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ANALYSIS OF LABOR MARKET TRANSFORMATION IN THE CONTEXT OF INDUSTRY 4.0

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Abstract: The digitalization of the economy and society in the context of Industry 4.0 affects the labor market. New jobs are being created with new personnel requirements. At the same time, digitalization processes affect countries and sectors of the economy in different ways. The number of employed is declining in some sectors and increasing in others. The ratio of people employed in different industries also differs from country to country. As the digitalization of production relations intensifies, transformation processes in the labor market will increase. In the context of the actualization of digital changes in modern society, the aim of the article is to analyze the labor market under the digitalization of economic relations. The World Development Indicators (WDI) and Digital Intelligence Index (DII) were used to realize the purpose of the study. The study covers 89 countries for 2019. Correlation analysis, standardization, cluster analysis and analysis of variance were used as methods in the research. As a result of the study, the following conclusions were obtained. A strong relationship was found between Gross Domestic Product (GDP) and DII for the whole sample. The cluster analysis process found that the variables form three clusters with values of most indicators by group: at the high, the average and the low levels. Plots of mean and confidence intervals for the variables in each cluster were also plotted. Correlation coefficients were calculated for each cluster. It was found that each group has its own internal patterns.

Keywords: digitalization; Industry 4.0; labor market.

JEL Codes: C38, E24, J01, J2, J40, O33.

1. Introduction

The digitalization of economic activity is changing production and market relations and is causing economic actors to search for new ways of doing business and forms of employment. The fact is, that Industry 4.0 has already influenced the automation

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and computerization of workplaces and created new jobs in information and digital technologies and other high-tech sectors of the economy. At the same time, the number of employed is falling in sectors with extensive use of unskilled manual labor.

The transition to a new society has been marked by changes in all spheres. Industry 4.0 has a significant impact on the content and the organization of work. The widespread introduction of cyber-physical systems, cloud computing and augmented reality technologies is on the one hand pushing labor out of production processes, on the other hand encouraging workers to improve their skills and gain new knowledge. The future is uncertain - with such a speed of technological change, it is currently difficult to determine which professions will emerge over the next few years and whether they will be in demand in the future. Changes in the labor market relate to the structure of employment by industries, professions, skill levels and tasks. There is no doubt that the labor market will continue to respond to the technological changes of the information age.

The purpose of the article is to identify the features of the relationship between the digital economy and labor market indicators. The solution to this problem involves determining the strength of this relationship for the data panel and whether the relationship is homogeneous across the sample or varies from country to country.

The structure of this study is as follows. The introduction highlights the importance of labor market analysis in the context of the digitalization of economic relations. The literature review aims to explore trends in labor market responses to the challenges of Industry 4.0. This part of the paper contains an analysis of current research on the impact of digitalization on the labor market, as well as the changes that are taking place due to the widespread use of digital tools in production processes and labor relations. The "Results" focuses on assessing the relationship between the degree of digital economy development, GDP and the state of the labor market. The assessment was made for the sample as a whole as well as for the selected country groups that were formed as a result of the cluster analysis. The relationships between the indicators in each cluster were analyzed in detail, including differences in the strength of the link for the variables in each cluster. The "Conclusion and Discussion" compares the results of this and previous studies. This section of the article also summarises the findings and offers the possibilities of using practical recommendations that follow from this study. This research differs from previous ones in that it attempts to quantify the extent to which labor markets and digital technologies are linked in the context of the emergence of Industry 4.0.

2. Review of literature

The attention of scholars has focused on labor market issues at both global and national levels. For example, Morelli et al. (2020) note that as a result of global

changes, the structure of economies around the world has changed significantly, which has had some impact on the labor market. Tu and Pham (2021) confirm the fact that Industry 4.0 affects the labor market and human resource development strategies at the national level.

It is obvious that the transformations caused by Industry 4.0 will affect industrial and service companies. There will be a growth in labor productivity and wages, including for part-time workers. Industry 4.0 will have economic consequences, such as the need for greater investment in equipment by companies and the government in the development of network infrastructure (Wolter et al., 2015).

Bayraktar and Ataç (2018) consider Industry 4.0 as increasing the degree of digitalization along the entire value chain and structuring the transfer of data between people, objects and systems in real-time.

The flexibility of Industry 4.0 production is achieved largely due to digitalization and requires appropriate skills from the staff. Experience-based learning and the ability to make constructive decisions in the face of profound changes in the external environment are becoming key tasks for personnel in the new industrial reality. Modern technological advances are opening up vast business opportunities, but these processes are causing humans to be displaced from production processes, where their labor is being replaced by machine labor.

Digitalization also brings significant benefits to employers, including reducing the transaction costs of market coordination and employee search. The speed of interaction between agents also increases. Digitalization will further contribute to a more efficient distribution of jobs in the labor market. In many ways, digitalization expands the possibilities for participation in production processes, including for people with disabilities, by enabling them to work remotely. In addition, the proliferation of robotics reduces the risks for workers under harsh, hazardous and dangerous labor conditions.

Walwei (2016) assessed the impact of digitalization on the labor market using Germany as an example. As he argued, the issue of technological skill obsolescence is more relevant than the threat of mass technological unemployment due to global digitalization. The solution to this problem lies in developing new staff skills and adapting them to Industry 4.0. In this context, issues of state regulation of labor relations, such as unemployment insurance, social security and pension insurance, become relevant.

New technologies, alongside the benefits of their implementation, also bring certain threats. In particular, the researchers respond that the ubiquity of artificial intelligence and robotics is significantly altering the labor market environment and exacerbating social and legal problems (Gutsu et al., 2021). Kurt (2019) explored the impact of Industry 4.0 on the labor market, pointing to such objective changes such as a reduction in unskilled labor, increased need for digital skills, growth in flexible

forms of employment, expansion use of robots, optimization of work-life balance, etc. As he notes, developing countries with low-skilled labor will face a significant increase in unemployment and low labor costs will no longer be a factor in ensuring economic competitiveness.

Manufacturing innovations as a manifestation of Industry 4.0 are being introduced into all areas of activity, changing the nature of work and raising productivity. Labor market-specific interactions are more often carried out on the internet as online platforms facilitate interaction between employers and job seekers. At the same time, inequalities and social stratification are rising as a result of modern technological changes, which is a consequence of the digital divide, weak social mobility, job losses and employment polarization (Kergroach, 2017). The technological changes brought about by Industry 4.0 will have a significant impact on the labor market in terms of job polarization and increased inequality. These trends actualize the need to solve emerging problems both at the individual and at the political level (Haiss et al., 2021). The changes that Industry 4.0 brings are irreversible. And the labor market has been affected by them too. Szabó-Szentgróti et al. (2021) found, based on a review of the economic literature, that the digital transformations of Industry 4.0 lead to higher productivity against the backdrop of reduced working hours in the labor market. These conclusions broadly confirm Keynes' predictions from as early as 1930.

