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DIGITALIZATION IN THE CONTEXT OF HOUSEHOLD ECONOMIC RESILIENCE

The transformation of the Ukrainian economy under the impact of full-scale invasion has created conditions for analyzing the relationship between digitalization and economic resilience of the household sector. Physical destruction of infrastructure and mass migration have transformed digital technologies from an optional tool into the primary means of preserving economic activity. However, despite the evident role of digitalization in ensuring Ukraine's economic resilience during shock impacts, a quantitative assessment of its contribution is almost absent. Therefore, this research is based on the hypothesis that digitalization can serve as a mechanism of economic resilience, partially compensating for losses from economic shocks through alternative channels of income generation and expenditure. To empirically test the proposed hypothesis, an Index of Economic Resilience of the Household Sector has been developed, which integrates economic indicators (consumption, income, lending, employment) and digital indicators (skills, infrastructure, institutions) into a single metric. The calculation results enabled the application of counterfactual analysis to compare actual resilience with a hypothetical scenario in the absence of the digital component. The calculations were based on data obtained from national statistics and international organizations for the period 2018–2024. It has been established that the sector's resilience decreased by 14% during 2021–2023; however, without the digital component, the decline would have been twice as deep. Thus, digitalization ensured 23–29% of the actual index value and prevented critical destabilization. At the same time, the research identifies problematic areas, such as rapid digital adaptation

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ЦИФРОВІЗАЦІЯ В СИСТЕМІ ЕКОНОМІЧНОЇ СТІЙКОСТІ ДОМОГОСПОДАРСТВ

Трансформація української економіки під впливом повномасштабного вторгнення створила умови для аналізу взаємозв'язку між цифровізацією та економічною стійкістю сектору домогосподарств. Фізичне руйнування інфраструктури та масова міграція населення перетворили цифрові технології з опціонального інструменту на основний спосіб збереження економічної активності. Проте через очевидну роль цифровізації у забезпеченні стійкості економіки України під час шоків вплив кількісна оцінка її внеску майже відсутня. Саме тому основу цього дослідження становить гіпотеза, що цифровізація здатна виступати механізмом економічної стійкості, частково компенсуючи втрати від економічних шоків через альтернативні канали генерування доходів та здійснення витрат. З метою емпіричної перевірки запропонованої гіпотези розроблено Індекс економічної стійкості сектору домогосподарств, який поєднує економічні показники (споживання, доходи, кредитування, зайнятість) та цифрові (навички, інфраструктура, інституції) в єдину метрику. Результати розрахунків дозволили застосувати контрфактичний аналіз та порівняти фактичну стійкість з гіпотетичним сценарієм за відсутності цифрової складової. Базою для розрахунків стали дані національної статистики та міжнародних організацій за 2018–2024 рр. Встановлено, що стійкість сектору знизилася на 14% протягом 2021–2023 рр., проте без цифрової компоненти падіння було б удвічі глибшим. Отже, цифровізація забезпечила 23–29% фактичного значення індексу та запобігла критичній дестабілізації. Водночас дослідження фіксує її проблемні зони: швидка цифрова адаптація населення відбувається за наявності суттєвих



of the population occurring in the presence of significant infrastructure constraints and institutional gaps, which restrain the full realization of digitalization's potential as a resilience factor.

Keywords: economic resilience, household sector, digitalisation, digital resilience.

інфраструктурних обмежень та інституційних прогалів, що стримує повну реалізацію потенціалу цифровізації як фактора стійкості.

Ключові слова: економічна стійкість, сектор домогосподарств, цифровізація, цифрова стійкість.

JEL Classification: D10, O33, E21, C43.

Introduction

Research on the economic sustainability of the household sector and digitalization processes usually develops as separate scientific directions with limited interaction between them. While the first direction focuses mainly on economic components – income levels, consumption, and savings, the second approach considers the development of digital skills, access to digital infrastructure, and the use of digital public services. In recent years, the Ukrainian economy has been experiencing significant shocks and, at the same time, experiencing a rapid digital transformation. These two factors, paradoxical in their simultaneity, actualize the need to integrate several scientific approaches to understand synergistic effects. The key problem remains the lack of a single methodology that would combine economic and digital indicators, as well as allow assessing the contribution of digitalization to the overall sustainability of the household sector.

Undoubtedly, digitalization has long been considered one of the drivers of the transformation of economic systems. There is a concept of the "second machine age" (Dong and McIntyre, 2014), according to which digital technologies are a key factor in structural changes in the organization of economic activity, with the transformation covering not only technological changes, but also economic relations in general. In parallel, the concept of economic resilience is developing: the economy is considered as a system, and its response to shocks determines the immediate level of resilience. Several works (Martin & Sunley, 2014) have proposed a multidimensional typology of economic resilience, which includes the ability to resist shocks (resistance), adapt (adaptation), and transform (transformation). The proposed conceptual framework is also relevant for studying the resilience of the household sector, since it allows us to capture all levels of response to shocks – from short-term shock absorption to long-term changes in economic parameters.

