning if the company uses data analysis to improve production processes or services delivery (data analysis refers to the use of digital tools for analyzing data collected within the company or from other sources) (ITPRODIMP).

Statistical analyses were performed in the Stata software application.

Germany was selected for comparative analysis for several reasons. On one hand, considering that almost double number of companies use robots, as well as the notoriety that Germany is a strongly industrialized state that has been using robots for many years. On the other hand, due to surprising aspects that emerged from the descriptive analysis, respectively (i) the high percentage of Romanian companies that use data analysis, a much higher percentage than German companies, and (ii) Romania ranks first in the EU regarding companies that have hired new staff in the 2016-2019 period (over 40% of staff), compared to Germany which ranks last in the EU.

4. Comparative analysis between Romania and Germany regarding the relationship between digitalization and employment at the company level

4.1. Digitalization and employment in Romania

According to the ECS 2019 data, Romanian companies were in the midst of digitalization, with Romania ranking 14th in the EU 27 in terms of highly digitalized companies. Surprisingly, Romania ranked first in the EU regarding the percentage (50%) of companies using data analysis to monitor employee performance, well above the EU average of only 27%. Additionally, the percentage of companies using data analysis to improve their production processes or service delivery was among the highest in the EU – ranking 5th (52%). Moreover, 51% of Romanian companies have acquired software designed or customized specifically for their needs since the beginning of 2016 (15th place in the EU27). However, the level of robotization was very low (4.4%) compared to Germany (7%) and Bulgaria (8.7%), which can be explained by the availability of relatively cheap labor.

The digitalization level of Romanian companies participating in the survey varies depending on the company size and type of digitalization. Overall, only 25% of companies are highly digitalized, while 31% are very minimally digitalized. Romania ranks 14th in the EU 27 regarding highly digitalized companies, with Malta (39%) and Denmark (37%) leading the ranking, and Latvia and Lithuania (12% each) at the bottom. A large percentage of 29% of companies using robots and use other digital technologies, while 15% of companies frequently use computers, at the expense of other digital technologies. The lowest level of digitalization is observed in companies with 10-49 employees (33%), although within the same companies, we note the predominant use of computers (16%). Companies with over 250 employees were those that used robotization and other digital technologies to a very large extent (65%).

Companies use computers or laptops (ICTCOMP) daily to varying degrees: 37% of companies have employees using computers less than 20% each day, 24% of companies use computers more than 80%, 5% use them between 60-79%, and 22% use them between 20-39%. The analysis also revealed that in the commerce and hospitality sectors (23% of respondents) and other services (57% of respondents), computers are used more than 80% every day, while in the industrial sectors (65%), construction (58%), and transportation (56%), computers are used by less than 20% of employees (excluding managers). Romania ranked 22nd in the EU regarding the number of companies whose employees use computers more than 80% of the time daily.

Approximately half (51%) of Romanian companies have acquired custom-designed or specifically tailored software (ICTAPP) for their needs between 2016 -2018 (15th place in the EU27), with the largest companies leading the ranking (61%), followed by companies with 50-249 employees (59%). Additionally, medium-sized companies (10-29 employees) have acquired software products (49%).

Romanian companies used robots (ICTROB) relatively low (see Figure 1), averaging at 4.4%, comparable to the UK (4.1), but far below the levels in Finland (13.8), Denmark (12.4%), Germany (7%), Bulgaria (8.7%), and Estonia (6.3%). In the survey's context, robots are programmable machines that can perform a series of complex actions automatically, including interactions with humans. Based on the size of Romanian companies, the top of robotization was led by companies with more than 260 employees (11%), followed by companies with 40-249 employees (9%), with the fewest robots reported in small-sized companies with 10-49 employees.

