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ВИКЛИКИ ТА МОЖЛИВОСТІ ДЛЯ УКРАЇНИ»**

**«DIGITAL TRANSFORMATION OF PUBLIC FINANCE: OPPORTUNITIES AND
CHALLENGES FOR UKRAINE»**

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INTRODUCTION

Relevance of the topic.

In the age of a digital revolution, the digital transformation of public finance plays a crucial role in the country's development and effective government operations. In such a vulnerable for Ukraine times with the ongoing Russian full-scale invasion and post-pandemic recovery, it is essential to have a quick reaction to external shocks, support the financial system, and ensure effective public funds allocation. Analyzing the current state of digital transformation of Ukraine, as well as defining its key opportunities and challenges could help to highlight the way of improving governmental efficiency and ensure further economic development.

The aim of the study.

The purpose of the research is quantitative analysis of the digital transformation of public finance in Ukraine, identification of its main opportunities and challenges, as well as proposing recommendations for the improvement of the state of digital information in Ukraine in the context of a full-scale invasion and in the recovery phase.

To achieve this aim, further tasks are highlighted:

1. Reveal the general theoretical foundations of digital transformation and show the evolution of digitalization of the public sector.
2. Highlight the digital transformation of public finance as a separate phenomenon.
3. Analyze the main global trends and international experiences in digital technologies implementation in the public finance sector.
4. Identify the main opportunities and challenges that arise in the digitalization of public finance.
5. Analyze the current state of public finance transformation in Ukraine through existing projects and initiatives.
6. Describe international assistance in the digitalization of public finance.

7. Use econometric research to identify the relationship between the digitalization of public finance and economic, social, technological, and institutional indicators which could be relevant to Ukraine.
8. Identify the main opportunities and challenges for Ukraine.
9. Provide recommendations to improve the state of digitalization of public finances in Ukraine based on the conducted analysis, including the post-war recovery period.

The object of the study is the state of digital transformation in Ukraine.

The subject of the study is the digital transformation policies of public finance in Ukraine, its opportunities, and challenges.

Research methods. This research was conducted using various general theoretical and more complex empirical methods. Theoretical approaches, using analysis, induction, and deduction methods were used to provide a general overview of the digital transformation, of public finance and analyze the transition towards digital government. Statistical methods and secondary data analysis were mainly used in order to provide competitive analysis to define global main tendencies, as well as to analyze the current state of digitalization in Ukraine. The same methods were used to estimate the effects of the digitalization of public finance. Econometric methods are used to define the relationship between digitalization and economic, social, and institutional factors in lower- and upper-middle-income countries, including Ukraine.

Information base is provided in the form of scientific articles, books, and research from both Ukrainian and international scientists. Moreover, it includes reports from international organizations like IMF, UN, OECD, et., companies like McKinsey and Transparency International, as well as from Ukrainian governmental authorities such as the Ministry of Finance, The Ministry of Digital Transformation, Treasury Service of Ukraine, etc. Moreover, it includes statistical data from World Bank Database and Ukrainian State Statistics Service, as well as from Open Budget Survey and Digital Society and Economy Index data.

The practical significance of this research. The results of the conducted research could be used as recommendations for further improvement of the digital transformation of public finance, as well as for future post-war recovery using digital tools in the public finance field. Moreover, it could be used as a base for policy redesign and public service delivery mechanism updating. It provides valuable insights on what opportunities to use to reduce the negative effect of the challenges and realize more benefits from public finance digitalization in Ukraine as a booster for further development.

Structure. The research consists of an introduction, 4 main chapters, a conclusion, and references. The first chapter provides a theoretical framework for digital transformation in general while identifying the evolution toward digital government and defining the digital transformation of public finance as a separate phenomenon. In the second chapter global tendencies and experiences in the digitalization of public finance are analyzed, as well as identified main opportunities and challenges. Moreover, the outlook of the current state of digital transformation of public finance is provided. The third chapter consists of an econometric modeling section researching the relationship between the digitalization of public finance and social, economic, institutional, and governance factors within two country groups – lower- and upper-middle countries. Along with the interpretation of estimation results, the main insights for the Ukrainian context are given. Chapter 4 provides information based on the conducted analysis defining the main opportunities and challenges in public finance digitalization for Ukraine. Finally, recommendations for improving the current digital transformation state of public finance are provided along with its practical use in the post-war recovery.

Key words: digital transformation; public finance; digitalization; open data; efficiency; government; public finance management; transparency; budget.

CHAPTER 1. THEORETICAL FRAMEWORK FOR DIGITAL TRANSFORMATION OF PUBLIC FINANCE

1.1 A general framework of the digital transformation concept

The relevance of the digital transformation concept has increased rapidly since the technological evolution. The advent of digital times made organizations adopt digital transformation as a part of their global strategy to boost overall performance and increase customer experience and modernization.

In this section, the theoretical concept of digital transformation will be explored to better understand using digital instruments to shape industries, organizations, businesses, or other aspects of society. Additionally, we will investigate relevant definitions from various perspectives to distinguish the difference between such phenomena as digitization, digitalization, and digital transformation, as well as explore the key components of the digital ecosystem.

One of the earliest attempts to provide the theoretical concept of the term “digitization” was in the XX century - late 50s-early 70s in academic works by Shannon (1948), Salton (1968), Rosenzweig (1971), and others. "Digitization is the process of converting analog information into digital form, which can be processed, stored, and transmitted using digital technology" (Liu et al., 2016). The importance here is to understand that digitization refers to transforming the information and data itself, however, it does not involve converting processes.

On the other hand, the term “digitalization” appears to be more controversial and is a subject of discussion among many researchers, including Kranzberg, (1986), Castells (1996), Shallmo et al (2017), Eisenmann et al. (2016) and others. It encompasses wider implications of the use of digital technologies and could be explained through different perspectives and approaches. Analyzing it through the prism of various angles helps to distinguish the concept of digitalization (Table 1.1).

Table 1.1. Concepts of digitalization from various perspectives

Aspect	Concept
Social	Referring to digitalization as a process of using digital tools across diverse domains of society. Castells (2010) focuses on digitalization as a process of shaping social and economic organization, cultural expression, transforming the way people work, communicate and collaborate and interact.
Technological	The focus is used to identify digitalization as a process of using advanced digital technologies like big data analytics, cloud computing, artificial intelligence (AI), machine learning etc. to improve efficiency, maximize value and encourage innovative approaches. Siebel (2019) highlights that digitalization is using innovative technologies to make a complete transformation across all spheres of business and society.
Economic	Characterizing digitalization as the transformation of traditional business models and operations by implementing new technology into each aspect of the economy and creating new value. Li et al., (2017), discuss that digitalization is a way to change and improve existing business processes. According to Pagani & Pardo (2017), IT technologies can be used to optimize business models, processes, and operations, creating new value and generating revenue.
Cultural	Describing the term as a way of changing to new forms of cultural representation cultural practices, values, and identities as well as cultural expression, production, and consumption. Hartl, E., & Hess, (2017) focus on the term as the process of implementation of digital technologies into cultural norms, institutions, and expression, resulting in the transformation of these practices and creating new cultural values.

Source: authors' compilation based on [69], [72], [16], [59], [27].

Moreover, with the further development of technologies and academic analysis, the term “digital transformation” appears more frequently in the works of researchers, international reports, or strategic plans, especially at the end of the XX - beginning of the XXI century. Although the terms could be used interchangeably, there is a growing consensus that they are distinct concepts.

Addressing the academic works, scientists such as Pagani and Pardo (2017), Gupta et al. (2017), Westerman & Bonnet (2014), and others focus on defining the process of digital transformation as a “radical, continuous, and fundamental”. Although there is a degree of similarity between digital transformation and digitalization, they are distinguished by their respective scopes and strategies. Digital transformation is regarded as a comprehensive and strategic approach, while digitalization is viewed as a tactical and operational way to enhance processes and operations. It encompasses strategic changes with the usage of ICT technologies and creating new data-driven business models, as well as digital platforms, and enables diversification. Thus, digital transformation entails a more revolutionary method of change, whereas digitalization is focused on making gradual improvements to existing processes via digital technologies [83].

It is widely recognized that these three terms typically progress in sequential order of maturity: first comes data digitization, then processes and operations could be digitalized, and radical shaping of the strategy is known as the digital transformation.

The discussion of the concept of both digitalization could be expanded to an even wider list of perspectives to define it, however, in this paper, the focus will be held on the economic and social perspectives. Thus, this will allow us to highlight the digital transformation in the public sector with a further focus on public finance as a part of national government policy strategy.

1.2 The concept of digital transformation in the public sector

After discussing the essential terminology that underpins the digital shaping of our world, it is important to explore the theoretical concepts that inform the digital transformation of governments, the public sector, and public finance. While these concepts may appear distinct and separate, they are in fact closely connected and interrelated, and exploring them together can provide a more comprehensive understanding of digital public finance transformation as well as understand how to realize the full potential.

The digital revolution has not only transformed the private sector but has also affected the way governments operate and deliver services to their citizens, reshaping its

relationship. The shift towards digital government services has become increasingly important as citizens demand more efficient and transparent services from their governments. Along with the analysis of the general theoretical framework of the phenomenon of digitization and digital transformation, this section will explore the concept of digital transformation in the public sector to create the theoretical base for further sections focusing on the field of public finance.

The theoretical background of digital transformation in the public sector revolves around the concept of electronic government. This section provides the outlook of an evolutionary approach to comprehending the theoretical framework for the transition from traditional government to a digital one.

United Nations (UN) Report 2020 states that “Digital government is not an end; it is a means to improving public service delivery, increasing people’s engagement, enhancing transparency, accountability, and inclusion, and ultimately making life better for all” [79, p.34].

In the field of public administration and information systems, there are two interrelated but separate concepts: e-government and digital government. According to Chen and Hsieh's (2009) definition, e-government involves the utilization of information and communication technologies (ICT) to enhance the efficiency, effectiveness, transparency, and accountability of interactions between various arms of government, citizens, and businesses. Similar thoughts have been presented in the works of Moon (2005) and Heeks (2006).

On the other hand, digital government encompasses a wider array of technological advancements and societal transformations in the public sector.

There are various ways to explain the concept of digital government in the academic literature. Table 1.2 represents some examples of defining the digital government from international organizations and various scientists.

Moreover, there are 3 types of digital government relationships: G2C – government to citizen, when providing information and services to residents, G2B – government to business transactions (procurement, and G2G – government to government – the

relationship between governmental structures. The digitalisation of these operations creates a complex digital environment [24].

Table 1.2 Concept of the definition of “digital government”

Author	Concept
Fountaine (2001)	“Digital government uses ICTs to blur boundaries between agencies, enhance the efficiency and accountability of delivering public services, fostering democracy, and empowering citizens”.
Holden, Norris, and Fletcher (2003)	“Digital government is perceived as the delivery of information and services to citizens using ICTs 24 hours a week”.
Norris and Moon (2005)	“Digital government encompasses the adoption of ICTs to elevate the provision of public services, amplify democratic engagement, and foster transparent and accountable governance”.
OECD (2019)	“The application of digital technologies to transform the public sector, boost the delivery of public services, and stimulate transparency in the governmental body. It is economic and social effects of digitisation and digitalization.”.
United Nations (2020)	“It is digital coordination between government, business, and society to build citizen-centered, accountable and effective system”.

Source: authors’ compilation based on data [24], [31], [53], [55], [79].

Overall, while e-government is more narrowly focused on the implementation of ICTs for government services, the digital government takes a more holistic and

transformative approach to public sector innovation. However, the terms could be used interchangeably as long as the intended meaning is not dependent on a specific definition. While there exists a vast and complex theoretical framework in the field of e-government, the academic literature suggests that further quantitative empirical research is necessary.

Along with the digital government concept, the one named as Government as a Platform (GaaP) was introduced first by Tim O'Reilly in 2011 [43].

The essence of the concept is that governments provide a multilayer digital platform that is used for public service delivery, building a citizen-centered model [42].

This is a new ecosystem transforming the governmental process of making policies and service delivery. The most common view on the GaaP was presented by Loosemore (2018), which is shown in Figure 1.1.

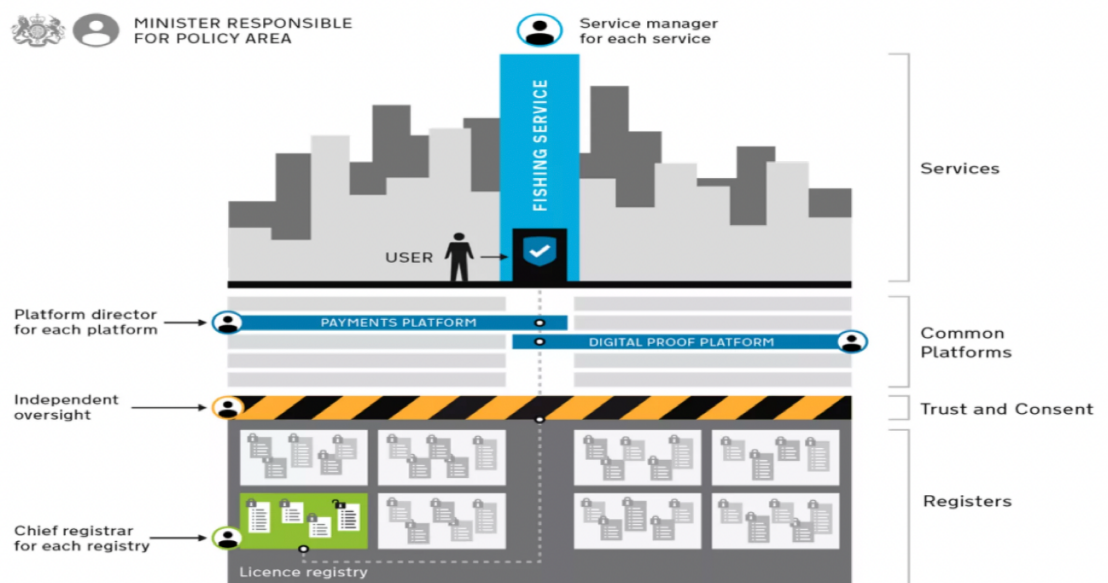


Figure 1.1 Government as a Platform concept

Source: Loosemore (2018), [43].

1.2.1. Theoretical Models of digital government evolution

In the last decade, electronic government has become an important topic of interest. Various authors have presented different views and approaches towards the development of the digital government, especially the stages of transformation, among them are Reece (2006), Norris and Lloyd (2006), Dixon (2010), Kromidha et al (2014), Jenssen (2015),

etc. During the 1990s, research on e-government consisted primarily of studies with an explanatory rather than practical focus as to the limited adoption among governments and politicians. However, in the middle of the 00s theoretical frameworks began to be supported by quantitative empirical research and allowed the further deeper of the digital government systematic analysis [61].

Among those works, there is plenty of literature that sheds light on the evolution of the digital government, as well as its growth. Although there is a great academic background of studies focusing on the development of the digital government, further in this section some of the models would be analyzed in order to view the concept from various perspectives.

Gartner's 4-stage model. One most widespread approach towards the classification of e-government development was published in 2000 by the Gartner Group titled "Gartner's Four Phases of e-Government Model". The aim was to identify 4 phases of e-government development to evolve the progress, factors, and strategy leading the country to success on each step. The framework for E-governance consists of four stages: Presence, Interaction, Transaction, and Transformation. It is not mandatory to incorporate all four stages or commence from the initial stage, as the decision can be made based on individual requirements [3].

1. Presence. This is the initial phase where a government provides information through the national website or in other forms of e-delivering information (e-brochures etc) without actual citizens' involvement in the process. The stage is characterized as low-cost, passive, and with limited functions.

2. Interaction. This phase is also addressed as an advanced form of the first stage, as it brings more interaction between the government and stakeholders. Two-way communication is built through using E-mail, feedback forms, chat databases etc. with a further response. Therefore, it enables transparency, accountability, and trust and reduces physical interaction, as well as time resources.

3. Transaction. The third stage facilitates electronic transactions and simplifies government processes for citizens, businesses, and departments. It involves a higher level of interaction than the previous stage, with a one-way flow of information from the

government to the client or vice versa. The transaction phase enables online transactions such as tax payments, license renewals, and contract procurement bids.

4. Transformation. The highest level of E-governance initiatives involves the full use of available advanced technology to transform government services, with a two-way flow of information to improve stakeholder relationships. The main advantage of this stage is the seamless flow of information and collaborative decision-making among various groups, which removes organizational barriers and reduces bureaucratic behavior.

Figure 1.2 from Baum & Maio (2000) summarizes the approach described above and provides a 4-dimension view using subcomponents as policy, people, processes, and technologies involved in governmental digital transformation in each of the development stages.