One of the most studied shocks is COVID-19 and the response of economic systems to it. Since this factor was the impetus for the accelerated development of digitalization for many economies around the world, many works examine its impact on sustainability specifically during this time period. However, it is important to note that the results of such empirical studies often depend on the specifics of the economic system under study. Thus, the results for the US economy (Fairlie et al., 2021) indicate the presence of an adaptive function of digital technologies. According to the data obtained, the ability to switch to a remote type of work reduces the risk of job loss during the lockdown (but, of course, the results are not the same for all types of

economic activity). A number of studies (Dingel & Neiman, 2020) have quantified the share of jobs (for the US, this figure is 37%). Digitalization and a developed digital infrastructure significantly increase the chances of survival of small businesses (20–25%, according to Bartik et al., 2020). There are indirect channels of influence of digitalization on the resilience of households through their economic connections with the business sector.

However, there are also negative effects of the impact of digitalization. On the one hand, digitalization acts as a tool for strengthening resilience, which can deepen inequality if the country has an uneven distribution of access to digital technologies. According to theoretical developments (Van Deursen & Van Dijk, 2018), digital inequality can be viewed as a multi-level model. It includes inequality in access to technologies (first-level divide), skills in their use (second-level divide), and results of their use (third-level divide).

Thus, even if a household has access to the internet, the lack of digital skills limits the full use of digital technologies to improve its economic situation. Some studies combine the assessment of digitalization and the level of economic resilience, but their number is quite limited. Most of the empirical studies concern the business sector, in particular the impact of digitalization on organizational resilience during COVID-19 (Soto-Acosta, 2020). The household sector was left out of the model, but the results for the business sector identify several channels of influence: digital infrastructure, digital competencies of personnel, digital business model, and digital ecosystems.

The scientific literature focuses on the role of digital technologies in supporting the resilience of households in rural areas (Phillipson et al., 2020). Access to broadband internet is a critical factor in maintaining economic activity, social ties, and access to public services. However, in this case, the quality of the digital infrastructure and access to it are important.

At the same time, research on the Ukrainian context in wartime conditions remains limited due to the difficulties of data collection. The developments mostly focus on separate aspects – either on the economic consequences of a full-scale invasion (Polyakova & Kogatko, 2025; Zayats, 2024; Nikolayets et al., 2023; Umantsiv & Shkuropadska, 2023) or on digitalization processes separately (Tomashevska, 2025; Novikova & Azmuk, 2023), without comparing these dimensions together.

The aim of the research is to quantify the contribution of digitalization to ensuring the economic resilience of the household sector of Ukraine under shocks for the period 2018–2024 based on an integrated index combining economic and digital dimensions of resilience.

The research is based on the hypothesis that digitalization is a significant factor in maintaining the economic sustainability of the household sector of Ukraine and is able to provide alternative channels of economic activity (remote work, digital payments, online services) in the event of a shock. The hypothesis is tested by constructing an integral resilience index that includes both economic and digital indicators. According to the results obtained, a counterfactual analysis of the contribution of digitalization was conducted: an alternative resilience index was calculated without taking into account digital indicators. A comparison of the actual index (with a digital

component) and the counterfactual index (without a digital component) allows us to quantitatively assess the contribution of digitalization to the overall resilience of the sector.

The information base for the quantitative assessment is the data of the State Statistics Service of Ukraine for 2018–2024 (indicators of household income, consumer spending, lending, employment), the National Bank of Ukraine (structure of the loan portfolio), the International Telecommunication Union (digital development indicators), the Networked Readiness Index (network readiness index), the Ministry of Digital Transformation of Ukraine (data on the level of digital skills of the population and digital transformation of regions). The study has limitations, which are mostly related to the complexity of collecting data during a full-scale invasion. The values for some of the indicators are not published after 2022, and detailed statistical reporting of the digitalization process, on the contrary, begins in 2022. Therefore, in order to avoid discrepancies, certain indicators were not taken into account for those years during which data were missing. It is also worth noting that the chosen method has binary normalization (more details in the methodological overview) – unfortunately, this does not allow for a detailed assessment of the degree of deviation of actual values from thresholds. In addition, the counterfactual analysis does not take into account possible indirect effects between digital and economic indicators.

The main part of the research has three parts. The first section substantiates the theoretical channels of influence of digitalization on sustainability and reveals the features of the construction of the proposed Index. The second is devoted to the calculations of the Index and a more detailed analysis of the indicators. The third section presents the results of the counterfactual analysis and analyzes the asymmetry of digital influence.