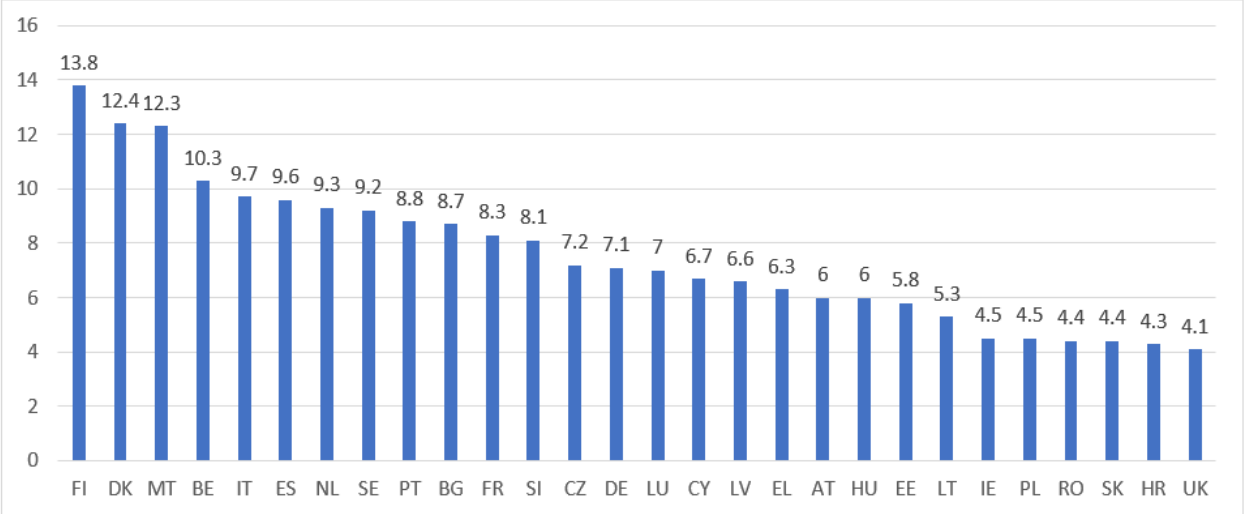

Figure 1. Robots usage at company level in Romania

Source: Authors' elaboration based on ECS 19 data.

The percentage of companies using data analysis to improve their production processes or service delivery (ITPRODIMP) was among the highest in the EU – ranking 5th (52%), in the same cluster as countries such as Spain (61%), Italy (59%), and at a significant distance from European countries at the bottom of the list, such as Ireland, Portugal, Bulgaria, and the Czech Republic (33%). Companies with over 250 employees used data analysis to a very large extent (83%), followed by companies with between 50-249 employees (66%) and companies with between 10 and 49 employees (48%).

Regarding e-commerce (ECOMMERCE), Romanian companies (30%) were slightly above the EU average (28%), far ahead of Bulgaria (17%) and Belgium (20%), but considerably behind the leading countries, such as Finland (47) and Hungary (43). The companies that used e-commerce the most are small companies with 20-49 employees (31%), followed by companies with between 50-250 employees (28%) and large companies with over 250 employees (24%).

The employment analysis in companies participating in the ECS 2019 survey revealed a positive trend. Romania ranked first in the EU in terms of new hires (CHEMP) in more than 40% of companies during the period 2016-2018 (50%), with Germany being at the bottom (11%). Romania ranked last in the EU regarding new hires under 20% of the number of employees and between 20-40%. 56% of new hires in more than 40% are found in companies with between 50-249 employees (56%), followed by companies with between 10-49 employees. The main sectors where new hires are found are construction and other services (each 53%), transport (52%), and industry (48%).

Regarding the evolution of the number of employees in a 3 years perspective (CHEMPFUT), 40% of Romanian companies highlighted they will have an increase in staff over the next 3 years (among the highest levels in the EU), 53% of Romanian companies believed the need for staff will remain unchanged (among the lowest levels in the EU), and 7% of companies believe staff will be reduced.

4.2. The linkages between digitalization and employment in Romania

Although the initial effect of substitution might suggest a significant risk of job loss due to digitalization, descriptive data analysis from the ECS 2019 survey of Romanian companies showed the opposite. The statistical analysis of the data highlighted a positive trend in employment among companies with various levels of digitalization, compared to traditional companies, considering the employment trends from 2016-2019 and the managers' estimates regarding future employment dynamics over the next three years.

The statistical correlation analysis using the Spearman method between the selected variables, namely employment dynamics and the type of digitalization in the company, showed a very weak link. This means that there is no clear connection between employment dynamics in digitalized companies and their level of digitalization, likely influenced by other factors such as the pace of innovation, openness to external markets, profitability, salary levels, and other elements which will be further analyzed in the final doctoral thesis.

The descriptive analysis of the data included in Table A1 in the Annex highlights several interesting aspects regarding employment based on the type of company digitalization.

The evolution of the number of employees in Romanian companies engaged in eCommerce from 2016 to 2018 was positive, with higher personnel increases compared to companies not involved in this activity. As shown in Table A1, approximately one in three (33%) e-commerce companies increased their staff by over 10%, compared to traditional companies, which increased staff by only 22%. The data highlights a trend of rising employment in e-commerce companies, unaffected by staff reductions. Additionally, even when it comes to staff reductions, traditional companies seem to be more affected.

Regarding the estimated personnel needs over a three-year perspective, nearly half of e-commerce companies (47%) intended to hire staff, compared to 38% of traditional companies. Moreover, approximately 9.5% of traditional companies estimated they will need to reduce staff, compared to 6% of e-commerce companies.

Between 2016 - 2018, there have been significant staff increases in Romanian companies that acquired customized software during the same period. Approximately 30% of companies hired more than 10% of their staff during this time, compared to about 20% of traditional companies. Conversely, the percentage of traditional companies that did not have staff fluctuations was 5% higher (41%) than digitalized companies (36%). More significant staff reductions were recorded in traditional companies compared to digitalized ones. As with e-commerce companies, there is a similar trend of increased personnel needs over a three-year perspective among companies using customized software: 46% of companies were planning to hire staff, compared to 34% of traditional companies. Additionally, approximately 10% of traditional companies estimated they might need to reduce staff, compared to only 6% of digitalized companies.