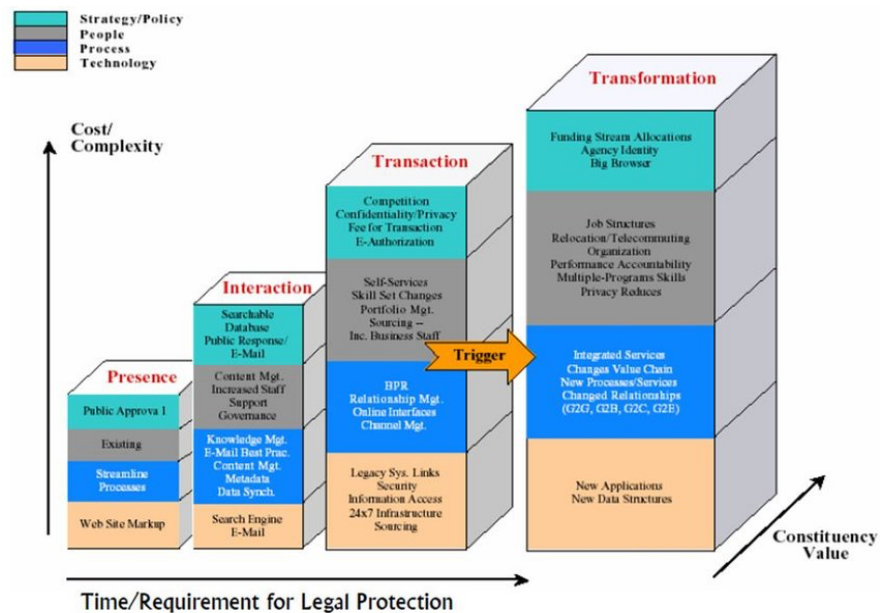


Figure 1.2 - The theoretical approach of Gartner's 4-stage model

Source: Baum & Maio (2000) [3]

World Bank 3-phase model. In 2002 Centre for Democracy and Technology in World Bank published the Handbook aimed to provide guidance on e-government implementation through a model consisting of 3 phases of development namely: publishing, interacting and transacting.

1. Publishing. Publishing government information online using ICTs, mainly through websites. The main goal is to ease and expand access to information to

stakeholders. The handbook emphasizes that the information needs to be valuable, regularly updated, divided into the national and local levels, and published by various governmental agencies.

2. **Interacting.** Expanding stakeholder participation in the governmental processes involving two-way communication using email, feedback forms, forums, etc in order to increase trust and transparency. The authors highlight the importance of the governmental response, simplifying information, and collaborative engagement in the design process.

3. **Transacting.** The focus of the phase is to make governmental services available online through the automatization and modernization of bureaucratic procedures, mainly in the areas connected with the financial matters like tax collection. Transaction implementation allows to reduce of corruption, physical interaction, and time, enhance revenues and elevate trust. Moreover, the Handbook provides recommendations on such projects to be target-oriented, held through special portals, and well-tested before launching.

IBM 4-waves model. In 2003 the four-wave model framework was developed by IBM for evaluating the progress of e-government initiatives. The model offers a guidance system for governments to assess their e-government efforts and recognize opportunities for advancement [33].

1. **Automate:** automating government processes and providing citizens with access to information through an online presence.

2. **Enhance:** make modifications to enable user interaction without reengineering existing processes and policies.

3. **Integrate:** requires a more radical change, planning greater integration of business processes and collaboration within the governmental agencies and departments

4. **On-demand:** requires a significant transformation and re-engineering of working culture, infrastructure, and business processes to adapt to forecasted demand.

The five stages of evolution approach. Since 2015 the QUT Centre for Digital Economy has been working on the topic of digital government development, which resulted in

developing the framework for the maturity stages of governmental public services. The concept districts the 5 stages of evolution from “Government 1.0” to “Government 5.0” respectively. Along with stage identification, the framework reflects the evolution trends in public services, as well as tries to predict the further direction of development [38].

1.0. Emergence. Governments provide standalone services focusing on expanding proper access via different channels as well as the quality of service. However, this results in the absence of cross-department integration and providing individual communication with stakeholders.

2.0. Industrializing. The focus of governments shifts towards the widespread implementation of digital services, with a particular emphasis on expanding the range and quantity of services offered, concentrating on the value chain, and yet preserving a high-quality experience.

3.0. Automation. The emphasis is on improving operating models to increase efficiency in service delivery concentrating on the improvement of the operating model. This may involve reducing the number of government services and platforms available but aligning service delivery across different government agencies to achieve a more integrated and seamless digital government.

4.0. Digitalizing. At this stage, the focus is on the business model by aligning the government towards a single entity through expanding the interaction within departments and agencies and providing clients with new and unique value and connectivity. Thus, at this stage comes the realization of developing the citizen-centric model.

5.0. Personalization. The efforts towards creating a citizen-centric model that would rather serve citizens than them. The main idea is to align services and processes with the daily lives of residents, thus minimizing the intervention and making it more seamless to serve the life-long relationship.

The main stages of the governmental evolution are provided in the Figure 1.3 below from the Report from the Chair in Digital Economy partnership on the evolution of e-government. It provides valuable insights into how governments are being transformed and enables the understanding of key focus areas, as well as enablers of such changes.

Such a framework is helpful particularly when talking about the analysis of the specific governmental system and providing policy and strategic recommendations [38].

Evolution	1.0	2.0	3.0	4.0	5.0
Title	EMERGENCE	INDUSTRIALISING	AUTOMATION	DIGITALISATION	PERSONALISATION
Description	Individual service delivery	Scaling service delivery (volume/variety)	Efficient service delivery	Whole-of-government service delivery	Whole-of-Life service delivery
Focus	Service access	Value chain	Operating model	Business model	Citizen model
KPI	Quality	Equitability	Practicality	Connectivity	Desirability
Enablers	Service designers	Operating officers (volume) Service designers (variety)	Operating officers	Cross-department teams Whole-of-government experience designers	Cross-government teams and partnerships

Figure 1.3. - The theoretical framework for the E-Government evolution stages

Source: Kowalkiewicz, M. and Dootson, P. (2019) [38].

Overall, across the aforementioned models, great assimilation could be found. The first stage is generally referred to as information broadcasting using the ICTs, as well as the second phase which is used to create an interaction with the citizens. Depending on the model, the third and fourth stages focus on the expansion of services and implementing transactions. The last phase is commonly described as a radically transformed e-government operating model.

The models discussed above try to assist policymakers in evaluating and measuring the level of development achieved. However, it is important to note that there is no universally standardized model that can be applied across all countries. Rather, the appropriate model to be used should be determined based on the unique characteristics and circumstances of each country.

1.3 Theoretical Foundations for the public finance sector

Before moving to how public finance was reshaped over the past decade, this section is focused on the defining main aspects of the public finance sector, key

components, and approaches towards defining the essence of the digital transformation of this sector.

Studies conducted on the topic of public finance provide diverse opinions on the public finance essence and structure. Generally, public finance is a key component of the national financial system and is used to influence economic and social welfare. For instance, Zagorodnyuk A. and Voznyuk G. highlight the economic perspective of public finance as a set of relations regarding the formation and allocation of national financial resources between government, business entities, and citizens. Kudryashov V., on the other hand, views public finance from the fiscal perception as a set of all state financial resources used for covering government performance.

Harvey S. Rose suggests that public finance is the field focusing on the microeconomic governmental management of both real and financial resources [63, p. 2]. At the same time, Corporate Finance Institute (CFI) provides a more grounded opinion on the public finance definition: the management of the governmental revenue, expenditures, and debt burden through specific institutional bodies.

Similarly, there are a few variations of frameworks behind the public finance system. For instance, in Ukraine, it is generally accepted that public finance consists of all-level budgets, budgetary funds, governmental debt, and finances of state and municipal enterprises (Abramova, M. G. Marich, et al, 2018). On the other hand, has a similar approach, which identifies further elements: tax collection, expenditures, national budget, national debt, and deficit/surplus. Ukrainian scientist, Anna Nechai identifies the public finance ecosystem adjusted to Ukrainian reality with further components [107]:

1. State public finance developed because of budget creation and allocation, as well as public funds usage.
2. Social assistance within funds allocation to fulfill social needs. This includes all of the government payments like social security benefits, pensions, insurance, etc.
3. Public finance under local authorities' jurisdiction.

There is no one unified theoretical approach that describes the ecosystem of public finance. According to Corporate Finance Institute (CFI), there could be defined through activities related to 5 main components:

- Tax collection;
- National Budget;
- Public expenditures;
- National debt;
- Deficit/Surplus.

Taking into account above mentioned approaches, in this work the alternative system of public finance will be used as a base for interpreting the digital transformation process in the field. It consists of 4 main elements:

- Revenue (tax and non-tax) - total state income both on national and local levels divided by the source of the collection;
- Expenditures;
- National debt;
- All-level budget;

Although there are a lot of diverse ways to define public finance, the main point is that it is a key element in the financial system, arising from various interactions with state financial resources and ensuring efficient governmental performance.

Another important figure in the public finance ecosystem is The Ministry of Finance, as it is considered the main governmental body responsible for implementing the state policy on public finance including Budgetary, Tax and Customs, Debt, and financial policies. Overseeing public finance management, MoF ensures efficient policy implication, enables government performance, as well as creates ground for financial stability based on transparency, openness, and accountability. Among the main state executives managed by MoF are the State Tax, Treasury, Customs, Audit, And Fin Monitoring Services of Ukraine. Moreover, from 2020, each of these agencies, as well as the MoF, are assigned to create a Digital Transformation and Development Department for managing projects and initiatives regarded as implementing digital tools [101].

In the world of public finance, everything is about money and processes related to using, raising, and allocating them. Thus, another crucial term in the case of public finance understanding is public finance management (PFM).

The system aimed to define such interactions as managing, collecting, and spending public finances is called Public Finance Management (PFM). It plays a vital role in the overall system of public finance: the stronger PFM is, the more benefits it brings to citizens' welfare and economic prosperity (Kristensen, Bowen, et al, 2019). The objective of PFM is aggregate fiscal control (revenue and expenditures are aligned with the target) as well as operational and allocative efficiency (maximum benefits from funds usage, allocating to predetermined priorities in a transparent and accountable way). According to Allen, Hemming, and Potter 2013, the difference between public finance and PFM is that the first one answers the question "what to do" in terms of policy, whereas the second provides the solution to "how to do" [30].

Public finance plays a crucial component in the public sector ecosystem, as it ensures the allocation and management of financial resources supporting the existence of government. Along with the governmental digital transformations, that are discussed above, the same processes are applied in the public finance field. Thus, to have a better understanding on what is the digitalization of public finance, it is essential to discuss the inevitable component of digital transformation in public finance is the Digital Public Infrastructure (DPI) - technological software foundations for creating digital interaction between government and its stakeholders: citizens and business, as well as with other governmental bodies. Moreover, it is impossible to develop a digital financial system without the proper infrastructure [71]. Although there is no universally approved ecosystem, OECD in its Development Cooperation Report 2021, mentions 3 main components: identification (ID) platforms, e-payment systems, and data exchange platforms. However, World Bank in its Digital Financial Services Report also indicates the importance of the more basic infrastructure like ICT coverage, electricity supply, mobile, and data access.

DPI is crucial when discussing the digital transformation of public finance, as it provides the background for the further implementation of digital tools in the financial sector:

- electronic payment systems - online systems enabling transfer between government, households, and businesses using digital intermediaries;

- open government data portals - online software enabling access to state data and shared information such as financial data or budgeting processes;
- electronic procurement systems – a unified platform for streamlining procurement process by using digital tools;
- digital identity systems - online identity verification using e-signatures, biometric authentication, special passwords, or blockchain technologies;
- state (public) financial management systems - software for managing the financial process such as budgeting, accounting, procurement, and reporting on each of step through automation and other digital tools [14].

Thus, it was shown that digitalization in public finance could be defined as a process of using digital technologies, systems, and platforms to digitize the public finance sector. It includes such processes as digitization, digitalization, integration, and automation of financial operations, data, and systems to enhance efficiency, transparency, accountability, and effectiveness in the management of public funds. Moreover, the digital transformation of public finance being a more complex phenomenon consists of a range of financial management areas like budgeting, revenue collection, expenditure tracking, procurement, payment systems, and financial reporting that are digitalized by using ICT technologies. It creates a separate ecosystem of the new, modernized and progressive public finance sector.

Conclusions to Chapter 1

As the overall theoretical approaches are provided in this chapter, it was first discussed the crucial terminology for understanding the essence of digital transformation, including digitization, and digitalization from various perspectives: social, cultural, economic, and technological. It was indicated that although there is a difference in the nature and characteristics of this process, they are interrelated and combine a wholesome ground for digital transformation in general.

On the basis of the literature review, the theory of the digital transformation of the public sector, as a more complex phenomenon was provided. The concept of digital government as a foundation for further digital transformation in the public sector, and specifically public finance was researched in the chapter as well. According to the evolutionary approach, the digital government uses different digital tools, policies, and strategies depending on the degree of technological, social, and institutional background. The outcome of each stage of the e-government development varies as well, with higher returns in the last stages. Therefore, it is important to ensure the use of appropriate policy methods, regulatory frameworks, and ICT instruments depending on the current state of development.

Lastly, it was given the framework for the public finance theory, indicating the main components, including the public finance management system, budgeting, national debt, revenue collection, and expenditures. It was indicated that the use of digital public infrastructure provides a foundation for further digital transformation of the public finance area. It is a complex phenomenon involving the use of ICT technologies for the digitalization of each of the components and enabling a new digital ecosystem, where governance provides more efficient and transparent services.

Finally, as could be seen from the literature overview, the scientific world has not yet set a single perception of the theoretical approach toward the digital development of public state fields. Moreover, there is no clear differentiation of the digitization of processes within the public service sector, particularly, one that would exclusively describe the transformation of public finance. Thus, this means that there is a need to

distinguish a separate area aimed specifically at studying the digitalization of public finance both in the global context and at the national level, taking into account the specifics of each country's development.

CHAPTER 2. ANALYSIS OF GLOBAL AND UKRAINIAN STATE IN DIGITAL TRANSFORMATION OF PUBLIC FINANCE

2.1 Trends in public finance digital transformation

Digital transformation has become a phenomenon in the last decade, due to the rapid development of ICT. There is no choice of staying behind in the process of the digital revolution. Therefore, as demonstrated in the previous section, governments are steadily transforming into more flexible and electronic structures, making the digitalization of public processes a priority policy. The advance of digitalization of public finance has especially raised after the pandemic, and made it crucial for governments to implement digital solutions.

This section aims to provide an outlook on the global tendencies in public finance digital transformation, as well as show the international implication of digital technologies in the public finance management system. Although digital tools usage in public sectors is considered to be governmental agenda, due to advanced technologies advancement the degree of newly developed features depends on the country's development.

As the years pass, technologies advance in development, such as digital transformation on various levels - worldwide, national, local or regional. According to the UN Survey 2022, the overall E-Government Index value has risen in 2 years by 0.2. Among the group leaders are mostly European and Asian Countries. However, it was indicated that generally, especially after the pandemic, digital transformation in the public sector was mostly in fields like health and education. Public finance was mainly transformed due to the social protection payments digitalization, namely governments enabling online applications and receiving social assistance [80]. This was allowed due to the development of Digital Financial Services (DFS) and its further advancement. The diffusion of online services has increased as well, having such a tendency for the past 5 years even despite the pandemic crisis. However, there is no evidence that the outcomes of the Russian invasion of Ukraine have already been outlined here. Though,

there is still a risk of the separate groups of the population being endangered, especially people in poverty, immigrants, women, people with disabilities, etc. Therefore, there is a need to focus that the benefits of digitalization are even for each group. In Figure 2.1 key trends for the past 5 years are summaries according to the E-Government Index

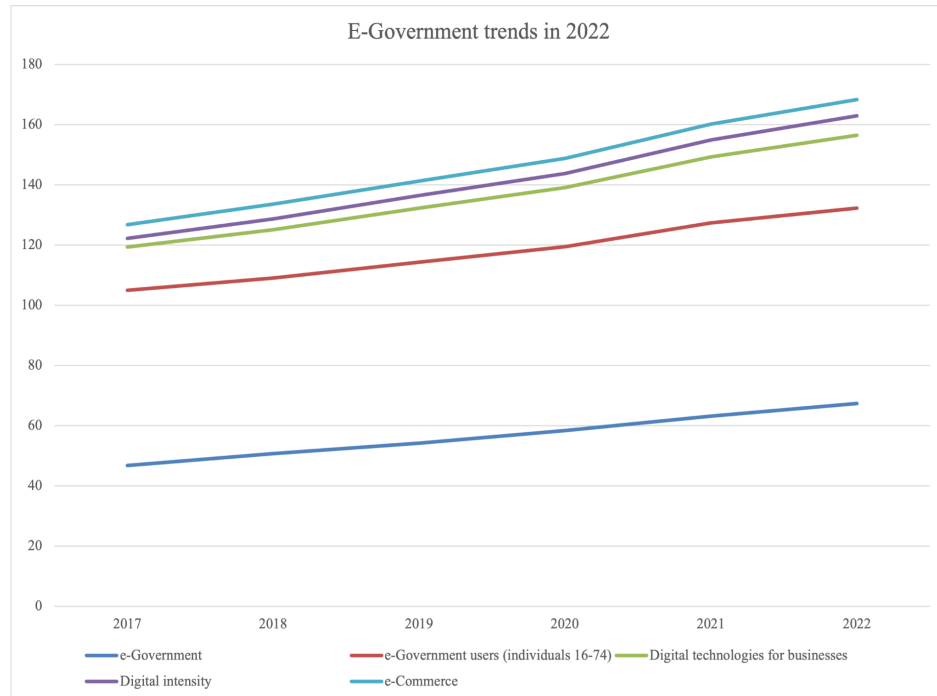


Figure 2.1 – Worldwide E-Government trends in 2022 according to the DESI Index 2022

Source: own calculations based on data [21]

Along with this trend, the rapid pace of the digital revolution increases the importance of cybersecurity and data privacy. European Union has recently updated its Data Privacy regulations. It was estimated that in 2020 the cybersecurity costs from committed crimes doubled since 2015 [23]. Moreover, after the pandemic, even more, users have become vulnerable to cyber-attacks and frauds and are being indicated as a 2nd risk. Thus, there is a general trend of focusing on security more than on the pace of digitalization, especially among more developed countries. Among popular tools are Data encryption used for securing ID signatures (Estonia), E-Payments (Kenia), or other fields. European Commission has even recently launched the European Cybersecurity Investment Platform (ECIP) in order to provide assistance to European countries in this area.