Workforce requirements are changing in the labor market. This is the result of the technological transformation of Industry 4.0. Costa and Portioli-Staudacher (2021), for example, conclude that one of the main requirements of Industry 4.0 for the labor market is workforce flexibility.

Achieving the goals of Industry 4.0 largely depends on choosing the right methods of working with staff. HR 4.0 practices play an important role in achieving Industry 4.0 goals by increasing labor productivity based on providing employees with renewed competencies (Gan & Halimah, 2019). In addition, industry specificity in developing human resource management strategies is also important (Stryzhak et al., 2021).

Industry 4.0 will have a strong impact on the labor market in the future. While there is a global expansion in the labor market due to the introduction of new technologies and the corresponding growth in productivity in some countries, such as Slovakia, the workforce is projected to shrink as a result of unfavorable demographic trends. There will presumably be a reallocation of jobs. The changes will primarily affect the manufacturing and administrative sector (Grencikova et al., 2020). Ziaei Nafchi and Mohelská (2021) forecast a decrease in the number of people employed in agriculture, industry and services while the number of people employed in high-tech manufacturing and services in the Czech Republic will increase in the long term. Moreover, the labor challenges of the fourth industrial revolution will primarily

influence the older generation, as new jobs typically require flexible skills that those aged 55-64 lack (Stojanova et al., 2019).

The role of the state in providing the economy with skilled labor is significant. Edeme et al. (2017) identified, using Nigeria as an example, that public expenditure has an impact (albeit a small one) on human development. By changing the structure of public expenditure, overall development goals such as economic growth, poverty reduction, social justice can be influenced (Patternosro et al., 2007). Tuegeh et al. (2021) emphasize the importance of orienting the education system to the updated requirements of Industry 4.0. The qualification and high level of education of company personnel is an essential condition for the holistic management of a company in the context of Industry 4.0. Competence management is essential for a company in a digital world (Hecklau et al., 2016).

3. Methodology, empirical data and results

This study proposes to use the Digital Intelligence Index (DII) to measure the level of digitalization of society. DII is a complex indicator that assesses the progress of the digital economy in 90 countries based on 160 different indicators. These indicators form four factors: Supply Conditions (SC), Demand Conditions (DC), Institutional Environment (IE), and Innovation and Change (IC). The index value varies from 0 to 100, where 0 is the worst value and 100 is the best.

World Development Indicators (WDI) have been used to assess the labor market situation in the economy, such as GDP - GDP per person employed (constant 2017 PPP $); Emp - Employers, total (% of total employment) (modeled ILO estimate); Self-emp - Self-employed, total (% of total employment) (modeled ILO estimate); Ww - Wage and salaried workers, total (% of total employment) (modeled ILO estimate); LF - Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate). The study covers 89 countries for 2019.

At the initial stage of the study, correlations between the indicators for the whole sample were calculated. The results of the correlation analysis are presented in Table 1.

Table 1 Results of Correlation Analysis for the Sample between labor market indicators and GDP and DII and its components

Variable	DII	SC	DC	IE	IC
	Pearson Correlations				
GDP	0,886762	0,878615	0,851417	0,812698	0,803478
Emp	0,084073	0,152333	0,082684	0,051763	0,029971
S-emp	-0,772018	-0,807161	-0,794952	-0,684410	-0,626194
Ww	0,772025	0,807168	0,794963	0,684414	0,626199
LF	0,450345	0,409838	0,465530	0,427521	0,396834

	Spearman Rank Order Correlations				
GDP	0,894688	0,905056	0,883388	0,814845	0,782434
Emp	0,128902	0,197512	0,182080	0,111767	0,044622
S-emp	-0,795785	-0,781927	-0,787651	-0,717916	-0,710526
Ww	0,795785	0,781927	0,787651	0,717916	0,710526
LF	0,422782	0,420262	0,433756	0,434333	0,393034
	Kendall Tau Correlations				
GDP	0,711440	0,731869	0,702592	0,612870	0,588175
Emp	0,091246	0,135208	0,125767	0,077444	0,038855
S-emp	-0,590549	-0,582886	-0,581173	-0,515453	-0,509133
Ww	0,590549	0,582886	0,581173	0,515453	0,509133
LF	0,330524	0,334610	0,336441	0,325926	0,290969

Note: Significant correlations are highlighted in red. Marked correlations are significant at p < ,05000; N=89 (Casewise deletion of missing data)

Source: Author's computation with data from WDI and DII using Statistica.

Table 1 shows that the relationship is strongest between GDP and DII. It is noteworthy that the relationship between self-employment and DII is negative. This suggests that the level of self-employment is declining as the degree of digitalization of society increases. In order to determine whether this dependence is homogeneous or varies from country to country, it is useful to carry out a cluster analysis procedure. The Euclidean distance was used as the proximity measure; Ward's method was used as the rule. The data were standardized before the cluster analysis was carried out. The results of the analysis are presented in Figure 1.

As can be seen from Figure 1, three natural clusters were formed during the cluster analysis process. The raw data were distributed into 3 clusters using the K-means method to determine the differences between clusters. The Euclidean distances of objects from the centers of their respective clusters are shown in Table 2.

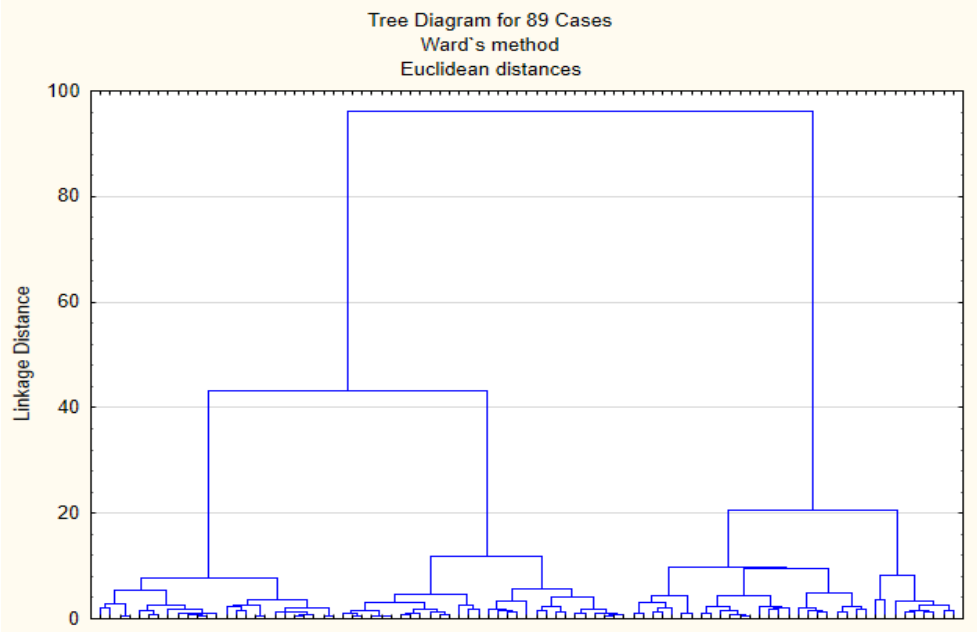

Figure 1 Distribution of countries by clusters (standardized values)
Source: Author's computation with data from WDI and DII using Statistica.

