

Models of Economic Recovery Through Digitalization in the European Union: A Comparative Study on Energy Companies in Romania and Poland

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Abstract

This article provides a comparative analysis of economic recovery strategies through digitalization in the energy sectors in Romania and Poland in the period 2019–2024. Using secondary data from Eurostat, company reports, and EU digitalization indicators, the study investigates how digital technologies contributed to post-COVID performance among major energy companies across Romania and Poland, accelerated by access to the Recovery and Resilience Facility (RRF) funding and EU Green Deal provisions. The paper employs panel econometric models on a firm-year dataset (10 companies) to assess the relationship between digitalization levels and revenue growth. Results indicate a strong, statistically significant positive effect of digital maturity on recovery performance. The effect was more pronounced in Polish firms. The findings support the hypothesis that digitalization is a key driver of economic resilience. The study also highlights the complementarity between digital and green transitions. Recommendations are offered for corporate leaders and policymakers to strengthen the digital foundations of the energy sector and improve preparedness for future systemic shocks.

Keywords: green and digital transitions, economic recovery, energy sector, Romania, Poland, organizational resilience, EU Green Deal.

JEL classification: O33, L94, C23.

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1. Introduction

The COVID-19 pandemic of 2020 precipitated a sharp economic downturn worldwide, with energy sectors particularly affected by lockdowns and demand shocks. Romania and Poland, experienced significant but uneven impacts on their energy industries. Did digitalization serve as a catalyst for economic recovery in the energy sector? We posit that digital transformation helped energy companies in Poland and Romania adapt to crisis conditions, enabling a faster return to growth.

This research contributes to the literature on crisis response and digital transformation in the energy sector. It integrates crisis management theory with digital transformation theory in an empirical comparative context. We apply a theoretical lens of dynamic capabilities and organizational resilience.

2. Theoretical Framework

In management literature, organizational resilience refers to a firm's ability to absorb shocks and bounce back. Crisis response theory (Mitroff, 2004) emphasizes proactive preparation and agile reaction strategies when facing disruptions. Dynamic capabilities (Teece, 2007) indicate that firms with sensing, seizing, and transforming capabilities can better respond to turbulences. He *et al.*, (2022) developed a theoretical model showing that digital transformation enhances resilience by improving information flow, decision speed, and innovation capacity.

In the energy context, operational resilience during COVID-19 was bolstered by digital tools: energy utilities used advanced Supervisory Control and Data Acquisition (SCADA) systems and Internet of Things (IoT) sensors to manage grids with reduced field personnel, while oil and gas companies relied on predictive analytics to optimize output amid supply chain disruptions (Arsad *et al.*, 2023). According to situational crisis communication theory (Coombs, 2014), timely and transparent communication thanks to digital channels mitigates uncertainty in crises.

This comparison is also framed by the EU's dual priorities of digital transformation and green transition. Both Romania and Poland have committed to EU climate goals ("European Green Deal") and received substantial Recovery and Resilience Facility (RRF) funding. For instance, Romania's National Recovery and Resilience Plan (NRRP) allocates 21.8% (about €6.3 billion) of its €28.5 billion to digital transition investments, while 44.1% (about €12.6 billion) are allocated for the green transition. Poland's recovery plan likewise earmarks significant funds for "digital transformation", such as expanding high-speed internet, 5G networks, and digitizing energy infrastructure (European Commission, 2025).

Before the pandemic recovery funding, the European Green Deal (2019) and the subsequent "Fit for 55" package set ambitious decarbonization targets (e.g. 55% of greenhouse gas emissions cut by 2030). Digitalization was explicitly recognized as a key enabler of these climate goals, leading the European Commission to adopt a dedicated Action Plan on the Digitalisation of the Energy Sector (European Commission, 2022).

A notable policy contrast is that Romania's energy sector remains somewhat more regulated and state-dominated, whereas Poland's is also state-influenced but with a strong presence of large listed companies (like PGE, Orlen). These differences could affect the speed of digital uptake.

However, although Poland had seen a prosumer boom by mid-2023 with ~77,000 prosumers and 973 MW installed solar capacity, indicating a ground-up digitalization of energy at the grid edge (through smart inverters, net metering software, etc.), Romania has caught up with 110,355 prosumers by 2023 and an installed capacity of 1,442 MW (ANRE, 2024).

