MANAGING THE DIGITAL SHIFT: INFORMATION SYSTEMS AND AI IN EU FIRMS

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Abstract
This paper compares how far enterprises in the 27 European Union Member States have integrated management information systems and artificial intelligence, and establishes where Romania stands. The data come from the Eurostat survey on information and communication technology usage in enterprises for 2019–2025 and cover enterprises with ten or more persons employed. Six indicators are analysed: enterprise resource planning, customer relationship management, business intelligence, cloud computing, artificial intelligence and data analytics. The methods are descriptive statistics, sigma and beta convergence, a composite integration index, hierarchical cluster analysis and correlations with labour productivity, income per capita and digital skills. The six indicators form a single coherent dimension. Four countries form a clearly separate leading group. Six Central and Eastern European countries, Romania among them, make up the low-adoption group. Romania is 26th on the composite index and has been last on artificial intelligence in every year observed. Its gap to the European Union aggregate, measured in percentage points, widened for all three technologies that have a time series, and it is present in every size class, large enterprises included. Across countries, integration is associated more closely with the digital skills of the population than with income per capita. Its association with labour productivity is moderate.
Keywords: Enterprise resource planning, Cloud computing, Artificial intelligence, Digital divide, European Union.
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1. INTRODUCTION

Enterprise resource planning, customer relationship management and business intelligence software integrate the internal processes of a firm. Together with cloud computing, data analytics and, more recently, artificial intelligence, they are the technologies by which the digital transformation of enterprises is usually assessed. In the European Union they are also a matter of policy. Under the Digital Decade Policy Programme 2030, at least 75% of Union enterprises should have taken up one or more of cloud computing

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services, big data and artificial intelligence. More than 90% of small and medium-sized enterprises should reach at least a basic level of digital intensity, and at least 80% of people aged 16 to 74 should have at least basic digital skills (Decision (EU) 2022/2481, 2022).

The latest monitoring report shows that the three technologies, taken one by one, are still far from widespread. In 2025 almost 20% of enterprises in the European Union used artificial intelligence, 46.7% bought intermediate or sophisticated cloud services and 39.9% performed data analytics. At the current pace, a share of 75% would not be reached before 2035 for artificial intelligence, 2040 for cloud computing and 2047 for data analytics (European Commission, 2026b). Romania's country report records the lowest share of people with at least basic digital skills in the Union and a level of artificial intelligence use well below the Union average (European Commission, 2026a).

Member States have been compared on enterprise digitalisation before. The studies reviewed in Section 2, however, use data up to 2021, or composite indices in which enterprise indicators are mixed with household and public-service indicators, or a single technology. None covers, for the most recent year, both the three enterprise systems that integrate internal processes and the three technologies monitored under the Digital Decade. Only one compares countries by enterprise size class, and it does so on a composite measure. These studies do not examine whether Romania's lag holds within each size class and each economic activity, technology by technology.

This paper compares how far enterprises in the European Union Member States have integrated management information systems and artificial intelligence into their activity, and establishes where Romania stands in the comparison. The analysis answers four research questions.

RQ1. How large are the differences between Member States in the adoption of enterprise resource planning, customer relationship management, business intelligence, cloud computing, artificial intelligence and data analytics, and what is Romania's position?

RQ2. Have these differences narrowed over time, and has Romania's gap to the European Union aggregate narrowed?

RQ3. Can Member States be grouped into distinct profiles of integration?

RQ4. How is the level of integration associated with labour productivity, income per capita and digital skills?

The paper is organised as follows. Section 2 reviews the literature, Section 3 presents the data and the methods, Section 4 reports and discusses the results, and Section 5 concludes.

2. LITERATURE REVIEW

2.1 Digital technologies, enterprise systems and firm performance

At firm level, most studies find that digital technologies are associated with higher productivity. How large the effect is, and how long it lasts, varies from one study to another. Bettiol et al. (2024) apply a difference-in-differences design to 907 micro, small and medium-sized manufacturing firms in Northern Italy. They estimate that adopting Industry 4.0 technologies raises labour productivity by about 7.4%, and that the effect becomes negligible two years after adoption. Amador and Silva (2025) follow Portuguese firms between 2004 and 2020. In their instrumental-variable estimation, a one standard deviation increase in an index of information and communication technology use raises labour productivity by 33%, and specialised staff are complementary to the other technologies.

At country level, Fulgenzi et al. (2024) apply a production-frontier decomposition to 24 countries of the Organisation for Economic Co-operation and Development. Capital invested in information and communication technology contributed on average to the growth of labour productivity, though not in every country, and its contribution to technological change appears only after a delay. None of these studies looks separately at enterprise resource planning, customer relationship management or business intelligence software.

2.2 The adoption of artificial intelligence by firms

In European Union enterprises, the use of artificial intelligence rose from 8% in 2021 to 20% in 2025, and the main reported barrier was lack of expertise (Ignaszak et al., 2026). Research on what drives adoption points to prior digitalisation and to skills. The review by Enholm et al. (2022) lists cloud infrastructure, data and employees' skills among the enablers. For French firms, Calvino and Fontanelli (2026) find that the use of cloud services and the use of enterprise systems are both positively associated with the use of artificial intelligence. Segarra-Blasco et al. (2025) study European small and medium-sized enterprises surveyed in 2020. Adoption of artificial intelligence is more likely in countries that score higher on a factor the authors label digital skills, which they build from indicators such as internet use, e-government use, specialists and training in firms. In their data, adoption was 4.56% in Eastern countries and 9.32% in Northern ones.