1. Conceptual foundations and methodology of the household economic resilience Index

The household sector is the main consumer of goods and services and significantly affects demand and the labor market. In the context of digital transformation, households are an important element of economic resilience, since the level of their digitalization affects the adaptability of the economy to shocks and changes in the internal/external environment. Assessing the impact of digital technologies on the economic resilience of the household sector will allow for a comprehensive understanding of their ability to:

- adapt to digital transformations;
- maintain productivity and employment in the digital economy;
- minimize risks and vulnerabilities of the economic system;
- promote sustainable economic growth at the macroeconomic level.

This will allow identifying the strengths and weaknesses of the sector's development in the context of economic sustainability and formulating effective public policies aimed at increasing the sustainability of the economy.

The economic sustainability of the household sector in the context of digitalization is the ability of households to maintain economic stability and adaptability through the use of digital tools. This includes the effective use of digital infrastructure, the development and maintenance of digital competencies, ensuring sustainable employment, and the ability to withstand shocks. Economic sustainability under the conditions of the use of digital technologies reflects the ability of households to maintain economic activity, integrate into the digital economy, and minimize vulnerabilities arising from the process of digitalization.

It is proposed to quantify the sector’s economic resilience and determine the role of digitalization in ensuring it, using the Economic Resilience Index. The Economic Resilience Index of the Household Sector (hereinafter referred to as the Index) is based on the understanding of resilience as the sector’s ability to maintain its own functionality and recover from shocks. In fact, the conceptual foundations of resilience make the proposed index a composite indicator. The index aggregates information on the main aspects of the functioning of households in the context of the transformation of the economic system: the components of the Index constitute 4 groups, the description and indicators of which are presented in *Table 1*. The index is built on the assumption that digital tools are able to increase economic resilience and mitigate the negative effects of shocks, and therefore, play an "auxiliary" function in the restoration of economic parameters.

Table 1

Indicators of the household sector economic resilience Index

Group of indicators	Description	Indicators
Financial sustainability and consumer potential	Covers basic economic parameters of household financial health. This group of indicators is included in the Index based on the fundamental role of consumption and financial stability in ensuring the sustainability of any economic system	1.1 Household final consumption expenditure to GDP (%). 1.2 Share of household loans in total gross loans (%). 1.3 Ratio of loans and loans for residential real estate to total gross loans (%). 1.4 Share of registered unemployed among the total population, %
Digital transformation and technological adaptation	Represents the sector’s ability to adapt in the digital economy through the development of digital skills (1.5, 1.7), access to digital infrastructure (1.6), use and development of human capital (1.9), and motivation to be part of the digital labor market (1.8). Conceptually, the indicators reflect the modern paradigm of economic development (recall that according to it, digitalization acts as a mechanism for increasing sustainability through diversification of income sources, access to information, and the ability to adapt to changing market conditions). The high weight of the group (33.3%) corresponds to the growing role of digital factors in the modern economy	1.5 Digital skills gap index. 1.6 Universal connectivity index. 1.7 Network readiness index: component – People. 1.8 Average monthly salary of employees working in the ICT sector. 1.9 Human capital index

End of Table 1

Group of indicators	Description	Indicators
Institutional environment and information infrastructure	The indicators are added to determine the environment in which households carry out economic activities in the digital space. They cover the parameters of institutional support for the digitalization process (1.10 – legislative data protection, 1.11 – access to information) and the state of technological infrastructure (1.12 – stability of mobile Internet, 1.13 – speed of fixed Internet)	1.10 Legislation on the protection of personal data. 1.11 Access to information index. 1.12 Mobile Internet stability index. 1.13 Fixed Internet speed
Economic activity and income Structure	The group characterizes the position of the household sector in the structure of the national economy through its participation in the creation of added value (1.14) and the distribution of national income (1.15). The lower weight of the group is because these indicators are more aggregated and partially reflect the resulting effect of the factors presented in the previous groups	1.14 Share of households in gross value added (%)/ 1.15 Share of household disposable income in gross disposable income (%)

Source: compiled by the author.

The index is calculated in three stages:

Step 1. Indicator normalization. A threshold value is set for each indicator, reflecting the minimum acceptable level for each. Normalization is performed using a binary principle:

$$N_i = \begin{cases} 1, \text{ if } X_i \geq T_i \text{ (for direct impact indicators)} \\ 1, \text{ if } X_i \leq T_i \text{ (for reverse impact indicators)} \\ 0, \text{ in other cases} \end{cases},$$

where N_i is the scaled value of the i -th indicator, X_i is the actual value of the i -th indicator, and T_i is the threshold value of the i -th indicator.

Step 2. Calculation of the composite index. The composite index is calculated using the following formula:

$$I_n = \frac{\sum N=1}{\sum N_x} \cdot 100\%$$

where I_n is the integral indicator of the n th sector of the economy; $n = (1, 2, 3)$;
 $N_x = 1$ is the number of indicators whose normalized value is equal to 1;
 N_x is the total number of indicators.

Step 3. Results interpretation. The obtained value is interpreted according to the stability level scale (Table 2).