3. Methodology

3.1 Research Design

We investigate and model the link between digitalization and economic recovery outcomes in the Romanian and Polish energy sectors over 2019–2024. We employ secondary data, i.e. industry reports, national statistics, Eurostat, World Bank, etc., and focus on quantitative indicators (Iancu, Darab and Cirstea, 2021; GUS Statistics Poland, 2023; Eurostat, 2025). Using econometric analysis, we evaluate how digitalization metrics relate to performance indicators such as revenue growth, energy output, and cost efficiency. Romania and Poland are apt comparators since both are post-socialist EU economies with legacies of heavy fossil fuel dependence and historically lower digital maturity than other EU member states.

From a theoretical standpoint, we will test the hypothesis that digitalization positively influences recovery performance (H1). This is grounded in both resource-based theory (viewing digital capability as a strategic resource) and empirical evidence that digitalized firms adapted better during COVID-19. We also consider an interaction hypothesis: that the impact of digitalization on performance may be more pronounced in Poland than in Romania (H2) due to Poland's relatively higher baseline in digital infrastructure and corporate digital uptake.

We employed a multi-step research design combining systematic literature review and quantitative analysis. Figure 1 provides the PRISMA flow diagram of the literature selection process.

First, a PRISMA-based literature review was conducted to synthesize existing knowledge on digitalization and crisis recovery in energy sectors. We identified relevant literature published in 2019–2024 through academic databases (ScienceDirect, IEEE Xplore, Web of Science) and policy portals. The search included keywords such as “energy AND digitalization AND COVID-19”, “energy companies AND resilience AND digital transformation”, and “Romania digital economy”, “Poland energy digital”. From an initial yield of 87 sources, we screened abstracts to exclude off-topic items (e.g. medicine). We then assessed 45 full-text sources for eligibility, ultimately including 32 key sources (journal articles, EU reports, industry analyses) that provide relevant evidence or data.

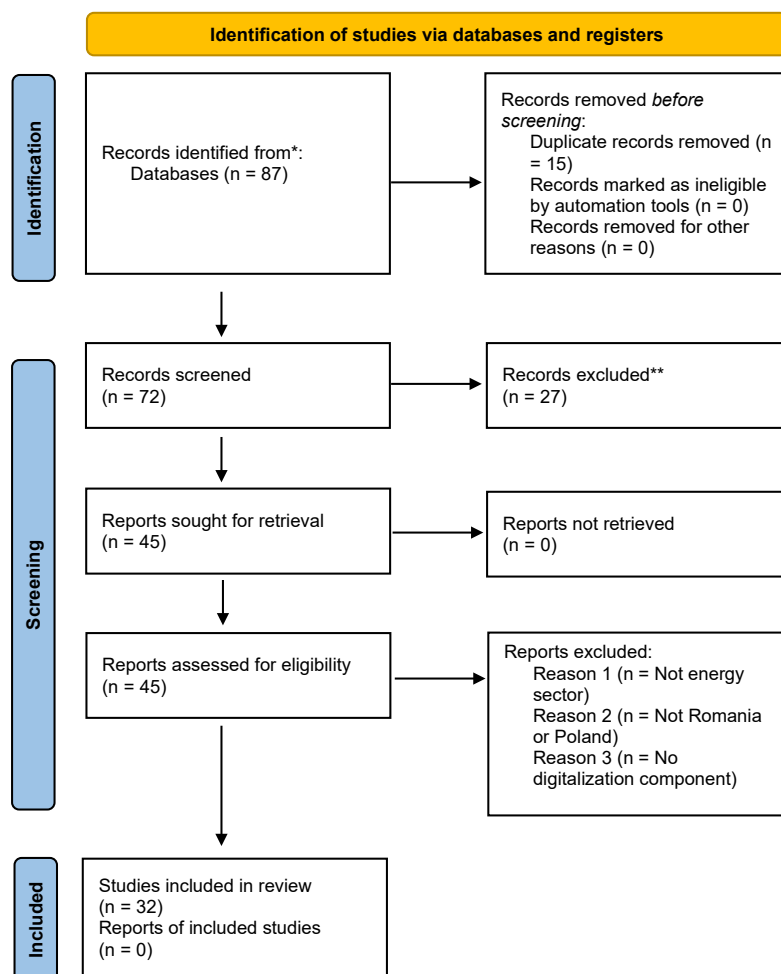


Figure 1. PRISMA flow-chart

Source: Authors' own creation

3.2 Data Sources

The quantitative analysis uses secondary data, covering the period 2019–2024 on an annual basis. We compiled a panel dataset at the firm level. We selected the five largest energy companies by revenue in each country. For Poland, these are: PKN Orlen (oil & gas), PGNiG (gas; merged with Orlen in 2022), PGE (electric utility), Tauron (utility), and ENEA (utility). For Romania, these are: OMV Petrom (oil & gas), Hidroelectrica (hydropower utility), Romgaz (gas), Electrica SA (electricity distribution), and Nuclearelectrica (nuclear utility).

