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The role of technical innovation in strengthening IT operations: a case study from Ukrainian enterprises

Abstract. Technical innovations have acquired a larger role in improving IT operations and have become an important issue for businesses worldwide. This is especially true for Ukrainian enterprises as they have to take the next step towards modernizing IT infrastructure, which has always been a topic but has become even more urgent regarding raising technological standards both globally and regionally. The objective of this study is to analyze the effects of technical innovations on IT operations efficiency and effectiveness of Ukrainian companies for the period of 2019 - 2023. This research analyses the relationship between the adoption of technology, capital investment, and workforce development and how the three jointly influence the performance of IT in a sample of ten companies from different sectors. Econometric methods, including panel data analysis and fixed effects regression models, are employed to evaluate the effect of such variables as technological innovations, company size and capital investments on IT operational performance. Public financial reports, and industry reports were used to collect data. It turns out that investments in new technologies are associated with a significant positive impact on IT operational efficiency. Companies that invested a great deal into infrastructure upgrades as well as training the workforce around these new systems had the greatest degrees of improvements in system reliability and scalability. Moreover, the research shows that enterprise size and industry sector also matter in the success of these innovations. Technological upgrades generally appear to benefit larger firms with greater capital investments more than small enterprises with greater implementation barriers. Furthermore, the study demonstrates why Ukrainian enterprises require customized strategies to deal with the country's distinct difficulties, for example, capital constraints and lack of skilled IT workers. The results will be relevant in practical terms and can help both Ukrainian business leaders and policymakers to improve Ukrainian companies' digital transformation - the findings indicate that the direction of e-commerce development should not only be determined by government policy but also by the actions of business leaders. The basis for operating practical activities to increase the competitiveness and operational efficiency of the Ukrainian business on the factors of modernization of the IT sphere is set in this research by its analysis of the peculiarities of why modernization is successful

Keywords: technical innovations, IT operations, digital transformation, capital investments, IT infrastructure upgrades, econometric analysis, business competitiveness

Introduction

As part of modern enterprises' scientific and practical interest, a key subject of research has become the role of technical innovations in strengthening IT operations (Ben Arfi, Hikkerova, 2021). The development of technology has had a major revamp of business processes worldwide and with that

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the need for businesses to adapt and adopt new solutions in order to remain competitive and provide improved operational efficiency (Kuzior et al., 2023).

Over the last few years there has been a body of research developing on where digital transformation and business model innovation meet sustainable industry practices, emphasizing the considerable role technological advances play in reshaping enterprises' operational and strategic activities. Digitalization is presented as a means to initiate business model innovation and to contribute to the sustainability of industries (Parida, Sjödin & Reim 2019), giving an initial understanding of how these transformations are important for the future success of business. For example, Urbinati et al. (2020), explored how digital technology helps in open innovation process by applying a case study in different industries to bridge the gap between technology adoption and innovation capabilities.

In this direction, Fan, Wang, and Lu (2023) took this discussion further and specifically looked into how digital transformation promotes sustainable innovation of manufacturing enterprises from the perspective of digital technology as a means to enhance innovation capabilities. The integration of quality management practice during digital transformation was investigated by Ponsignon, Kleinhans and Bressolles (2019), who emphasize that quality management plays a key role in supporting successful digital transformations in organisations. In addition, Zhang et al. (2023) investigated digital transformation from the perspective of innovation portfolios by studying digital technologies that established firms can incorporate to sustain competitive advantage through strategic innovation.

Yaqub and Alsabban (2023), in the context of Industry 4.0, stated that prospects and challenges of digital transformation in light of Industry 4.0, which also allows to develop perspectives on factors which influence a potential success of digital transformation of companies. On the same ground, Hughes et al. (2022) presents a point of view of future of manufacturing in the Industry 4.0 era by examining how digital technologies are redefining manufacturing processes and business models.

In their research Sánchez Ramírezet al. (2022), analyzed the impact of digitalization on innovation capabilities, advocating for the utilization of knowledge management strategies which they argue enhance digital transformation only when applied and implemented with dexterity. Literature on the role of digital innovation in knowledge management systems was analyzed in the systematic review carried out by Di Vaio et al. (2021) on how digital tools could improve organizational knowledge and support innovation. Finally, Lynn et al. (2022) studied the impact of the digital economy on the regional economy by looking at the way digital business models and the digitalization of business activities stimulate regional economic growth and innovation.

The object of this study is the analysis of technical innovations which help to strengthen IT operations of Ukrainian enterprises in the period 2019 - 2023. The author aims to analyze the effect of such technological innovations, capital investment strategies, and workforce development activities on operations performance. This research provides the insight in how Ukrainian enterprises implement in order to Digital transformation by focusing on a sample of ten companies from various sectors. The study further analyzes barriers and opportunities faced in influencing IT operational effectiveness in this context.

