sciendo

ISMSME International Society for Manufacturing, Service and Management Engineering

received: 14 May 2022
accepted: 23 August 2022

pages: 1-12

Formation of management and technological maturity levels of enterprises for their dynamic development

Nestor Shpak Olga Vytvytska Olena Martynyuk
Maria Kylaec Włodzimierz Sroka

Nestor Shpak

Lviv Polytechnic National University, Ukraine
ORCID 0000-0003-0620-2458

Corresponding author:
e-mail: nestor.o.shpak@lpnu.ua

Olga Vytvytska

National University of Life and Environmental Sciences of Ukraine, Ukraine
ORCID 0000-0002-2510-3562

Olena Martynyuk

International Humanitarian University, Ukraine,
ORCID 0000-0002-0377-7881

Maria Kylaec

National University of Life and Environmental Sciences of Ukraine, Ukraine
ORCID 0000-0003-4077-7861

Włodzimierz Sroka

WSB University, Poland
University of Johannesburg, South Africa
ORCID 0000-0002-8701-0716

ABSTRACT

Currently, the market environment contains many factors influencing the enterprise's competitiveness. Instability, the unpredictability of events, and insufficiently effective functioning of market mechanisms alter the management focus and processes engaged in an enterprise's functioning. Some of them are intensive in terms of required resources and finance. Such a dynamic situation requires the enterprise management to build innovative solutions to flexibly respond and timely adapt to change. Therefore, this study aims to develop theoretical and applied approaches to determining the level of managerial and technological maturity of the basic set of technologies implemented in enterprises. In the context of this issue's development and aiming to achieve the purpose, the study proposed a model approach where the introduction of individual technologies allows combining the rules for determining the enterprise's management and the technological maturity level, i.e., its readiness for such changes. The construction of the model was based on the analysis and calculation of statistical data from four groups of technologies (corporate, industrial, decision support, and information technologies, which are divided into subclasses) and based on the theory of dynamic innovation development. The results were tested at seven food industry enterprises in Ukraine. Based on the study, the actual level of managerial and technological maturity of enterprises was determined, creating one complex set of technologies that depend on the level and structural changes in management and the level of technological maturity of enterprises. It can be used as a typical model for differently sized enterprises representing various industries.

KEY WORDS

innovation dynamics, technological maturity, food enterprises, development management, resources

10.2478/emj-2022-0022

Introduction

Key management issues of an enterprise as an open economic system are especially relevant in the dynamically developing market environment. This situation largely ensued due to globalisation and current modern world challenges, such as accelerated innovation and information development, digitalisation, global integration processes, the Covid-19 pandemic, and armed conflict (e.g., Katou, 2021; Kaźmierska-Jóźwiak et al., 2021; Pelle & Tabajdi,

Shpak, N., Vytvytska, O., Martynyuk, O., Kylaec, M., & Sroka, W. (2022). Formation of management and technological maturity levels of enterprises for their dynamic development. *Engineering Management in Production and Services, 14*(3), 1-12. doi: 10.2478/emj-2022-0022

2021; Skrodzka, 2021). Climate change is yet another significant contributor (Shpak et al., 2022; Szpilko & Ejdys, 2022). Such changes in the external environment should be reflected by suitable organisational activities, including CSR and business ethics (Vveinhardt & Sroka, 2020). Under these conditions, management technology becomes a continuous creative analysis process, involving some coordination of management procedures and the selection of the most appropriate tools and methods for management regulation and decisions. Forms of information interaction and tangible or intangible transmission become the management object. It is based on the sequence of using tangible resources and intangible assets, opportunities, and the existing potential in the enterprise system (Sowden et al., 2008). New tools and elements The adaptive mechanism of dynamic enterprise development is supplemented by new tools and elements derived from the existing and recent knowledge on enterprise management methods, techniques, and procedures (Usyk et al., 2015). The managerial and technological maturity stages transform the existing management technologies into innovative ones and stimulate the transition to a higher level of development (Martyniuk et al., 2019).

In the 60s of the 20th century, the research focus fell on innovative management technologies as a key aspect of enterprise development and competitive advantage. Now, they are developing the most actively (Florek-Paszkowska et al., 2021). Some researchers, such as Weiner (2009), Mandra (2012), and Verba (2014), claimed that technologies in an enterprise should function as an active tool for change and influence the business process development. However, little is said about the ability of technologies to initiate innovation and become the primary tool for managing dynamic development. Several scholars have identified organisational commitment as an essential prerequisite for successfully implementing organisational change (e.g., Bella, 2007; Darwish, 2000; Lau & Woodman, 1995; Vakola & Nikolau, 2005; Yousef, 2000).

The study into the implementation of certain technologies and their impact on the development efficiency and enterprise operation is becoming increasingly important among scientists and practitioners. The reason behind such an unfolding is the emerging new concept of enterprise management and the systematisation into a single choice methodology, identifying a basic set of innovative technologies appropriate for each enterprise to determine their managerial and technological maturity level. This necessitates further research and scientific substantiation. Therefore, the study aims to develop theoretical and applied approaches to determining the managerial and technological maturity level of the basic set of technologies implemented in enterprises. The study's main objectives are (i) to determine the components and factors particular to the actual level of managerial and technological maturity of enterprises; (ii) to form a set of technologies depending on the level and purpose of structural changes in enterprise management and technological maturity; (iii) to offer a standard model for differently sized enterprises and industries and to test it at seven food industry enterprises in Ukraine.