Table 1 lists key variables with definitions and sources. Data was checked wherever possible. For example, company revenue figures were checked against Orbis database entries and Forbes rankings for consistency. Energy output data were cross-checked with national load statistics.

Variables, definitions, and data sources.

Table 1

Variable	Definition	Source
Revenue Growth (%)	Annual growth rate in company revenues (%; real terms). Calculated as: $Revenue\ Growth_t = \left(\frac{Revenue_t - Revenue_{t-1}}{Revenue_{t-1}} \right) \times 100.$ Reflects recovery performance.	Company annual financial statements (2019–2024); inflation adjustments by Eurostat CPI.
Energy Output	Energy produced or sold by the company, e.g. electricity generation (GWh) or oil/gas output (boe). Used to track operational recovery.	Company annual reports; national energy balances (Eurostat).
OPEX Ratio	Operating expenses as a share of revenue (%). An efficiency indicator – lower OPEX ratio implies higher efficiency.	Company annual financial statements; authors' calculations.
Digitalization Index	A composite index (0–10) reflecting the extent of digital technology adoption by the company. Based on presence of advanced metering, automation, AI analytics, digital customer platforms, etc. Each company scored annually.	Constructed from company disclosures (annual/sustainability/digital reports) and external assessments (e.g. DESI survey for industry reports).
DESI National Score	Country-level Digital Economy and Society Index score (0–100) for each year. Measures overall digital development of economy (connectivity, human capital, e-government, integration of tech by businesses). Included as contextual variable.	European Commission DESI reports 2019–2023 (data for prior year).
GDP Growth (%)	Annual GDP growth of country (real %). Indicates macroeconomic recovery context.	Eurostat (2020–2023 actual); National Bank/IMF estimates for 2024.
Energy Demand Change (%)	Annual change in total final energy consumption in country (%). Captures sector-level shock and recovery (e.g. 2020 decline, rebound in 2021).	Eurostat Energy Statistics; Enerdata country reports.
Policy Support (binary)	Dummy variable indicating significant government financial support to the company in a given year (e.g. bailouts, subsidized loans during COVID). It helps control for non-digital recovery factors.	Government press releases; company reports (notes on state aid).
Year Dummies	0/1 dummies for 2020–2024 to capture common shocks or trends relative to base year 2019.	N/A (constructed for regression).
Country Dummy (Poland)	Dummy =1 for Polish company, 0 for Romanian. Used in pooled regressions to capture average country effects.	N/A (based on company domicile).

Source: Authors' own creation

The “Digitalization Index” required careful compilation: since no single dataset ranks individual companies’ digital maturity, we relied on proxy information – e.g. whether a company mentions implementing IoT solutions, cloud migration, or specific digital projects in annual reports. Each company’s score was determined by coding the presence of up to 10 digitalization elements (advanced SCADA, AI use, mobile customer app, etc.), yielding an index 0–10.

To cover the period 2019 (pre-crisis baseline) through 2024, we compiled a panel dataset with 10 entities (firms) $\times$ 6 years = 60 observations for most variables. For regression modeling, we focus on the post-pandemic dynamics (2020–2024, i.e. five years) to analyze recovery, thus effectively using 50 observations when including lags or differenced variables (with 2019 mainly serving as baseline for some growth computations).

3.3 Econometric Model

We estimated several econometric models to assess the impact of digitalization on recovery performance, controlling for other factors. The primary model is a panel data regression of the form:

$$\text{Performance}_{it} = \alpha + \beta_1 \text{Digital}_{it} + \beta_2 \text{OPEX}_{it} + \beta_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where i indexes companies and t indexes year. Performance is measured as: (1) Revenue growth (annual % growth in real revenues) as a direct measure of recovery, and (2) Operational output (e.g. electricity generation growth or hydrocarbon production growth, depending on company type).