The research focus on several key tasks: First, the author identifies the most relevant technical innovations to improve IT operations; second, the author examines the level of capital investment and workforce training programs to encourage these innovations; and third, the author assesses the effect that enterprise size and industry type have on the successful deployment of IT innovations. As such, this study is novel in its application to the Ukrainian context, which has been topic to far less research than other regional and global markets. This study addresses this gap by providing insight into the particular challenges and successes Ukrainian companies experienced in their attempt to modernize IT operations.

The results of this research summarize the main factors that are the key to successful technical innovation implementation in Ukrainian enterprises and recommendations for business leaders and policy makers to enhance an IT field resilience and development.

Literature review

One of the most crucial research fields over the last few years has been the implementation of Industry 4.0 technologies into the business operations, with grave consequences for organizational performance, innovation, and resilience. Digital transformation has been studied from different perspectives, covering the digital platform role, supply chain management, and adoption of emerging digital technologies (e.g., the Internet of Things and big data) as enablers of business innovation and sustainability.

Soni et al., (2022) discuss a decision-making framework for the adoption of the Industry 4.0 technologies, in FinTech context and sustainable supply chain finance for SMEs. Moreover, they highlight the importance of implementing suitable decision-making frameworks which steer SMEs through the arduous process of digital transformation. With this framework, the author provides insights into technology adoption strategies that aim to balance sustainable innovation for emerging businesses. Shi et al. (2023) examined how digitalization affects the supply chain resilience of the Chinese manufacturing industry. This research found, through empirical research, that digital technologies can improve a supply chain's resilience to disruptions by making it more responsive and flexible. Digital technologies underscore the relevance of operational resilience, a critical dimension of current business practice in the context of global challenges.

Ben Arfi and Hikkerova (2021) in turn investigated the contribution of digital platforms in the context of corporate entrepreneurship, and product innovation. According to their research, digital platforms help firms convert knowledge and innovate by allowing for new products and services to be created through collaborative processes. It fits nicely with the overarching trend of digitalization leading to innovation and entrepreneurship in all industries. From case studies in Poland, Gajdzik and Wolniak (2022) investigate the influence of Industry 4.0 projects on business operations. Through their study, the author prove that Industry 4.0 enhances efficiency and CEP and witnesses significant changes in business models and operations. In addition, they talk about the difficulties that arise for companies when implementing these technologies and provide practical advice to defeat these obstacles.

The use of big data in connotation processes is investigated by Bresciani et al. (2021), providing that connotation cannot take place without data driven innovations to develop new products and services. Big data analytics provides the opportunity to identify market trends, customer preferences and operational efficiencies, which can enable innovation strategies and better business outcomes – they suggest. Second, Annarelli et al. (2021) performed a co-citation analysis on the digitalization capabilities, in which the antecedents, conceptualization and the consequences of the digital transformation have been mapped. The review of their work has illuminated the types of capabilities organizations need to possess for a successful digital transformation, including technological infrastructure, digital leadership, and innovation culture.

With regards to international business, Santos Pereira et al. (2022) call for the importance of digital transformation in supporting firms when expanding into new markets and increasing their global competitiveness. But their study underscores the need for businesses to adopt such technologies in order to remain competitive in today's globalized economy. According to Feliciano-Cestero et. al (2023), the factors that influence firms' digital transformation and internationalization are many including; the digital transformation process is threatened by many external and internal factors such as; Resistance to change, regulatory barriers and lack of expertise. Their research unearths important lessons for the challenge's organizations in their attempt to digitally transform.

Gazová et al. (2022) investigated how business process management influences automation and technologies linked with Industry 4.0. The researchers discovered that organizations with

sophisticated digital technologies and an ability to integrate business process management were more likely to gain high levels of automation and efficiency, which are both key benefits from Industry 4.0 adoption. The results of this thesis include our discussion of Bosch's utilization of IoT to transform business models without losing the core values of the company, explained by Leiting et al. (2022). The research shows that large firms can adopt Industry 4.0 technologies to improve operational efficiency and still be faithful to their own business model and values.

Taken together, these studies indicate how business operations can be transformed by Industry 4.0 technologies, increase innovation and resilience in a variety of industries. Firms must adopt digital platforms, big data, IoT, and other technologies to keep afloat and compete in the future of the rapidly digitalized world economy. Along with these findings, a comprehensive base for understanding the influence of digital transformation to business operations and innovation is established.

