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The impact of business process modelling on the companies' efficiency under Covid-19 conditions

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ABSTRACT

The purpose of this study is to form a methodological approach to assessing the impact of the effectiveness of business process modelling under the COVID-19 pandemic, which creates an opportunity to diagnose the impact of business modelling results on the company's activities, as well as to make justified management decisions concerning the integrated development of the most relevant and significant business components of the model. The research methodology consists of correlation and regression analysis, scenario modelling, and hierarchical synthesis. The research was carried out according to the materials from 16 road transport companies in Ukraine engaged in cargo transportation. Determination of the effectiveness indicators of business processes modelling per their quality, cost, and speed made it possible to identify leaders and outsiders among the companies under study based on the specified parameters. Regression analysis proves that the speed of business processes is the most significant factor in modelling efficiency for the surveyed companies. According to the determination of the impact of the business processes modelling effectiveness on the companies' financial efficiency and productivity, the connection between these indicators was diagnosed under the COVID-19 pandemic. The most effective scenario for the vast majority of the studied companies under the pandemic circumstances is one that focuses on the cost and speed of business processes. Modelling business processes based on the scenario of concentration on the cost and speed indicators of business processes have the highest positive effect of their modelling, which contributes to increasing the financial efficiency and productivity of the companies under study. The study confirms the need for integrated business processes modelling, which considers different combinations of the resulting indicators and contributes to increasing the efficiency of business processes modelling and the companies' financial efficiency and productivity under the COVID-19 pandemic.

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1. Introduction

Under the current circumstances of the COVID-19 pandemic's rapid spread, companies require constant improvement of their business processes in order to remain efficient and competitive. Failure to do so can increase costs, reduce revenues, decrease employee motivation, and cause low customer satisfaction. Business process management can be a powerful tool that helps companies achieve success in all aspects of their performance (Hameed et al., 2022). As civilization advances, business processes become increasingly sophisticated. And this business process's sophistication in the global economy requires both economic analysis and diagnostics of the business environment and the definition of the model itself and its influence on the company's performance, accompanied by a time perspective as a whole (Chatterjee et al., 2020). In the promptly changing conditions of the COVID-19 pandemic spread, an enterprise can have an effective business model that does not foster the company's performance. It is also important to place processes, phenomena, and objects in geographic space in order to get closer to creating a business model reflecting the real world (Zamarreño-Aramendia et al., 2021). It involves the creation of a spatial-temporal dynamic model, which effective diagnosis of the environment of the company, interactively connected with the existing databases, can later be used for its improvement and business processes reengineering (Shogrkhodaei et al., 2021).

Business process modelling enables a common understanding and analysis of the business process; it can provide a comprehensive understanding of the processes. Business can be analyzed and integrated with the help of business processes (Lamine et al., 2020). Modelling is inseparably connected to the relative simplification and highlighting critically important data and processes that require evaluation. The purpose of the model creation is important. The model facilitates dynamic reflection of the current state, detects deviations from the target, and makes adjustments, as well as planes fundamental modifications or creates a new object or idea. If the company has a constructed model, it will be easier to coordinate the team's work, as each member sees their role concerning the entire modelling process (Fischer et al., 2020).

Using the correct model requires taking into consideration the purpose of the analysis and possessing the available methods and tools for modelling processes. Meanwhile, under the COVID-19 circumstances, there is an objective need not only for the development and implementation of a business model, but also the need for its flexibility and adaptability to changes in business conditions based on appropriate diagnostics. Meanwhile, the prospects for the developed model and the identification of alternative options for the development of an enterprise capable of integrating the most important components of business success are significant. This induced the conduct of this study, which aims to bridge the scientific gap by developing a methodological approach to assessing the impact of business process modelling under the COVID-19 pandemic. The above-mentioned factors allowed for the diagnosis of the impact of business modelling results on company performance and the adoption of justified management decisions concerning the integrated development of the most relevant and significant business model components. The scientific contribution is to clarify the theory of asymmetries in company development by studying the operation effectiveness of business models. The developed approach enables reasonable demonstration that business modelling requires asymmetries in the company's performance, which contribute to the company's successful development. In this case, the complex model integrates three components of the business process efficiency assessment system (quality, cost, and speed), which significant performance can solely be achieved jointly. The key elements of effective business models under current circumstances are thus clearly defined. As a result, we can identify the primary vectors for adapting business models to COVID-19 economic changes. The approbation of the proposed methodological approach was carried out based on the materials from 16 road transport companies in Ukraine, since the spread of the COVID-19 pandemic has significantly influenced this sector. Road transport enterprises provide transportation of important cargo and food and carry out international transport. Furthermore, the effectiveness of business processes modelling is of great strategic significance under conditions of quarantine restrictions at the company development level, as well as at the national and international levels.