The analysis of companies using PCs/laptops daily also showed a trend of increasing employees, particularly in companies with over 80% or 100% computer usage (30% and 25% of these companies hired over 10% of their staff between 2016-2019). Significant staff fluctuations occurred in companies with up to 40% computer usage. The dominant trend of increasing the number of employees continued for these types of companies when estimating the needs for the next three years (starting in 2019), with the highest increase (68%) expected in companies with 80-99% computer use.

Although the percentage of companies using robots was small (2%, according to Eurofound), employment dynamics were significant, with 40% of these companies hiring over 10% of their staff between 2016-2018, compared to only 24% of traditional companies. Significant changes also occurred in the opposite direction, with more substantial staff reductions in these companies. Overall, staffing increases occurred in approximately 50% of companies using robots compared to 40% in traditional ones, with a similar decrease in employee numbers (28% in companies using robots compared to 25% in traditional ones), and a higher percentage of unchanged staffing levels in traditional companies (40% compared to 22% in companies using robots).

In terms of future expectations, companies using robots planned to make substantial staff hires (61%) compared to traditional ones (38%), a trend that appeared to be generalized among digitalized companies analysed. Staff reductions (13%) also seemed higher than in traditional companies (8%), while the percentage of companies with no staff changes (22%) was lower compared to traditional ones (40%).

Companies using data analytics to improve their product or service delivery processes (55%) showed the same upward employment trend compared to traditional companies from 2016 to 2018, a trend expected to continue over the forthcoming three years. Before the pandemic, 43% of companies using data analytics planned to hire staff, compared to 36% of traditional companies. Expected staff reductions were estimated to be similar: 8% of digitalized companies estimated staff reductions, compared to 9% of traditional companies.
The Spearman correlation test was applied to analyze the correlation coefficients between the main digitalization variables from the ECS 2019 survey (Table 1) and employment dynamics in Romanian companies. From the analysis of the results, we can draw the following conclusions:

The link between employment dynamics in Romanian companies (since 2016) with their level of digitalization is statistically significant, with a positive but weak correlation for the following variables: activity in eCommerce ($rs = 0.10$, $p = .005$), use of customized software ($rs = 0.14$, $p < .001$), and use of data analytics ($rs = 0.14$, $p < .001$).

The link between employment dynamics in Romanian companies (since 2016) with their level of digitalization is not statistically significant for the following variables: use of laptop/PC in daily activities ($rs = -0.02$, $p = .642$) and use of robots ($rs = 0.05$, $p = .211$).

In Romanian companies, the correlation between the future evolution of the number of employees over the next three years with eCommerce activity ($rs = 0.09$, $p = .010$), use of customized software ($rs = 0.13$, $p < .001$), use of robots ($rs = 0.09$, $p = .017$), and use of data analytics ($rs = 0.07$, $p = .045$) is statistically significant, with a positive but weak correlation.

In Romanian companies, the correlation between the future evolution of the number of employees over the next three years with the use of laptop/PC in daily activities ($rs = -0.10$, $p = .005$) is statistically significant, with an inverse and weak correlation.

Table 1. Spearman correlation coefficients (Romania)

	E-commerce – the company buys or sells goods/services over the internet	The company uses custom software (as of 2016)	Situation of employees who use laptop/PC in daily work	The company uses robots	The company uses data analytics to improve production processes or service delivery
Dynamics of the total number of employees within the company starting with 2016	0.1006	0.1395	-0.0168	0.0452	0.1441
p-value	0.0054**	0.0001***	0.6417	0.2114	0.0001***
Evolution of the total number of employees within the company in the next 3 years (starting with 2019)	0.0929	0.1314	-0.1025	0.0863	0.0726
p-value	0.0101*	0.0003	0.0045	0.0169**	0.0446**

*Source: Author's own calculations based on ECS 19 data [Where: *probability less than 0.1; **probability less than 0.05; probability less than 0.001]*

4.2. The linkages between digitalization and employment in Germany

Although much more digitized and with a double level of robots usage compared to Romania, descriptive statistical analysis highlights that Germany followed the same trend of employment growth in digitized companies as Romania. The pace of employee growth was upward, but it was not as intensive (when comparing traditional companies), as in the case of Romanian companies. However, Germany's effort to recover the employee and development gap in companies that present a lag in the use of data analytics compared to other EU MS was noteworthy, a field of digitalization in which Romania performed well compared to other developed European countries.

As in the case of Romania, the analysis of Spearman's correlation coefficients between the main variables and the employment dynamics in German companies shows that regardless of the type of digitalization, the link with employment within German companies is weak and very weak.

The descriptive analysis of the data included in Table A2 captured a series of interesting aspects regarding employment considering the type of digitalization of the German companies.

As with Romania, in Germany there was an observed positive trend in employment in e-commerce companies compared to traditional companies, although the growth rate was not as pronounced as in the case of Romania. For example, 16% of companies that engaged in e-commerce had increased their staff by over 10% from 2016 to 2018, and 25% by up to 10 employees, compared to traditional companies that have increased their staff by 13.5%, respectively 22% (for the same categories). There was observed a higher number of traditional companies that did not expect staff changes (54% vs 48%), as well as similar proportions of companies (traditional vs e-commerce) that had shown staff reduction (approximately 10%).