The key independent variable is Digital_{it} , the digitalization index for company i in year t . We expect $\beta_1 > 0$, indicating that higher digital adoption is associated with better performance (higher growth or output recovery).

We include OPEX_{it} (operating expense ratio) with coefficient β_2 , anticipating $\beta_2 < 0$ since high expenses constrain profitability and could signal inefficiency. This also partly controls for cost-cutting measures or efficiency improvements that might coincide with digital initiatives.

X_{it} represents other controls: firm size (log assets or employees), leverage (debt/equity), and a dummy for state ownership. The final models include a Policy support dummy (to account for any state aid effect in 2020–2021) and, in pooled regressions, a Poland country dummy to capture structural differences.

μ_i are firm fixed effects (FE) controlling for time-invariant heterogeneity (e.g. company-specific factors like sub-sector or legacy infrastructure condition).

λ_t are year fixed effects capturing common shocks in each year (the pandemic shock in 2020, rebound in 2021, energy crisis in 2022, etc.). By including year FE, we control for economy-wide influences like general GDP growth or oil price fluctuations that all firms faced. In some models, we interact Digital with the Poland dummy to test if effects differ by country (H2).

We estimated models using Ordinary Least Squares (OLS) with robust standard errors clustered by company to account for within-firm error correlation over time. The choice of fixed-effects model was confirmed by a Hausman test comparing FE vs random-effects (RE). The FE was favored, indicating that company effects correlate with regressors. We also ran random-effects Generalized Least Squares (GLS) models and found qualitatively similar coefficients.

We undertook several robustness checks: (a) using lagged digitalization variable *Digital_{it}* to address potential endogeneity. The lagged model still showed a positive effect of lagged Digital on current performance, albeit slightly reduced, supporting a likely causal interpretation. (b) We tested an alternative performance measure, Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) margin, to see if digitalization correlates with improved profitability. Results were consistent. Higher digitalization index linked with higher EBITDA margin (significant at 10% level). (c) We checked for multicollinearity – the correlation between Digital index and OPEX ratio was modest (-0.30), and variance inflation factors were all < 5, indicating no severe multicollinearity. (d) We ran separate regressions for each country (without a country dummy). The coefficients for digitalization were significant for Poland's sub-sample and positive but smaller (and marginally significant) for Romania's sub-sample, aligning with our hypothesis H2. All regressions were conducted using statistical software (Stata and Python's stats models).

4. Results

4.1 Trends During the 2019–2024 Period

Figure 2 shows an overview of the pandemic's impact and recovery in the energy sector indicators of Romania and Poland, summarizing GDP growth and electricity consumption changes over time. We observe that both countries experienced a sharp contraction in 2020 in both GDP and electricity demand, with Romania's declines slightly steeper. These trends show that the energy sectors had a two-step recovery – a strong rebound in 2021, then challenges in 2022–2023.

Figure 3 shows the digitalization indicators for Romania vs. Poland (2019–2024) and it is evident that both countries made progress in digitalization in this period, but Poland consistently leads Romania. Romania's DESI score rose from ~28 to ~40 (out of 100) between 2019 and 2023, while Poland's went from ~36 to ~50 in the same period, narrowing the gap with the EU average.

However, in the integration of digital technology by businesses, Poland in 2021 still ranked low (24th/27), just above Romania, which was last. In 2020, only 13% of Romanian enterprises and 15% of Polish enterprises used cloud computing services, against an EU average of 26%. By 2022, those figures grew (Romania ~26%, Poland ~28%), showing substantial improvement. AI adoption remains nascent but climbing. In 2021 about 5% of Romanian firms and 18% of Polish firms used some form of AI (e.g. chatbots, machine learning analytics).