2. Literature review

Companies still need to maximize their cost efficiency and profitability in order to prosper. Business process modelling presupposes the development of a strategy to maximize cost efficiency by optimizing business operations and interactions, automating repetitive tasks, improving product quality, and reducing corporate risks (Brazier et al., 2017). However, the business process needs to be digitized so that the workflow engine can comprehend it to launch such a process. Business process modelling tools allow the process to be digitized, which can later be automated, and obtain the results in real-time (Viriyasitavat et al., 2019). First of all, the advantages of business process modelling include comprehensive knowledge of the process performance and anticipation of process modifications, ensuring the consistency and control of the process, and eliminating redundancy (Perboli et al., 2018). Meanwhile, the benefit is determining the process's beginning and end, making it possible to group equivalent processes, and perform simulations in order to achieve better results (Lüdeke-Freund et al., 2018).

The trend in business process modelling is directed towards more flexible processes responding to the knowledge of the market organization, as well as changes in the business performance environment under the COVID-19 pandemic (Widarti et al., 2020). Nowadays, flexibility is frequently seen as one of the goals of the business process management and cost-effectiveness under the coronavirus pandemic circumstances. This has led to increased demand for immensely flexible business process management tools that can be easily designed, modified, and implemented. Processes are managed in the form of workflows that can be modified on demand. Therefore, it is possible to reuse workflows where needed and adapt them where required (Erasmus et al., 2020).

Changes in legislation and other factors have triggered the companies without a flexible system for ensuring full compliance with the law to incur enormous contingencies, both in terms of reporting and fines, against the background of massive COVID-19 vaccinations (Baghiu, 2020; Rodionov et al., 2021). However, within the framework of business process modelling systems, companies can introduce conformity in their business practices if applications designed for specific departments are integrated into the organization as a whole. This enables automated reports to demonstrate compliance with requirements in a cost-effective way (Burström et al., 2021).

Experienced customers may require complex proof-of-concept processes that document how their needs will be met with the help of maintenance-free functions. Business process management helps organizations connect people and technology in order to acquire and retain satisfied customers under the challenging circumstances of the coronavirus spread and its consequences remediation. This paves the path for continuous real-time collaboration with customers, demonstrating responsiveness, personalization, adaptation, and access to information (Lozada-Contreras et al., 2022).

Companies steadily strive to maintain a satisfying working environment that motivates their employees to work in the office and in remote mode. Developed and documented business processes will help motivate team members working in the company, but their support and effective work remotely against the backdrop of quarantine restrictions are also required. They will be more likely to develop their skills not only at work but also independently by attending diverse online courses and other similar events. In doing so, employees will become dedicated employees who will strive to optimize their work and increase their contribution to business development (Sott et al., 2021).

A properly developed organization model, especially a business process map, is aimed at describing the object of analysis and should represent the specificity of the organization, which will be a source of competitive advantage. Business models should refer to already created documents. These can be terms of reference documents or job descriptions. Therefore, modelling in a company can be divided into three levels: the level of the entire enterprise, the level of business processes, and the level of implementation (human and IT resources) (Mendling et al., 2020; Stević & Brković, 2020). It is worth emphasizing that the model itself should not be the subject of the project, as it is of no value as an object. It will only be an analytical tool that will support the work on reorganization, analysis of IT system requirements, and return on investment (Vještica et al., 2021). The main purpose of developing a model is to understand the area under analysis and formulate recommendations for its improvement. Each model has a specific purpose and depends on the type of project being implemented. If the goal is, for example, to optimize the company's activities or to analyse its profitability, then a business process model should be developed. As we go down the pyramid, the labour and cost of making models increase, so every effort must be made to make the models as reflective of reality as possible. Therefore, they should be considered consistent if they serve to reduce the risk of decision-making (Araz et al., 2020).

It is worth considering the business model interdisciplinary and applying methods used outside the business in today's challenging times when we have large amounts of data (Gandhi & Sucahyo, 2021; Taymouri et al., 2021). To model complex processes, it is advisable to consider them in time and geographic space, i.e., analyse data in chronological sequence using geographic information data. An important factor in modelling is the application of business indicators (so-called key performance indicators), which, as control tools, facilitate continuous monitoring of processes and enable potential adjustments if the indicators do not fit the assumed strategic, tactical, or operational goals (Lederer et al., 2020). In recent years, business modelling has been strongly influenced by the digitalization factor that shapes the way participants communicate (Baiyere et al., 2020).

In modelling a company's business processes in modern conditions, it is important to increase customer satisfaction by identifying activities that affect the duration of the production cycle (Bag et al., 2020); to set performance indicators focused on customer satisfaction by identifying factors that influence client satisfaction under COVID-19 pandemic (Nuseir, 2021); to reduce the number of deficiencies by identifying their sources (Querini et al., 2020); to reduce costs by identifying activities that do not add value to the product due to quarantine restrictions (Fletcher & Griffiths, 2020); to determine the causes of process failures by identifying gaps in the flow of information between functional teams and information redundancy, improving performance by eliminating the identified gaps in the process (Pérez-Álvarez et al., 2020).