Likewise, when estimating the need for staff in a 3-year perspective, the figures were close, in approximately 31% of German e-commerce companies it was estimated that new staff will be brought in, compared to 27% of traditional companies. Also, approximately 7% of traditional companies envisaged layoffs, compared to 9% e-commerce companies.

As in the case of Romania, significant increases in staff were observed at the level of companies that have purchased customized software beginning with 2016. Approximately 18% of companies have hired more than 10% of staff during that period, compared to approximately 9% in traditional companies. Likewise, approximately 27% of digitized companies have hired staff (up to 10% of staff), compared to 19% traditional companies). More significant staff reductions have occurred in traditional companies (6.39% have laid off more than 10% of staff), compared to digitized companies (3%).

As with e-commerce companies, a trend of increasing the need for staff in a 3-year perspective is also observed in German companies that use customized software. 31% of digitized companies intend to hire staff, compared to 25% traditional companies. Similarly, the same percentage (8%) of both types of companies predict that they will lay off staff in the next 3 years.

The percentage of German companies using computers in daily activities is much higher than in the case of Romania. However, regardless of the level of computer use, the analysis carried out at the level of German companies that use computers/laptops in daily activities showed a similar positive trend in employment as observed in the case of Romania. In Germany, the phenomenon was more pronounced at the

level of companies with over 60% computer use (30% respectively 25% of these have hired over 10% of staff between 2016-2019). Significant staff fluctuations were observed in companies with a computer usage rate between 20-39%, being recorded the highest level of staff cuts. In a 3 years perspective, these companies were about to experience staff increases (28%) that should have exceeded staff reductions (8%). Significant staff increase was also expected in German companies that were using computers over 80% of their time (36 and 33%), while it was expected that staff will stay the same in companies that either do not use computers at all or use it to a lower level.

Compared to Romania (2%), Germany has twice as many companies (4%) that use robots. In the period 2016-2018, German companies using robots recorded more staff increases than decreases. It was also observed that compared to traditional companies, companies using robots had significant staff increases in the category size of companies that had under 10% new hires (33%), compared to 22% traditional companies. Staff reductions were more significant in traditional companies (6% reduced staff by up to 10% and 5% over 10%), compared to 3% and 2% staff reductions in companies that use robots.

Over the next 3 years, German companies using robots predicted approximately the same recruitment rate as non-robotized ones (26% robotized - 28% traditional), while companies that use robots estimate having double staff reductions (15%) compared to traditional ones (7%).

In terms of the percentage of companies using data analytics, Germany ranks last in the EU countries (39%), while Romania is among the first (54%). Probably to bridge this gap, German companies that use data analytics have hired 20% of staff in the period 2016-2018 and estimated that they will continue to hire significantly more (35%). At the same time, staff reductions were higher, although not significantly higher, in these companies (10%) compared to the traditional ones (6.5%).

The Spearman correlation test was applied to analyze the correlation coefficients between the main digitalization variables from the ECS 2019 survey (see Table 2) and employment dynamics in German companies. From the analysis of the results, we can draw the following conclusions:

The link between the employment dynamics in German companies (starting with 2016) and their level of digitalization is statistically significant, and the correlation is positive but weak within the following variables: use of customized software ($rs = 0.19$, $p < .001$), use of robots ($rs = 0.09$, $p = .026$), and use of data analytics ($rs = 0.13$, $p < .001$).

The link between the employment dynamics in German companies (starting with 2016) and their level of digitalization is not statistically significant within the following variables: eCommerce ($rs = 0.04$, $p = .264$) and use of laptops/PCs in daily activities ($rs = 0.02$, $p = .518$).

The correlation between the future evolution of the number of employees in the next 3 years and the use of laptops/PCs in daily activities ($rs = -0.12$, $p = .001$) is statistically significant in German companies, with the correlation being inversely proportional and weak.

In German companies, the correlation between the future evolution of the number of employees in the next 3 years and the use of data analytics ($rs = 0.10$, $p = .007$) is statistically significant, with the correlation being positive but weak.

In German companies, the correlation between the future evolution of the number of employees in the next 3 years and activity in eCommerce ($rs = -0.001$, $p = .975$), the use of customized software ($rs = 0.05$, $p = .175$), and the use of robots ($rs = -0.02$, $p = .673$) is not statistically significant, with p-values being over $\alpha < .05$.

Table 2. Spearman correlation coefficients (Germany)

	Ecommerce - the company buys or sells goods/services on the internet	The company uses custom software (as of 2016)	Situation of employees who use laptop/PC in daily work	The company uses robots	The company uses data analytics to improve production processes or service delivery
Dynamics of the total number of employees within the company starting with 2016	0.0423	0.1869	0.0245	0.0869	0.1348
p-value	0.02638*	0.0000	0.5176***	0.0215**	0.003
Evolution of the total number of employees within the company in the next 3 years (starting with 2019)	-0.0012	0.0513	-0.1205	-0.0160	0.1015
p-value	0.9746***	0.1751	0.0014	0.6730	0.0071

*Source: Author's own calculations based on ECS 19 data [Where: *probability less than 0.1; **probability less than 0.05; probability less than 0.001]*

4.4. Comparative analysis of the linkages between digitalization and employment in Romania and Germany

The analysis of the relationship between digitalization and employment has revealed a set of general conclusions based on the Spearman correlation tests applied to Romania and Germany. Overall, it indicates a positive but weak influences in both countries. This trend could be linked to a wider trend that emerged over the last years which shows that while job creation slows down, whereas job destruction is accelerating (World Economic Forum, 2020).