Index interpretation scale

№	Index value, %	Number of indicators reaching threshold values	Stability level
1	86–100	13–15	High
2	66–85	10–12	Sufficient
3	45–65	7–9	Average
4	26–44	4–6	Moderate
5	0–25	0–3	Low

Source: compiled by the author.

The formation of the Index structure is based on the methodological principles of representativeness and availability of statistical data.

The representativeness principle assumes that each group of indicators covers key aspects of the sustainability of the household sector. The group of financial sustainability indicators (1.1–1.4) represents the basic ability of households to maintain consumption, accumulate financial resources, and maintain employment. The digital transformation indicators (1.5–1.9) reflect the adaptive potential of the sector and consider the accumulation of digital competencies and integration into the digital economy. The group of institutional environments (1.10–1.13) characterizes the conditions in which digital activity is implemented. Finally, the group of economic activity indicators (1.14–1.15) reflects the position of the sector in the structure of the national economy.

The principle of data availability has led to a restriction of the list of indicators to only those indicators for which there is regular statistical reporting or international indices with a transparent calculation methodology. This explains the absence of some potentially relevant variables in the structure of the Index. In particular, regional differentiation is not added due to the limited regional statistics in the period 2022–2024 (lack of data for occupied territories, inconsistent reporting). Digital literacy quality indicators (unlike the formal digital skills index) are not included due to the lack of regular measurements at the national level. Infrastructural constraints on the digital development of the sector are taken into account, but more detailed metrics (e.g., geographical coverage of broadband Internet, cost of access) are excluded due to data fragmentation.

The threshold values were set depending on the origin of the indicator. For example, for indicators based on international indices, the threshold values were set at the level of average indicators for Central and Eastern European countries or minimum values for EU countries. For example, the threshold level of the universal communication index of 70% (1.6) corresponds to the median

value for the countries of the region according to ITU data. For macroeconomic indicators (1.1, 1.14, 1.15), a normative approach based on theoretical models of the economic structure was applied. Thus, the threshold of 55% for consumer spending to GDP corresponds to the lower limit of the range of 55–65%, typical for stable market economies according to the OECD methodology. For financial indicators (1.2–1.3), an average statistical approach based on the historical dynamics of developed credit markets with an adjustment for the specifics of Ukraine was used.

The weights of the indicators in the basic calculation are equal (each indicator has a weight of $1/n$, where n is the number of indicators with available data). This decision is based on the principle of equal importance of all sustainability dimensions in the absence of unambiguous theoretical or empirical grounds for differentiating the weights.

The constructed Index uses binary normalization instead of the intensity scale (min-max normalization) for several reasons. First, it allows for clear interpretability: the indicator either reaches the minimum acceptable level or not. This corresponds to the concept of threshold effects in the theory of economic sustainability, according to which individual parameters of the system become functional only after reaching a critical level. Secondly, binary normalization is less sensitive to outliers and extreme values of individual indicators, which is especially relevant for the period 2022–2024. Thirdly, this approach allows for the aggregation of qualitatively heterogeneous indicators (percentage, index, absolute) without the distortions that arise with linear normalization of variables of different scales. However, it is worth recognizing the limitations of this choice – the use of a binary approach does not allow for the analysis of the degree of deviation from the threshold value.

The chosen method also has limitations related to the completeness of statistical data. Unfortunately, not all indicators have official data for the full selected study period. The lack of data for individual indicators in 2018–2021 (1.5–1.13) limits the comparability of the Index values between periods. The 2018 Index, calculated on the basis of 6 indicators, is conceptually different from the 2023 Index, based on 15 indicators. This is taken into account in the interpretation as a result of comparing trends within homogeneous periods, rather than absolute values between them. In addition, the conditions of a full-scale invasion led to territorial limitations in statistical data collection: the data do not cover occupied territories and territories without central government control. Also, mass migration (estimated at 6 million people in 2022) creates distortions in per capita indicators. Informal economic activity, which grows during the crisis, is not sufficiently reflected in official statistics, which may underestimate the real economic activity of households (indicator 1.14).

2. Dynamics of economic stability in Ukraine's household sector

Based on all the source data, the Index value for the period 2018–2024 is calculated (*Table 3*).