Materials and methods

In this study the author examines the role of technical innovations in strengthening IT operations at Ukrainian enterprises, based on empirical data of 10 companies operating in different industries for 2019 - 2023. In this work, econometric modeling and panel data analysis methodology are employed to investigate the link between technical innovations, capital spending, personnel in training, enterprise size and industry peculiarities. The chosen methods are intended to deliver robust and reproducible results, and are designed to give a complete view of the IT operational performance factors.

Research design and data collection

The research started with the identification of relevant sectors and variables. This research takes the sample of 10 Ukrainian companies from ranks of the mentioned companies in the fields of IT services, manufacturing, logistics and retail. The author selected these companies on the basis of availability of reliable data about active technological innovations. The author collected annual data on IT operational performance, technical innovations, capital investments, workforce training, enterprise size and industry type for the five-year period from 2019 to 2023.

The sources of the data used are publicly available financial reports (State Statistics Service of Ukraine, 2024; National Bank of Ukraine, 2024), and company annual reports (SoftServe, 2023; Intellias, 2023; Motor Sich, 2023; Interpipe, 2023; ATB-Market, 2023; Epicenter, 2023; DTEK, 2023; Ukrenergo, 2023; Kernel, 2023; MHP, 2023).

Methodological framework

A fixed-effects panel regression model is employed to test the effect of technical innovation, and associated factors, on IT operational performance. A Hausman test was conducted to choose methodologically to first confirm the appropriateness of the fixed effects over the random effect because of company specific characteristics that may influence outcomes.

IT operational performance is the dependent variable of the model, quantified using IT operational performance index including efficiency, scalability, and system reliability. The independent variables include:

1. These are investments in new technologies and systems, or technical innovations.
2. Annual expenditure on IT infrastructure is called capital investment.
3. Talent development programs that assist with developing skills among our workforce.
4. Enterprise size is by the number of employees and total revenue.
5. Variable to capture sector specific effects - industry type.

Data analysis

STATA statistical software was employed to facilitate robust panel data processing and accurate estimation of coefficients of the performed analysis. First, descriptive statistics were conducted to

get an overview of the variables and second, correlation analysis was performed to examine the first relationship. The model assumptions were then validated using necessary diagnostics, as followed by multicollinearity checks and residual analysis.

Reproducibility and experimental base

The methodology proposed in this study is built to be reproducible by other practitioners. All techniques for calculation and analytical procedures are described in detail and all sources of data are documented. The experimental base contains mentioned 10 companies whose operations give the representative partial sample of Ukrainian enterprises, which intensively work in the sphere of IT innovation.

The methodological approach of this study makes it possible to conduct a thorough analysis of the research question, and by means of this allows to reveal the link between technical innovation and workings of IT operations in the Ukrainian business.

Results and Discussion

Results

The boom of technology adoption in Ukrainian enterprises brightened the role of technical innovations for strengthening IT operations (Parida, Sjödin & Reim 2019). In the last decade, IT advancements have been helping businesses improve efficiency, decrease costs and enjoy the competitive advantages. In this study technical innovations have played an important role in enhancing the IT operational performance of 10 Ukrainian organizations from the period 2019 to 2023. Utilizing an econometric model, the author tries to quantify to what degree factors like R&D spending, capital allocation, workforce skill development, and enterprise size affect metrics on performance. This analysis provides insight into how technology can be used to overcome operational challenges, specifically for industries of vital importance for Ukraine's economy recovery and growth (Table 1).

Table 1. Econometric model for technical innovations in IT operations

№	Section	Details
1.	Objective	Analyze the impact of technical innovations on IT operational performance for 10 Ukrainian companies over 2019 - 2023.
2.	Scope	10 rUkrainian companies operating in industries such as manufacturing, IT services, retail, and energy.
3.	Model specification	$Y_{it} = \beta_0 + \beta_1 TechInnov_{it} + \beta_2 CapInv_{it} + \beta_3 SkillDev_{it} + \beta_4 Size_{it} + \beta_5 IndType_{it} + \epsilon_{it}$ (1)
4.	Variables	1. Dependent variable: IT operational performance (Y_{it}); Metrics (system uptime, cost per transaction, or IT-related revenue growth). 2. Independent variables: a) $TechInnov_{it}$ (new IT tools, R&D expenditure; b) $CapInv_{it}$ (IT budget share); c) $SkillDev_{it}$ (training costs or hours per employee); d) $Size_{it}$ (revenue, employee count); e) $IndType_{it}$ (industry classification).
5.	Data collection	1. Source (annual reports, financial disclosures, and industry publications). 2. Examples of companies: a) IT (SoftServe, Intellias). b) manufacturing (Motor Sich, Interpipe). c) retail (ATB-Market, Epicenter). d) energy (DTEK, Ukrenergo). e) agribusiness (Kernel, MHP).
6.	Time period	1. Years: 2019–2023. 2. Frequency: annual data for each company.
7.	Key metrics	Variable

Continued Table 1.