Digitalization in Romania is linked to the increase of the number of employees, but its effect is modest, while in Germany, employment trends are not significantly influenced by digitalization. Therefore, this could be explained by the fact that the German market is more mature and potentially more automated labor market. The analysis of robot's usage in Romania highlighted that the linkages with the workforce demand is not statistically significant, which means that robot's usage is not clearly linked to hirings. When analyzing future employment perspectives, the correlation becomes significant, but weak. Therefore, it was observed that even though at the level of 2018 the effects on robots' usage on employment were not significant, it could catch up in the future. In contrast, in Germany the correlation is statistically significant over the current period, but not on the longer term. Therefore, we can conclude that robot's usage had a positive effect on employment during 2016-2018, but once the automation phase is completed, there is no need of future personnel.

Likewise, the analysis highlighted that in Romania, the use of e-commerce is positively correlated with employment growth, however the effect is modest. As already highlighted above, companies that used e-commerce have hired more employees than those that do not use this technology. In a three-year perspective (CHEMPFUT), the correlation remains positive but weaker, which indicates that e-commerce contributes to employment growth to a small extent. On the other hand, in Germany was observed that there is no significant correlation between e-commerce usage and employment growth. This suggests that the German market is more mature in terms of technology usage and potentially more automated.

The use of customized software in Romania is linked to an increase in employment, but the correlation is weak. Thus, the companies that invest in such solutions tend to expand their teams, and this trend is expected to continue in the future. By comparison, in Germany, the correlation between customized software and employment is positive between 2016-2018. The companies that adopted such digital solutions increased their workforce compared to those that did not. However, future employment trends appear not to be correlated with customized software usage.

The analysis of robot's usage in Romania highlighted that the linkages with the workforce demand is not statistically significant, which means that robot's usage is not clearly linked to hirings. When analyzing future employment perspectives, the correlation becomes significant, but weak. Therefore, it was observed that even though at the level of 2018 the effects on robots' usage on employment were not significant, it could catch up in the future. In contrast, in Germany the correlation is statistically significant over the current period, but not on the longer term. Therefore, we can conclude that robot's usage had a positive effect on employment during 2016-2018, but once the automation phase is completed, there is no need of future personnel.

Data analysis usage appears to be positively correlated with employment trends both in Romania and Germany. Data analysis in Romania appears to positively support employment and this effect will most likely continue. Germany is trying to fill in the gap with other EU countries, therefore data analysis uptake is increasing, and this effect supports employment.

Overall, the usage of laptops and PCs in daily activities is the only variable with a significant negative correlation in Romania and Germany. Likewise, this could potentially indicate a higher degree of automation and the maturity of the labor market that may reduce the need for additional employees.

5. Conclusions

In conclusion, the analysis highlighted that both in Romania and in Germany, in digitalized companies, the number of jobs have increased in the pre-pandemic era, showing an upward trend in this regard during the period 2016-2019, as well as the fact that in the perspective of the next 3 years, company managers estimate that this upward growth trend will be maintained.

The correlation between digitalization and employment at company showed that digitalization is positively correlated with employment growth in Romania and Germany, but the correlation is weak and very weak, which means that there are other elements besides digitalization that have led to the increasing labor demand. However, this could also signify that the findings are in line with the worldwide trend that job creation is slowed down, while jobs loss is accelerating (World Economic Forum, 2020).

The usage of personalized software and data analysis are the two variables that are positively correlated with employment growth in both countries.

On the contrary, laptop/PC usage is negatively correlated with future positive employment trends in both countries, which could be one of the effects of automation.

Robots' uptake does not have a clear effect over employment trends in Romania, potentially due to the low uptake. However, robotization lead to positive employment trends in Germany during 2016-2018, which is in line with similar studies covering robots' effects on employment (Bachmann et al., 2022).

As all transition periods, the transition to e-commerce in Romania is positively correlated with employment growth, however in Germany this effect is not significant.

We can conclude by saying that digitalization did not lead to major job cuts, but its positive effects are more visible in Romania, a country that is gradually covering the gap in technology adoption, than in Germany.

The analysis is innovative, as it uses for the first time ECS19 microdata relevant for Romania and Germany to understand the relationship between digitalization and employment, shedding light on how Romania positions itself in one of the hottest debates of the decade.

From a practical perspective, the results of the analysis are useful for decision makers in Romania as it highlights overall positive effects of technologies on the labor market. This analysis could further on sharpen the measures envisaged for the digital transition of the country, highlighting the various effect of different digital technologies over the workforce demand and the need for more adapted employment policies, that could support the transition from Industry 4.0 to Industry 5.0, aiming to integrate cutting-edge technologies with human-centric approaches (Gorny, 2023). Further on, the analysis could be expanded by adding to the analysis the workforce adaptability angle, complemented by a better understanding of how ITC skills and R&D investments could potentially positively influence technologies adoption and employment (Muduli and Choudhury, 2025).