Table 3

Calculation result of the economic sustainability Index
for the household sector

1	Indicator	Threshold value	2018	2019	2020	2021	2022	2023	2024
1.1	Household final consumption expenditure to GDP, %	≥ 55	68.5	73.38	72.33	68.21	62.68	59.11	61.55
1.2	Share of household loans in total gross loans, %	≥ 35	18.73	21.87	21.77	24.37	21.94	23.7	26.36
1.3	Ratio of loans and advances for residential real estate to total gross loans, %	≥ 25	22.11	15.35	14.01	11.23	9.65	11.22	12.7
1.4	Registered unemployed as a share of total population, %	≤ 4	0.81	0.81	1.1	0.72	0.45	–	–
1.5	Digital skills gap Index	≥ 6	–	–	–	–	4.8	4.8	4.8
1.6	Universal connectivity index	≥ 70	–	–	–	–	74.6	74.6	74.6
1.7	Network readiness Index: people component	≥ 44	–	–	–	–	67.09	74.99	77.28
1.8	Average monthly salary of employees working in the ICT sector	≥ 2.2	–	–	–	–	3.3	3.4	3.6
1.9	Human Capital Index	≥ 0.40	–	–	–	–	0.51	0.51	0.51
1.10	Personal data protection legislation	≥ 3	–	–	–	–	2	2	2
1.11	Access to information Index	≥ 6	–	–	–	–	8	8	7.1
1.12	Mobile internet stability index	≥ 0.13	–	–	–	–	0.1	0.08	0.12
1.13	Fixed internet speed	≥ 100	–	–	–	–	75.81	92.85	88.01
1.14	Share of households in gross value added, %	≥ 30	22.48	23.32	23.91	23.87	17.49	18.38	–
1.15	Share of household disposable income in gross disposable income, %	≥ 65	67.58	69.98	72.35	70.68	61.71	61.51	–
Result by sector, %			50	50	50	50	47	43	46

Source: calculated by the author based on (Financial Sector Statistics, n. d.; State Statistics Service of Ukraine, n. d.; Minfin; Measuring Digital Development ICT Development Index 2024, n. d.; Network Readiness Index, n. d.; Minfin, 2024; Digital Readiness Index 2021, n. d.; Digital Quality of Life Index – Surfshark, 2020; Speedtest Global Index – Internet Speed Around the World – Speedtest Global Index, n. d.).

The level of economic resilience of the sector during 2020–2021 reached 50%, which at first glance indicates an almost imperceptible impact

of the COVID-19 shock on the economic system. However, a more detailed structural analysis reveals other trends.

Using the example of the unemployment rate indicator (1.4), one can observe sensitivity to the shock impact: the increase from 0.81% in 2019 to 1.1% in 2020 (an increase of 35.8%) reflects the deterioration of the labor market situation in the first months of the pandemic. However, since the value of the indicator remained significantly below the threshold level (4%), this did not affect its normalized value. Unfortunately, this also illustrates the limitations of the chosen methodology – binary normalization did not reflect the real deterioration, since it occurred within the "safe zone".

At the same time, the consumer spending to GDP indicator (1.1) demonstrated a counter-shock effect: the decrease from 73.38% in 2019 to 72.33% in 2020 (a decrease of 1.4%) is relatively moderate, which indicates the action of stabilization mechanisms, in particular state support and accumulated savings. In 2021, the indicator further decreased to 68.21%, which already reflects a longer-term effect of the shock on the structure of the economy.

The share of household income (1.15) demonstrates resilience to the pandemic shock: 72.35% in 2020 versus 69.98% in 2019, with a subsequent slight decrease to 70.68% in 2021. All these values exceed the threshold level, so the normalized indicator remained 1. The lack of a rapid deterioration can be explained by several factors: support for state social transfers, business adaptation to new conditions, and the relatively short-term nature of stricter restrictions. Thus, the relative stability of the integral index in 2020–2021 does not reflect the absence of a shock effect, but rather a balancing act between negative effects (deterioration of employment, gradual decline in consumption) and stabilization mechanisms of state policy (social support, adaptation). At the same time, for a number of indicators (1.5–1.13), data for 2020–2021 are missing, which limits the possibility of a full-fledged assessment of the impact of the pandemic on digital aspects of resilience.

The decrease in the index from 50% in 2021 to 47% in 2022 and 43% in 2023 clearly demonstrates the consequences of a full-scale invasion. The decline in the level of resilience can be explained, firstly, by the real deterioration of the economic situation, and secondly, by the expansion of the list of indicators monitored (statistical information has appeared for the group of digital indicators).

The share of disposable household income (1.15) fell sharply from 70.68% in 2021 to 61.71% in 2022 (a decrease of 8.97 pp, or 12.7%). This is the most dramatic change among all indicators, which may indicate a redistribution of national income in favor of the public sector (increasing military spending) and the corporate sector (in the case of enterprises providing military needs or critical infrastructure). The fall below the 65% threshold changed the normalized value from 1 to 0, directly lowering the integral Index. A further decrease to 61.51% in 2023 indicates the consolidation of this structural change.

The share of households in gross value added (1.14) decreased from 23.87% in 2021 to 17.49% in 2022 (a decrease of 6.38 pp or 26.7%). The

sharp drop reflects the collapse of household entrepreneurial activity due to forced migration, loss of access to markets, destruction of physical capital (equipment, premises) in occupied territories, and in zones of active hostilities. Self-employed persons in the trade, consumer services, and tourism sectors were particularly affected. A slight recovery to 18.38% in 2023 indicates the beginning of adaptation, but its level remains critically low.

