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NON-LINEAR NATURE OF THE IMPACT OF DIGITAL TRANSFORMATION ON STRATEGIC MANAGEMENT MODELS OF AGRICULTURAL ENTERPRISES

Abstract. The paper substantiates the non-linear nature of the relationship between the depth of an agricultural enterprise's digital transformation and the performance of its management. Three levels of this non-linearity are identified: the trajectory level (U-shaped dynamics of returns on digital investment), the security level (growing dependence on energy and communication infrastructure as digitalisation deepens) and the population level (stratification of enterprises in the industry by adaptation strategy). It is established that the wartime shock deepens and prolongs the phase of negative returns but, once this phase is overcome, raises the value of the enterprise's analytical capabilities. Three phases of the digital transformation trajectory (cost accumulation, turning point and returns) are proposed, and priority management tasks are defined for each of them. It is concluded that digital transformation should be managed at the strategic rather than the project level, and information and analytical support should show where on the transformation trajectory the enterprise currently stands.
Keywords: digital transformation; non-linear relationship; strategic management; agricultural enterprises; information and analytical support; digital resilience.

In the management practice of Ukrainian agricultural enterprises, digitalisation is still widely viewed as an investment with linear returns. Each new digital solution is assumed to improve performance proportionally. Yet industry experience does not confirm this.

Many enterprises have already spent considerable funds on digital technologies, but the quality of their strategic decisions has not changed noticeably. The reason is that the data obtained are used within the usual hierarchical logic of management [1, p. 108].

Another reason why digital investment appears ineffective lies in how it is evaluated. Digital solutions are often assessed in the same way as investment in machinery, that is, by payback period and cost savings.

Digital transformation, however, changes not a single resource but the way information is used in management. Its effect therefore accumulates more slowly and depends on whether managers are ready to work with data.

Therefore, the main question today is no longer whether digital investment is advisable, but how to manage a process whose results appear unevenly and with a considerable time lag.

The aim of the paper is to substantiate the non-linear nature of the impact of digital transformation on strategic management models of agricultural enterprises and to determine the managerial consequences of this non-linearity under war-related risks.

Our generalisation of the research findings allows us to consider non-linearity at three interrelated levels: the trajectory level, the security level and the population level.

The trajectory level reflects how returns change as the transformation deepens. Using panel data on agricultural companies, L. Zeng and co-authors found a statistically significant U-shaped relationship between the level of digital transformation and supply chain efficiency [2].

That is, at the start, performance does not rise but falls. The enterprise already bears the costs of technology, staff retraining and business process redesign, while the returns on them have not yet materialised. Performance begins to improve only after the curve has passed its minimum.

For agricultural enterprises, the seasonality of production further extends the time lag. In crop production, the effect of many digital solutions can be fully assessed only at the end of the production cycle.

The initial decline is aggravated by organisational resistance, since for the workforce digital transformation is a source of stress. That is why, as T. Z. Hviniashvili rightly observes, technological and digital priorities should be set even before the enterprise strategy is drawn up [3, p. 25].

The greatest danger of such dynamics is that they push enterprises to wind down digital programmes just when the turning point is within reach [4].

It follows that assessing digital transformation by the short-term payback of individual solutions systematically sends a false signal. A digital transformation strategy simultaneously covers the use of technologies, changes in value creation, structural changes and financial aspects [5, p. 339]. Hence its performance cannot be reduced to the financial effect of a single project.

L. O. Marmul and Yu. O. Tkachenko have proposed methodological principles for assessing the economic efficiency of digital innovations in agricultural enterprises [6]. Accordingly, in our opinion, such assessments should be supplemented by considering the phase of the transformation trajectory the enterprise is currently in.

In other words, negative returns at the start of the trajectory are the expected price of transformation, whereas after the turning point they are a warning sign.

At the start, it therefore makes sense to track, alongside profitability, interim progress indicators such as the share of management decisions based on data from digital systems and the timeliness of accounting information.

Under wartime conditions, the U-shaped curve is deformed in two directions at once.

First, the negative-returns phase becomes deeper and longer. In addition to development investment, the enterprise has to finance backup power sources, cybersecurity and redundant communication channels, which keep the systems running but do not directly improve performance.

Second, the right-hand branch of the curve also changes. Once the minimum has been passed, the value of analytical capabilities grows faster than in a stable environment. Under high uncertainty, it is the speed of obtaining and interpreting data that determines whether the enterprise is able to continue operating.