Table 2 Euclidean Distances between Clusters

Cluster number	№ 1	№ 2	№ 3
№ 1	0,000000	1,408530	0,935539
№ 2	1,186815	0,000000	3,701218
№ 3	0,967233	1,923855	0,000000

Note: The distances are below the diagonal;
The distance squares are above the diagonal.
Source: Author's computation with data from WDI and DII using Statistica.

To determine the significance of the differences between the clusters obtained, we use the procedure of analysis of variance. The results of the analysis of variance are presented in Table 3.

Table 3 Analysis of Variance

Variable	Between SS	df	Within SS	df	F	signif. p
GDP	64,85072	2	23,14928	86	120,4608	0,000000
Emp	11,74121	2	76,25878	86	6,6205	0,002117
S-emp	68,94571	2	19,05429	86	155,5904	0,000000
Ww	68,94728	2	19,05272	86	155,6068	0,000000

LF	23,92858	2	64,07143	86	16,0591	0,000001
DII	71,20126	2	16,79874	86	182,2550	0,000000
SC	67,28985	2	20,71015	86	139,7123	0,000000
DC	70,17776	2	17,82224	86	169,3190	0,000000
IE	61,84332	2	26,15668	86	101,6666	0,000000
IC	58,42587	2	29,57413	86	84,9497	0,000000

Source: Author's computation with data from WDI and DII using Statistica.

The p<0.05 value shows that there are significant differences between the clusters. Based on the results of the analysis of variance, we can conclude that all variables affect the membership of an object in a cluster since the p-level is less than 0.05. In other words, all factors are relevant.

Let's plot the mean and confidence intervals for the variables in each cluster (Figure 2). The visualization of the indicator values on the graph allows us to compare indicators in each cluster.

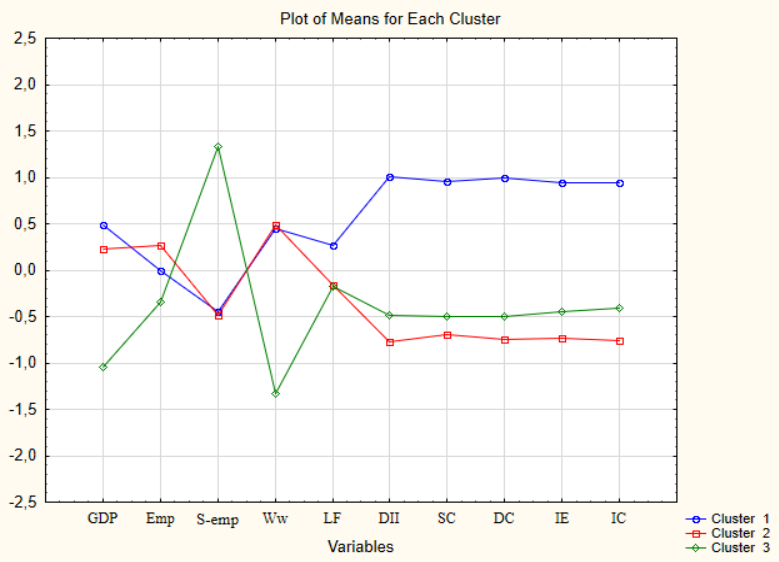

Figure 2 Values of indicators in clusters (standardized values)

Source: Author's computation with data from WDI and DII using Statistica.

For further analysis, the data were supplemented with information about the cluster to which the observation belonged (Appendix A). After that, the main descriptive statistics for each cluster were calculated. Descriptive statistics for indicators by cluster and for the sample as a whole are presented in Table 4.

Table 4 Descriptive Statistics

Variable	Mean	Standard Deviation	Min	Max
	Cluster (32 cases)			
GDP	49745,91	18308,98	22066,27	109575,7
Emp	4,535937	2,816243	0,770000	13,69000
S-emp	29,65937	13,29406	8,15000	67,85000
Ww	70,34187	13,29366	32,15000	91,85000
LF	64,26094	9,67500	41,78000	76,59000
DII	49,83719	7,12035	34,31000	62,13000
SC	54,69937	9,44219	34,97000	69,5200
DC	55,91469	12,37872	29,53000	82,2800
IE	42,63156	11,48302	15,93000	66,68000
IC	33,72437	7,06058	20,06000	56,02000
	2 Cluster (36 cases)			
GDP	99996,64	26666,39	59089,67	185460,4
Emp	3,645000	1,318762	0,270000	6,28000
S-emp	12,68694	5,54770	0,41000	27,40000
Ww	87,31444	5,54622	72,61000	99,59000
LF	76,48500	5,64227	57,95000	87,67000
DII	76,70778	9,34465	62,42000	98,82000
SC	79,08778	9,85910	60,77000	100,0000
DC	86,17361	9,01897	71,13000	100,0000
IE	76,08361	11,08312	55,15000	99,92000
IC	58,35528	12,96023	41,01000	90,18000
	3 Cluster (21 cases)			
GDP	15545,59	7632,50	4481,30	30994,5
Emp	2,418095	1,774857	0,040000	5,41000
S-emp	64,30762	12,71856	47,05000	84,15000
Ww	35,69333	12,71863	15,85000	52,95000
LF	70,87190	11,75404	48,73000	84,90000
DII	36,81286	7,31078	21,11000	47,72000
SC	35,10810	10,37386	18,57000	49,9600
DC	34,27286	10,29947	15,14000	54,8700
IE	34,27333	14,56521	6,00000	62,50000
IC	27,42762	6,38337	19,78000	42,27000
	Sample (89 cases)			
GDP	62002,31	39678,18	4481,30	185460,4
Emp	3,675843	2,201929	0,040000	13,69000
S-emp	30,96955	22,66835	0,41000	84,15000

Ww	69,03169	22,66828	15,85000	99,59000
LF	70,76539	10,28622	41,78000	87,67000
DII	57,63303	18,41542	21,11000	98,82000
SC	59,94169	20,04118	18,57000	100,0000
DC	63,04775	23,35200	15,14000	100,0000
IE	54,19056	21,97389	6,00000	99,92000
IC	42,20169	16,69119	19,78000	90,18000

Source: Author's computation with data from WDI and DII using Statistica.

Thus, the following clusters were obtained in the analysis:
Cluster 1: Values of all indicators, including income level, are at an average level;
Cluster 2: Values of all indicators are above average, also most of these countries have high-income levels;
Cluster 3: Values of all indicators are below average with low or below average incomes in the countries forming the cluster.
Plots of mean and confidence intervals for the variables in each cluster enable a visual comparison of the analyzed indicators across clusters (Figure 3-4).