Whether artificial intelligence improves performance is not settled. Studies based on patents report a positive association between artificial intelligence patenting and labour productivity (Damioli et al., 2021). They also report a negative direct association for patents on artificial intelligence applications, with effects that depend on firm size and on the distance to the productivity frontier (Kopka & Fornahl, 2024). Filip et al. (2026) surveyed 285 Romanian small and medium-sized enterprises, of which 18.6% had implemented

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artificial intelligence. In their model its use is not a significant predictor of self-reported performance, and training is the form of support the firms request most often.

2.3 The digital divide between Member States

In country-level comparisons, Finland, Denmark and the Netherlands are among the leaders and Romania is among the countries with the lowest levels. Brodny and Tutak (2021b) work with Eurostat enterprise indicators for 2018. They find a high level of digitalisation in Finland, Denmark, Belgium, Sweden, the Netherlands and Slovenia, and their cluster analysis identifies a group with the lowest level, formed by Bulgaria, Greece, Croatia, Cyprus, Latvia, Hungary, Romania and Slovakia. They note that Romania has long been near the bottom of European rankings of enterprise digitalisation. In a companion study of Central and Eastern European countries, the same authors report the lowest results for Bulgaria and Romania, with Croatia among the countries with the highest results (Brodny & Tutak, 2021a). Two studies examine the Digital Economy and Society Index itself. Bánhidi et al. (2020) show that the first principal component explains 72.9% of the variance of its dimensions, and that the official overall index ranks countries almost exactly as the statistically derived one does (correlation between the two rankings of 0.991). Olczyk and Kuc-Czarnecka (2022) also find that the pillars of the index are strongly correlated and that the ranking of countries changes little when the number of variables is halved. On this basis they propose a revision of its weights.

Income does not explain the whole divide. For the 27 Member States between 2014 and 2021, Karamujic (2026) finds that good governance positively affects the adoption of cloud computing by enterprises. Toader et al. (2023) report that in 2020 cloud services were bought by 16% of enterprises in Romania and by 36% in the European Union, and that adoption across countries is correlated with the share of private funding in research and development ($r = 0.578$). Holl and Rama (2024) use a 2020 survey of 12,915 enterprises with up to 250 employees. After controlling for firm size, sector, location, exporting and innovation, the coefficient for Romania, measured against France, is negative and significant for the adoption of any digital technology and of cloud computing, though not for artificial intelligence.

2.4 Digital skills and digitalisation

Skills recur in this literature as the complement of technology. In Bánhidi et al. (2020), the dimension that measures how enterprises integrate digital technology is correlated with human capital ($r = 0.709$), and the correlation persists when the other dimensions of the index are partialled out (0.407, $p = 0.044$). Tran et al. (2023) show that, across the 27 Member States, above-basic digital skills in four of five skill areas are correlated with gross domestic product per capita (Spearman coefficients between 0.51 and 0.71). In the

same study Bulgaria and Romania form a separate cluster, with the lowest rates for information and communication technology specialists in enterprises. At firm level, Moncada et al. (2025) find a complementary relationship between digitalisation and the demand for workers with tertiary education among manufacturing firms in an Italian region.

Romania's position at the bottom of European rankings is documented up to 2021, but not for the years in which artificial intelligence spread. The existing rankings rest on different sets of indicators and seldom separate the systems that integrate internal processes from the newer technologies. The factors most often associated with adoption are skills and prior digitalisation, and income alone does not account for it. The analysis that follows takes up the first two points with data up to 2025 and examines the third at country level.

3. RESEARCH METHODOLOGY

3.1 Data

The data come from Eurostat's annual survey on information and communication technology usage and e-commerce in enterprises. The survey covers enterprises with ten or more persons employed in manufacturing, energy and utilities, construction, trade, transport, accommodation and food services, information and communication, real estate, professional and administrative services and the repair of computers (NACE Rev. 2 sections C to J and L to N, and group 95.1). The financial sector is not part of the aggregate used here. All indicators are expressed as a percentage of enterprises. The unit of analysis is the Member State. The sample is the 27 Member States of the European Union, and none of the six core indicators has missing values in the reference year 2025.

Integration is described by six indicators: enterprises that have an enterprise resource planning (ERP) software package; enterprises using customer relationship management (CRM) software; enterprises using business intelligence (BI) software (all three from the dataset isoc_eb_iip); enterprises buying cloud computing services (isoc_cicce_use); enterprises using at least one artificial intelligence (AI) technology (isoc_eb_ai); and enterprises performing data analytics (isoc_eb_das). The same datasets give the breakdowns by size class (10–49, 50–249 and 250 or more persons employed). The breakdown by economic activity comes from isoc_eb_iipn2.

The cloud computing indicator used here counts all enterprises buying cloud computing services. The indicator monitored under the Digital Decade policy programme is narrower and counts only enterprises buying sophisticated or intermediate cloud services. On the narrower definition the 2025 values are 46.7%

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for the European Union and 22.1% for Romania (European Commission, 2026a, 2026b). On the definition used in this paper they are 52.7% and 24.9%.