The modern scientific literature contains a significant amount of research concerning the features of modelling business processes, most of which focus on various aspects of the modelling process itself. However, the efficiency of the business process simulations carried out, and their influence on the results of the business performance as a whole remain insufficiently studied. Therefore, the purpose of this study is to develop a methodological approach to evaluate the impact of the business processes modelling under the COVID-19 pandemic, which allows diagnosing the impact of the business modelling results on the company's performance and making well-founded management decisions in the context of the integrated development of the most relevant and significant for business model components. Meanwhile, it is proposed to evaluate the modelling efficiency based on such key parameters as quality, cost, and speed of business processes. Therefore, in order to achieve this goal, the following hypotheses were formed in the process of research:

Hypothesis 1: The cost and speed of business processes become a priority for the company's financial and productive performance under the COVID-19 pandemic.

Hypothesis 2: The quality of business processes affects their speed and cost in a COVID-19 crisis, ensuring the company's financial and productive efficiency.

3. Materials and methods

The research methodology includes correlation and regression analysis, scenario modelling, and hierarchical synthesis. A scientific contribution is a methodological approach to assessing the efficiency level of business processes modelling using an integral indicator, including three indicator components: quality, cost, and speed of business processes. The logic of the survey is given in Figure 1.

The first stage of the study is the selection of companies. The research was carried out according to the materials from 16 road transport companies in Ukraine engaged in cargo transportation. The key criteria for selecting these companies experienced in the market for at least 10 years are the number of employees—starting from 50

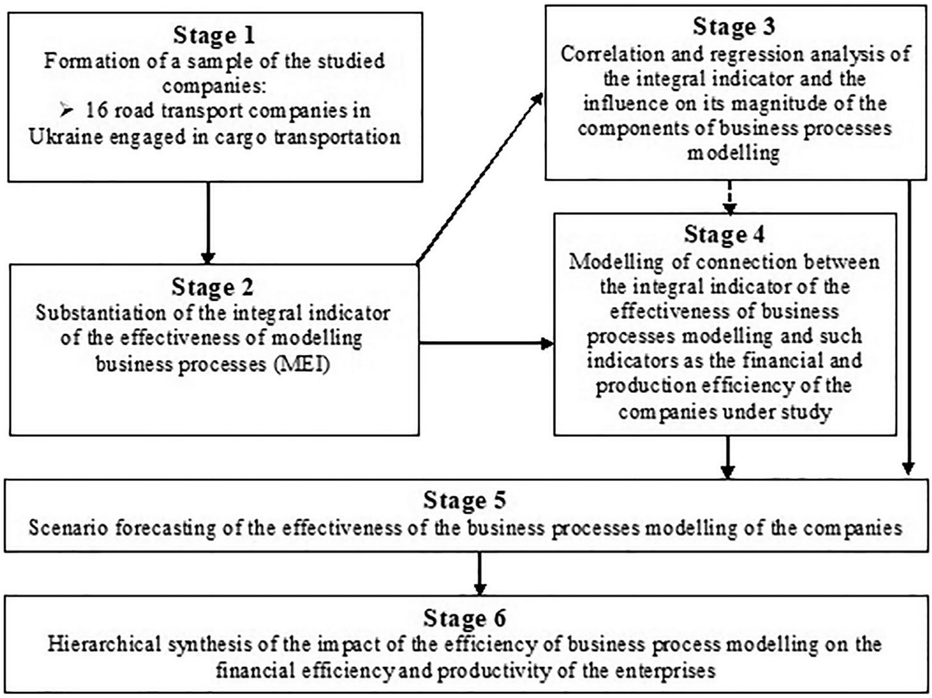

Figure 1. Stages of the research conduction.
Source: formed by the authors.

people, and the revenue volume—from $3 million per year. During the preparatory stage, 20 companies that met these criteria were selected. Letters of recommendation were sent to them in order to obtain consent to participate in this study as stakeholders and to provide the necessary information on the business processes underway. This is one of the most important factors in the study's credibility since obtaining this information is the basis for calculations. Sixteen companies accepted our offer and took part in the research. Thus, 4 companies were eliminated, accounting for 20%. The following companies took part in the study: LLC 'Autotransportnik', LLC 'Pan Logistics', General Trans Alliance Logistics LLC, LLC 'Cosmos', Hermes Transport Company LLC, LLC 'Logistic Professervice', Bon Logistics LLC, LLC 'VPTrans', PJSC 'Kyiv Production Company' Rapid', Obukhov Motor Transport Enterprise 13238 PJSC, PJSC 'Kyivtranspedition', PJSC 'TEK Zahidukrtrans', PJSC 'Golner Expedition', PJSC 'Kirovograd Transport Company', PJSC 'DHL International Ukraine' and PJSC 'Melavtotrans'.