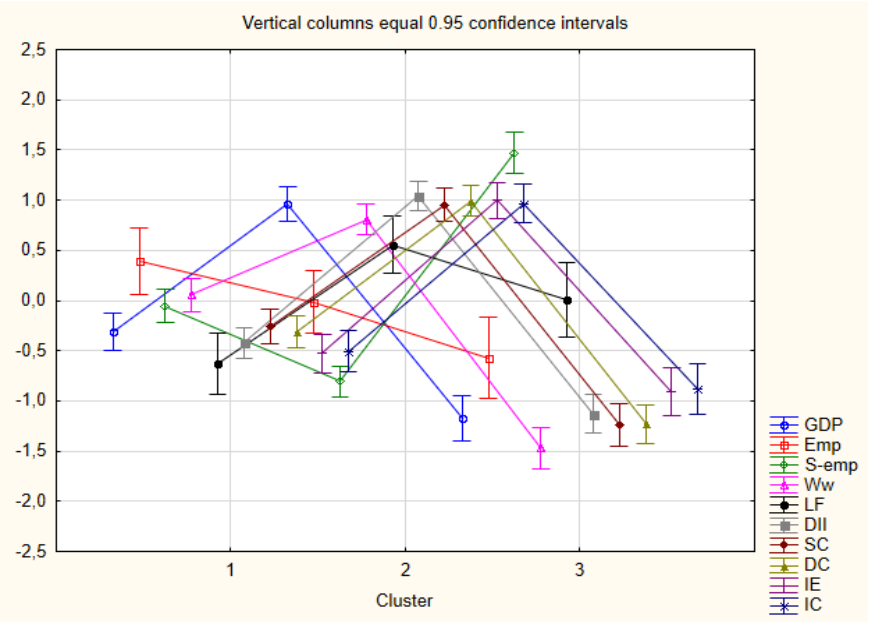

Figure 3 Mean and confidence intervals of variables in clusters (standardized values)
Source: Author's computation with data from WDI and DII using Statistica.

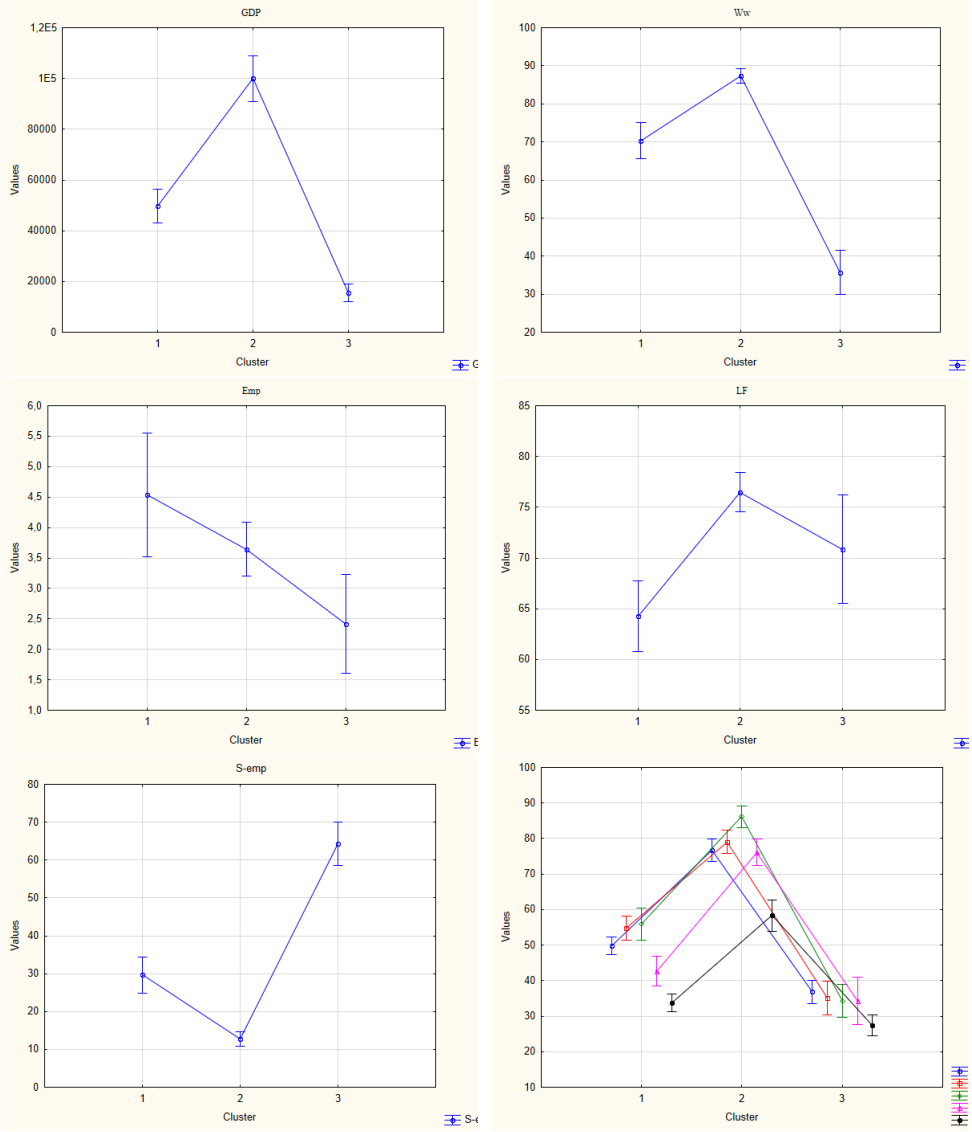

Figure 4 Mean and confidence intervals of variables in clusters (non-standardized values)
Source: Author's computation with data from WDI and DII using Statistica.

As can be seen from the figures, the ratio of self-employed to salaried workers varies across country groups according to the degree of digitalization. The share of self-

employed is decreasing, while the share of employees is increasing with the growth in the level of digitalization of the economy.

Let's analyze the indicators in the obtained clusters in more detail. This requires determining the closeness of the relationship between the analyzed indicators by calculating correlation coefficients. The correlation coefficients by cluster are presented in Table 5.