The article is structured as follows. First, it presents the theoretical research foundations. The theoretical discussions presented in this section focus on studying the formation of technological components required for the diagnostics of the managerial and technological maturity level, assessing the technological maturity of several models. The following presentation provides the basic assumptions behind the formation and implementation model of a set of innovative technologies in the food industry and its development. The next section presents the research results conducted at seven enterprises in the Ukrainian food industry. Finally, the discussion and conclusions are offered.

1. Literature review

The increasing pressure on the quality of products and services prompts enterprises to choose new approaches over traditional quality management methods as the used approach to quality can provide a competitive advantage in terms of unwavering quality, development, and time-to-market measurements (Wijaya & Suasih, 2020; Sujova & Simanova, 2021). As a result, management literature presents many variable management methods and techniques supporting the market activity of businesses. The methods can increase business efficiency and uprate their market value, e.g., by improving the ability to adapt to the current market strategy (Jurczak & Jurczak, 2021). The theory of cyclical and innovative development of enterprises was traced in the works of Tugan-Baranovsky and Schumpeter, whilst innovation issues were identified by Kondratiev. Simon Kuznets' Nobel Prize Lecture on new approaches to the theory of innovation focused on the problem of the relation-

ship between innovation and economic growth. The English researcher Freeman made a significant contribution to the formation of innovation theory, analysing industrial cycles, primarily long waves of economic development. In the twentieth century, these theories were actively developed in different directions. For example, equilibrium states were studied by Sowden et al. (2008), Goncharenko (2012), Lee et al. (2019), Shpak et al. (2019), Didyk (2016), and Kononiuk (2022). These studies focused on the socio-economic processes of the environment and the benefits of the enterprise. Less attention was dedicated to the state of the company's transition as a point of development and possible management changes. Besides, innovative management processes also have a multifaceted nature in research. Kerzner (2007) introduced the theory of management maturity levels. Theories of innovation dynamics as a basis for studying the enterprise as an open socio-economic system are presented by Khaken (2003), Bokhashko (2013), Gutsalyuka (2012), and Hagen et al. (2014).

The force majeure events of 2021 and 2022, such as quarantine restrictions, proved the relevance of the theory in determining the enterprise's managerial and technological maturity, the formation of necessary optimal development technologies, and the urgent implementation need. Now, the enterprise development dynamics are changing so rapidly that classical methods appear insufficient. Therefore, the introduction of technologies to which the company is adapted will allow it to respond quickly to environmental changes.

Approaches to measuring and assessing the enterprise's technological maturity level and managerial maturity separately have significantly different purposes, content, and the depth of factors and criteria analysis. The enterprise's technological maturity research has gained importance to allow the implementation of business processes or individual IT technologies (Grim, 2009; Potoczek, 2021). For example, the formation of enterprise management technologies with in-depth substantiation of basic management technologies and characteristics of their managerial and technological maturity levels is based on the study of existing classical models of such companies as Wipro, Harman Communicate, Real Story Group, Hewlett-Packard, CMMI (the Capability Maturity model by the US Mellon Institute), or Kerzner's models (Project Management Maturity Model, PMMM) and OPM3 (Organisational Project Management Maturity Model).

The essence of the existing assessment methods is to determine the enterprise's readiness for the technological improvement of the IT system without considering the update of existing technologies, equipment, organisational and information infrastructure, professional competencies, and enterprise management technology.

Technological components of management–technology maturity level diagnostics were formed based on the study of the following models' technological maturity assessment: (i) maturity assessment models developed by such consulting companies as Wipro, Real Story Group, (CMS Watch), Smigiel Consulting Group and Harman Communicate (Galimov, 2009); (ii) technological maturity assessment models developed by HewlettPackard experts (HP Enterprise Services, 2001–2015); (iii) models offered by a consulting company Infosys Technologies Limited, within the enterprise transformational development model (Reghunath Balaraman, Aromal Mohan) (HP Enterprise Services, 2001–2015); (iv) the technique for determining the technological maturity level, developed by the company Directum, presented on the site ECMJournal 2010; and (v) the model of the business processes maturity level, developed in the form of tests by the company FineXpert.ru 2003.

Furthermore, the following models were evaluated to base the formation of components for managerial maturity diagnostics of managerial–technological maturity level: (a) the Capability Maturity Model Integration by the Carnegie Mellon University, USA. CMMI is a process maturity model for software or the ability of a company to develop quality software (2010); (b) Kerzner's Maturity Model focused on the development of project management practices (Project Management Maturity Model, PMMM, 2003); (c) the PM Maturity model of Berkeley's University of California quantifying the project management maturity (2017); (d) the Organisational Project Management Maturity Model (OPMM) — an international standard of the Project Management Institute (2003).

Considering the above, the managerial and technological maturity level depends on the set of management technologies implemented at the enterprise. The change in the enterprise development level, progressively and regressively, is primarily determined using an innovative set of management technologies with high adaptability.

The enterprise's managerial and technological maturity levels are grouped according to the main

Tab. 1. Characteristics of the enterprise managerial–technological maturity levels by results of existing model generalisation

The level of managerial and technological maturity	Management characteristics at a given level
Level 1 — Initial, specialised management (Initial)	Business processes occur for the first time; management methods and tools are not used, or no single management strategy exists
Level 2 — Cyclical, control with scheduling elements (Repeatable)	Basic business processes are sustainable; the collection and processing of information are generally irregular, and no single management strategy exists
Level 3 — Process, process management (Processes)	The enterprise's basic business processes are formalised; the collection and processing of information are regular; a unified management strategy is based on experience in operational management; the use of specialised management technologies is intensified
Level 4 — Progressive, development management (Progress)	All business processes of the enterprise are formalised and refined; a unified management strategy is intentionally formed; management problems are subject to comprehensive analysis, elimination, and prevention
Level 5 — Dynamic, continuous improvement management (Sustained dynamic)	All business processes of the enterprise are subject to continuous improvement; the purpose is the dynamic development of the enterprise; the strategy is formed, constantly refined, and adjusted

business process parameters at a given level of enterprise management based on the results of the generalisation of existing models (Table 1).