According to Open Budget Survey 2021, although accountability has been

indicated to stay weak, and budget oversight and public participation showed negative tendencies, COVID-19 mostly had not changed an increasing trend in transparency (Figure 2.2). However, there is still no example of combining all adequate requirements in three dimensions of the Index, especially in the category of public engagement. This could be due to the increased tendency in public finance digitalization for the past two years, as well as the strengthening of the overall institutionalization base of digitalization. Among leaders, that have climbed up the ladder and experienced positive changes are African Countries – Nigeria and Gambia, Benin, as well as Georgia from the European continent [56].

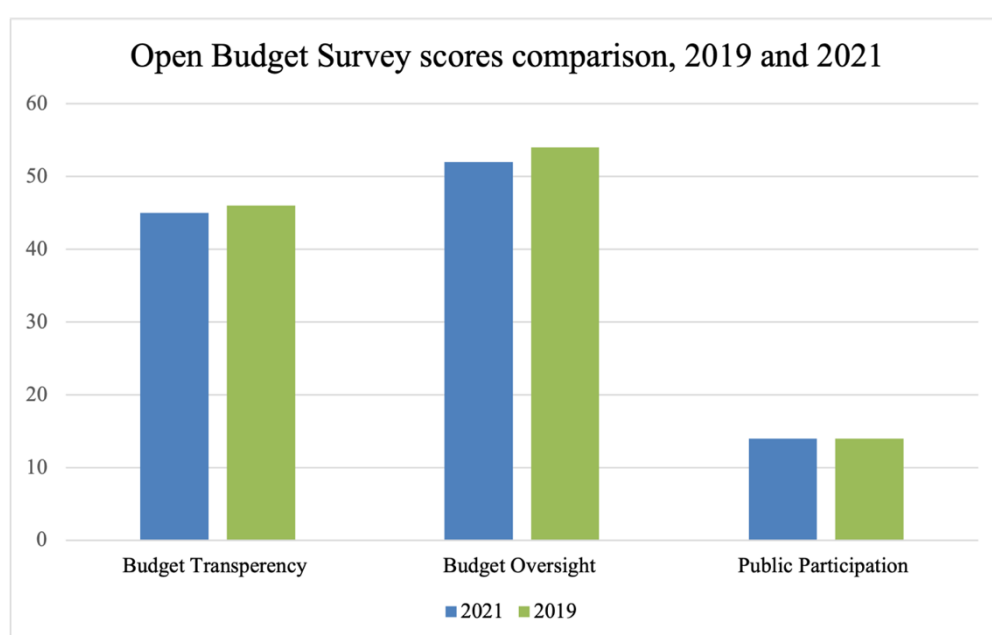


Figure 2.2 – Trends on Budget Transparency in 2019 and 2021

Source: author's calculations based on data [56].

In terms of the technological perspective, the most used tools for digitalization in public finance are Open Data, robotic automation, cloud computing, as well as blockchain, and artificial intelligence. The most popular areas of use are risk assessment, budget monitoring, data analysis as well as predictive modeling.

Overall, now the governments are concentrating more on engaging the public in the financial governmental process – Georgia launched a web portal for collecting people's opinions on budget priorities and South Africa created pre-budget consultations, and Argentina announced public groups for discussing auditing processes. It was also

defined that more countries decided to advance the mechanism of government-public participation by creating new forms of participation, sharing more relative and open information, and easing the way of public involvement in the public financial processes. However, the budgeting process participation still remains reserved according to the given evidence in the survey.

The European Union's choice to concentrate on digital development has begun mostly since the end of the XX century - the beginning of the XXI by drafting early principles and approaches for ICT development. It enables the implementation of a legal environment, sets goals, and prioritizes digitalization direction. In terms of the public sector, including public finance, and digital development EU has created several Strategic Documents like Digital Europe Program identifying development for the next decade [22].

As could be understood from the theoretical chapter, the ecosystem of the digital government involves the transformation of the digital public sector, which, in turn, includes the transformation of the public finance field.

Since the active digital diffusion and government digitalization, a lot of indicators and indexes appeared to help countries track their development dynamic in terms of digitalization. For instance, the UN E-Government Development Index, Digital Economy, and Society Index from the European Commission, OECD Digital Government Index, as well as others like Global Open Data, Open Budget Index, or OECD Open Government Index, and capturing other digital dimensions.

EU countries are considered to have a high degree of e-public services and infrastructure implementation. According to E-Government Development Index, 5 out of TOP-10 ranked countries in 2022 are Denmark (1st), Finland (2nd), Sweden (5th), Estonia (8th), and Netherlands (10th).

Digital Economy and Society Index were created in 2014 to track the digital development of EU members to help the countries analyze their performance in dynamic (Figure 2.3)

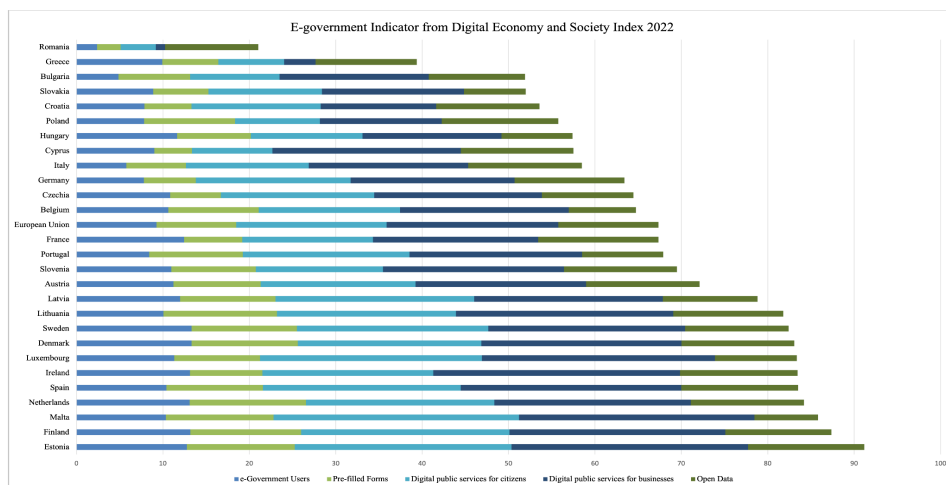


Figure 2.3 - E-Government Indicator by Digital Economy and Society Index (DESI) 2022

Sources: author's calculations based on data [21].

Estonia is considered to be a great example of efficient digitalization in public finance. Moreover, it is a European superior in digital public services, especially in the financial field. As a post-soviet country, which is now classified as a high-income country, it was one of the first headings towards digitalization (in 1996 Estonia launched the first IT infrastructure project development). Among the key focuses of Estonia in the digitalization of the public financial sector are cybersecurity, advancing ICT coverage, and further implementation of new technologies in digitizing state services [21].

In order to build proper DPI, the Estonian government has digitized the identity authentication system by creating digital ID cards and signatures allowing transparent social assistance, which now saves around 2% of GDP each year. Secondly, it made a famous data processing system X-road allowing fast and cheap data exchange within the governmental structure. According to DESI (Digital Economy and Society Index), the E-Tax system was created to enable online tax declaration, which eases the process, thus, now taxes could be paid in up to 3 minutes using automatically filled forms and approved with a digital signature [73].

On the other hand, India is classified as a lower-middle-income country (according to the World Bank classification) and has made an enormous digital revolution since 2009. Among the main principles are: corruption reduction, optimization of funds allocation, and stimulating tax revenue. It ensures highly valued DPI - India Stack

consisting of 3 key components: ID system, complex e-payment ecosystem, and data exchange platforms. It enables quick social transfers directly from treasuries using Direct Benefit Transfer, which saved around 1.1% of GDP during the COVID-19 pandemic. Moreover, it allowed 87% of the poorest to receive instant financial help. For the past 5 years, the Indian e-tax system GST attracted nearly 9 billion taxpayers, thus increasing revenues enormously [65].

It was estimated that Digital Financial System implementation reduced poverty by 2% (Suri and Jack, 2016). Among other effects, corruption has been declining since iTax launched, as well as reducing time and costs for tax processing and generating an increase in tax revenue.

Figure 2.4 presents the e-government development trends in lower-middle-income countries.

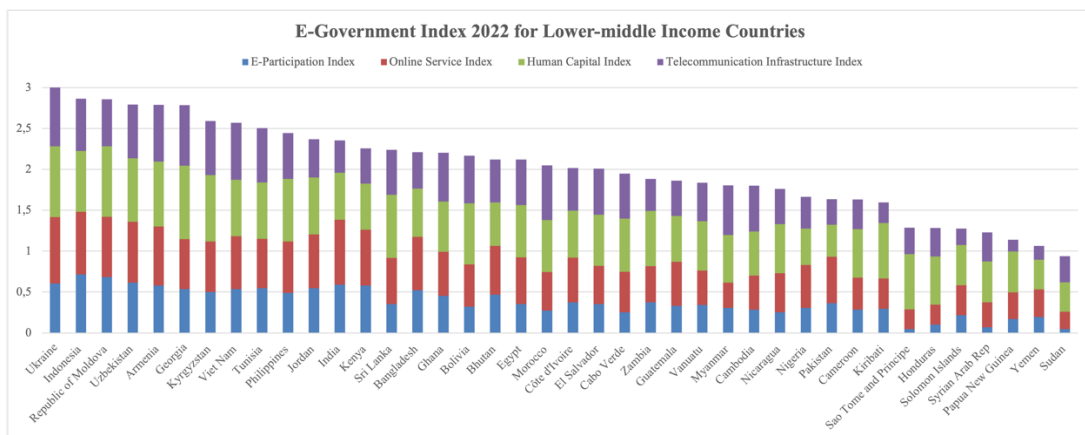


Figure 2.4 – E-government Index for Lower-middle income countries 2022

Source: own calculations based on data [80]

1.2 Opportunities and Challenges in the Digitalization of public finance

The digital revolution has transformed the way public finance operates, along with financial management systems, public service delivery, and decision-making procedures. With the advancing of technologies and rapid e-government approaches development, a lot of countries enhanced the integration of those tools in a public finance management system, as well as in other fields of public finance realizing the outcome of using such methods. Without a doubt, the digitalization of public finance has opened a new, more efficient reality for governments.

First of all, by embracing digital tools in the public finance sector government could improve operational efficiency and enable cost savings. By automating and streamlining financial processes operational efficiency is improved. Digital infrastructures for budgeting, e-transfers, payment systems, procurement, and processing can enable cost savings, reduce administrative burdens, and efficiently allocate resources.

Secondly, it also provides financial transparency and accountability by launching open data initiatives, and financial records, and providing information on financial data to provide transparency and facilitate efficient public decision-making and better allocation. It also provides accounting and tracking activities more effectively and at a smaller cost. Digital technologies like machine learning and artificial intelligence make it possible to identify fraud, and risk activities through automated approaches.

Thirdly, it provides efficient Service Delivery and public engagement with online portals, and digital platforms, so that citizens can conveniently government services, receive and make payments, and feedback. It improves the accessibility and convenience of public services and encourages citizen participation in financial decision-making processes. By adopting a citizen-centric approach to service delivery, governments can foster greater engagement, responsiveness, and inclusivity in serving the needs of their constituents.

Moreover, digitalization enables data analytics, governments can gain insights into financial patterns, trends, and performance indicators that support evidence-based policymaking. Additionally, it provides efficient resource allocation according to digital tools and data analytics, By analyzing financial data, governments gain insights into areas of inefficiency, enabling them to allocate resources. The digitalization of public finance allows for increasing revenue collection mainly by digitalizing tax compliance and management. State agencies have now wider access to information for data exchange platforms, automated form filling, online tax decorations, etc. Moreover, as a result of e-payments and e-transfers and e-wallets taxation administration has become easier [37].

Digitalization of public finance creates a huge potential for governments to increase their performance, and transparency and ensure efficient reactions to public needs. However, along with such opportunities, a lot of challenges may appear. This section

provides the outlook of the possible problems and risks appearing while the resolution in public finance.

The first challenge that appears as far as mentioning digital transformation is technological. For instance, outdated ICT infrastructure or lack of newly implemented technological developments. It could be raised from the low financial abilities of the government, an insufficient strategy of digitalization, the unwillingness of the citizens, or other factors. This also leads to the other problem of the technological gap, as some people (preferably living in urban areas) have more access to modern services, or even basic ones rather than the ones living in rural areas. This is also an evidence-based assumption: ITU states that about 76% of all urban dwellers use the internet, whereas the number for rural residents is twice less - 39%. Moreover, this gap is even bigger in Africa (50% and 15% namely), whereas in Europe the difference is only about 7% in favor of cities [35].

The next problem is the increasing gap between the countries with different incomes. The tendency is generally the same as in the previous case - more developed countries have greater access to more innovative tools. This could be addressed as the digital gap raised from financial, legislative, and institutional barriers. This leads to further inequality between the development and availability of benefits between countries (for instance European and African) and within countries (based on gender, education, and social status) leading to even bigger obstacles in transformation. This should be fought on both national and international levels [48].

Possible solutions for such technological obstacles are the development of a regulatory basis and friendly system for digital business and increasing the private and international financial investments in the country. State support is crucial as well. It could be in the form of subsidies for internet usage for vulnerable groups and businesses (such an experience was introduced in Nepal) and expanding the internet connection broadly [50].

This could be done by optimizing expenditures and revising the tax compliance as for the digital transformation. Moreover, governments should be able to cover basic needs like education and health, especially reaching the weakest households. Government should provide accessible, user-friendly, and secure services, gaining benefits from

digitalization.

Next, not all governments had built a proper legal framework for the digitalization of public financial services and data protection. There is also a problem in the degree difference between the comprehensiveness of the paper and electronic-based frameworks regulations. However, in most countries such phenomena, as digital signatures have been implemented and well-regulated (like Denmark and Sweden), the legislation is hard to be fully adapted to all of the new technologies concerning financial and document management. All countries should address the problem of the legal value of such documents and further actions, by updating frameworks towards more complex and comprehensive policies including the regulations for modern technological tools [81].

Within the same problem, the other hot problem is raised. With the advancement in digitalization, more open data has become. Thus, the risk of the low data protection instruments has been raised. It indicates controlling the access to user's data like taxpayers' numbers or financial data history to tackle the cybersecurity risks. Moreover, it is important to have a balance between the demand for open state data, which is crucial for governmental effectiveness, and protecting data for households and businesses as government openness could be possessed as information spilling. Again, this relates to having a proper Data protection law such as The General Data Protection Regulation (GDPR) in the EU [8].

However, there is a hidden risk of being trapped in lowering digital development for the fear of being caught in the middle of unobserved risks. This is more relatable for EU countries, which have historically strong institutional and law heritage and are developed enough to be able to lower the development level in digitalization. Moreover, digitalization in public finance requires changes in organizational culture, processes, and workflows, which some governmental ecosystems may see as an obstacle and expenditures on shifting policies and frameworks towards more flexibility.

According to Long, C., Cangiano, M., Middleton, E., et al. (2023) countries with lower economic development are the ones to have more benefits from government digitalization, especially public finance. Thus, for countries like Kenya or Ukraine, digitalization of public finance could be a path toward more developed economies without

paying a lot of attention to the legislative framework. Therefore, the balance between security, residential openness towards new services, and the possible benefits should be reached.