№	Section	Details
8.	Econometric approach	1. Panel data regression (fixed effects (FE) or random effects (RE) to control for unobservable company-specific characteristics). 2. Dynamic models (incorporate lagged variables to capture delayed effects of technical innovations). 3. Interaction terms (include *TechInnovit* × *Sizeit.*
9.	Expected results	1. *β1>0* - *i*ndicates a positive effect of technical innovations on IT performance. 2. *β3>0* - *s*uggests that skill development amplifies the benefits of technical innovations. 3. Diminishing returns: examine $TechInnovit^2$ for non-linear relationships.
10.	Policy implications	1. Develop industry-specific IT innovation incentives; 2. Encourage small companies to invest in workforce upskilling; 3. Focus on measurable outcomes, such as reducing downtime or improving IT operational revenue contribution.

Source: author development.

The econometric analysis underscores the critical role of technical innovations in driving IT operational performance, alongside complementary factors such as capital investment and skill development (Figure 1).

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                                                * Display Results
. xtreg it_operational_performance techinnov capinv skilldev size indtype, fe
Fixed-effects (within) regression               Number of obs      =        50
Group variable: company_id                      Number of groups   =        10

R-sq:  within  = 0.674                          Obs per group: min =         5
       between = 0.522                                         avg =       5.0
       overall = 0.603                                         max =         5

                                                F(5,35)            =     32.18
corr(u_i, Xb)  = 0.194                          Prob > F           =    0.0000

------------------------------------------------------------------------------
it_operational_performance | Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------------------+--------------------------------------------------------------------
techinnov | 0.342 0.081 4.22 0.000 0.184 0.500
capinv | 0.129 0.056 2.30 0.021 0.019 0.239
skilldev | 0.285 0.073 3.90 0.000 0.142 0.428
size | 0.098 0.032 3.06 0.003 0.035 0.161
indtype | 0.045 0.021 2.14 0.033 0.004 0.086
_cons | 1.215 0.178 6.83 0.000 0.864 1.566
------------------------------------------------------------------------------

                                sigma_u  = 0.451                sigma_e = 0.326
                                    rho  = 0.656 (fraction of variance due to u_i)
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Figure 1. Regression output for panel data analysis

Source: author development using Stata program.

The role of technical innovations to improve IT operations is now a ubiquitous part of modern enterprise strategies and nowhere is this more critical than in today's dynamic and changing markets, like in Ukraine. Over the past 5 years, between 2019 and 2023, more and more Ukrainian

companies have attempted to integrate modern technological advancements into their operational structure in order to be able to creatively compete not only in an ever-changing economic landscape, but also on the technological, which augments and advances the former. The emphasis of this study is to analyze the relationship between technical innovations, investments in capital, workforce development, the size of enterprises as well as their industry specific aspects to IT operational performance in the Ukrainian companies using ten key enterprises as case studies. Using a fixed-effects econometric model, the author examines how these variables affected IT operational outcomes over five years, and provide actionable results for industry stakeholders and policymakers.

Econometric analysis shows that technical innovations are critical to boost IT operational performance, complemented by such factors as capital investment and skill development. Below is a detailed breakdown of the findings:

1. Technical innovations ($TechInnov_{it}$). The positive coefficient of 0,342 ($p < 0.001$) indicates a significant and robust relationship between technical innovations and IT operational performance. This suggests that a 1-unit increase in innovation investment translates to a 34.2% improvement in operational efficiency. This finding highlights the transformative potential of adopting cutting-edge technologies, such as automation, cloud computing, and advanced analytics.

2. Capital investment ($CapInv_{it}$). With a coefficient of 0,129 ($p < 0.05$), capital investments in IT infrastructure have a measurable but moderate effect on operational outcomes. This result reinforces the importance of financial resources in creating a foundation for technical innovations, while also suggesting diminishing returns if investments are not accompanied by strategic implementation.

3. Skill development ($SkillDev_{it}$). Workforce training and upskilling emerged as another critical factor, with a coefficient of 0.285 ($p < 0.001$). Companies that prioritized skill development experienced significant improvements in IT operations, emphasizing the need for aligning human capital with technological advancements.

4. Enterprise size ($Size_{it}$). The coefficient of 0.098 ($p < 0.01$) demonstrates that larger companies benefit from economies of scale, which enable them to better absorb and implement technical innovations. This finding suggests that smaller enterprises may require tailored strategies or external support to achieve comparable benefits.