The company uses the theory and methods of innovation dynamics to identify certain needs and interests, decide on the existing managerial and technological maturity level, and consider the possibility of moving higher or lower. This transition is possible by using the theories paradigm on the development states and life-cycle phases inherent in every company. Also, it is possible to use activity optimisation mechanisms and create conditions for the company to promote its development in dynamics.

The implementation of management technologies with an optimally adaptive innovation component will create a path to a new higher managerial and technological maturity level. Conversely, the inadequate and untimely introduction of even the most efficient technology will burden the enterprise and create conditions for economic and industrial decline. Therefore, it is important to comply with the existing level, stimulating further enterprise development and supporting it long-term in a dynamic business environment.

Under modern, dynamic and highly competitive conditions, there are cases when companies with a sufficient level of managerial and technological maturity find themselves in crisis and are forced to fight for their survival. However, in such a case, only a small number of companies dare to introduce new management technologies with innovative effects.

2. Basic assumptions of the model

The enterprise development methods are dialectically connected with the corresponding development models, so regardless of the methods influencing the managed system, certain changes are expected in the current state. The use of management models can adequately reflect and describe the various discrete states of the enterprise. The transition between discrete states of a functioning enterprise means the system's exit from the equilibrium conditions and the growing uncertainty level in the change process (Kerzner, 2007). A system of differential equations is used to choose such system parameters that allow predicting the impact. The functional criterion of system quality $Q=Q(x,u,t)$ is a set of management technologies that can be applied. The process of enterprise functioning as a developing system is described by the vector differential equation (1). And equation (2) shows what fixed states an enterprise can have at a certain time.

$$\frac{dx}{dA} = B(t)X(t) + U(t,\gamma) \quad (1)$$

where: $x = (x_1, x_2, ..., x_n)$- system state vector;

B(t) — deterministic dimension matrix ^{mxn};

$U(t,\gamma) = (U_1(t,\gamma_1)),(U_2(t,\gamma_2)),...,(U_n(t,\gamma_n))$

n — dimensional control vector,

which depends on a random vector $\gamma = (\gamma_1, \gamma_2, ..., \gamma_m)$.

If the initial state of the system is a condition $x=(t_0)=x_0$ and the system quality criterion is functional $Q=Q(x,u,t)$, then they are functions of a random argument γ.

The type of control is selected so that the functionality can fall within the specified interval with the maximum probability.

Select the control type $U(t,y)$ that way Q to allow the functionality to fall within the specified interval with maximum probability (Q_1, Q_2).

Formula (2) is a mathematical expression of control of economical systems with additional connections.

Consider two systems of equations with respect to random parameters (2):

$$\begin{cases} Q(\gamma_1,\gamma_2,...,\gamma_m)=Q_1 \\ \Psi_1(\gamma_1,\gamma_2,...,\gamma_m)=Q_1 \\ ....,...,...,....,..... \\ \Psi_{m-1}(\gamma_1,\gamma_2,...,\gamma_m)=Q \end{cases} \quad \begin{cases} Q(\gamma_1,\gamma_2,...,\gamma_m)=Q_2 \\ \Psi_1(\gamma_1,\gamma_2,...,\gamma_m)=Q_2 \\ ....,...,...,....,..... \\ \Psi_{m-1}(\gamma_1,\gamma_2,...,\gamma_m)=Q \end{cases} \quad (2)$$

where: Q_1 and Q_2 — some fixed values of the functional Q.

Then, the solution of a particular case of equation (2) in will be (3):

$$x(t)=\frac{Ax_0e^{A\alpha t}}{1+x_0e^{A\alpha t}}+\gamma \quad (3)$$

where: $x=(x_1,x_2,...,x_n)$- system state vector;

Tab. 2. Formation of a basic set of innovative management technologies according to a certain level of managerial and technological maturity

The level of maturity	Grouping	Basic technologies and compositions
Initial	Corporate	Missing
	Production	Supply chain management; operational management
	DSS technology	Fragmentary decisions of the head
	Information technology	Information and accounting technologies (accounting, warehouse, logistic); WEB-business card
Cyclic	Corporate	Change management; budgeting system; brand management
	Production	Financial management; logistics management; marketing management
	DSS technology	Personnel management; BSC systems; benchmarking; outsourcing; risk management
	Information technology	Control and cost information technologies; information technology planning, ARM formation
Process	Corporate	Strategic planning; CRI Office; TQM implementation; controlling
	Production	Quality management; MRP technologies; MFE
	DSS technology	Management accounting and reporting; CRI systems; business process engineering and reengineering; crisis management; downsizing
	Information technology	CIS implementation; implementation of virtual offices, PR and sales informatisation; new business model formation; use of cloud technologies
Progressive	Corporate	Formation of mission and vision; corporate culture introduction; management of knowledge bases; QMS implementation; implementation of the sustainable development concept
	Production	Innovation management; investment management; CRM technologies; ERP, MRP II technologies; MFE
	DSS technology	Process-oriented management; social management; prognostic management; scenario planning; modelling the optimal decision-making mechanism; knowledge management
	Information technology	An online store implementation; developing own media resources (chats, messengers, video reviews, and directories)
Dynamic	Corporate	Strategic alliances; mergers and acquisitions
	Production	Price optimisation models; project management; environmental management, interactive marketing technologies; innovative production modernisation
	DSS technology	Benchmarking; ABB (Process-Oriented Budgeting); VIM (intellectual capital management)
	Information technology	Customisation and big data creation; activity software (creating your own software and custom software); use of mobile applications with artificial intelligence — creating business models

Note: DSS — decision support system.