Four context variables are used: nominal labour productivity per hour worked, expressed relative to the European Union average (nama_10_lp_ulc); gross domestic product per capita in purchasing power standards (nama_10_pc); the share of individuals with at least basic overall digital skills (isoc_sk_dskl_i21); and the share of enterprises employing information and communication technology specialists, for which the latest year available is 2024 (isoc_ske_itspen2). All data were extracted from the Eurostat database on 10 October to 12 November 2026 (Eurostat, 2026a, 2026b, 2026c, 2026d, 2026e, 2026f, 2026g, 2026h, 2026i). The target population, the statistical unit and the size classes are described in the compiler's manual of the 2024 survey (Eurostat, 2025).

Three indicators have a time series: ERP (2019, 2021, 2023, 2025), cloud computing (2020, 2021, 2023, 2025) and AI (2021, 2023, 2024, 2025). The CRM indicator was redefined in 2023, so its earlier values are not comparable. BI and data analytics are available only for 2023 and 2025. For this reason, the evolution over time is analysed only for ERP, cloud computing and AI.

3.2 Methods

The analysis has five steps. In the first, descriptive statistics are computed for each indicator across the 27 Member States, together with Romania's value, its rank and its gap to the European Union aggregate. In the second, convergence is assessed for the three indicators with a time series. Sigma convergence is measured by the change in the coefficient of variation, and beta convergence by a regression of the average annual growth rate (in logarithms) on the logarithm of the initial level.

The third step builds a composite integration index as the unweighted mean of the standardised values (z-scores) of the six indicators. Its internal consistency is checked with Cronbach's alpha and its dimensionality with a principal component analysis. In the fourth step, Member States are grouped by hierarchical cluster analysis (Ward's method, Euclidean distance on z-scores). The number of clusters is assessed with the silhouette coefficient, the solution is cross-checked with k-means clustering, and differences between clusters are tested with the Kruskal–Wallis test.

In the fifth step, Pearson correlation coefficients are computed between the indicators, the composite index and the context variables, and partial correlations control for gross domestic product per capita. In Ireland and Luxembourg, productivity and income figures are strongly influenced by the activity of multinational groups and by cross-border workers, so all correlations are also reported without these two countries.

The data were extracted from the Eurostat database and prepared for analysis, including the computation of the composite index. The statistical analysis and the figures were produced in JASP 0.99 (JASP Team,

2026); the correlation matrix and the cluster solution are reproduced as JASP output in Table 4 and in the Appendix.

3.3 Limitations of the data

The data have several limitations. Eurostat flags breaks in series for Czechia, France and Sweden in 2019 (ERP), for France and Sweden in 2023 (ERP, cloud computing and AI), for Sweden in 2025 (ERP), for the Netherlands in 2025 (AI) and for Czechia in 2025 (data analytics). The Swedish ERP value for 2025 (28.1%) is unusually low for that country and affects its position. Productivity and income data for 2025 are provisional. Labour productivity refers to the whole economy, not only to the enterprises covered by the survey. With 27 observations, the correlations describe associations between countries and cannot support causal claims.

4. RESULTS AND DISCUSSION

4.1 Differences between Member States and Romania's position

Adoption differs widely across Member States for all six indicators (Table 1). Cloud computing and ERP are the most widespread, at 52.7% and 46.5% of enterprises in the European Union. BI and AI are the least widespread, at 16.3% and 19.9%. Dispersion is highest for BI and AI, where the coefficients of variation are about 50%, and lowest for data analytics (22.1%). The maximum for every indicator belongs to Denmark or Finland. Bulgaria has the minimum for three of the six.

TABLE 1. ADOPTION OF THE SIX TECHNOLOGIES IN THE EU-27, ENTERPRISES WITH 10 OR MORE PERSONS EMPLOYED, 2025 (% OF ENTERPRISES)

Indicator	EU-27	Mean	SD	CV (%)	Minimum	Maximum	Romania	Rank of Romania
ERP	46.5	42.7	12.2	28.6	21.9 (HR)	66.2 (DK)	29.3	23
CRM	28.5	29.0	11.1	38.3	11.9 (BG)	55.8 (FI)	13.9	26
BI	16.3	19.4	9.9	51.1	6.8 (BG)	43.4 (FI)	8.2	26
Cloud computing	52.7	52.5	16.3	31.0	17.8 (BG)	79.2 (FI)	24.9	25
Artificial intelligence	19.9	20.7	10.3	49.5	5.2 (RO)	42.0 (DK)	5.2	27
Data analytics	39.9	41.2	9.1	22.1	24.5 (PL)	60.0 (DK)	35.1	22

Note: mean, standard deviation (SD) and coefficient of variation (CV) are computed across the 27 Member States.
Source: Author's own calculations based on Eurostat data

Romania is below the European Union aggregate on every indicator. It ranks 23rd for ERP (29.3%), 26th for CRM (13.9%) and for BI (8.2%), and 25th for cloud computing (24.9%). For AI it is last, with 5.2% of enterprises compared with 19.9% in the European Union. Only for data analytics is Romania close to the aggregate (35.1% compared with 39.9%, rank 22). Figure 1 places Romania within the distribution of the other Member States.