Consumer spending to GDP (1.1) decreased from 68.21% in 2021 to 62.68% in 2022 (a decrease of 5.53 pp, or 8.1%). Although the indicator remained above the threshold of 55%, the pace of decline indicates a significant shock to consumer behavior. The reduction in consumption reflects both a real decline in incomes and an increase in the propensity to save due to increased uncertainty.

Taking into account digital indicators also revealed vulnerabilities in digital resilience. In particular, the Digital Skills Development Index (1.5) is recorded at 4.8, which is only 80% of the threshold value (normalized value 0).

Fixed Internet speed (1.13) shows volatility: 75.81 Mbps in 2022, 92.85 Mbps in 2023 (22.5% increase), followed by 88.01 Mbps in 2024 (5.2% decrease). The sharp increase in 2023 can be explained by several factors: population concentration in regions with better infrastructure due to migration, exclusion from the sample of occupied territories with worse infrastructure, and investments by operators in restoring networks in controlled regions. At the same time, a decrease in the indicator was recorded in 2024, reflecting the impact of energy attacks on the functioning of network equipment. In addition, in none of the analyzed years was the threshold level of 100 Mbps reached, which limits the possibility of using the most technologically demanding digital services.

The stability of the mobile Internet (1.12) is characterized by even greater volatility: 0.1 in 2022, falling to 0.08 in 2023 (a 20% decrease), followed by a sharp increase to 0.12 in 2024 (a 50% increase). The drop in 2023 reflects the peak load on mobile networks due to population migration and the transition to mobile Internet as the main communication channel after the destruction of fixed infrastructure. The improvement in 2024 indicates the adaptation of mobile operators and investments in expanding network capacity, but the indicator still does not reach the threshold level.

Analysis of the dynamics of indicators allows us to identify three main mechanisms for the implementation of shock impacts on the stability of the household sector: a) income and employment; b) consumer behavior; c) digital adaptation.

The war shock directly affected income generation opportunities through job destruction (physical destruction of enterprises, loss of access to occupied territories), forced migration (loss of connection to sources of income), and structural reallocation of resources in favor of military needs.

The mechanism is manifested through a sharp decline in the share of households in gross value added (indicator 1.14) and the share of their income in national income (indicator 1.15).

Increased uncertainty about the future in wartime conditions has intensified caution as one of the main characteristics of consumer behavior, which has led to an increase in the propensity to save and a reduction in current consumption. At the same time, the real decline in income has limited consumer spending. Therefore, we can observe a shock impact mechanism through a decrease in the share of consumer spending in GDP (indicator 1.1), although this process was less rapid than the decline in income.

Unlike purely economic mechanisms, digitalization also partially performed a depreciation function. The possibility of remote work, access to online services, and digital payments allowed some households to maintain economic activity even in conditions of limited physical mobility. The paradoxical growth of individual digital indicators (1.7, 1.8) in the context of a general deterioration in resilience indicates the role of digitalization as a resilience factor. However, it is worth paying attention to the infrastructure limitations (indicators 1.12, 1.13), which somewhat limited the amortizing effect of digitalization; ultimately, this did not allow to fully compensate for the negative effects of shocks.

The increase in the index from 43% in 2023 to 46% in 2024 indicates the beginning of adaptation processes, but the level of stability is still lower than the baseline (50%). The improvement is mainly due to the performance of digital indicators: the increase in the network readiness index (1.7) to 77.28, the stabilization of the universal communication index (1.6) at 74.6%, and the improvement in the stability of the mobile Internet (1.12) to 0.12. At the same time, structural indicators of economic activity (1.14, 1.15) remain in the critical zone, which indicates the incompleteness of the recovery process.

3. Quantitative assessment of the role of digitalization in ensuring stability

Since the Index includes not only the economic, but also the digital component (1.5–1.9, 1.10–1.13), it is possible to assess the impact of digitalization on the overall sustainability of the sector. We assume that this impact will be observed at two levels – direct (as a change in the value of the Index itself) and indirect (through interaction with other indicators). To assess the direct impact of digital indicators, a counterfactual analysis was used: the index value for 2022–2024 was calculated excluding all digital indicators (1.5–1.9, 1.10–1.13), leaving only traditional economic indicators (1.1–1.4, 1.14–1.15).

Counterfactual index (without digital indicators):

- 2022: 2 out of 6 indicators = 33.3%;
- 2023: 2 out of 6 indicators = 33.3%;
- 2024: 2 out of 5 indicators = 40,0% (indicator 1.14 is missing).

Actual index (with digital indicators):

- 2022: 47%;
- 2023 p.: 43%;
- 2024 p.: 46%.

Changes due to the factor of digitalization of the economy:

- 2022: $47\% - 33.3\% = 13.7$ p. p.;
- 2023: $43\% - 33.3\% = 9.7$ p. p.;
- 2024: $46\% - 40.0\% = 6.0$ p. p.