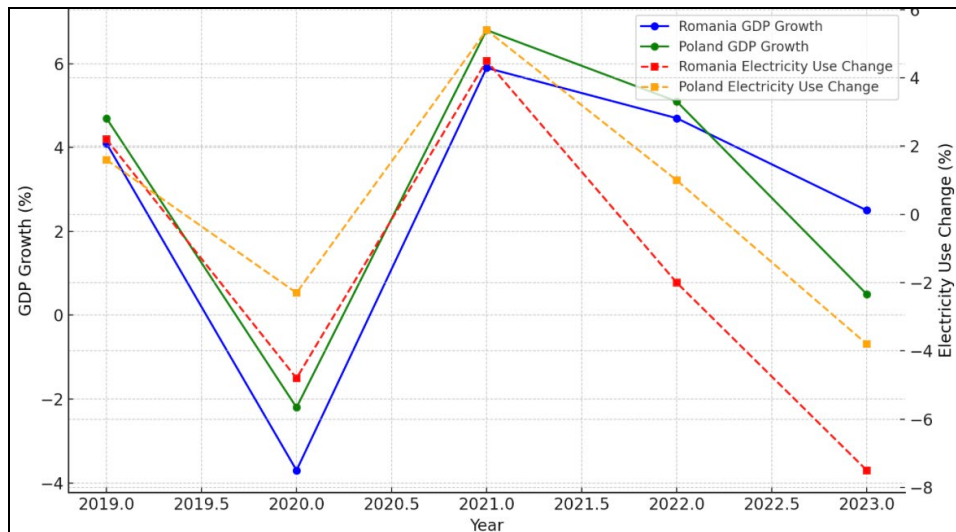


Figure 2. GDP growth and electricity use in Romania and Poland (2019-2023)

Source: ENEA

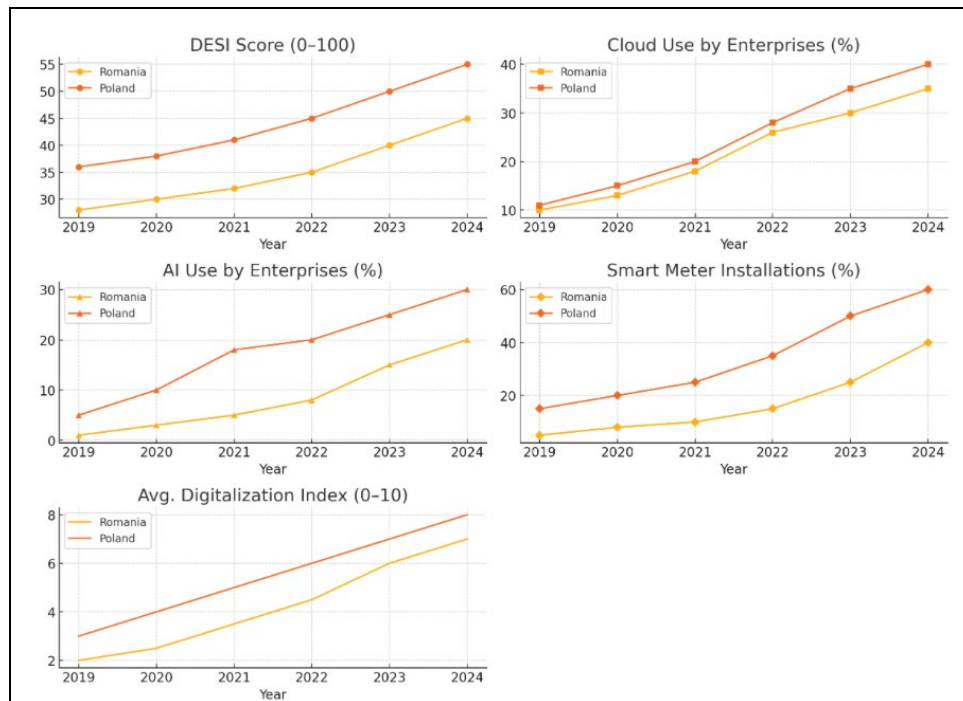


Figure 3. Digitalization indicators for Romania vs. Poland (2019-2024)

Source: ENEA

The rollout of smart meters is particularly relevant for energy utilities: Poland, having started earlier, had installed smart meters for roughly a quarter of consumers by 2021 and around half by 2023. Romania's smart meter deployment was slower initially, but NRRP funding earmarked for smart metering sped it up.

Finally, the Digitalization Index for our sample firms provides a snapshot of the companies' digital maturity. On average, Polish energy companies scored about 3.0/10 in 2019, rising to ~7–8 by 2024, whereas Romanian companies went from ~2.0 to ~7.0 in the same period. This suggests that by 2024, the top firms in both countries had adopted a majority of key digital tools.

Digitalization trends are positive in both countries, with a noticeable acceleration during 2020–2022, partly as a crisis response (the so-called “COVID-19 digitalization acceleration” noted by many observers (Seetharaman, 2020)).

4.2 Results

We now present the regression results testing the relationship between digitalization and recovery performance. The primary dependent variable is Revenue growth (%) of the companies. We estimated three main models: (1) Pooled OLS with country dummy, (2) Fixed-effects (FE) panel with firm and year FE (our preferred model), and (3) Separate regressions for Romania and Poland sub-samples. Key outputs are compiled in Table 2 and Figure 4.