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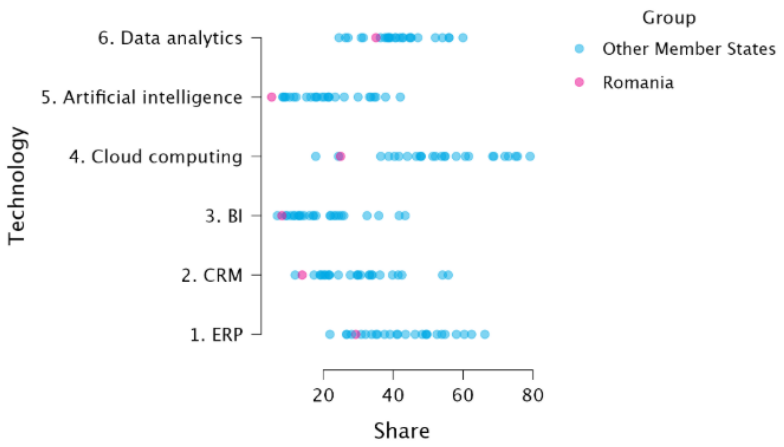


FIGURE 1. ROMANIA WITHIN THE DISTRIBUTION OF MEMBER STATES, 2025
Note: each point is a Member State; Share = % of enterprises.
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

4.2 Evolution over time and convergence

Table 2 and Figure 2 follow the three indicators that have a time series. Adoption increased in the European Union and in Romania alike, yet Romania's gap in percentage points widened in all three cases. For ERP it went from 12.4 to 17.2 points between 2019 and 2025. For cloud computing it went from 20.4 to 27.8 points between 2020 and 2025, and for AI from 6.3 to 14.7 points between 2021 and 2025. The ERP gap has narrowed since 2021, when it reached its maximum of 21.1 points. In relative terms the picture is different. Romania's position improved for cloud computing (from 43.6% to 47.3% of the European Union level) and for AI (from 18.0% to 26.1%). For ERP it is slightly below the 2019 ratio (63.0% against 65.4%). Romania ranked last for AI in each of the four years.

TABLE 2. EVOLUTION OF ERP, CLOUD COMPUTING AND AI ADOPTION: EU-27 AND ROMANIA (% OF ENTERPRISES)

Indicator	Year	EU-27	Romania	Gap (pp)	Romania as % of EU-27	Rank of Romania	CV across countries (%)
ERP	2019	35.9	23.5	-12.4	65.4	25	26.5
ERP	2021	37.9	16.8	-21.1	44.3	27	28.4
ERP	2023	43.4	22.6	-20.8	52.1	26	28.8
ERP	2025	46.5	29.3	-17.2	63.0	23	28.6
Cloud computing	2020	36.1	15.7	-20.4	43.6	26	45.6
Cloud computing	2021	41.0	14.1	-26.8	34.5	26	40.5
Cloud computing	2023	45.3	18.4	-26.9	40.6	26	35.2
Cloud computing	2025	52.7	24.9	-27.8	47.3	25	31.0
Artificial intelligence	2021	7.7	1.4	-6.3	18.0	27	65.3
Artificial intelligence	2023	8.1	1.5	-6.6	18.7	27	50.7
Artificial intelligence	2024	13.5	3.1	-10.4	22.8	27	50.3
Artificial intelligence	2025	19.9	5.2	-14.7	26.1	27	49.5

Source: Author's own calculations based on Eurostat data.

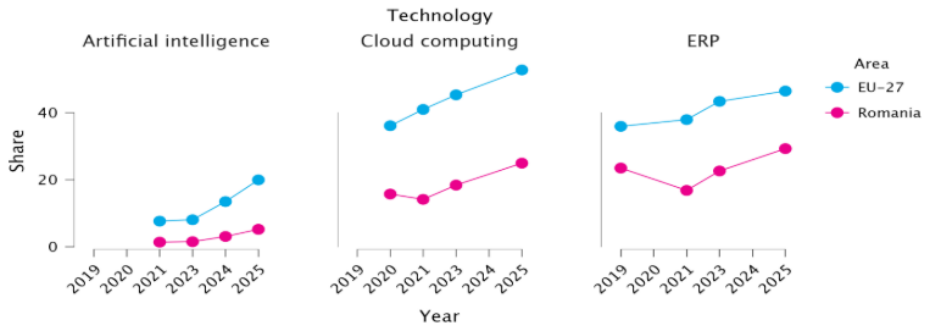


FIGURE 2. ERP, CLOUD COMPUTING AND AI ADOPTION OVER TIME: EU-27 AND ROMANIA
Note: Share = % of enterprises.
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

For the European Union as a whole, the evidence on convergence is mixed. The coefficient of variation fell markedly for cloud computing (from 45.6% to 31.0%) and for AI (from 65.3% to 49.5%). It did not fall for ERP (26.5% in 2019 and 28.6% in 2025). The beta-convergence regressions point the same way. The coefficient of the initial level is negative and significant for cloud computing ($\beta = -0.06$, $p < 0.01$, $R^2 = 0.49$) and for AI ($\beta = -0.08$, $p < 0.01$, $R^2 = 0.36$), and only marginally significant for ERP ($\beta = -0.05$, $p = 0.06$, $R^2 = 0.13$). Countries that started from lower levels therefore grew faster in relative terms. In absolute terms the spread in AI adoption widened. The standard deviation doubled from 5.0 to 10.3 percentage points, and the countries with higher initial levels gained more percentage points.