Finally, the availability and quality of human capital are also considered to be a challenge when discussing digitalization in public finance. The gap in skills is being addressed as one of the major concerns in digital transformation. On a management level, unskilled officials may lead to limited and insufficient use of digital technologies, without clear strategic vision and source allocation. This is addressed not only to those involved in tech positions but particularly those who do not have enough IT skills to use technologies. Moreover, unskilled society is less intense in both using and demanding further digitalization. This relationship will be described in the further section. Human capital development levels must be balanced with the ICT infrastructure degree, so as to avoid rising inequality. For instance, the government cannot just transfer all of the society only through e-platforms. In turn, the government should first ensure the availability of basic needs to compile such actions. It could be done by providing digital education free of charge, as well as ensuring access to essential infrastructure [15].

2.3 Overview of existing digital transformation projects in public finance in Ukraine

With the advancement of technology and e-governments around the globe, countries have been exploring possibilities of digital transformation to modernize financial systems and provide further economic growth. In recent years, more and more countries made digital transformation one of their key strategic aims, and Ukraine is not exception. This decade became a starting point for Ukraine to maximize efforts on digitizing public finances and gain benefits from it.

This section aims to provide an analysis of the current state of digital transformation of public finance in Ukraine, examining the progress made so far, the challenges faced, and the potential for further development.

On February 18, 2021, The Ministry of Digital Transformation presented a news special public portal with 94 projects of digital transformation in 23 key areas, including

public finance. The aim is to launch an online dashboard with each project description, deadlines, and responsible officials for implementation and rankings. Although the portal is still developing and is not fulfilled with all the required information like the current state of progress, it is still a useful tool helping to see the current state of steps taken so far and further implementation plan. As of 2023, there are 10 projects and 36 sub-projects of digital transformation of public finance. They are summarized in Table 2.1 below.

Table 2.1 Description of key electronical projects in public finance according to The Ministry of Digital Transformation Dashboard

Project name	Project description	Due dates	Responsible state agency
E-Auditor (8 subprojects)	Development and implementation of e-auditor system aiming to increase efficiency of financial control, transparency guarantees, quality and accountability of state agencies	2021-2022	State Audit Service of Ukraine
E-Financial monitoring (2 subprojects)	Prevention and combating to money laundering of proceeds of crime, terrorist financing and other crime	2021	State Service for Financial Monitoring
E-Treasury (1 subproject)	Paperless treasury procedures such as refund of funds erroneously and/or excessively credited to the budget, upon submission of the authorities controlling the collection of budget revenues	2021	State Treasury
E-Taxes (7 subprojects)	E-services for taxpayers based on unified state web portal of administrative services, automation of monitoring tax effectiveness procedures, as well as tax audits, international financial data exchange standards implementation, and launching archive of electronic documents.	2021	State Tax Service

Continuation of table 2.1

E-PTR (3 subprojects)	Development of an information system for the collection, storage, and use of data from payment transaction recorders and software payment transaction recorders	2021-2022	State Tax Service
E-Excise Tax (2 subprojects)	Creation of an information system for automating the work of customs authorities, introduction of electronic customs clearance services for foreign economic operators, automation, control and creation of analytical tools and public reporting tools	2022	State Tax Service
E-Customs (6 subprojects)	Creation of an information system for automating the work of customs authorities, introduction of electronic customs clearance services for foreign economic operators, automation, control and simplification of customs control and customs clearance processes, creation of analytical tools and public reporting tools, automation of checkpoints and customs clearance points	2021-2022	State Customs Service
E-Liquidity (3 subprojects)	Automation of liquidity calculation and forecasting	2022	The Ministry of Finance
E-local budgets (1 subproject)	E-interaction with local financial authorities, automation of interaction with the State Treasury Service and the State Tax Service on local budget execution and tax payments	2021	The Ministry of Finance
E-Budget (3 subprojects)	E-interaction with each of the of budget processes: planning, creation, execution, as well as implementation information system for budget planning and execution	2023	The Ministry of Finance

Source: author`s compilation based on data [104].

Because of the ongoing war and priorities changing, not all of the projects were able to be fully developed up the due date. Therefore, in the following section, the key e-services and projects that are currently developing and operating will be discussed.

Open Data Platforms.

On September 15, 2015, a revolutionary project “E-data” was created, which shifted the area of public finance in Ukraine. The story behind the project dates back to drafting the law about the openness of usage of public funds, which was accepted in 2015 after 2 years of consideration by the government. Shortly after that, on September 15, 2015, the Ministry of Finance announced the creation of the single web portal e-data.gov.ua according to Open Public Finance Data Act №183-VIII [110].

It is crucial to mention that in 2017 the Ministry of Finance initiated the creation of the state institution “Open Public Finance” to ensure technical administration for the above-mentioned projects related to the concept of open public finance. Nowadays, institutions take care of 3 open data portals from the “E-data” group, user verifications systems, full assistance of DWH, and infrastructure maintenance. Since then the platform has been constantly developing and consists of 3 units: Spending.gov.ua, Openbudget.gov.ua, and Proifi.gov.ua [18].

Spending.gov.ua - governmental open data site on the public finance usage from both regional and state budgets

Created in September 15, 2015, as a project “Treasury Transactions” platform implements Open Public Finance Data Act №183-VIII making the government more transparent and accountable. In 2019 it became part of the Open Budget project as an independent unit under the title “Spending”. Among data published in the platform in various formats is information on:

- payment transactions of governmental institutions, The Pension Fund, as well as social insurance funds;
- reports on the amount of financial resources receipt by recipients, budgets execution, number of payments made etc.;

- concluded agreements submitted by recipients and managers of the funds, contract execution invoices, as well as payment penalties information;
- key indicators: number and the total amount of featured transactions and documents, user activity indicators, and breakdown structure on registered entities.

Openbudget.gov.ua – an official governmental platform developed for providing people with budget policy information.

Launched on September 15, 2018, by the Ministry of Finance as a response to the Transparent Budget Concept. It makes government-citizens' communication more transparent by spreading information about financial resource allocation and giving them the possibility to actively participate in budget formation processes.

Among the information that the web portal include is:

- Ukrainian budget system structure;
- budget (local, state, communal) performance indicators;
- debt performance indicators;
- glossary with terminology related to budget policy;
- information about budget processes and their stakeholders.

Proifi.gov.ua - state platform with open data on social and economic development projects of Ukraine implemented using international financial organization`s funds.

It was created on October 18, 2019, implementing Corruption Preventing Act № 803-p to publicly feature the usage of involved resources from IFOs to increase transparency [94]. Within the platform, further information could be found:

- comprehensive project information like status, stakeholders, responsible parties, results, and reports on project implementation;
- such indicators as funds allocation dynamics, breakdown structure of funds usage by lender, sector, and responsible executors;
- terminology for better understanding the data;

Data uploading is made in Cooperation with IFO's Department. For all three units data could be downloaded via the public Application Programming Interface (API).

“E-data” platform also provides users with several analytical and monitoring tools, as well as Data Warehouse (DWH - data management system for data reporting and analysis) unit [18].

- Boost-analysis - developed in accordance with World Bank methodology, analytical tools functioning as “X-rays” for public finance. As a part of the Open Budget module, it allows budget indicators analysis on each level (state, local, communal) in different aspects (income, expenses, loans, etc.). Multi-dimensional tables, deep budget policy, and trends analysis - not even the full list of functions. The tool contributes to budget transparency, better decision-making processes, as well as efficient forecasting.

- State-owned banks - present key performance indicators for state-owned banks in the form of reports.

- Debt policy - data register of state guarantees, auction details, and dealer lists. After the full-scale war provides information about Governmental Bonds Issued during the wartime.

- VAT Refund - data register with applications for value-add tax refund (as the new mechanism for a tax refund was presented in April 2017). Aims to make this mechanism transparent, and reduce corruption and fraud, by creating equal conditions for taxpayers.

- Education expenditures - analytical tool ensuring the ability for the public to analyze educational institutions' financial activities.

Moreover, the platform also offers additional extensions:

- Extension for Chrome;
- Telegram-Bot;
- Educational courses and materials;
- Widgets for better visualizations;
- E-Indexes and E-Ratings, where Ukraine participates.

E-procurement systems.

In 2016 Ukraine started its path to being even more digitized and transparent, as of the creation of the official open source data portal Prozorro with the comprehensive

information on public purchasing on all Ukrainian tenders created in accordance with the Public Procurement Law [60]. Prozorro is an hybrid e-procurement public platform for tender announcements from state and municipal customers, and business representatives for competing for announced supply opportunities. It has more than 35,000 customers and 250,000 suppliers, who announce their need through Prozorro Market - directly from governmental e-catalog, or separately on either of 13 e-market platforms accepted by the system with further auction participation. After announcement this information is being shared in the Prozorro database, as well as on all e-market platforms. Before 2016, the public procurement area was data-closed, with tender information being published in one paper magazine with limited copies, bought by interested parties to speculate on deals. Therefore, volunteers initiated a reform of public procurement, sales and leases, right after the Revolution of Dignity in 2014. Platform development was in cooperation with NGO Transparency International Ukraine, foreign experts, other e-platforms, private IT company Quintagroup, and the Ministry of Economy without governmental financial funds. In 2016 Prozorro became 100% state-owned after transferring rights from Quintagroup to GO "Prozorro", subordinating agency of the Cabinet of Ministers. On April 1, 2016 - according to the adapted Public Procurement Law central executive authorities and existing market monopolists were obligated to use Prozorro, and on August 1, 2016 - for other governmental and public executives. Since then, the system is constantly developing, receiving worldwide recognition, among which are: best public procurement reform award (World Procurement Awards 2016), Open Governments Award winner (2016), as well as being accepted by The World Bank's standards, named as a recommended model for procurement reform by European Bank for Reconstruction and Development assessed as a most transparent public procurement system according to Transparent Public Procurement Rating.

Additionally, Prozorro has implemented extra tools for analysis and monitoring: Dozorro (platform forum for the community to monitor the procurement made through the Prozorro system, reporting suspected actions or agencies with further investigation from specially created agencies) and BI module (analytical tool containing data on all procurements in the Prozorro system since 2015 in form of charts, tables, and diagrams).

According to Prozorro reports, the number of signed contracts reached UAH 790 billion and UAH 343 thousand e-tenders. Moreover, due to the e-bidding usage on the platform, UAH 45 billion was saved in 2021 as for the transparent process, and business lowering process at the auctions. Despite the ongoing war in 2022, the system was managed not only to continue operating but to recover “pre-war” indicators: from 28% of competitive procurement in February-June 2020, to 44% at the end of the year (compared to 41 at the beginning in 2022). Moreover, the platform continues to implement new features and improve partnership relationships: integration with the Register of Corruption offenses and procedure development in accordance with World Bank methodology allowing to launch of procurement for reconstruction projects, funded by international organizations [95].

Currently, the public procurement area, especially the Prozorro platform, has a huge impact on further economic development and recovery. “The role of public procurement is to ensure the business has full access to the public procurement market to create new work opportunities and increase production capacity by receiving new contracts’ - Deputy Minister of Economy, Nadiia Bigun, said in one of her interviews [61].

Among key strategic goals for 2023 as a part of the Strategy Concept are:

- procurement convenience increasing (Прозручність);
- ensuring efficient implementation of reconstruction projects;
- full procurement chain digitalization;
- new standards and approaches towards procurement procedures: more sustainable procurement, new technology instruments implementation;
- new methods for defense procurement.

E-payment projects

Social governmental payments are an integral part of government expenditures, therefore a crucial component of public finance. Below some of the e-projects will be described in order to gain a better understanding of the transformation of public finance.

According to the Ministry of Finance, nearly 10% of all social expenses are inefficient. Overall, average yearly budget expenses for social areas exceed UAH 700 billion, which is hard to track [112].

In September 2021 the Ukrainian government announced the launching of the Unified Information System of the Social Sphere (UISSS) in some regions - a database containing information about citizens involved with the social support process to make social payment more transparent and accurate. It automates the process of payment calculation, as well as advanced processing of applications, eliminates corruption risks, and ensures reliable storage of data. In October 2022 it was nationally implemented. The Minister of Digital Transformation, Myhailo Fedorov, stated that the project could save up to UAH 11 billion yearly, which partially solves the problem of inefficient funds allocation.

One of the brightest cases in digitizing public finance is governmental payment in terms of the E-Support program created in 2021. At that time there were no other alternatives, considered to be an innovative approach to fighting the consequences of COVID-19. It was aimed to support industries mostly damaged in terms of the pandemic, such as the creative sector, as well as ensure proper levels of vaccinations for COVID-19. Financial aid of 1000 UAH was received through the special virtual card in DIIA from where funds could have been spent only on a specific list of items like books, cinema tickets, etc. to stimulate economic expenditures. In six months of development, it turned from “COVID thousand” to a universal system for convenient government payments.

The full-scale russian invasion of Ukraine has brought enormous negative consequences to economic and social welfare, infrastructure damages, and most importantly, people’s lives. Moreover, it brought a lot of new challenges, like the existence of almost 30% occupied territories, territories with active military actions (as of March 2023 includes 7 oblasts), more than 5 million internally, and nearly 8 million of people moved abroad [77]. Project “russia will pay” was developed in cooperation with governmental bodies, Kyiv-School of Economics, and international organizations to estimate damages due to russian aggression. As of February 2023, the total amount of damages is considered to be \$143.8 billion, including \$600 000 of digital infrastructure

damages and \$40 000 in financial sectors [38]. In such circumstances, the government is supposed to develop quick and efficient reactions to external shocks, ensure efficient allocation of public funds for providing safe circumstances for citizens, and further strategy for post-war reconstruction.

As was discussed above, the Ukrainian government, as well as other countries, managed to undergo essential digital transformation steps (especially after COVID-19), which helps to provide more efficient policies and actions, ensuring citizens' welfare now and can help in the future economic recovery. As was said earlier, temporary occupation of some territories, active military actions, and huge amounts of displaced people creates a problem in governmental financial interaction with citizens, and the inability to receive social payments offline is one of the biggest among them.

For instance, after the full-scale russian invasion, the governmental social platform EDopomoga (EHelp) was created to ensure that Ukrainians affected by the war could receive help either humanitarian or financial from state, volunteers or international organizations. In terms of this study, the interest is considered to be around governmental financial support and its implication. Types of social payments available:

- state financial assistance for IDPs - 2000 UAH (adults), 3000 UAH (people with disabilities and children);
- reporting damaged property;
- compensation of 6500 UAH to an entrepreneur for employing IDPs;
- financial assistance (social payments, pensions, subsidies, financial benefits) to residents of the recently liberated territories, refugees, and Ukrainians living in the temporarily occupied territories;
- instant financial assistance for residents of the recently liberated territories at 5 railway stations so far (Kyiv, Odesa, Kharkiv, Pokrovsk, Zaporizhzhia) [29].

Social payments are available for registered residents in Ukraine through identity identification in DIIA. Financial assistance is received through the virtual card from the program ESupport or a regular Ukrainian state banking card (for social payments) and private card (for entrepreneurs).

Such measures are crucial for supporting Ukrainian citizens and ensuring proper governmental performance. In this case, challenges created due to the full-scale invasion are being solved using digital tools and already existing DPI such as ID systems and e-payments.

E-financial monitoring.

The Financial Monitoring Service of Ukraine in May 2022 has launched a beta version of an electronic platform aimed to access information and services related to financial monitoring for Ukrainian citizens. E-cabinet creates opportunity for individuals and entities to interact with public monitoring authorities, submit reports and applications, receive information and participate in financial monitoring procedures.

The main functions and capabilities of the e-cabinet include:

- Submission of reports on financial transactions to reveal money laundering, fraud, terrorist financing, etc.
- Informational access to materials on financial sanctions, lists of individuals under special control, etc.
- Interaction with financial monitoring authorities to receive consultations, submit requests, and other communication processes.
- Transactions monitoring, defining suspicious transactions and taking further financial monitoring measures.
- Automating and simplifying financial monitoring processes, as well as increasing the efficiency of control over financial transactions and preventing financial laundering and fraud.

The transformation of financial monitoring services is still in development, as could be seen that the first electronic procedure was launched not long before the full-scale invasion.

E-Taxes and Customs initiatives

The collaboration between the State Tax Service and the Ministry of Digital Transformation has resulted in the launching of numerous digital services for convenience

and efficiency for Ukrainian taxpayers. These services include EMalyatko, i-tax numbers, document sharing, and income statements, accessible through the Diia portal.

Furthermore, the Diia portal has expanded its tax services to individual taxpayers. In the My Taxes section of Diia, individuals can access important information on their tax data, payment status, and bank account details. Additionally, taxpayers can conveniently pay taxes and file tax returns for individual entrepreneurs using the simplified taxation system.

This integration of digital services on the Diia portal streamlines the tax process for individuals, providing them with a centralized platform to manage their tax-related affairs efficiently and effectively.