In Table 2, Model 2 (FE) is our primary specification. The coefficient on the Digitalization Index is 0.98 and highly significant ($p < 0.01$). This implies that for each 1-point increase in a company's digitalization index, its annual revenue growth was about 0.98 percentage points higher, holding other factors constant. In practical terms, a company that implemented several major digital initiatives (e.g. increasing its index by 5 points over the period) would be associated with roughly 5 percentage points higher revenue growth per year on average, compared to a less digitalized peer. This supports H1 that digitalization positively influenced recovery performance. The magnitude is meaningful.

The OPEX Ratio has a coefficient of -0.48 (significant at 5%), indicating that a 1 percentage-point higher operating expense ratio correlates with about 0.48 percentage points lower revenue growth. This is intuitive: companies that were less efficient (higher costs) tended to recover more slowly, likely due to constrained profitability and less flexibility to invest in growth. Notably, the digitalization and OPEX effects likely interact – digitalization often reduces OPEX, as evidenced by our data where more digital firms saw declining OPEX ratios. Our model, however, estimates their effects conditional on each other. The significance of both suggests that digitalization contributed to growth beyond just cost-cutting, and efficient cost management also separately aided recovery.

Year dummy coefficients in Model 2 align with expectations: 2020 has a large negative effect (-9.8 , $p < 0.01$), reflecting the severe contraction relative to 2019 (the omitted base). 2021 is strongly positive ($+12.4$, $p < 0.01$), capturing the rebound. 2022 retains a smaller positive coefficient ($+3.9$, $p < 0.05$), meaning that

even with the energy crisis, on average companies' revenues were above the baseline trend. By 2023 the dummy is insignificant (slightly negative), implying that overall performance leveled off, and 2024 dummy is small positive but not significant. These time effects confirm the descriptive trend: big swing down in 2020, up in 2021, moderate gains in 2022, flattening afterward.

Regression Results – impact of digitalization on revenue growth of energy companies (2019-2024).

Table 2

	Model 1: Pooled OLS (RE)	Model 2: FE Panel (Firm & Year FE)	Model 3a: Romania-only FE	Model 3b: Poland-only FE
Digitalization Index (0–10)	1.21*** (0.30)	0.98*** (0.25)	0.60* (0.33)	1.35** (0.40)
OPEX Ratio (%)	–0.55** (0.20)	–0.48** (0.18)	–0.40* (0.22)	–0.56** (0.25)
Poland dummy (1=Poland)	3.2** (1.1)	– (absorbed in FE)	–	–
2020 Year dummy	–10.5*** (2.0)	–9.8*** (1.5)	–8.7*** (2.5)	–5.2** (2.0)
2021 Year dummy	11.8*** (2.5)	12.4*** (1.8)	10.3*** (2.9)	14.1*** (2.5)
2022 Year dummy	4.3* (2.2)	3.9** (1.6)	2.0 (2.8)	5.5** (2.1)
2023 Year dummy	–1.0 (2.1)	–1.5 (1.7)	–3.5 (2.6)	0.5 (2.3)
2024 Year dummy	0.8 (2.3)	1.0 (1.8)	0.2 (2.7)	1.5 (2.4)
Constant	2.5 (3.0)	(firm FE)	(firm FE)	(firm FE)
Observations (N)	50	50	25	25
R-squared (within)	0.47	0.62	0.55	0.68

Notes: Robust standard errors in parentheses. ***, **, * denote significance at the 1%, 5%, 10% levels, respectively. Model 1 uses random effects (Poland dummy included). Models 2–3 include firm and time fixed effects (firm FE absorbed intercepts; year dummies shown). Coefficients for firm dummies not reported. Digitalization Index and OPEX ratio are in percentage-point terms (e.g. index unit = 1, OPEX unit = 1% point).