In the second stage of the study, the substantiation of the integral indicator of the effectiveness of modelling business processes (*MEI*) was carried out, and the identification of key components (indicators) in its composition. The necessity to include these components is driven by induction in the opposite direction. Meanwhile, the control action concerning modelling in the context of quality (bp_q), cost (bp_v), and speed (bp_s) of business processes are considered as part of such an equation:

$$\max_{bp_s} aBP_v x_s - \beta BP_v(t_s - t_0) - bp_q - bp_v - bp_s$$

herewith the following condition must be met:

$$P_v(x_s = 1) = \chi_s(1 - \exp^{-\lambda_s bp_s})x_v,$$

$$t_s = t_v + a_s,$$

$$e_s \geq 0.$$

The equation $t_s = t_v + a_s$, in this case, has a constant form and does not depend on the business processes modelling in the context of e_s. At the same time: $BP_v x_s = 1 \cdot P_v(x_s = 1) = \chi_s(1 - \exp^{-\lambda_s bp_s})x_v$, which suggests transformation into the equation:

$$\max_{e_s \geq 0} a\chi_s(1 - \exp^{-\lambda_s bp_s})x_v - e_3$$

Meanwhile, its solution can be displayed in the first-order solution:

$$bp_s = \frac{1}{\lambda_s} ln a\chi_s\lambda_s, \text{ if } a\chi_s\lambda_s > 1 \text{ и } x_v = 1,$$

$$bp_s = 0, \text{ if } a\chi_s\lambda_s x_v \leq 1.$$

It can be concluded that the optimal business processes modelling $F_3(\cdot, \cdot, \cdot)$ in the context of bp_s can be specified as follows:

$$bp_s = F_3(e_v, x_v, t_v) = \frac{1}{\lambda_s} ln a\chi_s\lambda_s, \text{if } a\chi_s\lambda_s > 1 \text{ and } x_v = 1,$$

$$bp_s = F_3(e_v, x_v, t_v) = 0, \text{ if } a\chi_s\lambda_s x_v \leq 1.$$

Suppose we assume that the modelling effectiveness does not basically depend on the effectiveness of business processes modelling at the previous link e_v, as well as on the speed t_v of a certain business process performance. In that case, it can be assumed that the effectiveness of modelling business processes in the context of (bp_s) is more important in order to ensure the further company's activities $x_v = 1$ than in the case of (c). Likewise, one can determine the optimal modelling efficiency in the second iteration of the proposed system:

$$\max_{e_v} aBP_q x_s - \beta BP_q(t_v + a_s - t_0) - bp_q - bp_v - BP_1 bp_s$$

Considering the previous conditions, the following can be inferred:

$$BP_q x_s = BP_q(BP_v(x_s)) = BP_q(\chi_s(1 - \exp^{-\lambda_s bp_s})x_v)$$

Based on the effectiveness of business processes modelling in the context of bp_s, the following can be inferred:

$$BP_q x_s = \chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)P_q(x_v = 1),\ \text{if}\ a\chi_s\lambda_s > 1\ \text{and}\ BP_q x_s = 0,\ \text{if}\quad a\chi_s\lambda_s \le 1.$$

$$BP_q bp_s = \frac{1}{\lambda_s} ln(a\chi_s\lambda_s)\ P_q(x_v = 1) = \frac{1}{\lambda_s} ln(a\chi_s\lambda_s)\chi_v\left(1 - \exp^{-\lambda_v bp_v}\right)x_q,$$

$$\text{if}\ a\chi_s\lambda_s > 1,\ \text{and}\ BP_q bp_s = 0,\ \text{if}\quad a\chi_s\lambda_s \le 1.$$

With $a\chi_3\lambda_3 > 1$, the search for optimal business processes modelling in the context of e_2 can be inferred as follows:

$$\max_{bp_v}\left(a\chi_s - \frac{1}{\lambda_s} - \frac{1}{\lambda_s} ln(a\chi_s\lambda_s)\chi_v\left(1 - \exp^{-\lambda_v bp_v}\right)x_q - \beta BP_q(t_v - t_q) - bp_v\right.$$

When the above conditions are met, the solution to the problem with respect to a variable t_v can be as follows:

$$\max_{bp_v \ge 0}\left(a\chi_s - \frac{1}{\lambda_s} - \frac{1}{\lambda_s} ln(a\chi_s\lambda_s)\chi_v\left(1 - \exp^{-\lambda_v bp_v}\right)x_q - \frac{\beta}{\mu_s}\left(\gamma_v bp_v - \delta_v bp_q + a_v\right) - bp_v,\right.$$

$$\max_{bp_v \ge 0} - \left(a\chi_s - \frac{1}{\lambda_s} - \frac{1}{\lambda_s} ln(a\chi_s\lambda_s)\chi_v \exp^{-\lambda_v bp_v} x_q - \left(\frac{\beta}{\mu_s}\gamma_v + 1\right)bp_v.\right.$$

Likewise, one can determine the optimal efficiency of business processes modelling in the context of bp_v when $a\chi_s\lambda_s \le 1$ based on a solution:

$$\max_{bp_v \ge 0} - \frac{\beta}{\mu_s}\left(\gamma_v bp_v - \delta_v bp_q + a_v\right) - bp_v,$$