Table 5 Results of Correlation Analysis for the Clusters between labor market indicators and GDP and DII and its components

Variable	DII	SC	DC	IE	IC
	1 Cluster (32 cases)				
	Pearson Correlations				
GDP	0,440748	0,533100	0,506676	0,363811	-0,154516
Emp	-0,228200	-0,155578	-0,370507	-0,034038	-0,102744
S-emp	-0,170310	-0,211272	-0,225483	-0,132421	0,093000
Ww	0,170315	0,211291	0,225488	0,132418	-0,093008
LF	0,703240	0,700773	0,602756	0,399333	0,393753
	Spearman Rank Order Correlations				
GDP	0,429252	0,535557	0,546921	0,372801	-0,161290
Emp	-0,250573	-0,144808	-0,217029	-0,026945	-0,258088
S-emp	-0,268903	-0,300797	-0,304830	-0,260838	-0,129411
Ww	0,268903	0,300797	0,304830	0,260838	0,129411
LF	0,678886	0,674120	0,591642	0,383798	0,342742
	Kendall Tau Correlations				
GDP	0,302419	0,362903	0,435484	0,254032	-0,096774
Emp	-0,163471	-0,094854	-0,127144	-0,006054	-0,171544
S-emp	-0,179617	-0,203835	-0,191726	-0,219980	-0,106963
Ww	0,179617	0,203835	0,191726	0,219980	0,106963
LF	0,491935	0,463710	0,407258	0,282258	0,229839
Variable	**2 Cluster (36 cases)**				
	Pearson Correlations				
GDP	0,600097	0,533800	0,367914	0,545374	0,603971
Emp	0,205669	0,334230	0,267298	0,112888	0,087832
S-emp	0,001725	0,111847	0,027486	-0,158769	0,019772
Ww	-0,001770	-0,111927	-0,027507	0,158710	-0,019784
LF	0,333966	0,410229	0,371306	0,420640	0,108321
	Spearman Rank Order Correlations				
GDP	0,583526	0,548777	0,417916	0,541828	0,535684
Emp	0,136182	0,260909	0,201197	0,065646	0,070026
S-emp	-0,038741	0,044018	-0,025357	-0,194736	-0,037907
Ww	0,038741	-0,044018	0,025357	0,194736	0,037907

LF	0,335929	0,399640	0,362852	0,482657	0,152143
	Kendall Tau Correlations				
GDP	0,434921	0,400000	0,300238	0,374603	0,379667
Emp	0,101749	0,181240	0,141607	0,038156	0,062053
S-emp	-0,055600	0,011120	-0,031797	-0,122319	-0,022258
Ww	0,055600	-0,011120	0,031797	0,122319	0,022258
LF	0,233519	0,287530	0,248013	0,312947	0,139905
Variable	**3 Cluster (21 cases)**				
	Pearson Correlations				
GDP	0,487959	0,784851	0,168039	0,194546	0,315401
Emp	0,150196	0,210019	0,342592	0,025446	-0,137864
S-emp	-0,569937	-0,717506	-0,328997	-0,313943	-0,338862
Ww	0,569954	0,717498	0,329054	0,313958	0,338850
LF	-0,066807	-0,133786	0,313524	-0,193238	-0,115293
	Spearman Rank Order Correlations				
GDP	0,363636	0,781818	0,138961	0,248052	0,268831
Emp	0,087013	0,220779	0,364935	0,038961	-0,189610
S-emp	-0,514286	-0,659740	-0,324675	-0,333766	-0,376623
Ww	0,514286	0,659740	0,324675	0,333766	0,376623
LF	-0,115584	-0,167532	0,207792	-0,263636	-0,146753
	Kendall Tau Correlations				
GDP	0,238095	0,609524	0,095238	0,171429	0,200000
Emp	0,047619	0,114286	0,266667	0,019048	-0,142857
S-emp	-0,390476	-0,495238	-0,247619	-0,228571	-0,257143
Ww	0,390476	0,495238	0,247619	0,228571	0,257143
LF	-0,076190	-0,123810	0,142857	-0,200000	-0,114286

Note: Significant correlations are highlighted in red. Marked correlations are significant at p < ,05000; N=21 (Casewise deletion of missing data)

Source: Author's computation with data from WDI and DII using Statistica.

From the data presented in Table 5, it can be concluded that the relationship between LF and DII and sub-indices is strongest in the group with average values of the indicators (cluster 1). The group with the highest indicator values (cluster 2) has the strongest relationship between GDP and DII and sub-indexes. Of all the sub-indices, SC has the strongest relationship with employment rates in group 3, i.e. with low values of the indicators. The difference in the strength of the relationship between the indicators indicates that each group has its own internal patterns.

5. Conclusions and Discussion

The processes of modern digitalization affect the labor market by changing the conditions, content and nature of labor, the labor supply and the labor demand. The ratio of employment forms and the employment share by industries and sectors of the economy are also changing. It should be noted that, although there is plenty of research on labor market issues in the context of Industry 4.0 formation, most of them focused are on describing current trends in the digitalization of industrial relations. At the same time, the number of studies that quantify the impact of digital technologies on the labor market and employment is insufficient. This article partially addresses the issue of quantifying the impact of digitalization on employment in terms of determining the relationship between labor market indicators and the degree of development of the digital economy.

Digital technology, widespread with Industry 4.0, affects all areas, including the labor market. However, this influence is uneven across countries. Thus, the study found that most of the countries in cluster 1 have an upper-middle income level, and several countries have a high one. Cluster 2 is formed predominantly by high-income countries, while cluster 3 is by low- and lower-middle-income countries. This suggests that the level of economic development of a country, traditionally measured by income, is closely related to the degree of digitalization of society. In this case, further research is of particular interest to determine the direction of this relationship - whether high income contributes to widespread digitalization or either digitalization is a source of high income in the country.

The findings of this study are to some extent consistent with the results by Grencikova et al. (2020). They found that the highest labor productivity is in the USA, Germany and Japan, i.e. in the countries with the highest levels of digitalization of their economies. Our results are also in line with research by Bogoslov et al. (2022). The researchers determined that there is a strong direct relationship between digitalization, as expressed by the DESI index, and labor market indicators such as employment, labor force participation rates and unemployment in the EU countries. Other scientists have reached similar conclusions. According to Cirillo et al. (2021), digitalization has no negative impact on employment in the Italian labor market. The use of digital technology at the firm level (French experience) increases labor productivity (Cette et al., 2021). Analysis of the impact of digitalization on employment in Spain shows that investment in ICT has a positive influence on GDP, employment, welfare and unemployment (Gómez-Plana & Latorre, 2019).

The identification of patterns in labor market responses to the challenges of Industry 4.0 will provide a theoretical basis for creating an effective labor market governance mechanism. For example, the development of state programs such as stimulating the labor market, social policy, promoting the employment of the population,

determining the amount of income tax, etc. can be adjusted to reflect the strength of the relationship between employment rates and the level of digital development. The forecasts of Eder et al. (2022), further digitalization will lead to a fall in the employment rate in the primary and secondary sectors, with an increase in employment in the service sector (Austria case). This will necessitate a review of the distribution policy and social policy.

Our research shows that as digitalization increases, the share of the self-employed declines and the percentage of employed workers rises. Based on this fact, it can be concluded that economies of scale are strengthening as digital technology develops. These findings are supported by a comparative analysis of industrial employment in Germany, China and Brazil, which shows that the polarisation between skilled and unskilled labor is stronger in large companies in Germany and Brazil. But, in China, company size has an inverse effect on the required skills (Beier G. et al., 2022). Shuttleworth et al. (2022) also identified that the activities of large companies tend to be more digitally related than those of smaller firms.