Last but not least, the analysis has significant limitations. The data is relevant for the pre-pandemic period, which could influence the current context. Likewise, the correlation analysis could not substitute for a causality analysis, which means that other factors could influence the results, such as wage levels, R%D investments, human development investments, and others. Moving forward, the analysis could be replicated by using forthcoming ECS data.

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Appendix 1

Table A 1. Data from 2019 ECS regarding employment and digitalization in Romanian companies

ROMANIA

	Dynamics of the total number of employees within the company starting with 2016					
Ecommerce - the company buys or sells goods/services on the internet	1	2	3	4	5	Total
-3	1	0	0	0	0	1
	0.5	0	0	0	0	0.13
Also	73	25	81	14	26	219
	36.68	21.74	27.09	19.72	24.3	27.69
Right away	125	90	218	57	81	571
	62.81	78.26	72.91	80.28	75.7	72.19
Total	199	115	299	71	107	791
	100	100	100	100	100	100

Pearson chi2(8) = 16.2308 Pr = 0.039

The Pearson $\chi 2$ independence test was applied to investigate the association between eCommerce and the dynamics of the total number of employees in 2016 within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(8) = 16.23$, $p = .039$).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)			
Ecommerce - the company buys or sells goods/services on the internet	1	2	3	Total
-3	0	1	0	1
	0	0.25	0	0.13
Also	103	103	13	219
	32.29	25.43	19.4	27.69
Right away	216	301	54	571
	67.71	74.32	80.6	72.19
Total	319	405	67	791
	100	100	100	100

Pearson chi2(4) = 7.5941 Pr = 0.108

The Pearson $\chi 2$ independence test was applied to investigate the association between eCommerce and the evolution of the total number of employees in the next 3 years within Romanian companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables ($\chi 2(4) = 7.59$, $p = .108$).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses custom software (as of 2016)	1	2	3	4	5	Total
Also	119	68	145	27	47	406
	61.66	61.82	49.49	41.54	45.19	53.07
Right away	74	42	148	38	57	359
	38.34	38.18	50.51	58.46	54.81	46.93

Total	193	110	293	65	104	765
	100	100	100	100	100	100

Pearson chi2(4) = 16.6668 Pr = 0.002

The Pearson $\chi 2$ independence test was applied to investigate the association between the use of customized software and the dynamics of the total number of employees in 2016 within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(4) = 16.67$, $p = .002$).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)			
The company uses custom software (as of 2016)	1	2	3	Total
Also	187	194	25	406
	60.52	49.24	40.32	53.07
Right away	122	200	37	359
	39.48	50.76	59.68	46.93
Total	309	394	62	765
	100	100	100	100

Pearson chi2(2) = 13.2495 Pr = 0.001

The Pearson $\chi 2$ independence test was applied to investigate the association between the use of custom software and the evolution of the total number of employees in the next 3 years within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(2) = 13.25$, $p = .001$).

	Dynamics of the total number of employees within the company starting with 2016					
Employees use laptop/PC in their daily work	1	2	3	4	5	Total
1	6	5	6	6	3	26
	3.02	4.35	2.01	8.45	2.8	3.29
2	84	44	118	31	46	323
	42.21	38.26	39.46	43.66	42.99	40.83
3	45	31	66	14	30	186
	22.61	26.96	22.07	19.72	28.04	23.51
4	22	12	43	5	8	90
	11.06	10.43	14.38	7.04	7.48	11.38
5	5	3	11	4	5	28
	2.51	2.61	3.68	5.63	4.67	3.54
6	15	5	21	5	4	50
	7.54	4.35	7.02	7.04	3.74	6.32
7	22	15	34	6	11	88
	11.06	13.04	11.37	8.45	10.28	11.13
Total	199	115	299	71	107	791
	100	100	100	100	100	100

Pearson chi2(24) = 21.4799 Pr = 0.610
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of laptop/PC in daily activity and the dynamics of the total number of employees in 2016 in Romanian companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables ($\chi 2(24) = 21.48$, $p = .61$).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)			
Employees use laptop/PC in their daily work	1	2	3	Total
1	10	11	5	26
	3.13	2.72	7.46	3.29
2	115	170	38	323
	36.05	41.98	56.72	40.83
3	76	98	12	186
	23.82	24.2	17.91	23.51
4	47	38	5	90
	14.73	9.38	7.46	11.38
5	12	14	2	28
	3.76	3.46	2.99	3.54
6	29	19	2	50
	9.09	4.69	2.99	6.32
7	30	55	3	88
	9.4	13.58	4.48	11.13
Total	319	405	67	791
	100	100	100	100