At the same time, $x_v = 0,$ therefore with $a\chi_s\lambda_s > 1$ we obtain the optimal business processes modelling:

$$bp_v = F_v(e_q, x_q, t_q) = \frac{1}{\lambda_s} ln \frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v + \mu_s},$$

$$\text{Provided that}\ \frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v + \mu_s} > 1\ \text{and}\ x_q = 1;$$

$$bp_v = F_v(e_q, x_q, t_q) = 0,\ \text{if}\ \frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v + \mu_s} x_q \le 1;$$

$$bp_v = F_v(e_q, x_q, t_q) = 0,\ \text{if}\quad a\chi_s\lambda_s \le 1.$$

At the end of the implementation of these assumptions, it is necessary to determine the optimal business processes modelling at the first stage, considering those as mentioned earlier. In this case, the target function for the search of e_q can be displayed as follows:

$$\max_{bp_q} aBP_0x_s - \beta BP_0(t_s - t_0) - bp_q - BP_0bp_v - BP_0bp_s$$

It implies the following:

$$BP_0x_s = BP_0(BP_q(BP_v(x_s))) = BP_0(BP_q(\chi_s(1 - \exp^{-\lambda_s bp_s})x_v));$$

$$BP_0x_s = \chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)BP_0(P_q(x_v = 1)) = \chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)BP_0\left(\left(1 - \exp^{-\lambda_v bp_v}\right)x_q\right)$$

$$\text{if } a\chi_s\lambda_s > 1 \text{ and } BP_0bp_s = 0, \text{ if } a\chi_s\lambda_s \le 1.$$

Thus, the following can be inferred:

$$\begin{aligned} BP_0x_s &= \chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)\left(1 - \frac{\beta\gamma_v + \mu_s}{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s)}\right)P_0(x_q = 1) \\ &= \chi_q\chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)\left(1 - \frac{\beta\gamma_v + \mu_s}{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s)}\right)\exp^{-\lambda_q bp_q}x_0, \end{aligned}$$

$$\text{If } \frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v + \mu_s} > 1, \text{ and}$$

$$BP_0x_s = 0, \text{ if } \frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v + \mu_s}x_q \le 1 \text{ or } a\chi_s\lambda_s \le 1.$$

Then we have:

$$BP_0(t_s - t_0) = BP_0(t_v + a_s - t_0) = BP_0(t_v - t_q) + BP_0(t_q - t_0) + a_s.$$

This equation can be transformed as follows:

$$\begin{aligned} BP_0(t_q - t_0) = BP_0\left((\gamma_q bp_q + a_v)\varepsilon_q\right) = \frac{\gamma_q pb_q + a_v}{\mu_q} &\text{ and } BP_0(t_v - t_q) \\ = BP_0\left(\gamma_v e_v - \delta_v bp_q + a_v\right)\varepsilon_v = BP_0\left(BP_q\left((\gamma_v e_v - \delta_v e_q + a_v)\varepsilon_v\right)\right) \\ = \frac{1}{\mu_v}BP_0\left(\gamma_v e_v - \delta_v bp_q + a_v\right). \end{aligned}$$

As a result, it can be asserted that:

$$\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q > 1,$$

$$BP_0(t_v-t_q)=\frac{a_v-\delta_v bp_q}{\mu_v}+\frac{\gamma_v}{\mu_v\lambda_v}\ln\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}P_0(x_q=1)$$
$$=\frac{a_v-\delta_v e_q}{\mu_v}+\frac{\gamma_v\chi_q}{\mu_v\lambda_v}\ln\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}\exp^{-\lambda_q bp_q}x_0.$$

It should be taken into consideration that if $\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q \le 1$ or $a\chi_s\lambda_s \le 1$, then:

$$BP_0(t_v-t_q)=\frac{a_v-\delta_v bp_q}{\mu_v}.$$

If $\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q > 1$, then we will have:

$$BP_0bp_v=\frac{1}{\lambda_v}\ln\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v+\mu_s}P_0(x_q=1)$$
$$=\frac{\chi_q}{\lambda_v}\ln\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v+\mu_s}\exp^{-\lambda_q bp_q}x_0.$$

$$\text{If}\quad\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s\big)}{\beta\gamma_v+\mu_s}x_q\le 1,\ \text{or}\ a\chi_s\lambda_s$$
$$\le 1,\ \text{then we will have}: BP_0bp_v=0.$$

As a result, we obtain:

$$BP_0bp_s=\frac{1}{\lambda_s}\ln(a\chi_s\lambda_s)P_0(x_v=1)=\frac{\chi_v}{\lambda_s}\ln(a\chi_s\lambda_s)BP_0\Big(\big(1-\exp^{-\lambda_v bp_v}\big)x_q\Big)$$
$$=\frac{\chi_v}{\lambda_s}\ln(a\chi_s\lambda_s)1-\ 1-\ \frac{\beta\gamma_v+\mu_s}{\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))}{\lambda_s}})P_0(x_v=1)$$
$$=\frac{\chi_q\chi_v}{\lambda_v}\ln(a\chi_s\lambda_s)\left(1-\frac{\beta\gamma_v+\mu_s}{\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))}{\lambda_s}}\right)\exp^{-\lambda_q bp_q}x_0),$$

$$\text{provided that}:\ \frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q > 1.$$

If $\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q \le 1$ or $a\chi_s\lambda_s \le 1$, then we will have: $BP_0bp_s=0$.