Thus, digital indicators do make a significant positive contribution to overall resilience. In 2022, digitalization added 13.7 percentage points to the resilience Index, which is 29.1% of the actual index value. Without digital factors, the resilience of the sector would be estimated at 33.3%, which corresponds to the category of "moderate level of resilience".

In 2023, the contribution of digitalization decreased slightly, to 9.7 p.p. (22.6% of the actual value), which may be due to the deterioration of individual digital indicators (decrease in mobile internet stability from 1.12 to 0.1 to 0.08, decrease in the information access index 1.11 from 8 to 7.1 in 2024). However, even in 2023, digitalization remained a critical factor that maintained resilience above the critically low level.

In 2024, the lowest contribution of digitalization is observed – 6 p.p. (13% of the actual value). This is due to two factors: first, the improvement of the counterfactual Index to 40% (by excluding indicator 1.14 due to lack of data), and second, the lack of further growth of most digital indicators (stagnation of 1.5, 1.6, 1.9, 1.10).

Probably the most noticeable is the positive contribution of digitalization during the period of full-scale invasion – the time of the greatest shock impact. According to the results of the Index, in 2022–2023, economic indicators (1.14, 1.15) demonstrated critical deterioration, while digital indicators (1.6–1.9, 1.11) ensured the prevention of the transition of the level of resilience to the "moderate level" category. This empirically confirms the thesis about the role of digitalization as a factor in the sustainability of economic systems.

If not for the positive contribution of digital indicators, the resilience of the household sector in 2022–2023 would be assessed at a lower level, reflecting serious structural problems in most aspects of resilience. The actual values of 47% (2022) and 43% (2023), although corresponding to the category of "below average", nevertheless indicate the preservation of the basic functionality of the sector with moderate, rather than serious problems.

A detailed decomposition of the contribution of individual digital indicators allows us to identify the specifics of their impact:

The indicators of digital adaptation of the population (1.6–1.9) provide a stable positive contribution:

- in 2022–2024, four indicators of this group (1.6, 1.7, 1.8, 1.9) stably have a normalized value of 1;
- their combined contribution is $4/15 = 26.7\%$ of the maximum possible Index;
- without these indicators, the actual Index in 2023 (43%) would decrease to 28.6%, which would correspond to a low level of resilience.

This group of indicators is characterized by inertia and long-term effects of competence accumulation, which indicates resilience to short-term shocks. The growth of the network readiness index (1.7) from 67.09 to 77.28 during 2022–2024 demonstrates that even in conditions of military

shock, the process of accumulation of digital competences does not stop, but, on the contrary, may accelerate due to the effect of forced adaptation.

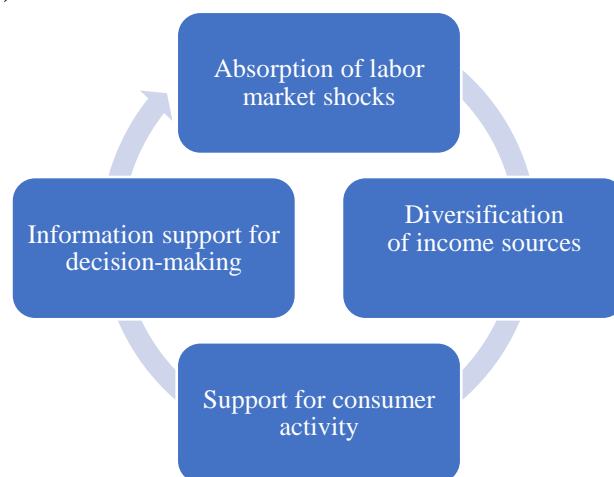
The infrastructure and institutional indicators (1.10–1.13) demonstrate a negative or zero contribution: none of these indicators reaches the threshold value during 2022–2024, and their combined contribution is $0/15 = 0\%$ of the maximum possible index.

The lack of a positive contribution of this group indicates the existence of infrastructural and institutional constraints that do not allow the full realization of the potential of the population's digital adaptation. High indicators of network readiness (1.7) and universal connectivity (1.6) do not ensure adaptability due to insufficient internet speed (1.13), instability of mobile communications (1.12), and weakness of legislative data protection (1.10).

At the same time, the Digital Skills Indicator (1.5) occupies an intermediate position: it consistently does not reach the threshold value (4.8 at a threshold of 6), but the absolute value is relatively high (80% of the threshold).

This indicator reflects the gap between the practical adaptation of the population to digital technologies (high network readiness 1.7) and the formalized level of digital skills. This gives grounds to argue that digital competencies are mostly formed empirically, while the systematic development of in-depth knowledge and skills remains insufficient. In turn, this limits the possibilities of using complex digital services and technologies.

Digitalization affects sustainability not only directly (through its own indicators), but also indirectly, through its relationship with economic indicators (*Figure*).



Indirect mechanisms of digitalization's impact on resilience

Source: compiled by the author.