4.3 A composite index of integration

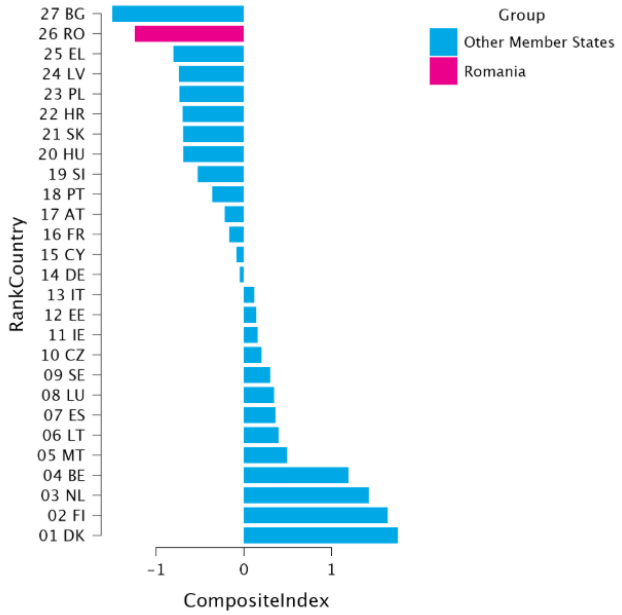


FIGURE 3. COMPOSITE INTEGRATION INDEX BY MEMBER STATE, 2025
Note: Member States are ordered by rank on the composite index (01 = highest).
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

The six indicators are positively correlated with one another. The coefficients range from 0.30 (ERP and cloud computing) to 0.88 (CRM and BI). The indicators form an internally consistent scale (Cronbach's alpha = 0.90). The first principal component explains 68.3% of the total variance, and all six indicators load strongly on it (loadings between 0.70 and 0.95). The composite index, computed as the mean of the z-scores, is almost perfectly correlated with the first principal component (r = 0.999). This supports the use of the simpler, unweighted index.

Figure 3 ranks the Member States by the composite index. Denmark (1.76), Finland (1.64), the Netherlands (1.42) and Belgium (1.19) are well ahead of the rest. Romania (−1.24) is 26th, ahead only of Bulgaria (−1.50).

4.4 Groups of Member States

The silhouette coefficient is highest for a two-cluster solution (0.44). This solution separates Belgium, Denmark, the Netherlands and Finland from the other 23 Member States, and Ward's method and k-means produce identical groups. The three-cluster solution has a weaker structure (silhouette of 0.27 for Ward's method; 85% agreement with k-means). It is more informative, though, because it also isolates a low-adoption group. Table 3 presents it, and it should be read as descriptive.

TABLE 3. PROFILES OF THE THREE CLUSTERS (WARD'S METHOD), CLUSTER MEANS, 2025

Cluster	n	Member States	ERP	CRM	BI	Cloud	AI	Data analytics	Composite index
1	4	BE, DK, NL, FI	59.8	48.5	38.4	69.5	36.9	53.3	1.50
2	17	CZ, DE, EE, IE, EL, ES, FR, IT, CY, LT, LU, MT, AT, PL, PT, SI, SE	44.0	28.7	18.0	54.2	20.2	39.9	-0.03
3	6	BG, HR, LV, HU, RO, SK	27.9	17.0	10.5	36.3	11.6	36.6	-0.93

Note: indicators in % of enterprises; composite index in z-score units.

Source: Author's own calculations based on Eurostat data

The low-adoption cluster consists of Bulgaria, Croatia, Latvia, Hungary, Romania and Slovakia. Compared with the leading cluster, its mean adoption is roughly half for ERP (27.9% against 59.8%) and for cloud computing (36.3% against 69.5%), and less than a third for BI and AI. The context of the three clusters differs as well. From the leading to the low-adoption cluster, mean labour productivity per hour is 124.8, 99.8 and 70.0 (European Union = 100), and the mean share of individuals with at least basic digital skills is 76.8%, 61.6% and 48.8%. For the two-cluster solution, the Kruskal–Wallis test indicates significant differences ($p < 0.05$) for all six indicators, labour productivity, income per capita and digital skills.

Poland and Greece have composite scores close to those of the low-adoption cluster (−0.73 and −0.81). They are assigned to the intermediate group because of their profile, since both have comparatively high ERP adoption (39.1% and 54.8%).

4.5 Integration, productivity, income and digital skills

Table 4 reports the correlations between the indicators and the context variables. The composite index is most closely associated with the digital skills of the population (r = 0.80). The association remains strong after controlling for gross domestic product per capita (partial r = 0.75, p < 0.001; 0.63, p < 0.001, without Ireland and Luxembourg). With labour productivity per hour the association is moderate (r = 0.53), and it becomes stronger when Ireland is excluded (r = 0.64). With income per capita it is weak for the full sample (r = 0.42) and strong once Ireland and Luxembourg are excluded (r = 0.78). This result is therefore very sensitive to the two outliers.

TABLE 4. PEARSON CORRELATIONS BETWEEN ADOPTION INDICATORS, THE COMPOSITE INDEX AND CONTEXT VARIABLES, 2025 (JASP OUTPUT)