As a result of combining the obtained equations into a target function in order to determine the optimal business processes modelling bp_q, we have: $\max_{bp_v \geq 0} -A\exp^{-\lambda_q bp_q} - Bbp_q$, when $B = 1 - \beta\left(\frac{\delta_v}{\mu_v} - \frac{\gamma_q}{\mu_q}\right)$, provided that: $\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s} > 1$. Thus, we have:

$$A = -a\chi_q\chi_s\left(1 - \frac{1}{a\chi_s\lambda_s}\right)\left(1 - \frac{\beta\gamma_v + \mu_s}{\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))}{\lambda_3}}\right)x_0$$

$$-\ \beta\left(\frac{\gamma_v\chi_q}{\lambda_v\mu_v}\ln\frac{\mu_s\lambda_v\chi_v\left(a\chi_s - \left(1 + ln(a\chi_s\lambda_s)\right)/\lambda_s\right)}{\beta\gamma_v + \mu_s}x_0\right.$$

$$+\frac{\chi_q}{\lambda_v}\ln\frac{\mu_s\lambda_v\chi_v(a\chi_s - (1 + ln(a\chi_s\lambda_s))/\lambda_s\Big)}{\beta\gamma_v + \mu_s}x_0$$

$$\left.+\frac{\chi_q\chi_v}{\lambda_v}\ln\left(a\chi_s\lambda_s\right)\left(1 - \frac{\beta\gamma_v + \mu_s}{\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))}{\lambda_s}}\right)x_0\right),$$

If $\frac{\mu_s\lambda_v\chi_v(a\chi_s-(1+ln(a\chi_s\lambda_s))/\lambda_s)}{\beta\gamma_v+\mu_s}x_q \leq 1$ or $a\chi_s\lambda_s \leq 1$, then we will have: $A = 0$.

Thus, the optimal business processes modelling in the case of $A\lambda_q\ B > 1$ and $B > 0$ provides $bp_q = \frac{1}{\lambda_s}\ln\frac{A\lambda_q}{B}$. If $A\lambda_q \leq B$ and $B \geq 0$, then it will be $bp_q = 0$. Thus, there will be no actual solution, if $B < 0$ either, in this case $B = 0$ and $A > 0$. But in real business functioning, such a case cannot arise since all three components of the proposed assessment of the business process model cannot be effective separately. The identification of an integral effectiveness indicator of the business processes modelling is proposed to be determined by the vector formula, based on three components (Kolpak et al., 2022):

$$MEI = \sqrt{BP_q^2 + BP_v^2 + BP_s^2}$$

where BP_q is an indicator of the modelling effectiveness in the context of the quality of business processes; BP_v is an indicator of the modelling effectiveness in the context of the cost of business processes; BP_s is an indicator of the modelling effectiveness in the context of the speed of business processes.

These indicators complied with the process of normalization (Kharazishvili et al., 2020), according to the results of which three components of the integral effectiveness indicator of the business processes modelling were determined, as the normalized average value: BP_q is the share of innovative processes in their total number (s_{q1}), the share of providing personnel with information (s_{q2}), the coefficient of used equipment progressiveness (s_{q3}); BP_v is labour costs, \$thousand (s_{v1}), equipment depreciation, \$thousand (s_{v2}), communication costs, \$thousand (s_{v3}); BP_s is the coefficient of the planned execution time of the business process (s_{s1}), the coefficient of the required time for servicing the client (s_{s2}), the functional-coefficient of the implementation time of the business process (s_{s3}) (Table 1). During the third stage of the study, a correlation and regression analysis of the integral indicator and the

Table 1. Initial data for determining key performance indicators of business process modelling.

Company	s_{q1}	s_{q2}	s_{q3}	s_{v1}	s_{v2}	s_{v3}	s_{s1}	s_{s2}	s_{s3}
Autotransportnik	0.04	0.56	0.29	1811	362	53	0.88	0.56	0.52
Pan Logistics	0.04	0.82	0.22	3656	825	12	0.92	0.78	0.31
General Trans Alliance Logistics	0.07	0.92	0.35	2784	658	35	0.74	0.95	0.59
Cosmos	0.04	0.63	0.2	1629	726	48	0.36	0.48	0.41
Hermes Transport Company	0.05	0.77	0.11	3898	1502	26	0.93	0.75	0.22
Logistic Professervice	0.11	0.89	0.22	4892	831	34	0.79	0.74	0.45
Bon Logistic	0.02	0.64	0.39	2761	268	25	0.86	0.85	0.53
VPtrans	0.06	0.91	0.32	1942	389	19	0.85	0.56	0.49
KPC 'RAPID'	0.07	0.75	0.21	2105	627	46	0.92	0.88	0.36
Obukhov MTE 13238	0.09	0.82	0.33	6835	1005	58	0.96	0.91	0.31
Kyivtranspedition	0.05	0.61	0.78	3096	399	45	0.79	0.62	0.57
TEC 'Zahidukrtrans'	0.05	0.92	0.8	4602	498	31	0.88	0.75	0.48
Golner Expedition	0.01	0.64	0.16	1748	953	52	0.91	0.86	0.36
Kirovograd Transport Company	0.02	0.85	0.27	3845	596	47	0.76	0.69	0.39
DHL International Ukraine	0.02	0.66	0.48	1922	257	55	0.82	0.78	0.39
Melavtotrans	0.01	0.71	0.19	1508	394	42	0.87	0.81	0.41

Source: formed by the authors.

influence on its magnitude of the components of business processes modelling was carried out.