However, it should be borne in mind also that digitalization is primarily changing the content of labor, requiring workers to have the skills needed to work in an environment of rapid technological change. Industry 4.0, therefore, makes it essential to improve the knowledge and skills of employees in order to develop the competencies that employers need in the new realities.

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References

1. Bayraktar, O., Ataç, C. (2018), The effects of Industry 4.0 on human resources management, Globalization, Institutions and Socio-Economic Performance: Macro and Micro Perspectives, 337-360. https://www.peterlang.com/abstract/title/64910?rskey=oklzGJ&result=2.

2. Beier, G., Matthess, M., Shuttleworth, L., Guan, T., de Oliveira Pereira Grudzien, D. I., Xue, B., de Lima, E. P., Chen, L. (2022), Implications of Industry 4.0 on industrial employment: A comparative survey from Brazilian, Chinese, and German practitioners, Technology in Society, 70. https://doi.org/10.1016/j.techsoc.2022.102028.
3. Bogoslov, I. A., Stoica, E. A., & Georgescu, M. R. (2022), The Labor Market in Relation to Digitalization — Perspectives on the European Union. In: Ciurea, C., Boja, C., Pocatilu, P., Doinea, M. (eds), Education, Research and Business Technologies. Smart Innovation, Systems and Technologies, 276. Springer, Singapore. https://doi.org/10.1007/978-981-16-8866-9_16.
4. Cette, G., Nevoux, S., Py, L. (2021), The impact of ICTs and digitalization on productivity and labor share: Evidence from French firms, Economics of Innovation and New Technology. https://doi.org/10.1080/10438599.2020.1849967.
5. Cirillo, V., Evangelista, R., Guarascio, D., Sostero, M. (2021), Digitalization, routineness and employment: An exploration on Italian task-based data, Research Policy, 50(7). https://doi.org/10.1016/j.respol.2020.104079.
6. Costa, F., Portioli-Staudacher, A. (2021), Labor flexibility integration in workload control in Industry 4.0 era, Operations Management Research, 14 (3-4), 420-433. https://doi.org/10.1007/s12063-021-00210-2.
7. Digital Intelligence Index, (2019). https://digitalintelligence.fletcher.tufts.edu/methodology.
8. Edeme, R. K., Nkalu, C. N., Ifelunini, I. A. (2017), Distributional impact of public expenditure on human development in Nigeria, International Journal of Social Economics, 44(12), 1683-1693. https://doi.org/10.1108/IJSE-05-2016-0152.
9. Eder, A., Koller, W., Mahlberg, B. (2022), Economy 4.0: Employment effects by occupation, industry, and gender, Empirica. https://doi.org/10.1007/s10663-022-09543-y.
10. Gan, J. L., Halimah, M. Y. (2019), Industrial Revolution 4.0: the Human Resource Practices, International Journal of Recent Technology and Engineering (IJRTE), 8(3), 620-624. https://www.ijrte.org/wp-content/uploads/papers/v8i3S2/C12031083S219.pdf.
11. Gómez-Plana, A. G., Latorre, M. C. (2019), Digitalization, multinationals and employment: An empirical analysis of their causal relationships, Jahrbucher Fur Nationalokonomie Und Statistik, 239(3), 399-439. https://doi.org/10.1515/jbnst-2017-0153.
12. Grencikova, A., Kordos, M., Berkovic, V. (2020), Impact of Industry 4.0 on labor productivity in the Slovak Republic, Problems and Perspectives in Management, 18 (2), 396-408. http://dx.doi.org/10.21511/ppm.18(2).2020.32.
13. Gutsu, S., Mkrtchyan, M., Strielkina, A. (2021), Social and Legal Aspects of the Transition to Industry 4.0, Lecture Notes in Networks and Systems, 188, 726-737. https://doi.org/10.1007/978-3-030-66717-7_62.
14. Haiss, P., Mahlberg, B., Michlits, D. (2021), Industry 4.0–the future of Austrian jobs, Empirica, 48(1), 5–36. https://doi.org/10.1007/s10663-020-09497-z.
15. Hecklau, F., Galeitzke, M., Flachs, S., Kohl, H. (2016), Holistic Approach for Human Resource Management in Industry 4.0, Procedia CIRP, 54, 1-6. https://doi.org/10.1016/j.procir.2016.05.102.

16. Kergroach, S. (2017), Industry 4.0: New challenges and opportunities for the labor market, Foresight and STI Governance, 11(4), 6-8. https://foresight-journal.hse.ru/data/2018/01/09/1160538630/0-Kergroach-6-8.pdf.
17. Kurt, R. (2019), Industry 4.0 in Terms of Industrial Relations and Its Impacts on Labor Life, Procedia Computer Science, 158, 590-601. https://www.sciencedirect.com/science/article/pii/S1877050919312633?pes=vor.
18. Morelli, G., Pozzi, C., Gurrieri, A. R. (2020), Industry 4.0 and the Global Digitalised Production, Structural Changes in Manufacturing, Lecture Notes in Information Systems and Organisation, 38, 187-204. https://doi.org/10.1007/978-3-030-47355-6_13.
19. Patternosro, S., Rajaram, A., Tiogson, E. R. (2007), How Does the Composition of Public Spending Matter?, Oxford Development Studies, 35(1), 48-82. https://www.tandfonline.com/doi/abs/10.1080/13600810601167595?journalCode=cods20.
20. Shuttleworth, L., Schmitz, S., Beier, G. (2022), Impacts of Industry 4.0 on industrial employment in Germany: A comparison of industrial workers' expectations and experiences from two surveys in 2014 and 2020, Production and Manufacturing Research, 10(1), 583-605. https://doi.org/10.1080/21693277.2022.2104400.
21. Stojanova, H., Lietavcova, B., Raguž, V. I. (2019), The Dependence of Unemployment of the Senior Workforce upon Explanatory Variables in the European Union in the Context of Industry 4.0., Social Sciences, 8(1), 29. https://doi.org/10.3390/socsci8010029.
22. Stryzhak, O., Akhmedova, O., Leonenko, N., Lopatchenko, I., Hrabar, N. (2021), Transformation of human capital strategies in the tourism industry under the influence of Economy 4.0., Problems and Perspectives in Management, 19(2), 145-156. http://dx.doi.org/10.21511/ppm.19(2).2021.12.
23. Szabó-Szentgróti, G., Végvári, B., Varga, J. (2021), Impact of Industry 4.0 and Digitization on Labor Market for 2030-Verification of Keynes' Prediction, Sustainability, 13, 7703. https://doi.org/10.3390/su13147703.
24. Tu, A. T., Pham, T. X. (2021), Vietnam's National Human Resource Development Strategy in Response to Industry 4.0: An Analysis from a Labor Market Perspective, Palgrave Macmillan Asian Business Series, 69-96. https://doi.org/10.1007/978-3-030-51533-1_3.
25. Tuegeh, O. D. M., Harangi-Rákos, M., Nagy, A. Sz. (2021), Industry 4.0 and human resource in Indonesia: a systematic literature review, Economic Annals-XXI, 190(5-6(2)), 171-180. https://doi.org/10.21003/ea.V190-16.
26. Walwei, U. (2016), Digitalization and structural labor market problems: The case of Germany, ILO research paper, no. 17. Geneva: International Labor Office. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---inst/documents/publication/wcms_522355.pdf.
27. Wolter, M. I., Mönnig, A., Hummel, M., Schneemann, C., Weber, E., Zika, G., Helmrich, R., Maier, T., Neuber-Pohl, C. (2015), Industry 4.0 and the consequences for labor market and economy. Scenario calculations in line with the BIBB-IAB qualifications and occupational field projections. Research Report, IAB-Forschungsbericht. https://doku.iab.de/forschungsbericht/2015/fb0815_en.pdf.
28. World Development Indicators. DataBank. The World Bank. https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