Pearson's Correlations ▼

Variable		ERP	CRM	BI	Cloud	AI	DataAnalytics	DigitalSkills	ICTSpecialists2024	ProductivityHour	GDPpc	CompositeIndex
1. ERP	Pearson's r	—										
	p-value	—										
2. CRM	Pearson's r	0.6664***	—									
	p-value	< .001	—									
3. BI	Pearson's r	0.6042***	0.8842***	—								
	p-value	< .001	< .001	—								
4. Cloud	Pearson's r	0.2998	0.6813***	0.7161***	—							
	p-value	.129	< .001	< .001	—							
5. AI	Pearson's r	0.4713*	0.7646***	0.8061***	0.6406***	—						
	p-value	.013	< .001	< .001	< .001	—						
6. DataAnalytics	Pearson's r	0.4711*	0.5180**	0.6626***	0.4696*	0.4849*	—					
	p-value	.013	.006	< .001	.013	.010	—					
7. DigitalSkills	Pearson's r	0.4574*	0.7818***	0.7402***	0.7106***	0.7127***	0.5220**	—				
	p-value	.016	< .001	< .001	< .001	< .001	.005	—				
8. ICTSpecialists2024	Pearson's r	0.3329	0.6234***	0.6019***	0.5290**	0.4023*	0.2227	0.5583**	—			
	p-value	.090	< .001	< .001	.005	.038	.264	.002	—			
9. ProductivityHour	Pearson's r	0.2955	0.4757*	0.5294**	0.4706*	0.6194***	0.2199	0.6223***	0.3873*	—		
	p-value	.134	.012	.005	.013	< .001	.270	< .001	.046	—		
10. GDPpc	Pearson's r	0.2081	0.3920*	0.4400*	0.3930*	0.4959**	0.1228	0.5115**	0.4001*	0.9141***	—	
	p-value	.298	.043	.022	.043	.009	.542	.006	.039	< .001	—	
11. CompositeIndex	Pearson's r	0.7129***	0.9162***	0.9484***	0.7727***	0.8458***	0.7318***	0.7965***	0.5504**	0.5298**	0.4164*	—
	p-value	< .001	< .001	< .001	< .001	< .001	< .001	< .001	.003	.004	.031	—

* p < .05, ** p < .01, *** p < .001

Note: n = 27. * p < 0.05; ** p < 0.01; *** p < 0.001. Variable names as in the data file: DigitalSkills = individuals with at least basic digital skills; ICTSpecialists2024 = enterprises employing ICT specialists, 2024; ProductivityHour = labour productivity per hour worked; GDPpc = gross domestic product per capita.

Source: screenshot of JASP 0.99, author's own analysis of Eurostat data.

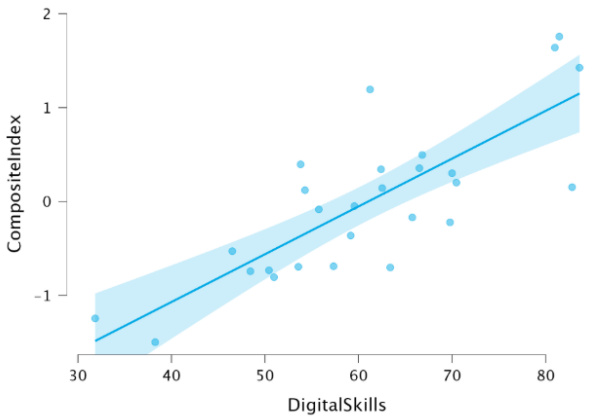


FIGURE 4. COMPOSITE INTEGRATION INDEX AND DIGITAL SKILLS OF THE POPULATION, 2025

Note: each point is a Member State; DigitalSkills = % of individuals with at least basic digital skills; the line is the linear fit, with its confidence band.

Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

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Among the individual technologies, AI and BI show the strongest association with productivity. ERP and data analytics show the weakest, and the correlation between ERP adoption and productivity is not significant for the full sample (r = 0.30). Figures 4 and 5 show the two main relationships. Romania has the lowest level of digital skills in the European Union (31.8%, against 60.4%) and the second-lowest composite index. Its productivity (76.1% of the European Union average) is higher than its level of integration would suggest.

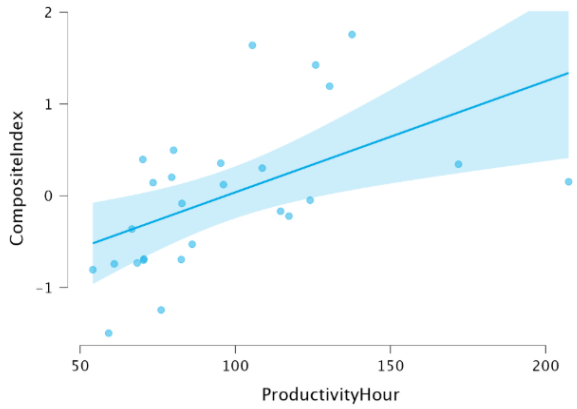


FIGURE 5. COMPOSITE INTEGRATION INDEX AND LABOUR PRODUCTIVITY PER HOUR WORKED, 2025
Note: each point is a Member State; ProductivityHour = labour productivity per hour worked (EU-27 = 100); the line is the linear fit, with its confidence band.
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

4.6 Romania by enterprise size and economic activity

TABLE 5. ADOPTION BY ENTERPRISE SIZE CLASS: EU-27 AND ROMANIA, 2025 (% OF ENTERPRISES)

Indicator	Persons employed	EU-27	Romania	Gap (pp)	Rank of Romania	Countries with data
ERP	10–49	41.1	25.6	-15.4	22	27
ERP	50–249	69.9	41.0	-28.9	26	26
ERP	250+	88.7	67.6	-21.1	27	27
CRM	10–49	24.7	12.0	-12.7	26	27
CRM	50–249	43.8	19.7	-24.1	25	26
CRM	250+	65.4	37.6	-27.8	26	27
BI	10–49	11.4	6.0	-5.4	25	27
BI	50–249	34.3	13.9	-20.4	25	26
BI	250+	69.2	35.8	-33.5	27	27
Cloud computing	10–49	49.3	23.1	-26.2	25	27
Cloud computing	50–249	66.8	30.1	-36.6	25	26
Cloud computing	250+	84.7	48.2	-36.5	27	27
Artificial intelligence	10–49	17.0	4.1	-12.9	27	27
Artificial intelligence	50–249	30.4	7.8	-22.6	27	27
Artificial intelligence	250+	55.0	20.8	-34.3	27	27
Data analytics	10–49	35.1	32.0	-3.1	21	27
Data analytics	50–249	59.8	45.5	-14.3	23	26
Data analytics	250+	82.0	66.0	-16.0	26	27

Source: Author's own calculations based on Eurostat data.