This is consistent, in particular, with the findings of M. A. S. Goraya and co-authors for organisations operating in a hostile environment, where performance gains come specifically from combining a digital transformation strategy with data-driven decision-making [7].

The security level of non-linearity stems from the fact that deeper digitalisation both expands the analytical capabilities of the enterprise and increases its dependence on uninterrupted power supply and communications.

Precision farming systems, machinery telematics, microclimate sensors in livestock buildings and storage facilities, and cloud-based accounting software depend on them.

In stable conditions this dependence remains latent. In wartime, however, it becomes a source of vulnerability: a system shut down by an outage loses its value at the very moment it is most needed.

An outage at the height of the sowing or harvesting campaign may disrupt not only analytics but also the production operations tied to digital systems.

Each further step of digitalisation can therefore make either a positive or a negative contribution to the resilience of the enterprise, depending on whether it is accompanied by fault-tolerance measures: 1) distributed data processing; 2) autonomous power supply for critical nodes; 3) backup data transmission channels.

For strategic management, this means that the digital investment portfolio has to be balanced between expanding functionality and keeping existing systems operational.

The population level describes the behaviour not of a single enterprise but of the industry's population of enterprises. Drawing on evolutionary game theory, M. Rong, H. Hu and Z. Qu showed that a farm's decision on digital restructuring is determined by three groups of factors: the ratio of expected benefits to costs, the actions of other market participants and state regulatory incentives. The equilibrium in this interaction emerges through an evolutionary process and is not predetermined [8].

The wartime shock has made both the adoption of digital solutions and the refusal to adopt them more costly, since a slow response to change today means the risk not so much of losing market position as of halting production altogether.

The result has been a stratification of the industry. Large integrated agribusinesses with the resources to get through the negative-returns phase have accelerated their transformation, whereas small and medium-sized farms have mostly postponed it for the sake of immediate survival [1, p. 110].

Under these conditions, the dependence of digital strategy content on business size, to which M. Kirzhetska and Yu. Kirzhetskyi draw attention [9, p. 7], becomes a source of structural duality in the agricultural sector.

We believe that this duality may deepen over time. Enterprises that have already passed the minimum of the curve may obtain growing returns from analytics. Those that have postponed the transformation, by contrast, will have to start it at a higher cost of entry driven by the wartime shock.

Combining the trajectory level of non-linearity with the war factor makes it possible to distinguish three phases of an agricultural enterprise's digital transformation, each of which places specific demands on strategic management. The logic we propose is summarised in Table 1.

As Table 1 shows, in the first phase the main task is to keep the programme going, in the second to embed data in management procedures, and in the third to scale up solutions while balancing functionality and fault tolerance.

Table 1. Phases of the digital transformation trajectory of an agricultural enterprise and their managerial content

Phase	Performance dynamics	Impact of the war factor	Priority management task
Cost accumulation	Decline due to spending on technology, staff training and process redesign	The phase deepens and lengthens due to spending on backup power, cybersecurity and redundant communications	Staying the strategic course; protecting the programme from premature curtailment; monitoring interim progress indicators
Turning point	Stabilisation at the minimum level; data begin to be used in decisions	The turning point shifts in time; the risk of exiting the trajectory increases	Embedding data in planning, control and decision-making procedures
Returns	Growth above the initial level	The marginal value of analytical capabilities is higher than in stable conditions	Scaling up solutions; balancing investment in functionality and fault tolerance

Source: developed by the author based on [2; 4].

In our view, the most vulnerable stage is the approach to the turning point. The costs have already been incurred, but convincing results are not yet visible, so this is where the risk of premature exit from the trajectory is highest.

The identified non-linearity entails a number of changes in the strategic management model of an agricultural enterprise.

First, we believe that digital transformation should be treated as a long-term strategic programme rather than as a set of stand-alone IT projects, each with its own payback. Decisions to continue or adjust it should take into account the phase of the trajectory, not just current financial indicators.

Second, the management functions themselves are transformed. Planning shifts to scenario-based logic, control becomes continuous and remote, and decisions increasingly rely on data. This is consistent with the Industry 5.0-based shift in the development paradigm of agricultural enterprises described by P. I. Yukhymenko [10].