Pearson chi2(12) = 29.0671 Pr = 0.004
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of laptop/PC in daily activity and the evolution of the total number of employees in the next 3 years within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(12) = 29.07$, $p = .004$).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses robots	1	2	3	4	5	Total
Also	22	5	12	8	7	54
	11.4	4.55	4.1	12.31	6.73	7.06
Right away	171	105	281	57	97	711
	88.6	95.45	95.9	87.69	93.27	92.94
Total	193	110	293	65	104	765
	100	100	100	100	100	100

Pearson chi2(4) = 13.2690 Pr = 0.010

The Pearson χ2 independence test was applied to investigate the association between the use of robots and the dynamics of the total number of employees in 2016 within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables (χ2(4) = 13.27 p = .010).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)			
The company uses robots	1	2	3	Total
Also	33	14	7	54
	10.68	3.55	11.29	7.06
Right away	276	380	55	711
	89.32	96.45	88.71	92.94
Total	309	394	62	765
	100	100	100	100

Pearson chi2(2) = 15.2471 Pr = 0.000

The Pearson χ2 independence test was applied to investigate the association between the use of robots and the evolution of the total number of employees in the next 3 years within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables (χ2(2) = 15.25, p < .001).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses data analytics to improve production processes or service delivery	1	2	3	4	5	Total
Also	128	70	156	37	49	440
	64.32	60.87	52.17	52.11	45.79	55.63
Right away	71	45	143	34	58	351
	35.68	39.13	47.83	47.89	54.21	44.37
Total	199	115	299	71	107	791
	100	100	100	100	100	100

Pearson chi2(4) = 13.3657 Pr = 0.010

The Pearson χ2 independence test was applied to investigate the association between the use of data analysis to improve production/services and the dynamics of the total number of employees in 2016 within Romanian companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables (χ2(4) = 13.37, p = .010).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)			
The company uses data analytics to improve production processes or service delivery	1	2	3	Total
Also	190	215	35	440
	59.56	53.09	52.24	55.63
Right away	129	190	32	351
	40.44	46.91	47.76	44.37
Total	319	405	67	791
	100	100	100	100

Pearson chi2(2) = 3.3709 Pr = 0.185

The Pearson χ2 independence test was applied to investigate the association between the use of data analysis to improve production/services and the evolution of the total number of employees in the next 3 years within Romanian companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables (χ2(2) = 3.37, p = .185).

Table A2: 2019 ECS data on employment and digitalization in German companies.

GERMANY

	Dynamics of the total number of employees within the company starting with 2016					
Ecommerce - the company buys or sells goods/services on the internet	1	2	3	4	5	Total
-3	1	0	1	0	0	2
	50.00	0.00	50.00	0.00	0.00	100.00
1	31	48	91	9	11	190
	16.32	25.26	47.89	4.74	5.79	100.00
2	70	115	282	31	20	518
	13.51	22.20	54.44	5.98	3.86	100.00
Total	102	163	374	40	31	710
	14.37	22.96	52.68	5.63	4.37	100.00

Pearson chi2(8) = 6.4630 Pr = 0.596

The Pearson $\chi 2$ independence test was applied to investigate the association between eCommerce and the dynamics of the total number of employees in 2016 within German companies. Following this statistical test, it can be seen that <u>there is no</u> statistically significant association between the two variables ($\chi 2(8) = 6.46$, $p = .596$).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)				
Ecommerce - the company buys or sells goods/services on the internet	-3	1	2	3	Total
-3	0	0	1	1	2
	0.00	0.00	50.00	50.00	100.00
1	0	59	114	17	190
	0.00	31.05	60.00	8.95	100.00
2	8	139	333	38	518
	1.54	26.83	64.29	7.34	100.00
Total	8	198	448	56	710
	1.13	27.89	63.10	7.89	100.00
-3	0	0	1	1	2

Pearson chi2(6) = 9.8383 Pr = 0.132

The Pearson $\chi 2$ independence test was applied to investigate the association between eCommerce and the evolution of the total number of employees in the next 3 years within German companies. Following this statistical test, it can be seen that <u>there is no</u> statistically significant association between the two variables ($\chi 2(6) = 9.84$, $p = .132$).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses custom software (as of 2016)	1	2	3	4	5	Total
-3	4	2	4	0	0	10
	40.00	20.00	40.00	0.00	0.00	100.00
1	68	102	176	21	11	378
	17.99	26.98	46.56	5.56	2.91	100.00

2	29	59	186	19	20	313
	9.27	18.85	59.42	6.07	6.39	100.00

Pearson chi2(8) = 30.0868 Pr = 0.000
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of custom software and the dynamics of the total number of employees in 2016 within German companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(8) = 30.09$, $p < .001$).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)				
The company uses custom software (as of 2016)	-3	1	2	3	Total
-3	0	3	7	0	10
	0.00	30.00	70.00	0.00	100.00
1	4	116	227	31	378
	1.06	30.69	60.05	8.20	100.00
2	4	77	208	24	313
	1.28	24.60	66.45	7.67	100.00

Pearson chi2(6) = 4.5206 Pr = 0.607
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of custom software and the evolution of the total number of employees in the next 3 years within German companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables ($\chi 2(6) = 4.52$, $p = .607$).