Table 5 and Figure 6 compare Romania with the European Union by size class. The gap is present in every class. In percentage points it is larger for medium-sized and large enterprises than for small ones. Among the 27 Member States, large Romanian enterprises rank last for ERP (67.6% against 88.7%), BI (35.8% against 69.2%), cloud computing (48.2% against 84.7%) and AI (20.8% against 55.0%). For AI, Romania is last in all three size classes. The distance between large and small enterprises is also wider in Romania than in the European Union for AI. Large Romanian enterprises use AI 5.0 times more often than small ones, while in the European Union the ratio is 3.2.

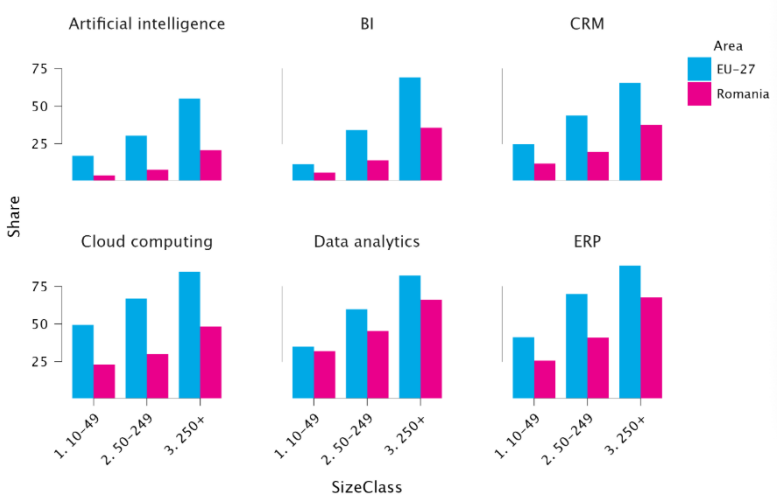


FIGURE 6. ADOPTION BY ENTERPRISE SIZE CLASS: EU-27 AND ROMANIA, 2025
Note: Share = % of enterprises; size classes by number of persons employed.
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

By economic activity (Figure 7), the gap in ERP adoption is largest in manufacturing (29.1% in Romania and 57.6% in the European Union), wholesale trade (41.9% and 67.7%) and energy, water and waste (30.8% and 55.0%). It is smallest in accommodation and food services (23.9% and 26.7%) and in information and communication (51.1% and 61.3%).



FIGURE 7. ERP ADOPTION BY ECONOMIC ACTIVITY: EU-27 AND ROMANIA, 2025
Note: ERP = % of enterprises using ERP software.
Source: output of JASP 0.99 (Plot Builder), author's own processing of Eurostat data

4.7 Discussion in relation to previous studies

Earlier studies documented Romania's position up to 2021, and the present results extend it to 2025. Brodny and Tutak (2021b) placed Romania in the group with the lowest level of digitalisation on data for 2018. Among Central and Eastern European countries, the lowest results were those of Bulgaria and Romania (Brodny & Tutak, 2021a). On the six indicators used here Romania ranks 26th. The values for artificial intelligence and data analytics in Romania coincide with those in the Commission's country report for 2025, which draws on the same Eurostat source (European Commission, 2026a). The position has therefore held across years and across indices, and it has not improved during the period in which artificial intelligence spread.

The grouping of countries is also close to earlier ones. All four leaders identified here belong to the highest group of Brodny and Tutak (2021b). Five of the six countries of the low-adoption group belong to the lowest class of their ranking. The sixth, Slovakia, is in their medium-low class, although their cluster analysis groups it with the low-level countries. Croatia is the exception. It is among the Central and Eastern European countries with the highest results in Brodny and Tutak (2021a) and belongs to a group with higher digital skills in Tran et al. (2023). Here it falls in the low-adoption cluster, with the lowest share of enterprises using enterprise resource planning in the Union. Its classification depends on which technologies are counted, which is consistent with the weak separation of the three-cluster solution.

Romania's gap is present in every size class and in every economic activity examined. This agrees with the firm-level evidence of Holl and Rama (2024), in which the coefficient for Romania remains negative and significant for any digital technology and for cloud computing after controls for size and sector. The lag therefore cannot be attributed to the structure of the Romanian business population. Large Romanian enterprises rank last in the Union on four of the six indicators, something that surveys of small and medium-sized enterprises cannot show.