During the fourth stage of the study, the connection between the integral indicator of the effectiveness of business processes modelling and such indicators as the financial and production efficiency of the companies under study was determined. Financial efficiency includes the following indicators: financial independence ratio, absolute liquidity ratio, return on assets, and equity capital. Production efficiency integrates such indicators as the increment rate of fixed assets, the serviceability rate of fixed assets, capital productivity, the profitability of fixed assets, and the proportion of material costs in the cost price of services.

During the fifth stage, scenario forecasting of the effectiveness of the business processes modelling of the companies under study was carried out. Meanwhile, seven scenarios were created, suggesting an increase in efficiency of 10% in terms of quality, cost, or speed of business processes, their paired combinations, and a reference option. All three components of the simulation are improved simultaneously.

The final (sixth) stage is a hierarchical synthesis of the impact of the efficiency of business process modelling on the financial efficiency and productivity of enterprises (Zahedi et al., 2022). The regression models obtained at the previous stages were used to carry out a hierarchical synthesis based on the mean values for the surveyed companies for all scenarios. As a result of applying the scenario approach, a matrix assessment of the link between the studied factors was made. This methodology was adopted in the study to solve the nonlinear optimization problem by selecting the optimal scenario. This was carried out based on the regression dependence of the company's financial efficiency (FE - y_{FE}) and production efficiency (PE - y_{PE}) on the integral indicator of business model efficiency (x). That is, the construction of paired linear regression models was considered:$y_{FE} = a_{FE} + b_{FE} \cdot x_{FE}$,

$$y_{PE} = a_{PE} + b_{PE} \cdot x_{PE}.$$

Table 2. Normalized indicators for determining the effectiveness of business process modelling.

Company	s_{q1}	s_{q2}	s_{q3}	s_{v1}	s_{v2}	s_{v3}	s_{s1}	s_{s2}	s_{s3}
Autotransportnik	0.300	0.000	0.261	0.943	0.916	0.109	0.867	0.170	0.811
Pan Logistics	0.300	0.722	0.159	0.597	0.544	1.000	0.933	0.638	0.243
General Trans Alliance Logistics	0.600	1.000	0.348	0.760	0.678	0.500	0.633	1.000	1.000
Cosmos	0.300	0.194	0.130	0.977	0.623	0.217	0.000	0.000	0.514
Hermes Transport Company	0.400	0.583	0.000	0.551	0.000	0.696	0.950	0.574	0.000
Logistic Professervice	1.000	0.917	0.159	0.365	0.539	0.522	0.717	0.553	0.622
Bon Logistic	0.100	0.222	0.406	0.765	0.991	0.717	0.833	0.787	0.838
VPtrans	0.500	0.972	0.304	0.919	0.894	0.848	0.817	0.170	0.730
KPC 'RAPID'	0.600	0.528	0.145	0.888	0.703	0.261	0.933	0.851	0.378
Obukhov MTE 13238	0.800	0.722	0.319	0.000	0.399	0.000	1.000	0.915	0.243
Kyivtranspedition	0.400	0.139	0.971	0.702	0.886	0.283	0.717	0.298	0.946
TEC 'Zahidukrtrans'	0.400	1.000	1.000	0.419	0.806	0.587	0.867	0.574	0.703
Golner Expedition	0.000	0.222	0.072	0.955	0.441	0.130	0.917	0.809	0.378
Kirovograd Transport Company	0.100	0.806	0.232	0.561	0.728	0.239	0.667	0.447	0.459
DHL International Ukraine	0.100	0.278	0.536	0.922	1.000	0.065	0.767	0.638	0.459
Melavtotrans	0.000	0.417	0.116	1.000	0.890	0.348	0.850	0.702	0.514

Source: formed by the authors.

In this case, x has been replaced with the values associated with each scenario. Seven scenarios were generated, each assuming a 10% improvement in business processes' quality, cost, or speed: their paired combinations and a benchmark where efficiency improvements coincide in all three modelling components. Using the created business process factors, seven possible combinations of increasing efficiency were developed at this stage. The arithmetic means of all y_{FE} and y_{PE}, and their share for each scenario (the arithmetic mean of the sum of the shares) were determined separately in order to normalize the values. Therefore, normalized values were calculated.

Finally, a balanced sum of indicators for each scenario was determined. A hierarchical synthesis was conducted: the obtained values are compared, and the scenario with the highest efficiency level is selected.

4. Results

Diagnostics of the effectiveness of business process modelling. The performance indicators of the surveyed companies' business processes have different units of measurement; therefore, in order to bring them to a single scale and subsequently integrate them into three components (indicators) of the effectiveness of business process modelling, the initial data was normalized. The results of it are displayed in Table 2.