$A(x)$ - square matrix, the elements which characterised the impact on the economic state of the enterprise system.

It should be borne in mind that enterprises as open economic systems cannot be in a state of absolute equilibrium because they are in a state of constant motion. Such systems are prone to transformations, and when the system approaches critical values of external parameters, there are sudden, unpredictable structural changes or chaos. To neutralise such effects, a certain stabiliser must be introduced into the system. The authors propose management technologies in their transformed, innovative form as such a stabiliser.

3. Model development

As mentioned, enterprises as open economic systems cannot be in absolute equilibrium due to the state of constant motion. Therefore, they are prone to transformation, and once such systems approach critical values of external parameters, sudden and unpredictable structural changes or chaos undoubtedly occur.

A particular stabiliser/inhibitor must be introduced into the system to counteract such effects. Such proposed stabilisers/inhibitors are control technologies in their transformed, innovative form.

The composition of the optimal set of management technologies should be calculated separately for each enterprise. Then, the enterprise's phase portrait is determined by balance, the actual level of managerial and technological maturity of the enterprise. Also, the genetic predisposition of the enterprise to a certain maturity level to ensure dynamic development in the future is determined.

Innovative management technology is a materialised implementation result of a newly created or improved algorithm aimed at optimal and adaptive improvement of certain enterprise activities based on the achievements of scientific and technological progress.

Once a set of measures for the management technology introduction is implemented, the final stage of this process begins, aiming to identify and eliminate shortcomings and prepare the company's staff to use the technology regularly. The final implementation stage begins with the control technology verification. The use of technology is a cyclical process, so testing is considered complete when the control cycle and technological operations and procedures are finished. Increasing the enterprise's managerial and technological maturity level is a complementary process and depends on the level of management technologies innovation and the existing complex optimality.

On the one hand, the managerial and technological maturity level is a determining indicator of the existing technologies set, and on the other hand, it is the implementation of the complex that significantly changes the enterprise's maturity level, development, and the system as a whole. The proposed basic set of management technologies in accordance with a certain managerial and technological maturity level is presented in Table 2.

The data provided in Table 2 allow determining the limits of global performance standards, starting with the introduction of individual management technologies, grouped according to research by foreign scholars and leading companies. It should be noted that the introduction of innovative management technologies has a complex effect, as it radically changes the general balance of the enterprise's system, its managerial and technological maturity level, and its development vectors.

4. Research results

Table 3 presents the effectiveness limits of innovative management technologies optimisation used by significant food industry enterprise groups. The specific attitude and priorities of specialists to the implementation results of each group of technologies were determined: corporate technologies, production technologies, DSS technology, and IT technologies.

Each enterprise was assigned a number in the study group: No. 1 — PJSC Bashtansky Cheese Factory; No. 2 — PJSC Kherson Oil Factory; No. 3 — PJSC Wimm-Bill-Dunn; No. 4 — PJSC Kalanchatsky Oil and Gas Plant; No. 5 — PJSC Zhytomyr Oil Plant; No. 6 — PJSC Yantar; No. 7 — PJSC Yagotinsky Creamery.

The cognitive performance matrix developed for the food industry enterprises shows that enterprises considered the information technologies implementation and the production of complex technologies the least important. Almost all enterprises had upgraded their equipment over the past ten years, and there was no urgent need to retool production. Automated modern production complexes allowed reducing the costs of persons/hours, with no need for additional information technologies.

Tab. 3. Determining possible optimisation effectiveness of innovative management technologies complex for food processing enterprises

Grouping	Boundary standards	S / N No. 1	S / N No. 2	S / N No. 3	S / N No. 4	S / N No. 5	S / N No. 6	S / N No. 7
Corporate technologies	90 %–70 %	85	60	95	70	85	50	85
Production technologies	19 %–48 %	45	20	30	19	20	15	45
DSS technology	60 %–70 %	60	50	40	40	65	35	75
IT technologies	70 %–20 %	60	40	60	50	70	15	80