It also plays a crucial role in the implementation of Diia.City, a distinctive legal and tax environment designed specifically for IT companies. Diia.City encompasses the territory of Ukraine and offers pleasant conditions according to the needs of technology businesses, considering individual aspects of the domestic market and competition with other countries [105].

Customs are also being reformed with the purpose of enhancing customs procedures, efficiency improvement, and providing modern and convenient customs services. It involves both modernization of existing processes and the launching of new processes and services, aligning with EU standards. The IT transformation of the State Customs Service includes 6 main aspects: the Cabinet for Interaction with Customs Customs Control and Clearance, Public Reporting and Analytics, Smart Checkpoint, Cybersecurity, and Harmonization with the EU.

Regarding E-Customs project implementation, it will include the following House will execute the following initiatives [36]. Among them are:

- online services for customs clearance, payment of customs duties, obtaining administrative services, and facilitating interaction with other government authorities ;
- automated Customs Clearance System: streamline the clearance process, ensuring efficiency and accuracy in customs operations.
- Electronic Complaints System: a platform for submitting and resolving complaints related to customs service;

- HelpDesk: support and assistance to customs stakeholders;
- Services will be made available to aid in the accurate calculation of customs duties and proper classification of goods, supporting compliance with regulatory requirements;
 - open data; publish relevant data in an open data format, promoting accessibility and accountability.
 - security tools and monitoring of cyber threats.

2.4 International assistance in the digital transformation of public finance

For the past few years, Ukraine has been actively receiving help for further advanced digital transformation in various fields, including public finance. It has given a huge potential for further overall economic and welfare development.

The Ministry of Finance is responsible for developing an international partnership to accelerate the digital development of public finance. This would ensure a multinational exchange of technologies, knowledge, practices and resources. Nowadays, Ukraine has been actively participating in international collaborations and exchanges, as well as receiving financial and technical assistance on ongoing and planned projects. International assistance plays a crucial role in public finance digital transformation, as projects related to digitalization in this field are mainly sponsored by international partners.

Therefore, in this section, information would be presented and analyzed on the completed, current, and potential international projects of technical assistance with the participation of the Ministry of Finance.

According to Reports from The Ministry of Finance of Ukraine and public reports from international partners on receiving technical and financial assistance, Ukraine's biggest partners are Germany, Sweden, Japan, the USA, the UK, The European Bank for Reconstruction and Development, and the European Union, as well as the International Monetary Fund [98].

Key areas of assistance:

- institutional capacity, budget transparency, fiscal risks, tax and customs system;
- small and medium-sized enterprises assistance;
- state-owned banks reform;
- IT support for the development of the Ministry of Finance, as well as accounting and audit;
- improving the performance indicators of the public financial sector of Ukraine in the process of system reforms and implementation of EU standards.

Here and further, we will focus only on the main programs aiming to advance the efficiency of public finance using digital transformation. Key international programs and projects, as well as their implementation details, are shown in Table 2.2

Table 2.2 Information on the programs of digital transformation of public finance with international assistance

Project Name	Funded by	Project aim and description	Budget	Duration
Public Financial Management Support Program for Ukraine (EU4PFM): 1, 3, 4 Components	European Union	Assistance in creating a modern, efficient and transparent revenue collection system, as well as support with development relevant PFM institutions and its organizational capacity	€36 985 000	19.12.2018 – 19.12.2024 (ongoing)
Effective public finance management III	Government of Germany through the Federal Ministry for Economic Cooperation and Development (BMZ)	Strengthening effective public finance management by providing information and experience exchange, consultations, as well IT infrastructure assistance	€3 950 000	01.07.2019 - 30.12.2022

Continuation of table 2.2

E-government support for digital transformation in Ukraine (EGOV4UKRAINE)	European Union	Transparent and accountable governance, efficient public services and advanced digital transformation of the governance	€9 381 649	11.2016 - 08.2021
EU4DigitalUA: Components 1, 4, 5	European Union	Digital transformation support in terms of cyber security and data protection, following EU-Ukraine Agreement, as well as advancing towards the EU Digital Single Market (continuation of EGOV4UKRAINE)	€10 002 600	10.2020 - 03.2024
The USAID Competitive Economy of Ukraine (USAID CEP) program. Component: Support for the transformation of the State Customs Service of Ukraine	The U.S. Government through the U.S. Agency for International Development	Customs procedure reforming, improving trade and customs operations and institutional initiatives promotion	\$41 959 487	16.10.2018-15.10.2023
Ukraine Reforms Architecture (URA)	European Bank for Reconstruction and Development	Assisting the Ministry of Finance of Ukraine in implementing reforms in key areas: reform of the public financial management system (PFMS), tax and customs reforms, optimization of budget expenditures and others.	€17 800 000	24.04.2020-31.08.2023
E-governance for government accountability and community participation (EGAP)	Funded by government of Switzerland through Eastern Europe Foundation in	Assist in advancing e-government services development through 3 components: e-services, e-democracy, regional digitalization	Fr11 060 813	2015-2023

Source: author's compilation based on data [93],[98],[99],[111].

Ukraine started its path toward digital partnership not so far ago, mainly starting in 2014. Those relationships could be defined as long-term and prosperous, to coordinate

and assist Ukrainian digital development. Among key partners are EU countries, such as Estonia, Sweden, and Germany, as well as other major players like the US and UK. This section shows the importance of international assistance for further e-public finance projects development and support, especially in times of full-scale invasion and shortage of financial resources. It helps with aligning Ukrainian paths towards European standards, involving foreign human capital and technological innovations. More importantly, such cooperation is based on the intellectual and technological exchange in both ways, with the ability for Ukraine to export key innovative approaches to such countries like Estonia. Therefore, ensuring further long-term partnership with both European and Non-European countries is essential for digital development of the country.

Conclusions to Chapter 2

Overall, there is a general technological advancement, and hence, an increase in the level of digital tool implementation in the public sector, especially public finance. However, there are still low levels of public participation on a global level. Governments continue to develop digital public infrastructure and provide a more city-centered approach to service delivery and decision-making process in policy making. European countries are still the ones leading in the levels of digitalization in the world and continue to update legal frameworks and advance institutional capacities. African countries like Kenya and Eastern European countries like Georgia and Ukraine have grown in terms of the digitalization level of public finance and continue to launch e-services related to budget management, tax administration, and state social payments.

Among the key benefits of digitalization are increasing government effectiveness, financial transparency, and accountability, improved resource allocation, and increased revenue collection. While there were also defined main risks associated with the digitalization of public finance such as data privacy, digital divide gap within and between countries, human capital and technological scarcity, as well as regulatory challenges.

Ukraine has been actively developing in terms of digitalization in the public sector, especially public finance. For the past few years, numerous projects like Diia, Prozorro, Open Budget, online tax declarations, and e-payment projects like ESupport were launched. After a full-scale invasion. Ukraine has used e- public services as an effective method to overcome challenges and fulfill citizens' need like Edopomoga. The ministry of Digital Transformation in cooperation with other authorities is implementing new strategic goals and digital plans, according to which one of the biggest Ukrainian priorities for the future will be public finance digitalization. Governmental authorities cooperate with international organizations and partners in order to endure the exchange of technologies, and experience. Ukrainian digital transformation is highly dependent on international financial assistance and, in terms of war, could use it as a great opportunity for improvement. Overall, Ukraine tries to build a complex GaaP approach with a city-centered approach.

CHAPTER 3. ESTIMATION OF DIGITALISATION OF PUBLIC FINANCE INFLUENCE AND DEFINING KEY INSIGHTS FOR UKRAINE

3.1 Theoretical framework of the following research

All governments are trying to use digital tools to advance public finance by sharing information, digitizing public services, involving public participation in decision-making processes, and fighting public policy challenges. However, there is a huge difference in the outcomes and effectiveness of using digital tools in the public finance field. Many international organizations address this question in surveys and report the UN's E-Government annual Survey, OECD Digital Government Performance, and others.

In this section the factors that may influence the level of digital development in the public finance sector, as well as in general e-government efficiency.

First of all, there is a difference in the capabilities of modern technologies due to the degree of development. Digital and ICT infrastructure including internet coverage, availability of modern technologies usage, etc. is the crucial component of efficient public service delivery, and its availability and quality influence the effect of the field modernization. Meaning, that some governments are basically in scarcity of the capabilities to use modern tools. Moreover, it is also influenced by the factor of whether the government could create such a digital ecosystem with its own resources, or whether there is an urgent need in importing technologies from other, more developed countries.

Secondly, the pace and range of the available services depend on the demand from the citizens. The desire for more qualified and accessible services, transparent spending information, and emerging public participation in budget processes or fiscal policy design led to digital-driven and citizen-centered governments. It may help to create more public value through digitalization and provide a better response to the needs of the residents [25].

In Figure 3.1 the correlation between the ICT technologies measured by broadband coverage and digital public services is visualized.

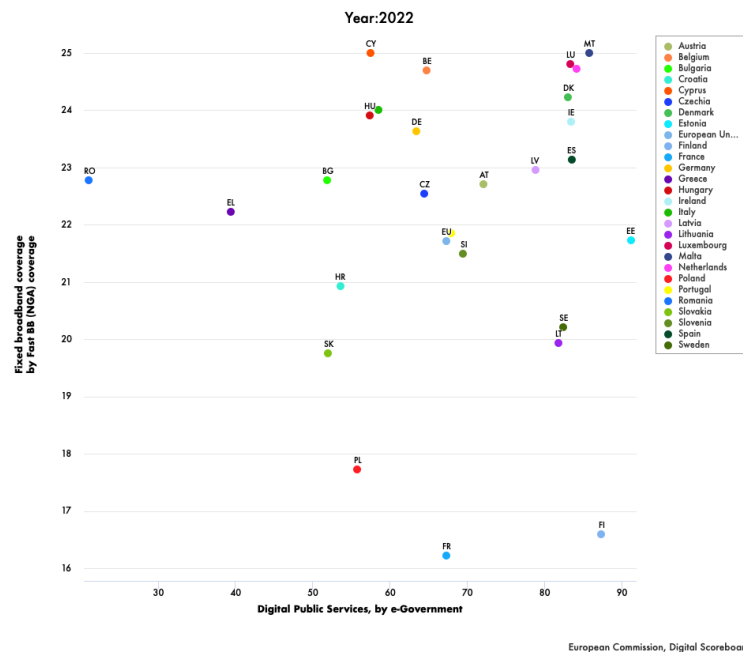


Figure 3.1 - The relationship between the level of Fixed broadband coverage as an indicator of ICT infrastructure development and the range of digital public services provided by the government within the EU.

Source: Digital Dashboard, European Commission [21].

Thirdly, the overall willingness to digitalization in public finance, social background, and educational aspects plays a vital role in the levels of digital transformation. On average, people with tertiary education are willing to adopt new technologies and realize the full potential of using them. The problem of higher education diffusion concerns lower-middle-income countries; however, digital literacy levels are more of the spectrum of challenges for more developed countries with established social and institutional backgrounds (like Scandinavian countries). This relationship could be seen in Figure 3.2. Moreover, there is a tendency that people with higher income in the age of 22-54 to be the ones using online services like e-tax filing. Whereas the aged group above 54 shows little e-government engagement, even when it comes to G2P payment. The difference in needs, as well as in socio-cultural background could be seen as a factor influencing such behavior [25]. According to the Pension Fund of Ukraine, 20-30% of all pensions are paid through cash payments.

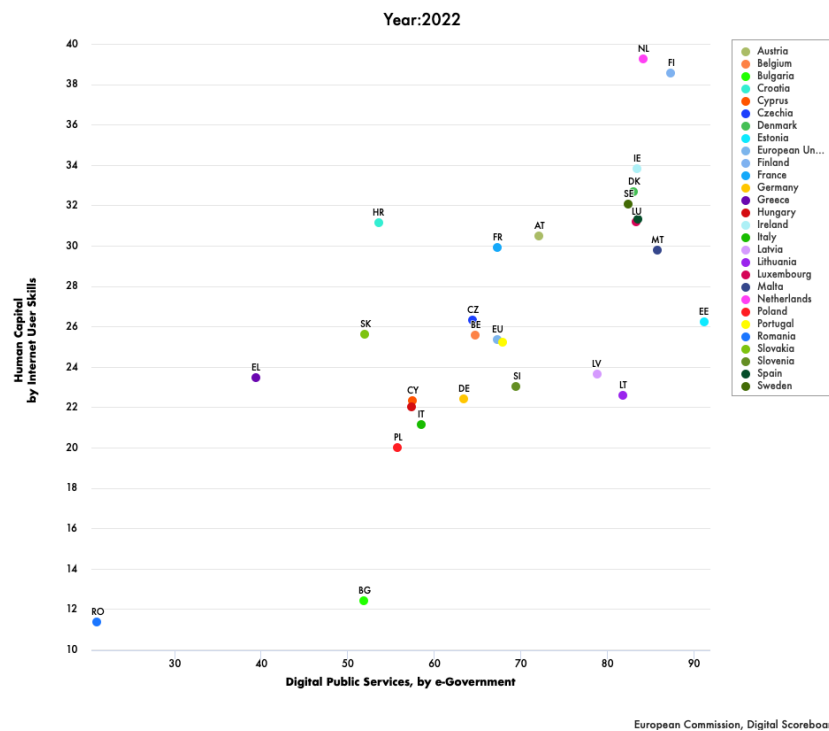


Figure 3.2 - The relationship between the level of Human capital as an indicator of educational skills and the range of digital public services provided by the government within the EU.

Source: European Commission, Digital Dashboard [21].

This also raises the connection between the country's expenditures on enabling both easy and great access to higher education institutions, as well as encouraging the increase in digital literacy levels and providing basic infrastructure means. For instance, the European Commission has presented an updated Digital Education Plan up to 2027, whereas in Africa the project from UNESCO for transforming the educational system by using ICT has been working since 2015 [34]. Therefore, with the higher level of digital education, the government transformation also exceeds and enables better state serving.

Here comes the next factor - institutional and governance development. The quality of the implemented policy, basic needs coverage, and the effectiveness of institutions - all of these indicate the ease, intensity, and diffusion of digital public services. Moreover, the quality of the governmental strategy and policy implementation, as well as the financial system development and basic political ecosystem define how advanced the digital transformation of public finance, as well public sector in general, could be. The World Governance Indicators produced by Daniel Kaufmann and Aart Kraay, measures

the governance and institutional development through 6 sub-indicators: Government Effectiveness, Regulatory Quality, Voice and Accountability, Control of Corruption, Political Stability and Absence of Violence, as well as Rule of Law. There is also an idea that countries with different levels of development are influenced by different factors, for their institutional development [1].

Finally, there is a theoretical approach to the connection between economic growth and the digitalization of the public sector, including public finance. The idea is that digitalization could enhance the governance operations efficiency, increase the transparency of public funds, and ease the interaction with the governmental structures. Moreover, it could increase accountability and auditing, as well as lower costs, generate higher taxes revenue and add value to the overall economic output of the country. However, the level of impact may range due to different degrees of economic development [6].

3.2 Approach towards using panel data regression, data description, and hypotheses

Unfortunately, there is no unified indicator measuring the digitalization of public finance, as it consists of various components. Therefore, to investigate the relationship between the levels of digital transformation of public finance and other factors, Open Budget Index (OBI) was used as a “proxy”. Although it is not a direct measure of such phenomena, OBI could be used to see the level of the digital tools in public finance being used by the government as a higher level of transparency and accessibility of OBI is associated with the countries advancing in the digital transformation.

OBI is a part of the Open Budget Survey (OBS) launched in 2006 by The International Budget Partnership (IBP). It is aimed to help national governments assess their openness and transparency in managing public finance. OBS is conducted biannually and provide independent research on the 3 following fields: transparency, oversight, and participation using world widely accepted criteria developed by international organizations, including OECD, IMF, and other [54].

Open Budget Index measures how well the information on public finance allocation (8 key documents) is accessible, updated, and comprehensive and was calculated in the following years: 2006, 2008, 2010, 2012, 2015, 2017, 2019, and 2021. In this research, the data from 2008 to 2021 was used, as in 2006 only 59 countries participated in the survey whereas in 2008 the amount increased to 85 respondents. The data is gained through the Questionnaire with 228 questions conducted by the country's representative and is double-checked by the independent auditor. Additionally, all countries are ranked from 0 to 100 according to their level of the above-listed spheres scores.

In 2011 a study by Renzo and Masud was conducted, researching the changes in the OBI over time. They defined that although at that time the level of government transparency remained low on a global level, there were some cases where the value was raised dramatically and thus conducted further development. M. Cimpoerua & V. Cimpoeru (2015) and Cuadrado-Ballesteros and Bisogno (2022) respectively also contributed to the investigation on the positive correlation between OBI and financial stability, generally defining that there is a more advanced way to enhance society trust. This led to further discussion within the countries, with citizens demanding the participation of such surveys.