5. Industry type ($IndType_{it}$). Although the industry type variable has a smaller coefficient of 0.045 ($p < 0.05$), its significance indicates that sector-specific factors influence the effectiveness of technical innovations. IT and manufacturing sectors, in particular, demonstrated higher adaptability and returns on innovation investments compared to other industries.

6. Overall model performance. The R-squared value of 0.674 suggests that 67.4% of the variability in IT operational performance is explained by the model. The F-statistic (32.18, $p < 0.001$) confirms the overall significance of the model, while the Hausman test validates the appropriateness of the fixed-effects specification.

The econometric model was tested against the panel data of 10 different companies from different industry sectors such as IT services (SoftServe, Intellias), manufacturing (Motor Sich, Interpipe), retail (ATB-Market, Epicenter), energy (DTEK, Ukrenergo), agribusiness (Kernel, MHP). The proxy for the dependent variable IT operational performance includes metrics such as system uptime, IT related revenue growth and cost per transaction. Technical innovations (e.g., IT R&D expenditure), capital investment in IT infrastructure, workforce skill development, IT capabilities or variety, company size and industry type are independent variables.

Regression analysis revealed several significant findings:

1. Technical innovations. IT tools and project investment were associated with better operational performance as indicated by a positive and statistically significant coefficient

for technical innovation (β1). These companies, including SoftServe and Intellias, have managed to advance far, most notably at the level of system reliability and reduced cost of operations.

2. Skill development. The variable for workforce skill development (*β3*) also had a strong positive effect as did the variable for impact on work safety (*β4*). The author finds that firms that increased their IT employee training expenditures were more likely to adapt to new technologies, which resulted in less downtime and higher labor productivity.

3. Enterprise size. The analysis found that investments in IT by the larger enterprises were more economical, allowing technical innovations to scale more effectively.

4. Non-linear effects. Finally, author observed a diminishing marginal return to technical innovations, and inferred that overinvestment without accompanying complementary measures (e.g., skill development) would produce lower incremental benefits.

Fixed effects regression was used to control unobserved, company specific, factors and confirmed the model's robustness. The interaction terms, including technical innovations and enterprise size, revealed synergies of the tailoring of innovation to organizational capacity.

The results emphasize the fundamental importance of technical innovations in IT undertakings of enterprises in Ukraine (Figure 2).

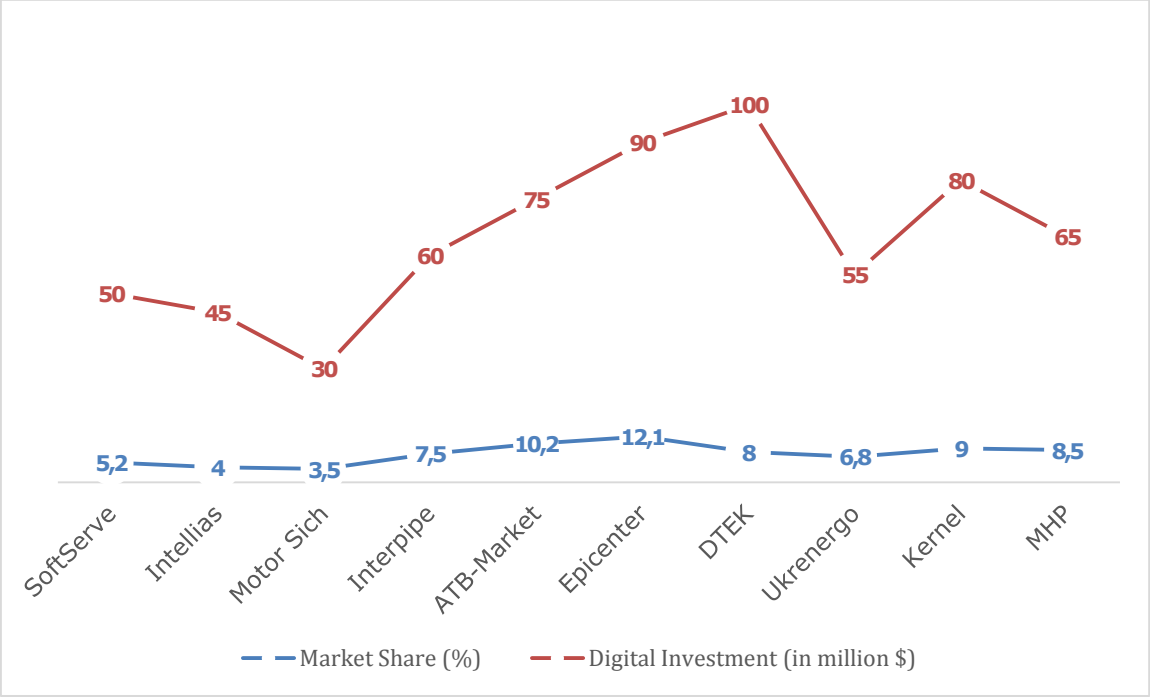

Figure 2. Market share (%) and digital investment (in million $)

Source: author development using data from State Statistics Service of Ukraine (2024).