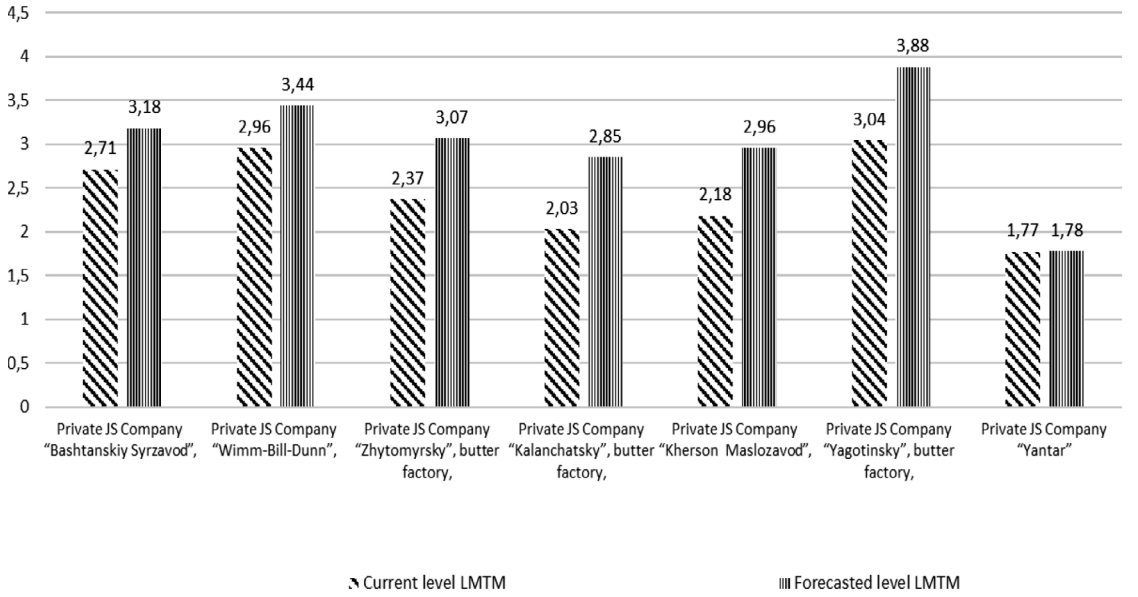

Fig. 1. Determining the managerial and technological maturity level for food industry enterprises

The quantitative and qualitative scales of differentiation of technological and socio-economic development levels were determined, and inhibitors that directly impact enterprise development were identified.

The introduction of innovative management technologies is among the top priorities for the company development of three food market leaders, PJSC Yagotinsky Creamery, PJSC Bashtansky Cheese Factory and PJSC Wim-Biel-Dann. The management of the Milk Alliance (PJSC Yagotinsky Dairy Plant, PJSC Bashtansky Cheese Factory) and PJSC Wimm-Bill-Dann also pay significant attention to corporate and DSS technologies due to their influence on the market segment development and conditions for increasing customer loyalty. The management includes professionals with extensive experience in this field.

The development lag in the PJSC Kalanchatsky Oil and Gas Plant is a warning sign that high-quality products are insufficient without adequate attention to innovative DSS technologies to achieve the necessary development impetus and the enterprise's goals.

In terms of production volumes, PJSC Yantar is an outsider despite the fifty-year history of the company's existence and the brand recognition as a child-friendly company. At some point, the company could not handle the competition and almost closed; however, a strategy to renew the main line of activity has been developing for the past two years.

The management and technological maturity were also diagnosed at other food industry enterprises, i.e., PJSC Bashtansky Cheese Factory, PJSC Kherson Oil Factory, PJSC Wimm-Bill-Dunn, PJSC Kalanchatsky Creamery, PJSC Zhytomyr Butter Factory, PJSC Yantar, PJSC Yagotinsky Creamery. The exercise allowed determining three plants in-between maturity levels 1 and 2 and four large Ukrainian plants that rose to maturity levels 2 and 3 (Fig. 1).

The process of control technology transformation into the innovative state using the key imperatives, methods, and tools of the innovative dynamics theory is investigated and substantiated. The uniqueness of an enterprise's behaviour in space (business environment) and time (equilibrium state) is determined by the point of change of the system (bifurcation point) and the movement vector of the enterprise system (attractor) if it affects the company in a certain period and a certain segment of activity can avoid crises and achieve the enterprise's development in an effective direction.

The criteria allow using a simple algorithm for determining the managerial and technological maturity level, the application of the optimal set of innovative management technologies for the company and obtaining results for their development.

The Covid-19 pandemic in 2021 has clearly shown that enterprises can find themselves in a difficult situation regardless of their development level and country of origin. This is especially difficult in a highly competitive environment. Only a few enterprises manage to adapt and overcome the consequences of such unforeseen events. It was only possible for the companies that managed to make striking changes and adaptively introduced new management technologies with an innovative effect.

5. Discussion

Most companies use a standard set of actions close to the relevant anti-crisis, corrective and other management technologies applied under conditions of unstable operation. Therefore, a detailed analysis of factors affecting the management technology choice does not always determine what technologies are needed at certain management and technological

Tab. 4. Setting performance limits of control technologies

Grouping	Management technologies	Standardisation of regulatory formats for implementation efficiency	Sources of recommendation and format definition
Corporate technologies	Balanced scorecard, strategic audit, strategic controlling	Achieving a common understanding of activities and areas of development — in 90 % of enterprises; improvement of strategy implementation — 70 % of enterprises; an increase in profit — 80% of enterprises; an increase in the planning efficiency — 90 %; the budgeting efficiency increase — 74 % of enterprises	Company research "Horvath & Partners" (2003)
	Designing effective management processes and organisational structure	Increase in return on capital; increase in competitiveness; increase in income; reducing costs; increasing customer retention rates	International standard ISO 10014
DSS technology	BPM ABB	Increasing the efficiency of key cross-functional business processes by 100 %	Lean Institute (J. Vumek, D. Jones, 2003)
	Budgeting, controlling	Increase in profitability of the main activity of the enterprise; reducing capital expenditures by 1–3 % per year	Naidermans Finance Corporation (2002)
	Personnel management technologies	19 % to 48 % non-sales related performance improvement; 48 % to 120 % increased sales performance	Competency International, (1993–2007)
Production technologies	Quality management	Increase in sales volumes — at 61 % of enterprises; increase in consumer satisfaction — 67 % of enterprises; improvement in product quality — in 78 % of enterprises	Research of the Urals Interregional Certification Centre
Information technology	Developing IT strategies, preparing TK for implementing IP	Reduction in the term of closing of the accounting period by five times; reducing the cost of management apparatus by 30 %; reduction of accounts receivable by 13 %; 70 % reduction in budgeting time	Statistics APICS (American Production and Inventory Control Society), "Corus" corporation data

maturity level or clarifies the technology for a particular enterprise.