29. Ziaei Nafchi, M., Mohelská, H. (2021), Strategic challenges of human resources allocation in industry 4.0., Information (Switzerland), 12 (3), art. no. 120. https://doi.org/10.3390/info12030120.

Appendix A - Table A1 Data for the analysed countries

№	Country	GDP	Emp	S-emp	Ww	LF	DII	SC	DC	IE	IC	Income	Cluster
1	Algeria	44345,19	4,65	32,29	67,71	46,37	34,31	34,97	40,81	26,57	20,06	Lower middle	1
2	Argentina	53836,03	3,79	26,51	73,49	69,37	48,26	54,15	59,16	43,73	25,71	Upper middle	1
3	Azerbaijan	29812,98	13,69	67,85	32,15	72,04	51,85	56,03	43,35	49,93	43,05	Upper middle	1
4	Bosnia and Herzegovina	49550,88	5,82	24,90	75,10	57,74	39,65	44,38	54,23	26,70	20,67	Upper middle	1
5	Brazil	33832,42	4,75	33,08	66,92	70,93	47,19	53,33	58,30	36,06	29,00	Upper middle	1
6	Bulgaria	50326,97	3,55	10,83	89,17	73,37	57,14	69,52	55,85	55,59	36,71	Upper middle	1
7	Chile	56064,11	4,18	27,22	72,79	68,90	62,13	66,25	67,75	66,68	39,67	High	1
8	China	29445,94	2,11	44,66	55,34	75,88	61,89	65,14	82,28	30,49	56,02	Upper middle	1
9	Costa Rica	48179,45	3,36	26,64	73,36	71,15	52,08	52,12	55,35	52,14	36,88	Upper middle	1
10	Croatia	71958,02	4,92	12,35	87,65	66,99	56,60	63,63	72,69	52,96	29,67	High income	1
11	Egypt, Arab Rep.	45702,21	12,45	30,43	69,57	47,87	39,41	48,21	29,53	35,12	28,13	Lower middle	1
12	Georgia	33682,44	2,00	49,71	50,29	69,40	53,46	59,00	53,70	60,07	31,17	Upper middle	1
13	Greece	80275,40	7,40	31,90	68,10	68,70	56,54	63,88	69,45	48,92	34,54	High	1
14	Hungary	68987,95	4,49	10,83	89,17	72,57	57,75	67,65	64,06	57,13	33,3	High	1
15	Iran, Islamic Rep.	50721,27	3,59	47,22	52,78	48,00	43,13	45,00	58,53	33,43	23,95	Upper middle	1
16	Italy	109575,69	5,97	22,74	77,26	65,82	61,27	67,32	76,39	54,22	38,85	High	1
17	Jordan	46437,70	3,35	13,92	86,08	41,78	49,07	45,22	45,18	51,77	39,94	Upper middle	1
18	Kazakhstan	55538,77	1,48	23,46	76,54	76,59	50,71	55,63	64,14	38,52	33,05	Upper middle	1
19	Lebanon	49763,78	6,90	37,48	62,53	51,07	40,05	46,22	48,41	15,93	32,61	Upper middle	1
20	Mexico	45949,96	4,79	31,00,95	68,05	65,25	45,86	49,74	41,56	42,19	34,94	Upper middle	1
21	Namibia	33001,42	6,63	38,37	61,63	60,59	42,69	39,09	53,51	37,47	27,96	Upper middle	1

22	Philippines	22066,27	2,95	36,15	63,85	62,30	44,29	41,84	36,08	35,26	45,18	Lower middle	1
23	Romania	66786,35	1,14	24,23	75,77	68,75	54,06	66,88	54,93	53,27	30,81	High	1
24	Russian Federation	56965,96	1,55	8,15	91,85	73,96	52,78	61,43	71,09	28,82	37,45	Upper middle	1
25	Serbia	44276,95	3,36	27,70	72,30	67,60	52,27	57,97	59,4	44,79	35,17	Upper middle	1
26	South Africa	48820,54	5,67	16,34	83,66	60,13	50,79	52,77	55,38	46,19	36,31	Upper middle	1
27	Sri Lanka	35153,83	2,77	41,72	58,29	57,52	42,83	47,66	42,88	34,56	31,06	Lower middle	1
28	Thailand	33346,53	2,54	50,28	49,72	74,17	53,04	59,02	59,19	45,38	36,64	Upper middle	1
29	Tunisia	37875,74	6,23	25,16	74,84	51,53	40,94	45,64	34,04	35,39	32,03	Lower middle	1
30	Turkiye	81538,11	4,47	31,54	68,46	58,09	52,43	61,16	62,16	44,34	31,43	Upper middle	1
31	Ukraine	27895,02	0,77	14,94	85,06	66,64	46,03	46,01	55,9	30,21	37,17	Lower middle	1
32	Uruguay	50155,39	3,83	28,55	71,46	75,28	54,29	63,52	63,99	50,38	30,05	High	1
33	Australia	97659,63	5,97	16,58	83,42	78,51	80,09	84,27	95,29	79,99	56,14	High	2
34	Austria	111248,31	4,79	12,16	87,84	76,86	75,42	77,57	86,14	77,10	54,53	High	2
35	Bahrain	78064,95	1,64	2,67	97,33	75,09	63,00	60,89	78,24	63,01	42,25	High	2
36	Belgium	121649,56	3,64	14,23	85,77	69,06	74,51	77,12	88,36	73,49	52,88	High	2
37	Canada	94256,13	4,39	15,23	84,77	79,04	80,24	79,12	91,77	83,00	61,22	High	2
38	Czech Republic	82186,71	3,03	16,80	83,20	76,86	68,68	74,75	77,45	62,23	51,17	High	2
39	Denmark	115423,97	3,40	8,34	91,66	79,01	87,17	97,56	98,62	87,28	61,38	High	2
40	Estonia	71648,22	4,55	10,99	89,01	78,90	76,66	81,39	87,87	81,72	50,91	High	2
41	Finland	104333,40	3,78	13,46	86,54	78,15	87,30	86,40	97,14	94,63	66,73	High	2
42	France	110592,53	4,25	12,13	87,87	71,82	72,99	75,71	82,00	71,93	54,57	High	2
43	Germany	104313,41	4,26	9,61	90,39	79,08	79,27	79,48	85,35	83,51	61,82	High	2
44	Hong Kong SAR, China	115616,89	2,66	8,40	91,60	72,27	88,12	81,98	90,41	83,24	86,37	High	2