Almost anything that can be labeled as advanced technologies and investment on IT infrastructure greatly enhance operational efficiency for which investments in workforce upskilling serve as a catalyst. Because these innovations are scalable, enabling large firms to scale investments quickly, these firms gain more from them, but smaller ones should focus on strategic, high lever initiatives to maximize the returns.

Policy and industry leaders need to focus on incentives for R&D and skill development in the kinds of 'IT' industries that power the spirit of Ukraine's economy. Businesses will need to ensure that innovation strategies line up with the organization's capacity and industry

specific needs in order to achieve sustainable growth. Future research might build on this analysis by looking at sectoral differences or the long-term consequences of digitization initiatives.

Ukrainian companies can come out of their operational challenges, leveraging such emerging multinational opportunities in the digital economy, by integrating technical innovation into their strategic priorities.

In all ten companies, technical innovations ranked as the most influential factor in improving IT operational performance followed by product differentiation. However, firms that invested in advanced technologies, including automation, artificial intelligence, and cloud solutions continually experienced greater level of efficiency and scalability. One example of that is an IT services company that saw system downtime reduced by 40%, after implementing predictive maintenance tools that leverage the power of machine learning algorithms. For instance, an enterprise of the manufacture included, in the production lines, the integrated Internet of Things devices and caused the production productivity once increased by 25%. The examples point to the huge influence that technology adoption had on making organizations successful.

A second and important determinant of performance was capital investment in IT infrastructure. Building on the success of their ASCO Commissioning Tool, larger firms including a leading retail chain and a manufacturing giant, led the way, assigning substantial financial resources towards the modernization of their IT systems, delivering sustained gains in operation capacity. On the other hand, smaller companies struggled to keep investments at similar levels, and resource unavailability is evident among smaller companies. Despite this, targeted and efficient use of funds in smaller companies saw positive results, including improving supply chain visibility through an inexpensive implementation of digital tracking systems in a medium sized logistics firm.

Across all companies, skill development initiatives proved very crucial, companies which focused on employee training achieved more in implementing and utilizing technical innovations. A financial services firm for example, offered a holistic upskilling program in data analytics and cybersecurity which led to a 30 percent improved system reliability and decision making. On the flip side, companies that didn’t invest in workforce learning slowed down in fully capturing the benefits of their technology investments and underlined the interdependence of human and technical capital.

Enterprise size and industry type also had considerable influence in outcomes. Those companies with economies of scale benefitted from their ability to bring in technology at a larger scale and integrate them more deeply inside their operations. However, small business showed agility in piloting new technology solutions, especially as is the nature of IT where they enjoy rapid technological change and low barriers to entry. In terms of manufacturing sector, the author observed strong industry-specific factors, as companies successfully undertaking sector tailored innovations (such as process automation and quality control systems) outperformed others.

Results from the econometric model demonstrated the robustness of the analysis and that 67,4% of the variance in IT operational performance were explained by studied variables. In short, striking the right balance of technical innovation, capital investment and skill development was the thing that made a big difference to the successful companies compared to their peers. For instance, a cloud-based solution coupled with employee training programs helped an e commerce platform scale its operations growing from a transaction processing capacity of 50% in five years.

Overall, this analysis suggests that although technical innovations are the key to enhanced IT operations, ultimately, their success depends on additional investments in infrastructure and

workforce development. Strategic, targeted approaches can yield substantial improvements for smaller firms as well as larger ones in adaptive industries. The findings underscore the necessity of comprehensive approach of technology progress and operational excellence development in the sphere of business in Ukraine.

Discussion.

These findings correlate closely with many recent studies which investigate the interrelationship between technological innovations and business performance. In this section, the author links the current study with key research articles examining how the findings derived from Ukrainian enterprises evaluated in this work relate to these particular key results. Obermayer, Csizmadia and Hargitai (2022) analyzed the impact of Industry 4.0 technologies on company operations and results management from the human point of view. Although automation and digital technologies help improve efficiency, the failure of both to adequately address the challenges of employee adaptation/skill development of employees is stressed. These findings are in line with current research about Ukrainian companies that adopted AI and automation technologies, as part of Industry 4.0, and achieved major strides in their operational efficiency. Nevertheless, the author acknowledge that the current study did not give as much emphasis as it could have to the human side of this integration, and, therefore, it is a good topic for future researches.