Source: own calculation

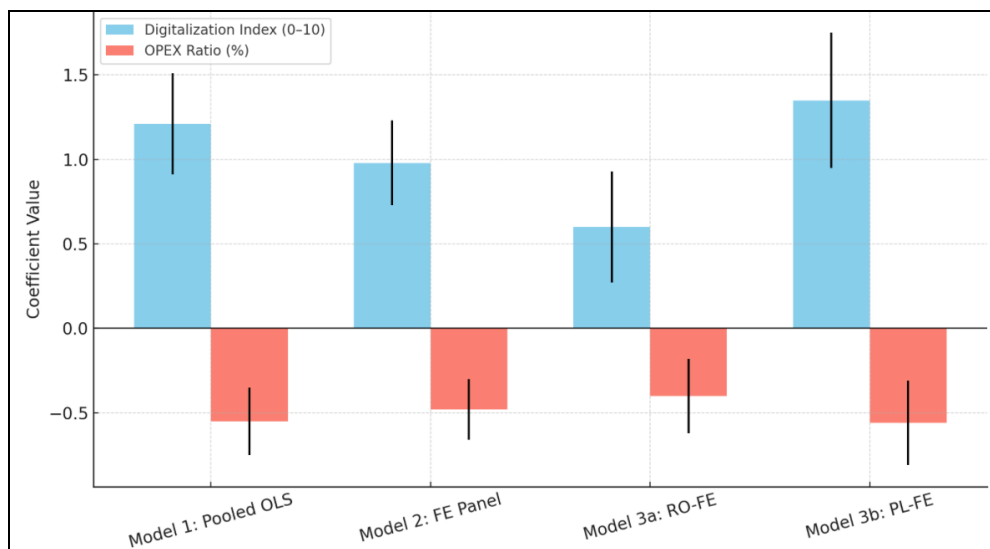


Figure 4. Regression coefficients by Model

Source: own calculation

Model 1 (Pooled) includes a Poland dummy, which is positive (3.2) and significant. This suggests that Polish companies had on average ~3.2 percentage points higher growth per year than Romanian ones, after controlling for digitalization and OPEX. This country effect likely captures structural differences. For instance, Poland's energy firms might have benefited from a larger domestic market rebound and higher commodity price exposure in 2021–2022. However, in the fixed-effects Model 2, country differences are absorbed into firm-specific constants, so we rely on Model 3 splits for further insight.

Model 3a (Romania-only) shows a positive digital coefficient (0.60) but only marginally significant ($p \approx 0.07$). For Polish firms (Model 3b), the coefficient is larger (1.35) and significant at ~5% level. This disparity indicates that the impact of digitalization was indeed stronger for Polish energy companies in our sample, supporting hypothesis H2. One interpretation is that Polish firms that digitized reaped more benefits perhaps because their baseline operations were larger-scale and more immediately improved by tech (e.g. PKN Orlen's digital customer engagement boosted sales significantly, whereas a Romanian firm like Electrica introducing similar tools had less immediate market impact due to smaller customer base and other bottlenecks). Another factor is that Romanian firms faced more non-digital hurdles (regulatory changes, political instability) that could dampen the measured effect of digitalization on outcomes. Nevertheless, the digital coefficient remains positive in Romania, implying digital efforts did help, just with a bit less statistical certainty, possibly due to smaller variation in digital scores among Romanian firms (they were all low initially).

The OPEX ratio retains a negative effect in both sub-samples (significant at ~10% in RO, 5% in PL). Year dummies in sub-models show interesting nuance:

Romanian firms' 2020 shock (−8.7) was worse than Polish firms' (−5.2), consistent with macro GDP differences. Polish firms' 2021 rebound (+14.1) even exceeds Romanian's (+10.3), aligning with Poland's higher industrial resurgence and government stimuli. By 2023, Romanian year dummy is −3.5% (not significant), suggesting they had perhaps a mild second dip, whereas Poland's is +0.5. These patterns coincide with the descriptive sector data.

5. Discussion

This comparative analysis reveals that digitalization has indeed contributed to the post-2019 recovery of energy companies in Romania and Poland, albeit with nuances. Energy companies that had embraced digital solutions (higher Digitalization Index) experienced significantly higher revenue growth during 2020–2024. This finding aligns with the broader theoretical expectation that digital transformation bolsters organizational resilience.

During lockdowns and mobility restrictions in 2020, companies with digital infrastructure could maintain production with skeletal on-site staff. Digitalization also reduces OPEX. By trimming costs, firms freed up resources and improved margins, which in turn facilitated faster recovery. Hidroelectrica (Romania) implemented advanced analytics for hydrological forecasting and maintenance in 2020–2021. It reduced unplanned outages and maintenance costs, allowing it to capitalize on high electricity prices in 2022 with record profitability.