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45	Iceland	98769,45	3,48	11,93	88,07	86,67	84,29	89,9	97,18	85,02	60,66	High	2
46	Ireland	185460,40	4,20	14,40	85,60	73,51	82,32	85,27	82,62	77,48	73,75	High	2
47	Israel	92222,19	3,94	12,31	87,69	72,18	75,02	71,22	77,62	67,00	71,97	High	2
48	Japan	78689,97	1,83	10,05	89,96	79,82	77,76	79,78	84,18	75,83	62,95	High	2
49	Latvia	64593,96	4,09	11,59	88,42	77,74	65,06	69,61	78,08	64,10	41,33	High	2
50	Lithuania	75244,82	2,57	11,66	88,34	78,24	68,02	73,61	77,88	67,3	45,83	High	2
51	Malaysia	59089,67	3,61	27,40	72,61	68,64	69,03	64,07	71,13	68,49	61,12	Upper middle	2
52	Netherlands	107854,95	3,85	16,62	83,38	80,94	85,48	91,87	93,29	83,77	66,73	High	2
53	New Zealand	79227,78	6,28	18,57	81,44	80,89	80,46	80,77	94,96	86,08	56,06	High	2
54	Norway	126124,69	1,69	6,46	93,54	78,17	85,34	86,25	99,11	93,38	59,73	High	2
55	Poland	71980,98	4,03	20,01	79,99	70,85	63,58	67,00	78,08	60,19	41,37	High	2
56	Portugal	72673,10	4,83	16,86	83,14	75,77	65,75	70,22	75,34	67,33	42,74	High	2
57	Qatar	118126,56	0,27	0,41	99,59	87,67	66,58	70,40	73,58	65,83	47,78	High	2
58	Saudi Arabia	112735,74	1,73	4,62	95,38	57,95	62,42	60,77	71,94	65,56	43,02	High	2
59	Singapore	163463,10	4,26	13,46	86,54	77,42	98,82	100,00	97,73	99,92	90,18	High	2
60	Slovak Republic	67184,29	2,99	15,05	84,95	72,72	63,01	69,51	75,51	55,15	42,89	High	2
61	Slovenia	82681,48	3,59	13,67	86,33	75,13	67,35	75,22	75,00	66,83	44,63	High	2
62	Korea, Rep.	80091,82	5,65	24,57	75,44	69,11	83,09	91,55	100,00	64,06	68,61	High	2
63	Spain	96004,57	4,83	15,68	84,32	74,17	66,95	77,17	78,84	63,97	41,01	High	2
64	Sweden	106879,82	3,62	9,84	90,16	83,13	85,07	83,84	96,32	88,40	66,45	High	2
65	Switzerland	127854,27	5,57	14,37	85,63	84,21	86,89	97,06	89,12	82,97	70,80	High	2
66	United Arab Emirates	103390,29	3,54	4,94	95,06	82,76	74,44	69,78	87,52	76,65	57,02	High	2
67	United Kingdom	94572,42	2,21	15,57	84,43	78,01	81,48	80,13	95,18	84,90	60,73	High	2

68	United States	127969,07	2,20	6,09	93,91	73,11	89,82	85,92	93,4	87,67	83,46	High	2
69	Bangladesh	13678,18	5,41	59,27	40,73	61,54	32,67	36,68	28,74	27,57	20,96	Lower middle	3
70	Bolivia	18499,36	4,95	68,25	31,75	74,21	30,82	38,52	41,69	6,00	19,78	Lower middle	3
71	Cambodia	7857,96	0,11	47,05	52,95	84,90	32,31	32,82	32,83	25,22	21,75	Lower middle	3
72	Cameroon	8868,21	3,09	74,39	25,61	76,90	28,01	25,63	25,89	15,03	25,61	Lower middle	3
73	Colombia	30994,45	3,65	49,57	50,44	72,86	43,80	48,75	43,73	38,74	29,77	Lower middle	3
74	Cote d'Ivoire	16534,79	1,63	70,93	29,07	54,56	32,16	22,88	34,68	28,13	26,02	Lower middle	3
75	Ecuador	24707,41	2,83	51,23	48,77	70,96	40,90	46,49	37,85	42,10	23,51	Upper middle	3
76	Ethiopia	4724,78	0,46	84,15	15,85	81,34	21,11	18,57	16,26	8,35	19,86	Low	3
77	Ghana	13383,59	5,35	72,25	27,75	69,21	41,69	29,68	44,78	50,80	28,79	Lower middle	3
78	India	19989,57	2,05	75,83	24,17	52,13	46,57	46,48	30,66	53,4	39,57	Lower middle	3
79	Indonesia	24351,38	3,50	51,75	48,25	70,20	47,72	49,10	47,52	44,75	35,61	Lower middle	3
80	Kenya	10431,92	0,18	49,27	50,73	74,56	44,08	32,48	54,87	41,36	34,32	Lower middle	3
81	Lao PDR	15214,94	0,44	74,72	25,28	81,38	32,14	35,42	27,30	18,05	28,25	Lower middle	3
82	Morocco	25468,77	2,46	48,56	51,44	48,73	40,58	46,57	23,22	46,28	29,74	Lower middle	3
83	Nigeria	18153,97	0,30	79,87	20,13	56,66	27,75	23,80	23,06	24,89	20,99	Lower middle	3
84	Pakistan	16660,99	1,41	56,32	43,68	54,50	34,03	36,12	15,14	37,30	28,61	Lower middle	3
85	Peru	23015,33	3,90	55,46	44,54	81,04	40,15	42,46	37,98	40,42	25,47	Upper middle	3
86	Rwanda	4481,30	0,04	66,29	33,71	84,08	42,75	33,04	31,700	62,50	30,35	Low	3
87	Tanzania	5609,38	2,81	83,68	16,32	84,52	33,34	21,44	38,50	38,04	21,22	Lower middle	3
88	Uganda	5978,91	4,21	77,32	22,69	70,94	33,70	20,38	40,35	35,94	23,53	Low	3
89	Vietnam	17852,30	2,00	54,30	45,70	83,09	46,79	49,96	42,98	34,87	42,27	Lower middle	3

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