However, this research will focus on the defining relationship between government budget transparency as an indicator of the digitalization of public finance and factors within various dimensions: technical, institutional, governance, economic, and social. It will allow us to analyze the influence of the variable from various aspects and indicate the level of influence on the OBI, given as a "proxy."

The cross-section section stays for the countries that were participating in the OBI since 2008, and the time section is defined by 7 years, when the index was calculated (2008, 2009, 2012, 2015, 2017, 2019, 2021). To address the problem of the unbalanced data, from each of the subgroups were taken out countries that had omitted variables for the series chosen before. Moreover, the problem is to find relative and complex data with proper extensions fulfilling all aspects of each of the variables. To conduct a proper econometric analysis numerous observations are likely to be run, which assumes a great range of data. It was first decided to conduct a regression based only on data from

Ukraine, to relieve the relationship within one country. However, as for a few observations, the model did not fit into the criteria of autocorrelation and multicollinearity, and normal distribution.

Therefore, it was decided to conduct research with more observations. To omit the problem of differentiation within one group, countries were split into 2 subsamples – lower- and upper-middle-income. Therefore, in the lower-middle income group 23 countries for 7 periods were picked, and in the upper-middle income - 26. Therefore, in each of the categories were run 161 and 182 observations. Another problem is that modern indexes related to measuring digital processes and effects are relatively new, or conducted with different frequencies, therefore there was not an option to include, E-government Index, for instance.

The overall form of the equation for panel regression is shown below in the equation 3.1:

$$Y_{it} = \beta_0 + \beta_1 * X_{1,it} + \dots + \beta_k * X_{k,it} * X + u_{it}, \quad (3.1)$$

$$i = 1, 2, \dots, N;$$

$$t = 1, 2, \dots, T,$$

where

β_0 – the intercept;

$\beta_1 - \beta_k$ – regression (slope) coefficients;

$X_1 - X_k$ – independent variables;

u_{it} – the error term;

N – number of cross – sections;

T – number of time periods;

Moreover, before presenting a more detailed view on the used variables, there is an important thing to mention. This research was conducted by subsampling data into 2 income groups. New World Bank Classification from July 2022 (Atlas Method) was used to divide countries for the subgroups by their GNI per capita (US dollars) of the previous year. Generally, there are 4 income groups: low, lower-middle, upper-middle, and high-

income countries. However, in this research only 2 subgroups were used: lower-middle income and upper-middle income for the following reasons. Firstly, there are different reactions of the digitization processes to the same factors due to different levels of development. In order to see those differences, it was decided to conduct research between those groups, as they are close to each other in terms of development, however, still there is a variation in the development. Secondly, as this research addresses the problem of the Ukrainian digitalization of public finance, it must bring valuable insights. Ukraine is now considered to be a lower-middle income country, with the perspectives (not so quick as before the full-scale invasion) for stepping on the higher level of development, as for the fast pace of the digital transformation process. Being realistic, there is no possibility to overstep the next stage, therefore, analyzing the tendencies behind the relationship between factors in upper-middle income countries could be used as guidance for further policy implications.

Now, it is essential to provide an outlook on the independent variables. As was mentioned previously, the idea is to analyze the digitalization of public finance from numerous perspectives, especially technical, institutional, governmental, economic, and social. For each of the aspects, the defining factor was chosen. All the indicators used while conducting a regression are listed in Table 3.1.

Table 3.1 – Description of the independent variables’ description

Perspective	Variable name	Variable sign	Description	Source
Technical	Individuals using the Internet (% of the population)	INTERNET	Internet users are individuals who have used the Internet (from any location) in the last 3 months;	WORLD BANK DATABASE - World Development Indicators (WDI)
	ICT goods imports (% of all imported goods)	ICT_I	Info and technology (equipment, information, e-components) goods imports	
Economic	GDP growth per capita (annual %) Foreign direct investments, net inflows (BoP, US\$)	GDP_PC_GROWTH FDI	The GDP growth rate in percent annually in US dollars Direct investments in terms of equity capital, reinvestment etc. in the economy	WORLD BANK DATABASE - (WDI)

Continuation of table 3.1

Institutional	Government effectiveness; Political stability; Voice and accountability.	GOVEFF; POL; VA;	GOVEFF - public service and policy quality, independence from political pressure; POL- probability of political instability, political and terrorism; VA - free participation in government selections, media, and expression All in a range of [-2.5-2.5].	WORLD BANK DATABASE - Worldwide Governance Indicators (WGI)
Governmental	Corruption control; Regulatory quality; Rule of law;	CC; RQ; LW;	CC- extent to which public power is exercised for private gain; RQ - extent of providing policies and regulations for enhancing or permitting the development of private sector; RL - degree of rules respecting and following in society; All in a range of [-2.5-2.5]	WORLD BANK DATABASE - (WGI)
Social	Government expenditure on education (% of GDP); Population, total	EDUCATION POPULATION	Overall state education expenditure. Total population amount (all residents)	WORLD BANK DATABASE - (WDI)

Source: completed by author based on sources [84], [85], [86], [87], [88], [89], [90].

Therefore, according to the theoretical background, several hypotheses for further

investigation could be made.

Hypothesis 1. The positive relationship between the digitalization of public finance and economic growth is measured as the GDP growth rate. It is assumed that the higher level of budget transparency, taken as a proxy for digital transformation in public finance, the higher rate of GDP output is predicted. The hypothesis is based on the idea that digitalization increase in the efficiency of public funds allocation, higher transparency, ease of doing business, and operational efficiency leading to a more competitive economy with higher GDP growth rates.

Hypothesis 2. The positive relationship between the digitalization of public finance and ICT infrastructure. Hypothesis indicates that the more countries advance ICT infrastructure, shown as individuals using the Internet for the past 3 months, the more they are digitally developed and transparent. The technological background is essential for further digitalization, decreasing the digital gap and enabling citizens to use e-services. If the ICT infrastructure is measured by the ICT goods imports, then the positive correlation could indicate that the countries with higher volumes of imported technologies are the ones that are more open and are able to choose between the technological range and the more efficient tool for specific purposes.

Hypothesis 3. The positive relationship between the digitalization of public finance and expenditure on education. The assumption is that the more governments invest in education, the better output in terms of digitalization and budget transparency, as a proxy. As was discussed in the previous section, a better-educated society is more willing to implement and use new services. On the other side, there is an assumption that with better public funds allocation (as a result of digitalization), the government is willing to increase education expenditures as well.

Hypothesis 4. The negative relationship between the digitalization of public finance and the population. The idea is the larger population, it is harder to provide digitalization in public finance as for the increased costs, and higher data processing levels, as well as enable security and manage public funds. Therefore, it is assumed that with population growth, the levels of digitalization lowers.

Hypothesis 5. The positive relationship between the digitalization of public finance

and FDI. Countries that embrace the digitalization of public finance and are more transparent are more likely to attract foreign direct investment as it increases trust in the government, develops the overall business environment, and increases effectiveness.

Hypothesis 6. The positive relationship between the digitalization of public finance and population with institutional indicators such as government effectiveness, voice and accountability, and political stability. Embracing digitalization in public finance leads to higher levels of governmental effectiveness by increasing operational capabilities and reducing costs. It provides more open data, as well as promotes citizen participation, which leads to higher levels of freedom and accountability and contributes to the overall political stability in the country.

Hypothesis 7. The positive relationship between the digitalization of public finance and population with governance indicators such as corruption control, rule of law, and regulatory quality. The assumption is based on the idea that the more transparent and digitalized governments are more likely to better fight corruption (processes become open and transparent due to the digital tools), and have higher regulatory quality (ease of bureaucracy, advanced regulatory systems) and society is more likely to see the law as a very influential factor. And increase governmental trust.

Hypothesis 8. Different influential levels of variables are based on the income type group. It is assumed that within two income groups, the significance and level of influence on the same indicators will be different, for the level of development. Thus, it is also assumed that⁵ in terms of the same aspect there will be a difference in the variables which will be valuable for the research.

3.3 Estimating Panel data regression of lower-middle income countries

In order to analyze and reveal the relationships between the variables in accordance with the hypotheses, it was chosen to conduct a panel data regression using the Least Squares Method. Panel data combines cross-sectional and time-series data, allowing to conduct of analysis for several countries during various periods, allowing to use of data in a more efficient way. Moreover, it allows the inclusion of individual effects (fixed or

random) to control the unobserved heterogeneity and exclude omitted variable bias. Further research was conducted using EViews 12 Student Version software.

Firstly, it will be discussed the relationship between the dependent variable OBI and the independent variable within the lower-middle income countries group.

In the following research, we will try to use different combinations of independent variables within different aspects, to define the most significant ones.

Equation 3.2 to be analyzed within the lower-middle income countries is:

$$OBI = \beta_0 + \beta_1 * INTERNET + \beta_2 * GDP PC GROWTH + \beta_3 * POPULATION + \beta_4 * VA + \beta_5 * CC + [CF = F], \quad (3.2)$$

First of all, it is essential to understand which method for model testing fits the best: Common Effects (CE) using the Pooled Least Squares method, Fixed Effects (FE) with the Least Squared Dummy Variables method, or Random Effects model (RE) (GLS method). To estimate it several tests could be run, especially Chow and Hausman tests. First one could help to choose whether FE or CE or the most appropriate. If the null hypothesis is accepted by the results ($p > 0,05$), the CE model should be chosen or vice versa: if the hypothesis is rejected ($p < 0,05$) FE fits better and the Hausman Test should be run as well. In the case of this research, further results shown have been achieved after the Chow Test. (Figure N) Thus, it could be seen that fixed effects must be included for cross-section data ($p < 0.05$), whereas none of the effects must be included for the period ($p > 0.05$). (Figure 3.3)

Redundant Fixed Effects Tests			
Equation: Untitled			
Test cross-section and period fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	6.702281	(22,125)	0.0000
Cross-section Chi-square	125.441865	22	0.0000
Period F	0.913150	(6,125)	0.4879
Period Chi-square	6.906546	6	0.3296
Cross-Section/Period F	5.456839	(28,125)	0.0000
Cross-Section/Period Chi-square	128.567680	28	0.0000

Figure 3.3 - Chow Test results for lower-middle income countries group

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Next, the Hausman Test must be run in order to check for the RE from the cross-section period. The value is $p = 0.0369 < 0.05$, thus fixed effects must be included in the cross-section data. (Figure 3.4)

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	14.933092	7	0.0369

Figure 3.4 - Hausman Test results for lower-middle income countries group

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

The last step in this section is to run the Lagrange Multiplier and see what effect must be included in the period data. The value for the period is higher than 0.05. Therefore, no effects must be included in the period section. (Figure 3.5)

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	66.28816 (0.0000)	1.188980 (0.2755)	67.47714 (0.0000)
Honda	8.141754 (0.0000)	-1.090404 (0.8622)	4.986058 (0.0000)
King-Wu	8.141754 (0.0000)	-1.090404 (0.8622)	2.802360 (0.0025)
Standardized Honda	9.904074 (0.0000)	-0.813555 (0.7921)	2.089761 (0.0183)
Standardized King-Wu	9.904074 (0.0000)	-0.813555 (0.7921)	0.083966 (0.4665)
Gourieroux, et al.	--	--	66.28816 (0.0000)

Figure 3.5 - Lagrange Multiplier results for lower-middle income countries group

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

After defining the model method and adjusting effects, it is essential to run several equations to estimate which are the most suitable in terms of their characteristics. They should be significant within the 95% level of confidence, as well checked according to t-

statistics and F-fisher statistics. Firstly, it was decided to choose the following independent variables to check the hypothesis:

- internet users;
- GDP growth;
- population;
- voice and accountability;
- ICT goods import;
- education.

In Figure 3.6 below, the panel data regression with fixed cross-section effects is presented. As could be seen, several variables, namely education and ICT goods imports are not significant, whereas others fit under the requirements. Therefore, the research could be conducted further and see whether the other assumptions are correct.

Dependent Variable: OBI Method: Panel Least Squares Date: 05/14/23 Time: 15:17 Sample: 2008 2021 Periods included: 7 Cross-sections included: 23 Total panel (balanced) observations: 161				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	54.03740	9.678356	5.583324	0.0000
INTERNET	0.321916	0.058300	5.521676	0.0000
GDP_PC_GROWTH	1.199424	0.413931	2.897644	0.0044
POPULATION	-1.86E-07	6.58E-08	-2.822321	0.0055
VA	17.58798	5.776600	3.044695	0.0028
GOVEFF	0.055135	0.209892	0.262685	0.7932
ICT_I	-0.485773	0.523871	-0.927276	0.3555
FDI	2.45E-10	4.00E-10	0.613175	0.5408
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.699936	Mean dependent var	38.14286	
Adjusted R-squared	0.633510	S.D. dependent var	18.87818	
S.E. of regression	11.42856	Akaike info criterion	7.876572	
Sum squared resid	17110.16	Schwarz criterion	8.450746	
Log likelihood	-604.0640	Hannan-Quinn criter.	8.109710	
F-statistic	10.53702	Durbin-Watson stat	1.664721	
Prob(F-statistic)	0.000000			

Figure 3.6 - Regression results

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

After this, several more attempts were completed, using education and comparing different governance and institutional variables. As a result, it was indicated that education as a variable is not significant, and among institutional factors, the most influential is voice and accountability. The final regression is shown below (Figure 3.7).

It was also tried to make a logarithm of the population indicator; however, it made the value insignificant.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	53.11913	6.801061	7.810417	0.0000
INTERNET	0.337043	0.055236	6.101857	0.0000
GDP_PC_GROWTH	1.145645	0.399146	2.870243	0.0048
VA	17.63847	5.741232	3.072246	0.0026
POPULATION	-1.78E-07	5.98E-08	-2.978962	0.0034

Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.696437	Mean dependent var	38.14286	
Adjusted R-squared	0.637537	S.D. dependent var	18.87818	
S.E. of regression	11.36559	Akaike info criterion	7.850896	
Sum squared resid	17309.66	Schwarz criterion	8.367654	
Log likelihood	-604.9972	Hannan-Quinn criter.	8.060721	
F-statistic	11.82402	Durbin-Watson stat	1.646796	
Prob(F-statistic)	0.000000			

Figure 3.7- Final regression results

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Therefore, there is presented that all 4 independent variables are significant with a confidence level of 95%, as well as according to the value of t-statistics (higher than |2|). Model adequacy is also related to the F-statistics indicator, excluding the null hypothesis that all coefficients are equal to zero. This could be done in accordance with the p-value associated to check whether the samples are independent samples with the F-statistics, which in this case equals zero and rejects the null hypothesis.

R-squared is the next coefficient to be analyzed. It helps to see how well this type of model explains the data - it shows the variance in the percentage of the independent variables' explanation in the dependent variable. After making additional changes to the model specification, the final regression explains the relationship between the OBI and institutional and economic factors for 69,6%. It means that the model provides valuable insights for interpreting results, however, there is a need for further advancement of the model, as it could avoid some underlying influences. In order to increase the explanatory ability of the model, several methods were tried including changing variables, including lags or logarithmic processes. However, 70% was the highest value for the given dataset.

Moving further, the model should be checked for autocorrelation using Durbin-Watson statistics to indicate the existence of autocorrelation. The value of DW is 1.65, which for critical values with 4 independent variables and 161 observation $dL= 1.557$, $dU=1.679$ is in the zone of first-order autocorrelation absence.

To make sure the model does not have multicollinearity issues, the correlation matrix will be used. The results are shown in the figure below. As could be seen, the values are low ($<0,7$), therefore it could be stated that there is no multicollinearity issue, and the model is adequate. (Figure 3.8)

Correlation					
	OBI	INTERNET	GDP_PC_G...	VA	POPULATION
OBI	1.000000	0.252383	0.283459	0.419122	0.226902
INTER...	0.252383	1.000000	-0.065294	0.070985	-0.097673
GDP_P...	0.283459	0.065294	1.000000	0.109560	0.175624
VA	0.419122	0.070985	0.109560	1.000000	0.318556
POPUL...	0.226902	-0.097673	0.175624	0.318556	1.000000

Figure 3.8 - Correlation matrix (final regression)

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Further, the model will be tested using the Jarque-Bera Test for normality. Normality distribution is, when the null hypothesis is accepted. Below it is illustrated the results of the conducted test. (Figure 3.9)

It is generally observed that the p-value is higher than 0,05 therefore the normality distribution is fulfilled, however graphically there are still some variations.