The development of digital skills and infrastructure allowed a part of the workforce to quickly switch to remote work after the outbreak of the war. This softened the shock of the employment decline, which could have had a much greater impact in the absence of digital opportunities. The growth of wages in the ICT sector (indicator 1.8) from a coefficient of 3.3 to 3.6 in the

context of an overall decline in incomes indicates the emergence of the digital sector as a certain center of stability in the labor market. Digital platforms have allowed households to diversify sources of income through freelancing, the export of services, and e-commerce. Although this did not fully compensate for the decline in traditional sources (which was manifested in the decrease in indicator 1.15), digitalization partially softened the shock. This is evidenced by the fact that the rate of decline in consumer spending (indicator 1.1, a decrease of 8.1% in 2022) was lower than the rate of decline in the share of household income (indicator 1.15, a decrease of 12.7% in 2022), which may be due to compensation through digital tools.

The development of e-commerce and digital payments has allowed for consumer activity to be maintained even in conditions of limited physical mobility. This partly explains the relative resilience of the consumer spending indicator (1.1), which has remained well above the threshold level even in the most difficult periods. Without digital channels of trade, the decline in consumption could have been much deeper due to the physical inaccessibility of goods and services.

A high index of access to information (1.11) provides households with the opportunity to quickly obtain critical information about safety, market conditions, and available support services.

This reduces information asymmetry and allows for more informed economic decisions under conditions of high uncertainty.

However, the analysis also reveals limitations in digitalization as a factor of resilience. First, digitalization cannot fully compensate for fundamental economic shocks. The 26.7% decline in the household share of gross value added (indicator 1.14) in 2022 was not compensated by digital factors, as many types of economic activity (manufacturing of tangible goods, construction, physical services) cannot be fully digitalized.

Second, the impact of digitalization is limited by infrastructural and institutional factors. Insufficient internet speed (1.13), instability of mobile communications (1.12), and weakness of legal data protection (1.10) create additional negative effects that prevent digitalization from realizing its full potential.

Third, the effects of digitalization are unevenly distributed. Digital inequality, which manifests itself as a result of infrastructure constraints, lack of digital skills among parts of the population, or financial constraints, means that not all households receive the positive effects of digitalization.

Fourth, digitalization creates new vulnerabilities: dependence on the functioning of electricity networks (critical in the context of energy attacks), cyber threats, and risks of loss of personal data. In addition, the low level of legislative data protection (indicator 1.10) further strengthens these vulnerabilities. It is important to recognize that the identified mechanisms are based on the analysis of the dynamics of indicators and qualitative observations. The growth of digital indicators (1.7) in parallel with the relative conservation of consumption (1.1) does not prove unequivocally that the former

caused the latter – other alternative explanations can be assumed (state support, use of savings, remittances from migrants). For mathematically clear causal identification, microdata at the household level are needed with the ability to control for multiple factors, which is beyond the scope of this study. The presented analysis establishes the plausibility of causal relationships based on theoretical mechanisms and empirical consistency with aggregated data, but does not claim to definitively prove causality.

Conclusions

Empirical results suggest that digitalization plays a significant role in maintaining the resilience of the household sector, especially in the face of shocks. In 2022–2023, digital indicators provided 23–29% of the actual value of the resilience index, which avoided the transition of resilience to the "low" category.

The analysis reveals four main mechanisms of the digitalization impact on the economic resilience of the household sector: maintaining employment through the transition to remote work (which in turn mitigated the labor market shock for highly skilled workers), diversifying income sources, maintaining consumer activity through e-commerce (which prevented an even deeper decline in consumption under limited physical mobility), and reducing information asymmetry (which accelerated access to state support and optimized economic decisions).

The results obtained confirm the hypothesis that digitalization is a significant factor in maintaining the economic sustainability of the household sector as a result of providing alternative channels of economic activity. At the same time, the research reveals the limitations of this impact: digitalization partially compensates for losses from economic shocks, but cannot fully replace economic stabilization tools.

At the same time, the impact of digitalization is asymmetric: high rates of digital adaptation of the population (indicators 1.6–1.9) partially compensate for structural economic problems (indicators 1.14–1.15), but cannot fully replace them. Infrastructural and institutional constraints (indicators 1.10–1.13) hinder the realization of the potential of digitalization.

To maximize the contribution of digitalization to resilience, a comprehensive policy approach is needed that combines human capital development (formal digital skills), infrastructure modernization (fast and stable internet), and institutional improvements (data protection legislation). Without synchronous progress across all these dimensions, digitalization will not be able to fully realize its potential as a resilience driver.

Future research opportunities include analyzing regional differences in the impact of digitalization on household resilience (if relevant statistical data are available) and examining the long-term effects of digital transformation on the structure of income and employment in the sector in the post-conflict period. Additional research is also needed on the issue of digital inequality and its impact on the differentiation of resilience between social and economic groups of households.

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