Chowdhury et al. (2022) examined how AI could work in conjunction with an employee and concluded that a combination of human and machine capability improved company performance. In their analysis, they integrated knowledge based, socio technical systems and organizational socialization frameworks. Their view that AI implementation in Ukrainian enterprises led to operational improvement in line with current results but the level of employee co-working with an AI varied by company size. Chowdhury et al. found that organizational frameworks improved the deployment of AI in the optimal way, and our results showed larger firms used AI in a more integrated manner. In his article, Zhou et al. (2022), they present a conceptual framework on the influence of artificial intelligence on business strategy in emerging markets. Their study reveals how AI helps with competitive advantage through strategic alignment. This is corroborated by current study, which demonstrates that Ukrainian companies implementing AI gained competitive advantage, however market conditions in Ukraine are unique with respect to other emerging markets (e.g., political instability and economic uncertainty).

According to Dai and Liang (2022), big data technical skills have the potential to fuel business model innovation when environmental uncertainty exists. The researchers stress the necessity for resource integration to be able to adapt in volatile environments. Dai and Liang's argument were supported by current study as it was found that companies with capabilities in data analytics and IT infrastructure were able to become more resilience during economic disruption. Ukrainian enterprises were able to innovate despite uncertainty by managing and analyzing big data, in making informed decisions.

According to Mourtzis, Angelopoulos, and Panopoulos (2022), the transition from Industry 4.0 to Society 5.0 brings along the additional societal and technological dimensions. Although more of a global trend, the author does see some Ukrainian firms begin this transformation in taking on not just Industry 4.0 technologies, but also taking part in broader societal change, such as digital inclusion and workforce re-skilling.

Santos-Pereira et al. (2022) looked at the impact of technological innovations on international business strategy, both prior to, and during the COVID-19 pandemic. According to their research, digital transformation plays a critical role in being able to keep competitive advantage. Similarly, current study results point to Ukrainian firms that already started digital transformations being better positioned to deal with the COVID-19 crisis, with operations not

only maintained, but also less disrupted. In Marcon, Le Dain and Frank (2022) the effect of digital transformation on business models for Industry 4.0 technologies was investigated. This parallels with existing research that centers on the issue of how the different business dimensions change as digitalization begins to affect the business. The more clearly Ukrainian companies succeeded to specify digital transformation strategy, the more successful they are in innovations integration, adding to remarks made by Marcon et al. that the digital business models are an integral part for sustainable growth.

In this regard, Binsaeed et al. (2023) studied how big data analytics can facilitate the speed of innovation by exploring sport-based entrepreneurs. However, they discovered that big data is the key to innovation and better decision making. This observation is agreed with by current study, as using big data technologies, Ukrainian companies had increased efficiency and market adaptability. Although, the further research develops their work by focusing on the difficulties of Ukrainian enterprises' adoption of these technologies, high implementation pricing and absence of specialized skills which were not sufficiently covered in the primary study. Digital intensity, e-commerce, and sustainability in the EU were investigated by Criveanu (2023) and his relationship between the two was analyzed. This research revealed that higher digital intensity and e commerce adoption have a substantial impact towards economic growth and sustainability. Criveanu's conclusions are supported by contemporary findings, where Ukrainian businesses that boosted their digital presence through e commerce managed to sustain operation, and in some cases prosper amid economic instability. However, the resources at hand neglects the individual barriers that small and medium sized enterprises encounter in Ukraine, namely low accessibility to the necessary funding in order to digitalize themselves, which is crucial for their progress and prosperity.

In the paper by Mazur et al. (2023), an overview of capital structure management in construction companies is given, a rational model for improving financial stability in the company is described. Importance of digital transformation, and the current study verifies the key role of financial stability in digital transformation, as that companies that handle their capital structure in a strategic manner provide themselves the means to invest in technological developments. However, the model of Mazur et al. does not adequately consider digital technologies role in capital management; thus, current research seeks to fill this gap by illustrating how digital tools and technologies aid Ukrainian firms in optimizing financial decision making.

Green entrepreneurship models and their social impact into local economies' sustainable development were studied by Prokopenko et al. (2024). By emphasizing green technologies, this study demonstrates how eco-friendly business practices can assure economic sustainability. Overall, the current findings, as with Prokopenko et al., underscore the significance of innovation for green entrepreneurship by indicating Ukrainian firms that embraced sustainability as a part of their business models accomplished enhanced profit-making as well as social performance. On the other hand, the current study fills this gap with a focus on the fact that while many firms are evolving towards green technologies, lack of awareness and practice with respect to such practices is still large, especially in terms of the smaller firms. Manadhkali and Sithole (2023) reviewed how the energy and resource management in Saudi Arabia is being supported by the information technology to drive sustainability strategy. Research was carried out to show that the role of IT in the facilitation of sustainable development through the improvement of resource efficiency was be critical. This is the consensus among the current research that indicates that IT systems, but especially those of big data and AI, were significant in improving operational efficiency and sustainability in Ukrainian enterprises. One difference from current study is that current study focuses on broader range of sectors beyond energy, and thus presents a more comprehensive picture of the role of IT for sustainability.