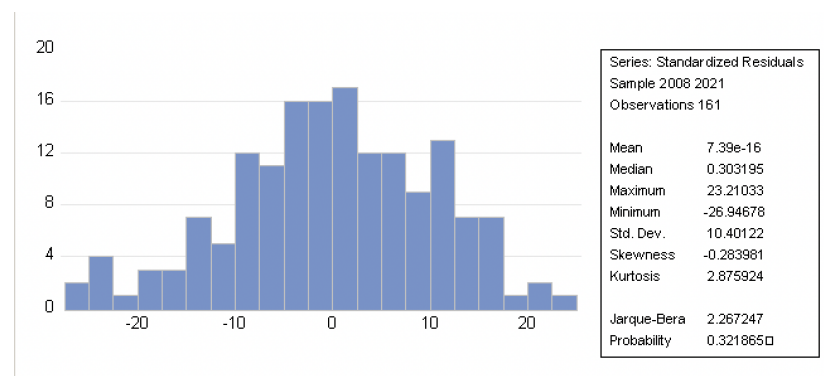


Figure 3.9 – Normality Test results

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Overall, the final equation is presented in eq. 3.3:

$$\begin{aligned}
 OBI = & 53.1191274505 + 0.337042769848 * INTERNET + \\
 & 1.15564464526 * GDP PC GROWTH - 1.7804975299 * POPULATION + \\
 & 17.6384734187 * VA + [CF = F],
 \end{aligned}
 \tag{3.3}$$

3.4 Estimating Panel data regression of upper-middle-income countries

The equation 3.4 to be analyzed within the lower-middle income countries is:

$$\begin{aligned}
 OBI = & \beta_0 + \beta_1 * INTERNET + \beta_2 * GDP PC GROWTH + \beta_3 * \\
 & EDUCATION + \beta_4 * GOVEFF + \beta_5 * + LW + [CF = F],
 \end{aligned}
 \tag{3.4}$$

Secondly, further analysis relates to estimation panel regression to research the relationship between the dependent variable OBI and the independent variable within the upper-middle income countries group.

To investigate the relationships within the upper-middle income group, the same panel data regression was run. Similarly, firstly there is a need to identify the best model for this type of data. Chow, Hausman, and Lagrange Multiplier were run to help with this issue.

Chow Test showed the following results (Figure 3.10). If the null hypothesis is accepted by the results ($p > 0,05$), the CE model should be chosen or vice versa: if the hypothesis is rejected ($p < 0,05$) FE fits better and the Hausman Test should be run as well. Thus, it could be seen that fixed effects must be included for cross-section data ($p < 0,05$), whereas none of the effects must be included for the period ($p > 0.05$).

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section and period fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	25.376308	(25,148)	0.0000
Cross-section Chi-square	303.059790	25	0.0000
Period F	0.575113	(6,148)	0.7497
Period Chi-square	4.194689	6	0.6503
Cross-Section/Period F	21.028411	(31,148)	0.0000
Cross-Section/Period Chi-square	307.079566	31	0.0000

Figure 3.10 - Chow Test output for the upper-middle income countries

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Next, the Hausman Test must be run in order to check for the RE from the cross-section period. (Figure 3.11) The value is $p = 0.1622 < 0.05$, thus fixed effects must be included in the cross-section data

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	5.176759	2	0.0751

Figure 3.11 - Hausman Test results for upper-middle income countries

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

The last step in this section is to run the Lagrange Multiplier and see what effect must be included in the period data. The value for the period is higher than 0.05. (Figure 3.12). Therefore, no effects must be included in the period section.

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	302.9137 (0.0000)	0.790120 (0.3741)	303.7039 (0.0000)
Honda	17.40442 (0.0000)	-0.888887 (0.8130)	11.67824 (0.0000)
King-Wu	17.40442 (0.0000)	-0.888887 (0.8130)	6.858679 (0.0000)
Standardized Honda	18.48942 (0.0000)	-0.672351 (0.7493)	8.773181 (0.0000)
Standardized King-Wu	18.48942 (0.0000)	-0.672351 (0.7493)	4.200070 (0.0000)
Gourieroux, et al.	--	--	302.9137 (0.0000)

Figure 3.12 - Lagrange Multiplier results for upper-middle-income countries

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

In Figure 3.13 below, the panel data regression with fixed cross-section effects is presented. As could be seen, several variables, namely education and Population, as well internet are not significant, whereas others fit under the requirements. Therefore, the research could be conducted further and see whether the other assumptions are correct. After this, several more attempts were completed, using education, and comparing different governance and institutional variables. As a result, it was indicated that education as a variable is not significant, and among institutional factors, the most influential is voice and accountability. The final regression is shown below (Figure N). It was also tried to make a logarithm of the population indicator; however, it made the value insignificant.

Dependent Variable: OBI Method: Panel Least Squares Date: 05/17/23 Time: 16:24 Sample: 2008 2021 Periods included: 7 Cross-sections included: 26 Total panel (balanced) observations: 182				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.807791	12.36800	0.550436	0.5828
GOVEFF	0.363488	0.088062	4.127643	0.0001
GDP_PC_GRPWTH	0.001525	0.000468	3.261162	0.0014
EDU	0.472708	0.382671	1.235285	0.2186
POP	-0.011852	0.011010	-1.076452	0.2834
INTERNET	0.079388	0.045289	1.752914	0.0816
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.831045	Mean dependent var	51.40659	
Adjusted R-squared	0.797478	S.D. dependent var	19.56600	
S.E. of regression	8.805188	Akaike info criterion	7.342492	
Sum squared resid	11707.23	Schwarz criterion	7.888229	
Log likelihood	-637.1667	Hannan-Quinn criter.	7.563726	
F-statistic	24.75760	Durbin-Watson stat	1.134863	
Prob(F-statistic)	0.000000			

Figure 3.13 –Intermediate results for upper-middle-income countries

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Model adequacy is also related to the F-statistics indicator, excluding the null hypothesis that all coefficients are equal to zero. This could be done in accordance with the p-value associated to check whether the samples are independent samples with the F-statistics, which in this case equals to zero and rejects the null hypothesis (Figure 3.14)

Dependent Variable: OBI Method: Panel Least Squares Date: 05/17/23 Time: 21:03 Sample: 2008 2021 Periods included: 7 Cross-sections included: 26 Total panel (balanced) observations: 182				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LW	22.99506	4.158985	5.529008	0.0000
GDP_PC_GRPWTH	0.001579	0.000352	4.480997	0.0000
C	31.62836	6.350740	4.980263	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.835433	Mean dependent var	51.40659	
Adjusted R-squared	0.806580	S.D. dependent var	19.56600	
S.E. of regression	8.605038	Akaike info criterion	7.283211	
Sum squared resid	11403.19	Schwarz criterion	7.776135	
Log likelihood	-634.7722	Hannan-Quinn criter.	7.483035	
F-statistic	28.95507	Durbin-Watson stat	1.287483	
Prob(F-statistic)	0.000000			

Figure 3.14 - Final regression

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

R-squared is the next coefficient to be analyzed. After making additional changes to the model specification, the final regression explains the relationship between the OBI

and institutional and economic factors for 83,5%. Adjusted R-squared is somehow lower and is equal to 80,1%. It means that the model indicates a significant amount of underlying influence and provides valuable insights for interpreting results. However, there is a need for further advancement of the model.

Additionally, the model should be checked for autocorrelation using Durbin-Watson statistics to indicate the existence of autocorrelation. The value of DW is 1.31, which is for critical values with 2 independent variables and 182 observations $dL=1.498$, $dU=1.651$. After adding the lag variable GDP_GROWTH (-1), the value has increased up to 1.48, closer to the zone. (Figure 3.15) It also increased the R-squared value up to 85%. It was also tried to add log variables, however, coefficients have become insignificant. Thus, it indicates that further research for the specification ways how to increase the value up to the critical corridor is needed to be done.

Dependent Variable: OBI				
Method: Panel Least Squares				
Date: 05/19/23 Time: 15:59				
Sample (adjusted): 2010 2021				
Periods included: 6				
Cross-sections included: 26				
Total panel (balanced) observations: 156				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	31.76542	7.423725	4.278906	0.0000
LW	22.81038	4.574262	4.986680	0.0000
GDP_PC_GRPWTH(-1)	0.001615	0.000426	3.795267	0.0002
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.846413	Mean dependent var	52.20513	
Adjusted R-squared	0.814016	S.D. dependent var	19.75714	
S.E. of regression	8.520444	Akaike info criterion	7.283962	
Sum squared resid	9292.539	Schwarz criterion	7.831373	
Log likelihood	-540.1491	Hannan-Quinn criter.	7.506297	
F-statistic	26.12608	Durbin-Watson stat	1.488014	
Prob(F-statistic)	0.000000			

Figure 3.15 - Final regression specification

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

To make sure the model does not have multicollinearity issues, the correlation matrix will be used. The results are shown in the figure below. As could be seen, the values are low ($<0,7$), therefore it could be stated that there is no multicollinearity issue, and the model is adequate. (Figure 3.16)

Correlation			
	OBI	LW	GDP_PC_G...
OBI	1.000000	0.177709	0.234627
LW	0.177709	1.000000	0.151650
GDP_P...	0.234627	0.151650	1.000000

Figure 3.16 - Correlation matrix

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Further, the model will be tested using the Jarque-Bera Test for normality. Normality distribution is considered to be when the null hypothesis is accepted. Below it is illustrated the results of the conducted test. (Figure 3.17) It is generally observed that the p-value is higher than 0,05 therefore the normality distribution is fulfilled.

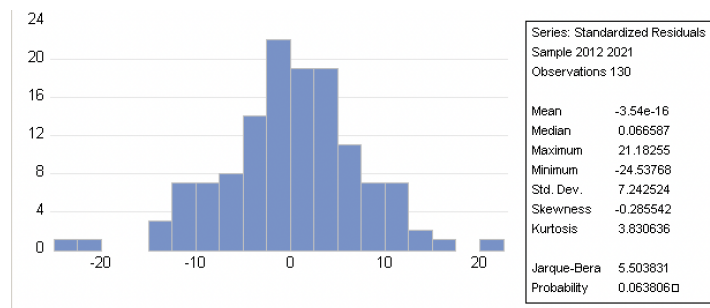


Figure 3.17 - Jarque-Bera Test results

Source: calculated by the author using EViews 12ST based on data [84], [85], [86], [87], [88], [89], [90].

Therefore, as a result of the concocted tests for model adequacy, it could be stated that the model fulfilled all requirements. Thus, the results of the model could be used as guidance for further analysis and recommendations.

The overall equation for the model with a fixed effect for cross-period is shown in the equation below:

Overall, the final equation is presented in equation 3.5:

$$OBI = 31.62836 + 22.99506 * LW + 0.00579 * GDP PC GROWTH + [CF = F], \quad (3.5)$$

3.5 Model Results Interpretation

After conducting a two-stage regression analysis, now the results could be interpreted to make proper conclusions.

With the increase in internet users of 0,33%, the OBI index could be increased by 1%. This could be explained through the better maintenance of the ICT infrastructure, hence wider and easier access to governmental services and using better technological equipment. Meaning that to stay transparent in terms of public finance, it is essential to first build proper digital infrastructure. As could be seen from the results, there is no such tendency in the countries with higher development, possibly because other more influential factors influence the transparency and digital transformation of public finance overall. However, it was expected that a higher influence will be indicated in such a relationship, especially for less developed countries.

Next, we could compare the relationship between economic growth and digitalization in public finance. There is a positive correlation between the variables, indicating that with the budget transparency increase by 1%, GDP growth in the lower-middle countries would increase by 1.14%, whereas in upper-middle countries only by 0,001%, which is relatively small. This huge difference supports the assumption of different reactions for economic growth rates and could be explained that in the countries with lower development, IT value in the GDP could be more significant.

Moving further, it was shown that among institutional and governmental factors, the most influential among the lower-middle income group is voice and accountability (with an increase in 1% of the OBI, VA increases for more than 17%), whereas, in the higher income group, it is rule of law (with the increase of 1% in the transparency, LW exceed by 22%). It may be because in poorer countries democracy, openness, and freedom levels are less than in more rich countries, therefore transparency phenomena are much more valued.

Finally, in terms of the research, such variables as population have been investigated as well. Although it was insignificant for countries with higher income, there is a relationship between the number of people and digitalization in public finance. The

model showed a negative relationship between the number of citizens and digitalization, as it was assumed in the begging. With the 1.9% raise in population, transparency is decreased by 1%. This could be explained through the assumption that, first there are higher negative tendencies in population growth in poorer countries. Secondly, it is harder for countries from lower income groups to finance the expansion of the infrastructure as well as conducting surveys and measuring OBI as for the lack of financial resources.

Unfortunately, other indicators did not seem to be significant. Therefore, further research should pay attention to defining the relationship between the factors excluded from the model.

Overall, the model presents some valuable insights:

The relationship between the institutional and governance factors is significant for both income groups, however, is different in terms of the factors, Therefore, for more poor countries it is essential to advance digitalization levels in order to improve the institutional background and enable effective government operation. However, for more developed countries, there is a need to pay more attention to the regulation quality and rule of law. Moreover, there is evidence that digitalization influences economic development with higher levels in less developed countries, why there is a minimum sign of GDP growth. Moreover, there is evidence that there is harder to digitalize more populated countries, especially with low income.

3.6 Value for Ukraine based on the estimation results

As Ukraine is a lower-middle-income country, which tries to improve its current economic state despite the current circumstances such analysis shows some valuable insights.

First of all, as was estimated in the research, it is essential for developing countries to improve the ICT infrastructure for a positive correlation between the factors. It is essential to ensure broad internet connectivity and access to technologies for all individuals. Therefore, it must become one of the main priorities, especially in terms of a full-scale invasion.

Secondly, there is a high influence of the digitalization of public finance on the GDP growth rates. Therefore, by investing in the advancement of the digital ecosystem Ukraine could enhance economic development, especially while the ongoing war. Digital transformation could be used as a factor for further recovery from such influence.

Moreover, there is a significant connection between institutional capabilities and digitalization, while governance remained insignificant. In the case of less developed countries, voice and accountability play the most crucial role, enabling democracy levels to increase. Thus, it is essential to advance institutional capabilities in order to achieve government effectiveness.

It may be harder for Ukraine to implement some digital tools, as for the high rates of the population compared to some other European countries. Thus, it is crucial to provide effective financial resource management by lower costs and optimizing allocation.

Conclusions to Chapter 3

Overall, using the econometric modeling method with the panel data regression in the EViews software 12SV for analyzing the relationship between the OBI, as a proxy for digitalization of public finance and social (education), economic (GDP), governance (voice and accountability) and institutional (rule of law), ICT (Internet) within two income groups: lower-and upper-middle-income countries. The model was adequate, according to the given criteria, however, there was a small problem with the autocorrelation criteria, that could be improved. It was estimated that the most significant relationship is between institutional and governance factors in both groups. It was also estimated that there is a different effect for groups with different income levels. Within the poorer countries it defined a huge influence on economic growth, whereas in more developed countries, it was a more significant influence by the rule of law factor.

Overall, there are some areas of improvement in the model, as some problems appeared, which could have been fixed by the specification like R-squared adjustment to higher explanation abilities, as well as Durbin Watson's statistics improvement in the second model. It is also crucial to investigate the connection between factors, that did not show significant values and analyze the whole picture. Moreover, it is also important to understand that OBI may not capture fully the effect of the digitalization of public finance. Therefore, with the insights from the model further advancement could be used to conduct research with more complex tools.

CHAPTER 4. CHALLENGES AND OPPORTUNITIES FOR UKRAINE IN THE DIGITAL TRANSFORMATION OF PUBLIC FINANCE

4.1 Challenges for Ukraine in digitalization of public finance

The full-scale invasion has significantly impacted the financial system of Ukraine. According to Preliminary economy ministry data GDP has fallen up to 29,1% in 2022. Deputy Economic Development and Trade Minister Yulia Svyrydenko mentioned that it was the worst GDP drop since Ukraine gained its independence. Therefore, with the ongoing war, budget expenses, especially for defense, are rising, and revenue for both state and local budgets is decreasing.

Both increasing inflation and devaluation have a huge pressure on the economy. The UN report shows an outlook for the Ukrainian economy in 2022 with an economic recession of over 35%, and a monthly budget deficit over 5 billion US dollars. According to the Ministry of Finance, the budget deficit in 2022 exceeded UAH 911 billion and was mainly financed by foreign grants and international loans, as well as direct monetary financing and military bonds [76].

In such hard times, it is crucial to ensure the proper functioning and further development of the financial system with proper fiscal policy. In the case of public finance management, it is important to administrate expenditures more efficiently, ensure cooperation between the government and business, increase investment climate, reduce corruption, and increase trust, especially from foreign partners to invest and provide financial aid to ensure stability and further recovery.

Russia continues destroying ICT infrastructure leading to lower internet connectivity, disruption of data centers, and decreasing data transmission. More than 4 000 TC stations and around 60K kilometers of Internet lines have been damaged since February 24th [4].

Since 2014 Russia has been launching cyberattacks on governmental platforms, IT, and energy providers. A month before the full-scale invasion, in January 2022, the Ukrainian government and banking system was under heavy DDoS attacks, with the spread of misinformation, which is also the other strategy of Russia - decreasing

governmental trust and raising panic among citizens. After February 24th, cyberattacks have been massively happening along with missile attacks as well. Therefore, data protection and cybersecurity should become the priorities for further development.