The strong association between integration and the digital skills of the population is in line with Bánhidi et al. (2020). The firm-level result of Segarra-Blasco et al. (2025) points in the same direction, although their country-level skills factor is broader than the indicator used here. Income matters as well. Without Ireland and Luxembourg, gross domestic product per capita is almost as closely correlated with integration as skills are. Skills, however, remain associated with integration after income is controlled for, both in the full sample and without the two outliers. Karamujic (2026) points to a different factor, the quality of governance, and the present data cannot separate the role of skills from that of governance. The correlations of artificial intelligence with cloud computing, business intelligence and customer relationship management indicate complementarity between technologies. Calvino and Fontanelli (2026) provide a partial firm-level counterpart, for cloud services and enterprise systems.

The moderate correlation with labour productivity should be read with caution. At firm level, the productivity gains from digital technologies are real but temporary (Bettiol et al., 2024). Studies of artificial intelligence patenting find that the association with productivity differs by type of artificial intelligence and of firm (Kopka & Fornahl, 2024). On convergence, the results reconcile two readings of the same data. The Commission notes that adoption grows faster in Romania than in the Union in relative terms (European Commission, 2026a). The gap in percentage points keeps widening all the same, because the Union starts from a much higher level.

5. CONCLUSIONS

This paper compared the integration of management information systems and artificial intelligence in the enterprises of the 27 Member States, on Eurostat data for 2019 to 2025. On RQ1, differences between Member States are large for all six technologies, and largest for business intelligence and artificial intelligence. Romania ranks 26th on the composite index and last for artificial intelligence in every year observed. On RQ2, relative differences between Member States narrowed for cloud computing and artificial intelligence but not for enterprise resource planning, while Romania's gap to the Union aggregate, measured in percentage points, widened for all three technologies. On RQ3, four countries form a clearly separate leading group. A low-adoption group of six Central and Eastern European countries, Romania among them, can also be identified, with a weaker statistical separation. On RQ4, integration is associated most closely with the digital skills of the population, also after controlling for income per capita. Its association with labour productivity is moderate and sensitive to outliers.

The paper brings together, for the most recent year available, the enterprise systems that integrate internal processes and the technologies monitored under the Digital Decade. Earlier studies documented Romania's lag up to 2021. The results here show that it has persisted, and has widened in absolute terms, during the diffusion of artificial intelligence. They also show that the lag holds in every size class, large enterprises included, and in every economic activity examined.

For managers, the country-level correlations suggest that artificial intelligence spreads where cloud services and enterprise software are already in use. Less than a third of Romanian enterprises use enterprise resource planning and a quarter buy cloud services, so this base has to be built before artificial intelligence can spread. For public policy, two results matter: integration is closely associated with digital skills even after income is controlled for, and the gap is present among large enterprises too. Support measures directed only at small firms, or only at the purchase of technology, are therefore unlikely to be sufficient.

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The limitations of the study are those of its data. The observations are at country level, several series have breaks and the number of cases is small, so the results show associations and do not support causal conclusions. Further research should use firm-level data to test whether the order of adoption suggested by the correlations holds within Romanian enterprises. It should also examine the role of governance quality alongside skills.

DECLARATION OF COMPETING INTEREST

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author used ChatGPT (OpenAI) and Gemini (Google) for text formatting, language refinement, and rephrasing to improve clarity and readability. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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APPENDIX. OUTPUT OF THE ANALYSES IN JASP

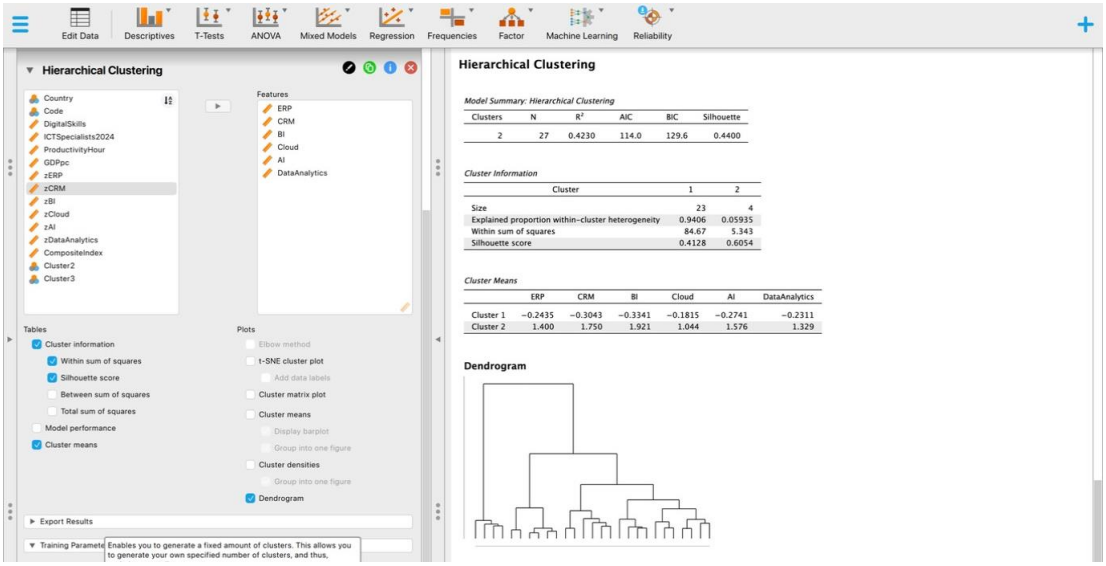


FIGURE A1. HIERARCHICAL CLUSTERING, TWO-CLUSTER SOLUTION, WARD.D2 LINKAGE (JASP OUTPUT)
Source: screenshot of JASP 0.99, author's own analysis of Eurostat data