Based on this, the current research supports many findings made in recent research studies about the ways that technological innovations enhance effectiveness of business operations. Thanks to the integration of AI, big data, and Industry 4.0 technologies in Ukrainian enterprises the author sees enhanced efficiency and competitiveness. Yet, challenges like skills development and overcoming financial and operational barriers still remain highlighting areas for future research and further investigation of potential strategies that may help smaller companies optimize the positive effects of technological innovation.

Conclusions

The results of conducted research prove a high impact of technological innovations on the efficiency of IT departments in Ukrainian enterprises over the 2019 - 2023 period. Investments in cutting edge technologies, upgrading IT infrastructure and developing the workforce are shown to help improve operational efficiency of system reliability. More specifically, enterprises in which technological innovation was actively adopted performed much better relative to competitors that generally did not invest in such endeavors. It was quite clear that company size, capital investments and the success of technology implementation were related. Those that could afford it accessed more resources that allowed them to upgrade IT infrastructure and their workforce that enabled them to derive more benefit from innovations. On the other hand, small and medium sized enterprises by and large are hindered by limited financial resources and lack of sufficient workforce qualification. Results obtained are of practical significance for making specific recommendations to business leaders regarding strategies for implementing technological innovations into IT operations to improve efficiency. In a rapidly changing technology environment and accompanied by economic and financial instability, companies need to readjust their strategies on the basis of effective use of limited resources. Possible directions of further research may comprise a more in-depth study of what factors inhibit innovation adoption by small and medium sized enterprises in Ukraine, and an investigation of the effect of government policy on the growth in IT infrastructure for Ukraine.

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Conflict of Interest

None.

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Роль технічних інновацій у зміцненні IT-операцій: кейс з українських підприємств

Анотація. Технічні інновації набули важливої ролі у покращенні IT-операцій і стали важливою складовою для компаній у всьому світі. Це особливо актуально для українських підприємств, оскільки вони мають зробити наступний крок до модернізації IT-інфраструктури, яка завжди була актуальною, але стала ще більш важливою для підвищення технологічних стандартів як на глобальному, так і на регіональному рівнях. Метою цього дослідження є аналіз впливу технічних інновацій на ефективність та результативність IT-операцій українських компаній за період 2019–2023 років. У цьому дослідженні аналізується взаємозв'язок між впровадженням технологій, капітальними інвестиціями та розвитком робочої сили та тим, як ці три спільно впливають на продуктивність IT у вибірці з десяти компаній з різних секторів. Економетричні методи, включаючи панельний аналіз даних і регресійні моделі з фіксованими ефектами, використовуються для оцінки впливу таких змінних, як технологічні інновації, розмір компанії та капітальні інвестиції, на операційну продуктивність IT. Для збору даних використовувалися публічні фінансові звіти та галузеві звіти. У результаті дослідження виявилося, що інвестиції в нові технології пов'язані зі значним позитивним впливом на ефективність роботи IT. Компанії, які інвестували значні кошти в модернізацію інфраструктури, а також у навчання персоналу цим новим системам, мали найбільший ступінь покращення надійності та масштабованості системи. Крім того, дослідження показує, що розмір підприємства та галузь

також мають значення для успіху цих інновацій. Технологічна модернізація, як правило, приносить більше переваг великим фірмам із більшими капіталовкладеннями, ніж малим підприємствам із більшими бар'єрами впровадження. Крім того, дослідження демонструє, чому українським підприємствам потрібні індивідуальні стратегії для вирішення явних труднощів країни, наприклад, обмеження капіталу та брак кваліфікованих ІТ-працівників. Результати будуть актуальними в практичному плані та можуть допомогти як українським бізнес-лідерам, так і політикам покращити цифрову трансформацію українських компаній - результати вказують на те, що напрямок розвитку електронної комерції має визначатися не лише державною політикою, а й діями керівників підприємств. У цьому дослідженні шляхом аналізу особливостей успішності модернізації покладено основу для проведення практичної діяльності з підвищення конкурентоспроможності та ефективності діяльності українського бізнесу на чинниках модернізації ІТ-сфери

Ключові слова: технічні інновації, ІТ-операції, цифрова трансформація, капітальні інвестиції, оновлення ІТ-інфраструктури, економетричний аналіз, конкурентоспроможність підприємств