Another problem is the “brain drain”, which was even more accelerated by the war. More than 10% of the ICT employees were relocated to foreign countries, and IT companies that have mainly invested in the Ukrainian Economy have postponed their operations to better times. Moreover, there is a big problem of students and R&D workers displacement - nearly 16% of all enrolled students have fled Ukraine, along with the 6% of people involved in the education processes. Additionally, more than 2,5 thousand educational institutions have been damaged or destroyed. Moreover, according to the Open Budget Survey, Ukraine has a low public participation rate, especially, 33/100, which states citizens have low motivation to be engaged in the decision-making processes [91].

Among other key problems in further digitalization of public finance that appeared after the full-scale invasion are:

- impossible presence of governmental financial institutions on the occupied or under the active war-actions territories;
- budget cutting on most governmental agencies as a result of the military area being prioritized (especially in the expenditure of the Ministry of digital transformation (-86% compared to 2022) [106];
- decrease in budget revenues (mainly through taxes), recession, inflation, currency devaluation, increasing budget deficit, and public debt;
- infrastructure and logistic demolition due to war attacks;
- failure of launching practices to combat fraud, corruption, and terrorism using tax and customs tools;
- slowing down the EU integration due to not fully harmonized legislation on the financial system;
- incapability to realize potential in digital transformation, as the spending got cut off due to reprioritization towards defense are or related.

- cybersecurity risks associated with Russian hackers;
- inefficiency in using funds from international assistance due to corruption risks;
- low levels of coordination in financing recovery of individual objects;

4.1 Opportunities for Ukraine in digitalization of Public finance

As was shown in the previous chapter, there are numerous opportunities in terms of the digitalization of public finance. For Ukraine, it might be a key component for Ukrainian further recovery. Therefore, it may help Ukraine to gain new opportunities even in such hard times.

Firstly, it may help to increase international support and assistance. By advancing in digitalization, international investments and organizations may see the potential, and transparency and perceive Ukraine as an attractive asset. Thus, banks, private companies, or other international entities may provide technical, financial, and human capital support for increasing capacity in digital transformation.

Secondly, with collaborative efforts, Ukraine could bring it closer to EU standards. Ukrainian desire, as well as the EU's willingness to support the country, become closer to EU membership. Therefore, now there are a lot of initiatives and organizations being present to coordinate and help Ukraine to align the law regulatory framework in accordance with EU criteria and fulfill all the needs [49].

Thirdly, EU integration with a trustful tax policy, accountable budget and debt policy as well as a transparent and responsible government has become an opportunity for Ukraine as well. The embracement of digital technologies may help Ukraine to improve tax administration, budget management, and execution as well as reporting. Thus, it is a step forward in the case of the EU alignment and cooperation.

Moreover, there is potential access and integration to EU countries' financial systems through the development of national financial systems and establishing connections with the EU entities. This could reduce border barriers and ensure cost-saving.

Additionally, as digitalization drives advancement, there is a chance to improve digital financial services development in Ukraine with international funding cooperation. E-Systems expanding, launching new database management tools, as well as mobile financial applications help to increase convenience, ease government-citizen interactions, as well improve financial inclusion [108].

Finally, it will be able to increase financial institutions' security. New regulations, cybersecurity measures, as well as AI and encryption usage for risk assessment could boost data protection. It will allow us to build the institute of data protection and cybersecurity, contributing to the modern and complex institutional background.

Overall, despite the ongoing wars in Ukraine, still, digital transformation in public finance enables access to a huge list of opportunities that could level the challenges. Among prior problems are still infrastructural and institutional capacities, as well as reducing the amount of human capital. However, with the current international help and Ukrainian potential even in such hard times, it is possible to use digitalization as a leapfrog and try to battle the problems with the tools that became available recently.

4.3 Recommendations for digital transformation public finance development in Ukraine

The full-scale invasion has brought up even more challenges for the Ukrainian economy, which emerged as ones that already existed. Therefore, there is now an important time for Ukraine to accelerate and use the opportunities raised to be able to overcome the existing challenges. Although it is extremely hard to make strategic plans in periods of unknown and instability, there is a need to have guidance for the future. In Ukrainian reality, with the ongoing war and upcoming recovery, recommendations and guidance could be provided using the following time structure:

- short-term (up to 1 year, assuming that it is a period of an active war phase);
- medium (2-5 years, that is mostly focused on the post-war recovery and minimization of the active war period);
- long-term (5-10 years – further recovery and development phase).

In the first period, it is essential to provide an immediate reaction to the challenges that mainly appeared due to the full-scale invasion and address resources for overcoming them. Therefore, in war times, it is essential to ensure proper Internet connectivity, and telecommunication infrastructure with new tech solutions while rebuilding the damaged infrastructure, as well as to ensure it in the rural areas. With the skyrocketing numbers of migrants within and out of the country due to the war, national authorities should be able to cover the needs, like receiving social payment, e-transfers, and tax compliance without physical presence.

Several new financial e-services like EDopomoga were launched. Thus, it must be ensured that it is available for all of citizens, including the most vulnerable groups. It is important to also develop a more complex ecosystem for support of veterans and displaced people and possibly build a digital system for easy reintegration and relocation. Moreover, it is important to prevent cybersecurity risks and protect governmental data. It should become one of the priorities in the case of the digitalization strategy as for the war risks. In order to do this, there is a need in updating the legal framework in Data Protection and aligning it to the European GDPR, which could be done in partnership with international initiatives, which are now providing assistance to Ukraine like EU4Digital, UK/USAID, as well as German and Sweden programs.

Moreover, as of the rising amount of financial assistance, and demand for recovery of regions, there is an urgent need to create separate platforms for single coordination of such projects in order to decline the risk of corruption and funds misuse. For instance, the platform will be integrated as a national web system to track all of the projects under reconstruction with the ability to track funds allocation, the status of the project, and responsible people. Moreover, there is a need to ensure proper accounting systems and auditing in such projects. Additionally, with the rising demand in reconstruction and recovery procedures, to ensure transparency writing such procedures, a platform for collection and analyzing projects for demand could be created as well on the governmental level.

In the medium term, it is crucial to ensure that the fiscal, digital, and regulatory strategies and instruments align and focus on the post-war recovery. In this period will be

important to focus on the reforming legislative environment, increasing institutional capacities, as well as reducing the digital gap, and focusing on security measures. All of these objectives will lead to EU integration in the future, opening even more opportunities. For instance, joining EU Digital Single Market could be useful in terms of overcoming challenges and enabling further development. It could be helpful to align the legal framework with the EU regulations enabling recognition of governmental e-services and projects internationally. Even more, it will ease the external barriers of exporting digital services and goods, as well as importing essential ICT products. Along with the unbalanced budget revenues and spending, DSM membership could help to reduce costs and increase financial investments and assistance for higher transparency and accountability, as well as help in fighting the digital divide gap within the country by recovering damaged infrastructure, developing programs for digital education free of charge for people in need, create new ICT workplaces.

As for the shortage in public funds and scarce governmental investments in digitalization, there is a need to attract private and international assistance. It may be done through the special tax regime for IT companies. A similar tax initiative has already been introduced before the war – the Diia City, which is relevantly new and should be aligned to international standards. Alternatively, a simple easing in the digitally innovative projects and initiatives loaning for further support of the digitalization.

In order to overcome the challenges associated with human capital, the Ukrainian government could consider the following steps:

- creating educational programs encouraging students to gain foreign education free of charge under of circumstances to return to Ukraine and realize their potential here.
- encourage private investments by leveraging small and medium businesses with governmental programs to create additional ICT workplaces.
- launching educational resources (like DIIA. Education), grants, and programs that will be available to the individual's vulnerable society members: elderly people, people in urban areas, women, people with disabilities, or displaced people.

- Promote information accessibility and enhance communications challenges, as for the digital divide problem.
- Collaboration with various active society organizations (like students' organizations etc.) and facilitate public participation in budget processing, policy-making, or auditing;
 - update and provide digital instruments and infrastructure for educational institutions, as well as for households.
 - special tax and loan regimes: in international practice, especially in Germany, there are such phenomena as a tax credit for R%D development, which promotes and eases the research sectors;

In July 2022, The Recovery Plan was presented by the National Recovery Council of Ukraine created to coordinate further Recovery Plan Implementation, where among the key focuses are cybersecurity, EU integration, infrastructure recovery, economic boost, and macro stability.

In the long term, it would be essential to focus on advancing and aligning the digital ecosystem and enabling its full potential, when ensuring proper economic growth and further development. As for now, there is a lack of measurement and quantitative data analysis for forecasting policies. Thus, integration into the international statistics bases would stimulate and ease the creation of policy strategies based on evidential data. It would allow us to become a part of the European assessment system, including DESI, OECD Digital indexes, and other indicators to gain better evidence for further usage as a part of the decision-making process. Therefore, at this stage the focus will be more on changing the structure of policy decision-making, implementing new assessment methods, and usage of new technologies, available at that time.

Conclusions to Chapter 4

Digital transformation of public finance both brings risks, as well as creates opportunities for further development. The current state of the Ukrainian public finance system is challenged by corruption, low institutional capacity, the legal framework for data protection, as well as decreasing financial capabilities and growing expenditure, reprioritizing funds allocation towards defense areas.

However, the digitalization of public services could be a tool for further economic recovery, fighting the problems of corruption, inefficient funds usage, and complexity in the accounting of international assistance and funds management. Because of the rising international support, there is a chance for quicker aligning Ukrainian legal and institutional foundations along with international standards. Moreover, with the

To enhance the return from digitalization, as well as bring it to a higher level of development, a set of recommendations based on the analysis was presented. In order to ensure accountable and transparent public funds flow, especially in terms of international assistance for further recovery it is recommended to create separate governmental platforms, which will show all project funds allocation concerning the recovery. Moreover, there is a need to cooperate with international experts in developing legal frameworks on data protection and cybersecurity. It is also essential to stimulate investments into the IT sector, to ensure funds availability for further technical development.

CONCLUSIONS

Digital transformation in public finance is an integral part of the government, especially with the rapid pace of digital technologies. While digital transformation presents a more complex approach towards using digital tools as a way to change various aspects of life, digitalization stands for a more gradual advancement of the process through digital technologies, and digitization related to data transformation. Thus, there a sequence where data digitization comes first, then processes are digitalized, and the sector is digitally transformed.

Moreover, in the first chapter, the theoretical approach toward digital tool implementation in the public sector was discussed. Digital government is defined as an implementation of ICT technologies into changing the public sector, service delivery model, and governmental ecosystem toward more digital and city centered.

It was explained the approach towards public finance and identified that there are 5 key components: public finance management system, budgeting, national debt, revenue collection, and expenditures. The utilization of digital public infrastructure has laid the groundwork for further digital transformation in the field of public finance. This transformation involves the adoption of ICT technologies to digitize each component and create a new digital ecosystem that enables more efficient and transparent governance.

According to the second chapter, where the first global, Ukrainian analysis on the current state of digital transformation of public finance was conducted, government enhance the using of digital technologies in the public finance sector. The main focus in now on the essence of digital public infrastructure, service delivery, and decision-making processes advancement, as well as citizen-centric public services.

European Union is estimated to have leading positions in the overall digital advancement in the public sector, with the developed Denmark, swede, and Estonian digital public finance ecosystems. These countries have not only progressed in digital technologies implementation but also continuously update their legal frameworks as well as digital architecture. The main areas of focus are institutional capacities, regulations,

and data protection, human capital advancement, as well as expanding the e-services ecosystem. Among countries that experienced significant digital implementations level are Kenya, Ukraine, and Georgia – examples of less developed economies benefiting from expanding digital capacities. By enabling a long-term journey of digitalization and continuously update of strategies, legal frameworks, and institutional capacities, governments can ensure that their public finance systems remain agile, responsive, and well-equipped to meet the evolving needs of their citizens.

Ukraine has focused on digital transformation and made it one of the priorities for further development. For the past few years, numerous projects e-taxes, e-customs, procurement and e-payment projects was launched. Among others are Diia City, Prozzoro, Open Budget, Spending, and Proifi. The development of new projects has not stopped even after a full-scale invasion E-service ecosystem has been constantly expanding, responding to the most urgent needs of the citizens, and are used as an effective tool for overcoming challenges. A project like Edopomoga or Diia has helped migrants and displaced people by being in the contact with government, receiving financial assistance, and be a part of the Ukrainian government, even with the physical connection.

Cooperation within governmental agencies like The ministry of Digital Transformation and The Ministry of Finance as well as with international partners enables financial, human, and technological assistance for ongoing and developing projects. Among key partners in public finance digitalization are Germany, Sweden, US, UK, and Estonia. With their help, Ukraine has financed complex programs like ID signatures, law framework updating, assessment of public fiancé management allocation, and others. Currently, Ukraine tries to build. a complex GaaP approach with a city-centered approach.

The last chapter uses EViews software 12SV panel data regression for estimating the relationship between digitalization of public finance and social, economic, governance, and institutional, ICT technologies indicators within two income groups: lower-and upper-middle-income countries. The Open Budget Index was used as a proxy for presenting the digitalization of public finance. There are still adjustments and further advancements of the model that should be made, however, it still presented useful infights

for Ukraine as a part of the lower-income middle group with the aim of further development.

Institutional and governance factors have shown a significant dependency on the digitalization of public finance within both income groups. Thus, it was indicated that by advancing in encompassing digital tools in the public finance sector, the overall institutional capacity could be greatly increased, and vice versa. The results have shown an increase of more than 17% for poorer counties in voice and accountability within the 1% change in digitalization, and, in the higher income group with the increase of 1% in transparency, LW exceeds by 22%. Moreover, there is evidence that digitalization influences economic development with higher levels in less developed countries, why there is a minimum sign of GDP growth: with the budget transparency increase by 1%, GDP growth in the lower-middle countries would increase by 1.14%, whereas in upper-middle countries only by 0,001%, which is relatively small. Moreover, there is evidence that there is harder to digitalize more populated countries, especially with low income, with effect only in the less developed countries. With the 1.9% raise in population, transparency is decreased by 1%.

Further, it defined the main challenges for Ukraine that were and appeared after the full-scale war. There was evidence presented about a huge brain drain process leading to a decline in human capital. Moreover, because of the constant attacks and military actions, a lot of ICT infrastructure was damaged or destroyed, with the electricity shortage on top. It indicated that instant actions should be taken in order to recover access to essential ICT needs, and e-services respectively. Moreover, there is a problem in the institutional and regulatory capacities, as to the absence of a complex institutional ecosystem. There is a need to ensure financial transparency and accounting, as well to update data privacy regulations and align them with international standards. Moreover, cybersecurity is defined as one of the most important areas to improve and ensure proper operations, as for the risk of national data security systems being under hacker attacks, especially from the Russian side.

Along with the key challenges, a lot of opportunities have appeared. Increase international support and assistance due to the war has led Ukraine to open the door

towards more complex and advanced technologies being implemented. Moreover, now there is a huge chance for Ukraine to align the law regulatory framework in accordance with EU criteria and fulfill all the needs with the help of international organizations and governments. EU partial integration with a trustful tax policy, accountable budget and debt policy as well as a transparent and responsible government has become an opportunity for Ukraine as well, which could reduce border barriers and ensure cost-saving leading to easier goods and services exchange within the Digital EU Market. It will increase convenience, ease government-citizen interactions, as well improve financial inclusion in Ukraine. Additionally, , it will be able to increase financial institutions' security. New regulations, cybersecurity measures, as well as AI and encryption usage for risk assessment could boost data protection.

Based on the provided analyses, as well as my own estimated research, the recommendation has been written. It was suggested to divide them into the three dimension-period:

- short-term (up to 1-year, active war phase);
- medium (2-5 years, post-war recovery and minimization of the active war period);
- long-term (5-10 years – further recovery and development phase).

In the first period, it is crucial to focus on the war consequences and recover damaged infrastructure, ensuring the launching of services according to the needs of citizens, especially for vulnerable groups. This phase involves great international financial and technological assistance.

In the second period, the main area of focus will be on reforming the legislative environment, increasing institutional capacities, as well as reducing the digital gap, and focusing on security measures. Moreover, it is crucial to endure human capital development and create circumstances like tax credits for R&D, IT companies or other stimulations for people returning to Ukraine.

The third phase is generally aimed at maintaining reached development and enhancing the full potential of digital transformation in public finance. It is suggested that data analysis, indicators assessment, and joining international statistics systems will help

to provide policies based on evidential data. Moreover, it will ensure better shaping of the decision-making process, as well as advance forecasting and implementing of new assessment methods.

Overall, Ukraine has a huge potential to use the digitalization of public finance as a tool for further recovery and development. However, there is a broad range of reactions that needed to be firstly done in order to feel the full benefits. By fulfilling all recommendations, based on the international outlook, trends and challenges and opportunities, Ukraine may build an not only a complex digital public finance system, but also use full capacities to ensure development and further growth.

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