The fundamental difference between the approaches is in determining the quantitative and qualitative scales of differentiation between technological, managerial, economic, and environmental economic development levels. Also, different approaches differently reveal factors and mechanisms of negative influence levelling on enterprise development.

According to Table 4, the limits of management technologies productivity are determined, which are grouped according to the research of foreign scientists and leading companies.

When considering corporate governance technologies and, in particular, the system of balanced scorecards (BSC), the formation and standardisation of regulatory formats were based on a study by Horvath & Partners. They found that with the implementation of BSC, a common understanding of activities and development directions increases in 90 % of enterprises, thus improving the implementation of the strategy in 70 % of enterprises. However, they do not associate increasing budgeting efficiency with growing profits. The research was supplemented and found that all these qualitative parameters were directly related to the quantitative result of increased profits.

Support and decision-making technologies indirectly capitalise on and increase the company's efficiency; however, studies of the largest international corporations, including the Lean Institute (James Vumek, Daniel Jones), Naidermans Finance Corporation, and Competency International, have substantiated and set the limits within which quality positions can change. This research partly confirmed such findings in theory and practice.

In accordance with the International Standard ISO 10014, the introduction of effective management processes and organisational structure reflects an increase in competitiveness, income increase, cost reduction, and customer retention improvement. Therefore, this research suggests a direct effect on return on capital. It should be noted that quality management technologies were introduced only by those Ukrainian enterprises that entered the international market or had foreign investors. Hopefully, under the conditions of victory and joining the European Union, this will become a mandatory and necessary requirement for all Ukrainian enterprises.

According to the Statistics APICS (American Production and Inventory Control Society), "Corus" corporation data, the development and active implementation of IT technologies, especially the latest generation, reduces the cost of management by 30 % and budgeting time by 70 %. However, this is typical for the US, which regulates the IT market and rules governing budgeting and doing business. In Ukrainian businesses, the introduction of modern IT technologies increases management efficiency by 10–15 times. A certain managerial phenomenon occurs in developing countries, where the payback of technology or IT systems is five times faster than in developed countries.

The implementation of innovative management technologies radically changes the overall balance of the enterprise's system, its management and technological maturity level, and the development vectors. The adaptation mechanism encompasses qualitative changes in the enterprise through an introduced innovative set of management technologies. The basic set of innovative technologies is compiled for using the full range of management technologies for a targeted impact on the enterprise through the improvement of the managerial and technological maturity level to achieve dynamic development.

Conclusions

The innovative dynamics concept was used to substantiate the possibilities of movement and development among food technology enterprises. The methodological apparatus allowed to form the concept of "innovative management technology". A comparative analysis of management and technological maturity evaluation was performed on the basis of different models, such as CMMI (Capability Maturity Model Integration) by the Carnegie Mellon University, Kerzner's Maturity Model, PM3M Portfolio, Programme, and Project Management Maturity Model) by the Ministry of State Trade of the United Kingdom, and the PM Maturity model of Berkeley's University of California. It allowed to form five managerial and technological maturity levels and determine the characteristic processes that occur in the enterprise at each maturity level. Each of the five levels has its own strategies for describing and formalising business processes, management technologies, the state of information, and communication space formation.

In contrast to existing models, methodological approaches to determining the state of financial and economic equilibrium in a changing business envi-

ronment allow to form the existing vectors of enterprise development and choose a multivariate model of its dynamic development. This constitutes the research's contribution to the theory. They can be used as a typical model for enterprises of different sizes and industries. The proposed approaches were used by enterprises and allowed a quick result in the development and saving of resources.

The study has limitations. First, companies from a developing country (Ukraine) were analysed only, thus making it unclear whether the proposed approaches can be used in more developed countries. Secondly, the number of analysed companies (seven) is relatively small. Therefore, further research on a larger sample should be conducted. Furthermore, future research should be more in-depth, apply the optimal set of innovative management technologies for enterprises, and consider the basic set that affects the activities of the enterprise and the effectiveness of its development.

Literature

Bohashko, O. L. (2013). Evolution of Theoretical Approaches to Innovation Development in Economic Science. *Bulletin of the Berdyansk University of Management and Business, 2*(22), 23-29.

Bushuyev, S. D., Bushuyeva, N. S., Babayev, I. A., Yakovenko, V. B., & Grisha Ye. B. (2010). *Creative technologies of project and program management. Ukrainian Project Management Association*. Kyiv: Sammit-Kniga.

Cieslinska, K. (2007). The Basic Roles of Manager in Business Organization. *Roczniki Akademii Rolniczej w Poznaniu, CCCLXXXV, Ekon, 6*, 3-12. Retrieved from http://www.jard.edu.pl/ pub/1_6_2007.pdf

Ciocanel, A. B., & Pavalescu, F. M. (2015). Innovation and Competitiveness in European Context. *Procedia Economics and Finance*, *32*, 728-737. doi: 10.1016/ S2212- 5671(15)01455-0

Didyk, A. M. (2016). Innovative dynamics as an element of the system of poluvector development of enterprises. *Economy. Finances. Law, 5,* 4-6.

Florek-Paszkowska, A., Ujwary-Gil, A., & Godlewska--Dzioboń, B. (2021). Business innovation and critical success factors in the era of digital transformation and turbulent times. *Journal of Entrepreneurship, Management, and Innovation*, *17*(4), 7-28. doi: 10.7341/20211741

Gloet, M., & Samson, D. (2020). *Knowledge management and systematic innovation capability*. In Disruptive Technology: Concepts, Methodologies, Tools, and Applications (pp. 1198-1218). IGI Global.