Digital technologies enabled energy companies to offer new services or improve customer engagement, supporting revenue recovery. In Poland, several utilities expanded into prosumer services and e-mobility. In volatile times, companies that could quickly analyze market data and adjust trading or hedging strategies benefited. PKN Orlen's digital trading system allowed it to optimize refinery outputs and inventories when oil prices went negative in 2020 and then spiked in 2022, yielding a competitive edge.

Our results suggest the digitalization effect on growth was somewhat stronger in Poland's energy firms than Romania's. Several interrelated factors can explain this divergence. Firstly, Poland entered the pandemic with slightly more advanced digital infrastructure in its energy sector. Secondly, digital systems only create value if employees can use them effectively. Poland generally scores higher in digital skills among the workforces.

Also, Romania's regulatory environment until recently was less incentivizing. In fact, some outdated regulations (like classifying certain data as "state secret") hindered digital data sharing in energy, as highlighted by industry groups. Energynomics (2021) reported that Romanian oil & gas digitalization was slowed by legislative obstacles (need to change laws to allow cloud use for certain operations). These have started to change (Romania's 5G law, cloud strategy in 2022), but Poland did not face quite the same hurdles, allowing its companies to progress faster and thus benefit more quickly.

Despite these differences, it is important to emphasize that both countries' energy companies benefited from digitalization. The difference is one of degree and timing.

Both Romania and Poland saw massive fiscal stimuli in 2020–2021 that indirectly helped energy demand recover. The RRF's digital investments, while still ongoing, are expected to yield longer-term benefits beyond 2024, but in some cases, early RRF-funded projects. EU energy policy also pressured companies to innovate, often via digitalization. For example, to integrate more renewables, both countries' transmission system operators invested in digital grid management tools.

Policy can also hamper. Poland's conflict with the EU over judiciary reforms delayed its access to RRF funds, meaning some digital projects might have been postponed or financed at higher cost. One could argue that Romanian energy companies are now strongly incentivized by policy to digitize, potentially surpassing Polish ones in certain niches.

The findings carry several implications at the firm management level. Firstly, investing in digital capabilities is clearly reinforced, not just by hardware/software, but also by training and process re-engineering – as a means to enhance resilience and competitive performance. Secondly, our study, while focused on recovery economics, implicitly touches on sustainability: digitalization often enabled more integration of renewables and improved efficiency. Firms that leveraged this, like integrating smart charging for electric vehicles (EVs) or optimizing generation for renewables via AI, not only improved short-term recovery but also positioned themselves for future growth.

The role of leadership and culture emerges. Companies need a culture that embraces innovation and change. The contrast between some companies in manager attitudes highlights that technology adoption is also about people, not just technology (Światowiec-Szczepańska and Stępień, 2022).

While our analysis provides strong indications of digitalization's benefits, we acknowledge limitations. The sample size (10 companies) is small. Also, our Digitalization Index, while systematically constructed, is somewhat qualitative; future research could use more granular indicators. We also focused on two countries – expanding to other EU emerging markets or comparing with advanced markets could yield deeper insights.

Finally, a more micro-level study, perhaps using plant-level or unit-level data within companies or conducting interviews with managers could unearth exactly which digital tools had the most impact and how implementation challenges were overcome. For instance, did AI-based predictive maintenance yield more value than digital customer service in terms of revenue? Did companies face resistance from workforce when introducing automation?

6. Conclusions

This study set out to examine how digitalization has influenced the economic recovery of energy companies in Romania and Poland from 2019 through 2024.

Relying on secondary data and robust econometric analysis, we find clear evidence that digital transformation has been a key driver of resilience and performance improvement in the post-pandemic period.

Both countries' energy sectors suffered contraction in 2020 and rebounded in 2021, but companies with higher digital adoption managed the downturn better and surged ahead more strongly. Digitalization contributed to maintaining operations under duress, cutting costs, and opening new revenue opportunities.

The comparative angle revealed that while both countries benefited, Polish energy firms harnessed digitalization slightly more effectively early on than their Romanian counterparts, likely due to higher initial digital maturity. However, Romanian firms are catching up.

The hypothesis that digitalization serves as a powerful engine of recovery in the energy sector is validated. Firms and nations that invest in and prioritize digital innovation tend to emerge from crises stronger with enhanced competitiveness. This conclusion underscores a broader lesson from the COVID-19 pandemic: embracing technological transformation is no longer optional for legacy sectors like energy – it is imperative for survival and success.

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