Third, the transition from the cost phase to the returns phase is possible only when accounting information arrives quickly enough to be used in decision-making, that is, when the time between a business transaction and its appearance in management reports is shortened. It also requires integrating primary data from digital systems into the accounting system and preparing operational reports for managers.

For this reason, the growing requirements for the timeliness of accounting data in the digital economy, which we have pointed out before [11, p. 125], acquire strategic, and not merely accounting, significance for agricultural enterprises.

Conclusions. Thus, the impact of digital transformation on strategic management models of agricultural enterprises is non-linear: it manifests itself at the trajectory, security and population levels, and the wartime shock intensifies non-linearity at each of them.

In practical terms, this calls for information and analytical support that assesses more than the level of digital technology already in place. It should also capture: 1) the

position of the enterprise on the transformation trajectory; 2) the ratio between development investment and investment in system fault tolerance; 3) the risk of premature exit from the trajectory, i.e. curtailment of the programme before the turning point.

Prospects for further research in this area lie primarily in testing, on Ukrainian data, the assumption that the wartime shock changes the shape of the U-shaped curve, and in developing indicators for identifying the trajectory phase of an individual farm.

REFERENCES

1. Burdiak M. Digitalisation as a factor of economic resilience and efficiency of agricultural enterprises: strategic decisions. Visnyk Khmelnytskoho natsionalnoho universytetu. Ekonomichni nauky. 2025. No. 4. P. 108–113. DOI: https://doi.org/10.31891/2307-5740-2025-344-4-13. [in Ukrainian]

2. Zeng L., Wan J., Chen L., Wang J. Does digital transformation improve supply chain efficiency of agricultural enterprises? Frontiers in Sustainable Food Systems. 2026. Vol. 10. Article 1728693. DOI: https://doi.org/10.3389/fsufs.2026.1728693.

3. Hviniashvili T. Z. Changing the paradigm of strategic enterprise management in the digital economy. Ekonomichnyi prostir. 2021. No. 172. P. 23–28. DOI: https://doi.org/10.32782/2224-6282/172-4. [in Ukrainian]

4. Olkhovskyi A., Minina V. Digitalisation of agribusiness: implementation of IT solutions in agriculture. Ekonomika ta suspilstvo. 2025. No. 74. DOI: https://doi.org/10.32782/2524-0072/2025-74-39. [in Ukrainian]

5. Matt C., Hess T., Benlian A. Digital Transformation Strategies. Business & Information Systems Engineering. 2015. Vol. 57, No. 5. P. 339–343. DOI: https://doi.org/10.1007/s12599-015-0401-5.

6. Marmul L. O., Tkachenko Yu. O. Methodological principles of assessing the economic efficiency of implementing digital innovations in domestic agricultural enterprises. Ahrosvit. 2024. No. 22. P. 44–50. DOI: https://doi.org/10.32702/2306-6792.2024.22.44. [in Ukrainian]

7. Goraya M. A. S., Kemal A. A., Xu M., Shareef M. A., Akram M. S. Leveraging digital transformation strategy and data-driven decision-making to improve organisational performance in a hostile environment. Industrial Management & Data Systems. 2026. Vol. 126, No. 2. P. 650–677. DOI: https://doi.org/10.1108/IMDS-10-2024-1039.

8. Rong M., Hu H., Qu Z. Strategic research on the digital transformation of agricultural businesses based on evolutionary game theory. Frontiers in Sustainable Food Systems. 2025. Vol. 9. Article 1575265. DOI: https://doi.org/10.3389/fsufs.2025.1575265.

9. Kirzhetska M., Kirzhetskyi Yu. Features of an enterprise's digital strategy depending on business size. Halytskyi ekonomichnyi visnyk. 2020. Vol. 66, No. 5. P. 7–15. [in Ukrainian]

10. Yukhymenko P. I. Changing the paradigm of agricultural enterprise development based on Industry 5.0 technologies. Ekonomika ta upravlinnia APK. 2024. No. 1 (189). P. 110–118. DOI: https://doi.org/10.33245/2310-9262-2024-189-1-110-118. [in Ukrainian]

11. Oneshko S., Shchyrba I., Kudlaieva N., Bagrii K., Khomovyi S. Integration of accounting management standards into the digital economy: analysis of needs and trends. Pacific Business Review International. 2024. Vol. 17, No. 6. P. 123–130.