Grim, T. (2009). Foresight Maturity Model (FMM): Achieving Best Practices in the Foresight Field. *Journal of Futures Studies, 13*(4), 69-80.

Hagen, B., Denicolai, S., & Zucchella, A. (2014). International entrepreneurship at the crossroads between innovation and internationalization. *Journal of International Entrepreneurship*, *12*(2), 111-114.

Hilkevics, S., & Hilkevica, G. (2017). New information technologies use for Latvian stock companies financial health. *Entrepreneurship and Sustainability Issues, Entrepreneurship and Sustainability Center, 5*(2), 178-189. doi: ff10.9770/jesi.2017.5.2(1)

Honcharenko, O. M. (2012). Analysis of synergetic phenomena of the economic system and their role in the stability of its development. *Bulletin of the Vinnytsia National Polytechnic University, 6*(105), 83-87.

Hutsalyuk, O. M. (2012). Methodological Approach to the Estimation of Enterprise Technology Mature. *Business Information, 11,* 200-204.

Jain, S., & Lechevalier, D. (2016). Standards based generation of a virtual factory model. In P. I. Frazier, R. Szechtman, E. Zhou, T. Huschka, & S. E. Chick (Ed.), *Proceedings of the 2016 Winter Simulation Conference* (WSC '16) (pp. 2762-2773). Piscataway: IEEE. doi: 10.1109/WSC.2016.7822313

Jurczak, J., & Jurczak, G. (2021). Application of factor analysis in company management — selected examples related to competitiveness and market success. *Engineering Management in Production and Services*, *13*(3), 25-36. doi: 10.2478/emj2021-0019

Katou, A. A. (2021). COVID-19 and organisational performance: a quasi-longitudinal and multilevel study of Greece. *Forum Scientiae Oeconomia*, *9*(4), 117-135. doi: 10.23762/FSO_VOL9_NO4_6

Kaźmierska-Jóźwiak, B., Sekuła, P., & Socha, B. (2021). Analysis of the effects of COVID-19 on companies listed on the Warsaw Stock Exchange. *Forum Scientiae Oeconomia*, *9*(4), 99-116. doi: 10.23762//FSO_ VOL9_NO4_5

Kalyuzhna, N. H. (2011). *Self-organization and development of the socio-economic system: synergistic approach. Problems and prospects of market-oriented management of innovation development.* Sumy: Printing House Papyrus Ltd.

Khaken, G. (2003). *Secrets of Nature. Synergetics: the science of interaction* (translated from German). Moscow Izhevsk: In-t computer. Research.

Kerzner, H. (2007). *Strategic Planning for Project Management Using a Project Management Maturity Model.* New York: John Wiley & Sons Inc.

Kondratiev, N. D. (2002). *Long Cycles of Economic Conjuncture and the Theory of Foresight*. Moscow: Ekonomika.

Kononiuk, A. (2022). Determinants of Foresight Maturity in SME Enterprises of Poland. *Foresight and STI Governance*, *16*(1), 69-81.

Lee, R., Lee, J. H., & Garrett, T. C. (2019). Synergy effects of innovation on firm performance. *Journal of Business Research*, *99,* 507-515. doi: 10.1016/j. jbusres.2017.08.032

Mandra, A. V. (2012). Models of technological maturity for assessing the functioning of the information resource of a shipbuilding enterprise. *East European Journal of Advanced Technologies, 1/13*(55), 61-63.

Martunyuk, O., Vitvitskaya, O., Lagodiienko, V., & Krupitsa, I. (2019). Formation of an innovative concept of

management on the basis of reconstruction of genetic algorithm of management technology. *Periodicals of Engineering and Natural Sciences, 7*(2), 487-499. doi: 10.21533/pen.v7i2

Miller, R., Weir, C., & Gulati, S. (2018). Transforming primary care: scoping review of research and practice. *Journal of Integrated Care*, *26*(3), 176-188. doi: 10.1108/JICA-03-2018-0023

Mintzberg, H. (1973). *The Nature of Managerial Work*. New York: Harper & Row.

Mohnen, P., & Hall, B. H. (2013). Innovation and productivity: An update. *Eurasian Business Review*, *3*(1), 47-65.

Organizational Project Management Maturity Model (OPM3®) Knowledge Foundation (2003). Cleveland. PMI.

Pelle, A., & Tabajdi, G. (2021). Covid-19 and transformational megatrends in the European automotive industry: Evidence from business decisions with a Central and Eastern European focus. *Entrepreneurial Business and Economics Review*, *9*(4), 19-33. doi: 10.15678/EBER.2021.090402

Potoczek, N. R. (2021). The use of process benchmarking in the water industry to introduce changes in the digitization of the company's value chain. *Journal of Entrepreneurship, Management, and Innovation*, *17*(4), 51-89. doi: 10.7341/20211743

Ramadani, V., Hisrich, R. D., Abazi-Alili, H., Dana, L. P., Panthi, L., & Abazi-Bexheti, L. (2019). Product innovation and firm performance in transition economies: A multi-stage estimation approach. *Technological Forecasting and Social Change*, *140*, 271-280.

Shen, H., Gao, Y., & Yang, X. (2017). Matching organizational climate and control mechanisms for fast strategic change in transitional economics: Evidence from China. *Journal of Organizational Change Management*, *30*(2), 124-141. doi: 10.1108/JOCM-04- 2016-0064

Schumpeter, J. (1939). *Business Cycles,* New York.