	Dynamics of the total number of employees within the company starting with 2016					
Employees use laptop/PC in their daily work	1	2	3	4	5	Total
1	1	0	8	0	0	9
	11.11	0.00	88.89	0.00	0.00	100.00
2	16	21	52	4	2	95
	16.84	22.11	54.74	4.21	2.11	100.00
3	17	28	74	12	7	138
	12.32	20.29	53.62	8.70	5.07	100.00
4	10	26	40	2	4	82
	12.20	31.71	48.78	2.44	4.88	100.00
5	15	22	38	4	4	83
	18.07	26.51	45.78	4.82	4.82	100.00
6	17	29	53	6	4	109
	15.60	26.61	48.62	5.50	3.67	100.00
7	26	37	109	12	10	194
	13.40	19.07	56.19	6.19	5.15	100.00
Total	102	163	374	40	31	710

	14.37	22.96	52.68	5.63	4.37	100.00

Pearson chi2(24) = 20.9022 Pr = 0.644
The Pearson χ2 independence test was applied to investigate the association between laptop/PC use in daily work and the dynamics of the total number of employees in 2016 in German companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables (χ2(24) = 20.90, p = .644).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)				
Employees use laptop/PC in their daily work	-3	1	2	3	Total
1	0	2	6	1	9
	0.00	22.22	66.67	11.11	100.00
2	2	21	60	12	95
	2.11	22.11	63.16	12.63	100.00
3	1	27	101	9	138
	0.72	19.57	73.19	6.52	100.00
4	1	19	53	9	82
	1.22	23.17	64.63	10.98	100.00
5	2	26	47	8	83
	2.41	31.33	56.63	9.64	100.00
6	1	39	61	8	109
	0.92	35.78	55.96	7.34	100.00
7	1	64	120	9	194
	0.52	32.99	61.86	4.64	100.00
Total	8	198	448	56	710
	1.13	27.89	63.10	7.89	100.00
1	0	2	6	1	9

Pearson chi2(18) = 23.7925 Pr = 0.162
The Pearson χ2 independence test was applied to investigate the association between laptop/PC use in daily work and the evolution of the total number of employees in the next 3 years within German companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables (χ2(18) = 23.79, p = .162).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses robots	1	2	3	4	5	Total
-3	1	2	0	0	0	3
	33.33	66.67	0.00	0.00	0.00	100.00
1	13	31	45	3	2	94
	13.83	32.98	47.87	3.19	2.13	100.00

2	87	130	321	37	29	604
	14.40	21.52	53.15	6.13	4.80	100.00
Total	101	163	366	40	31	701
	14.41	23.25	52.21	5.71	4.42	100.00

Pearson chi2(8) = 12.6541 Pr = 0.124
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of robots and the dynamics of the total number of employees in 2016 in German companies. Following this statistical test, it can be seen that there is no statistically significant association between the two variables ($\chi 2(8) = 12.65$ p = .124).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)				
The company uses robots	-3	1	2	3	Total
-3	0	2	1	0	3
	0.00	66.67	33.33	0.00	100.00
1	4	24	52	14	94
	4.26	25.53	55.32	14.89	100.00
2	4	170	389	41	604
	0.66	28.15	64.40	6.79	100.00
Total	8	196	442	55	701
	1.14	27.96	63.05	7.85	100.00

Pearson chi2(6) = 19.5837 Pr = 0.003
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of robots and the evolution of the total number of employees in the next 3 years within German companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(6) = 19.58$, p = .003).

	Dynamics of the total number of employees within the company starting with 2016					
The company uses data analytics to improve production processes or service delivery	1	2	3	4	5	Total
-3	2	3	4	0	0	9
	22.22	33.33	44.44	0.00	0.00	100.00
1	60	85	153	18	13	329
	18.24	25.84	46.50	5.47	3.95	100.00
2	40	75	217	22	18	372
	10.75	20.16	58.33	5.91	4.84	100.00
Total	102	163	374	40	31	710
	14.37	22.96	52.68	5.63	4.37	100.00

Pearson chi2(8) = 16.1174 Pr = 0.041
The Pearson $\chi 2$ independence test was applied to investigate the association between the use of data analysis to improve production/services and the dynamics of the total number of employees in 2016 in German companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(8) = 16.12$, p = .041).

	Evolution of the total number of employees within the company in the next 3 years (starting with 2019)				
The company uses data analytics to improve production processes or service delivery	-3	1	2	3	Total
-3	0	2	7	0	9
	0.00	22.22	77.78	0.00	100.00
1	4	116	177	32	329
	1.22	35.26	53.80	9.73	100.00
2	4	80	264	24	372
	1.08	21.51	70.97	6.45	100.00
Total	8	198	448	56	710
	1.13	27.89	63.10	7.89	100.00

Pearson chi2(6) = 23.6396 Pr = 0.001

The Pearson $\chi 2$ independence test was applied to investigate the association between the use of data analysis to improve production/services and the evolution of the total number of employees in the next 3 years within German companies. Following this statistical test, it can be seen that there is a statistically significant association between the two variables ($\chi 2(6) = 23.64$, $p = .001$).