Shpak, N., Kuzmin, O., Dvulit, Z., Onysenko, T., & Sroka, W. (2020). Digitalization of the Marketing Activities of Enterprises: Case Study. *Information*, *11*, 109. doi: 10.3390/info11020109

Shpak, N., Ohinok, S., Kulyniak, I., Sroka, W., Fedun, Y., Ginevičius, R., & Cygler, J. (2022), CO2 Emissions and Macroeconomic Indicators: Analysis of the Most Polluted Regions in the World. *Energies*, *15*, 2928. doi: 10.3390/en15082928

Shpak, N., Satalkina, L., Sroka, W., & Hittmar, S. (2017). The social direction of enterprises' innovation activity. *Polish Journal of Management Studies*, *16*(1), 187-201. doi: 10.17512/pjms.2017.16.1.16

Shpak, N., Odrekhivskyi, M., Doroshkevych, K., & Sroka, W. (2019). Simulation of innovative systems under industry 4.0 conditions. *Social Sciences*, *8*, 202. doi: 10.3390/socsci8070202

Skrodzka, W. (2021). The impact of the pandemic on the investments effectiveness in the shares of IT sector companies listed on the Warsaw stock exchange. *Polish Journal of Management Studies, 24*(2), 414-430. doi: 10.17512/pjms.2021.24.2.26

Sorgner, A., Bode, E., & KriegerBoden, C. (2017). *The effects of digitalization on gender equality in the G20 economies*. Kiel: Kiel Institute for the World Economy.

Sowden R., Hinley, D., Clarke, S. (2008). *Portfolio, Programme and Project Management Maturity Model:P3M3 Public Consultation Draft v.2.0*. London: Office of Government Commerce.

Stark, R., Kind, S., & Neumeyer, S. (2017). Innovations in digital modelling for next generation manufacturing system design. *CIRP Annals*, *66*(1), 169-172. doi: 10.1016/j.cirp.2017.04.045

Sujova, A., & Simanova, L. (2021). Improvement of production process capability — a case study of two furniture companies. *Engineering Management in Production and Services*, *13*(3), 37-49. doi: 10.2478/emj-2021-0020

Szpilko, D., & Ejdys, J. (2022). European Green Deal — research directions. A systematic literature review. *Ekonomia i Środowisko*, *81*(2), 8-38. doi: 10.34659/eis.2022.81.2.455

Tugan-Baranovsky, M. I. (2004). *Industrial crises. Essay on the social history of England*. K.: Science. Opinion.

Tena-Chollet, F., Tixier, J., Dandrieux, A., & Slangen, P. (2017). Training decision-makers: Existing strategies for natural and technological crisis management and specifications of an improved simulation-based tool. *Safety Science, 97*, 144-153. doi: org/10.1016/j.ssci.2016.03.025

The level of maturity of the standardization system of business processes of the company. Test. Retrieved from http://www.finexpert.ru/tests.php.

Thiers, G. S., Graunke, A., & Christian, M. (2016). Automated production system simulations using commercial off-the-shelf simulation tools. In P. I. Frazier, R. Szechtman, E. Zhou, T. Huschka, & S. E. Chick (Eds.), *Proceedings of the 2016 Winter Simulation Conference* (pp. 1036-1047). Piscataway: IEEE. doi: 10.1109/WSC.2016.7822163

Uhlemann, T. H.-J., Lehmann, C., & Steinhilper, R. (2017). The Digital Twin: Realizing the Cyber-Physical Production System for Industry 4.0. In V S. Takata, Y. Umeda, & S. Kondoh (Eds.), *Procedia CIRP: Proceedings of The 24th CIRP Conference on Life Cycle Engineering,* 335-340. doi: 10.1016/j.procir.2016.11.152

Usyk, Y. (2015). *The cyclical development of the economy - Challenges for Ukraine. Theoretical and practical aspects of economy and intellectual property*. Vip, *2*(3), 78-84.

Verba, V.A. (2014). *The evolution of managerial technologies as a reflection of the problems and tasks of enterprise development.* Strategy of Ukraine's Economic Development, *34*, 148-156.

Vojtovic, S. (2016). The Impact of the Structural Funds on Competitiveness of Small and Medium Sized Enterprises. *Journal of Competitiveness*, *8*(4), 30-45. doi: 10.7441/joc.2016.04.02

Visagie, C. M., & Steyn, C. (2011). Organisational commitment and responses to planned organisational change: An exploratory study. *Southern African Business Review*, *15*(3), 98-121.

Vveinhardt, J., & Sroka, W. (2020). Mobbing and Corporate Social Responsibility: Does the status of the organisation guarantee employee wellbeing and intentions to stay in the job? *Oeconomia Copernicana*, *11*(4), 743-778. doi: 10.24136/oc.2020.030

Vytvytska, O., Martynyuk, O., Shpak, N., Karcheva, G., Medynsky, I., Nodzhak, L. (2020). Structural-functional modeling for the determination of the company's equilibrium conditions in the dynamic business environment. *Mathematical Modeling and Computing, 7*(1), 104-111. doi: 10.23939/mmc2020.01.104

Weiner, B. (2009). A theory of organizational readiness for change. *Implementation Science*, *4*(67). doi: 10.1186/1748-5908-4-67

Wijaya, P. Y., & Suasih, N. N. R. (2020). The Effect of Knowledge Management on Competitive Advantage and Business Performance: A Study of Silver Craft SMEs. *Entrepreneurial Business and Economics Review*, *8*(4), 105-121. doi: 10.15678/EBER.2020.080406

Zhao, J. X. (2018). *An empirical study on the impact of technological innovation on economic growth-taking Shandong Province as an example*. Proceedings of the 4th Annual International Conference on Social Science and Contemporary Humanity Development (SSCHD) (pp. 454-457). doi: 10.2991/sschd-18.2019.82