Based on the obtained efficiency indicators of the studied companies' business processes and their normalization, key indicators of the modelling effectiveness were determined in such three areas as the quality, cost, and speed of business processes. The resulting indicators for each surveyed company are displayed in Figure 1.

Among the surveyed enterprises, companies 13, 6, and 3 display the highest quality of business processes. However, these companies tend to have a high level of speed of business processes under the COVID-19 pandemic. For example, enterprise 3 has the highest rate of speed among the surveyed companies. It was observed for leaders in the quality of business processes that the cost of business processes is in last place among the indicators.

Table 3. Indicators of analysis of variance of business process modelling performance indicators.

Indicator	df	SS	MS	F	F Significance
Regression	3	0.4390	0.1463	121.3815	0.0000
Residue	12	0.0145	0.0012		
Total	15	0.4535			

Source: formed by the authors.

Table 4. Indicators of regression analysis of indicators of the effectiveness of modelling business processes.

Factor	Coefficient	Standard error	t-statistics	P-Value	Low 95%	High 95%
Y-crossing	0.1122	0.0490	2.2891	0.0410	0.0054	0.2190
BP_q	0.4310	0.0459	9.3875	0.0000	0.3310	0.5310
BP_v	0.5152	0.0526	9.7890	0.0000	0.4005	0.6298
BP_s	0.6302	0.0602	10.4649	0.0000	0.4990	0.7615

Source: formed by the authors.

4.1. Modelling the efficiency of business processes

Each company is characterized by a specific efficiency of modelling business processes, as it is impossible to visually distinguish the general characteristics and trends under the COVID-19 pandemic. Therefore, in order to determine the most significant factors of effective business modelling, a regression analysis was carried out for the companies under study, taking into consideration the integral indicator of the business process modelling effectiveness. Its results are displayed in Tables 3 and 4.

The results of the performed regression analysis are valuable as they are applicable to and appropriate for the operating conditions of the companies under investigation. Several benchmarks confirm this. For example, the P-value for the resulting coefficients is lower than 0.05. Herewith, the coefficient of determination is $R2 = 0.96$. According to Fisher's criterion, $Ftabl < F$ $(3.49 < 121.38)$, which confirms the applicability of the former model. According to Student's criterion, $tobs = 19.08$ exceeds $tcrit = 2.12$, which also indicates the appropriateness of the designed model. In general, the regression model can be expressed by means of the following equation:

$$MEI = 0.431 \cdot BP_q + 0.515 \cdot BP_v + 0.63 \cdot BP_s.$$

Thus, it can be argued that the most significant factor in the modelling effectiveness for the companies under study is the speed of business processes. An increase in the speed indicator of business processes by one will increase the level of modelling efficiency, expressed by the integral indicator, by 0.63.

The second most important factor is the cost of business processes. Therefore, there is an objective necessity to determine the impact of the effectiveness of modelling business processes on the companies' financial efficiency and productivity. To this end, a regression analysis of these indicators was carried out for the companies under investigation, which are visualized in Figures 2 and 3.

The leading companies in terms of financial efficiency and business process modelling are enterprises 7, 8, 3, and 12. According to these criteria, enterprises 4, 14, and 5 are the outsiders. In general, there is a sufficient correlation level between the

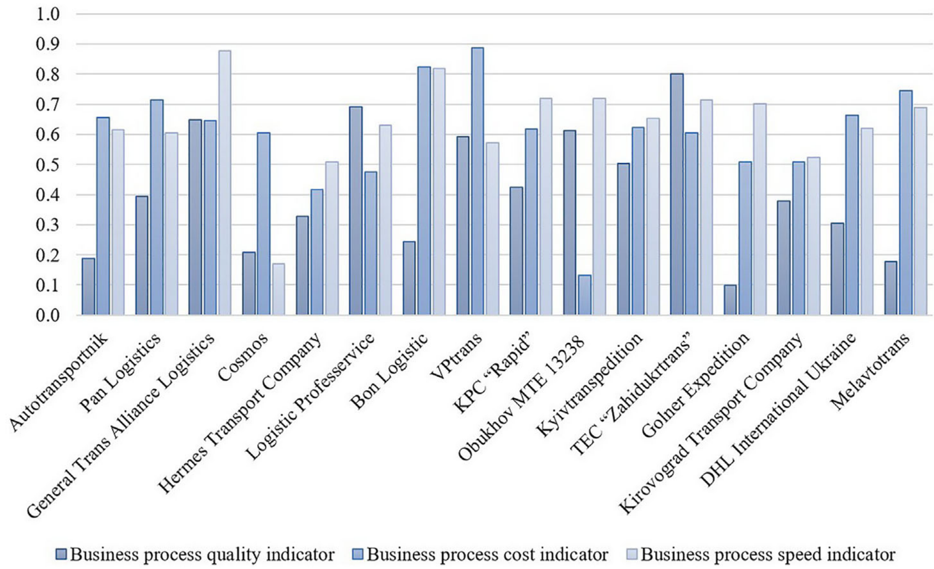

Figure 2. Effectiveness indicators of business processes modelling of the surveyed companies in 2020.
Source: formed by the authors.

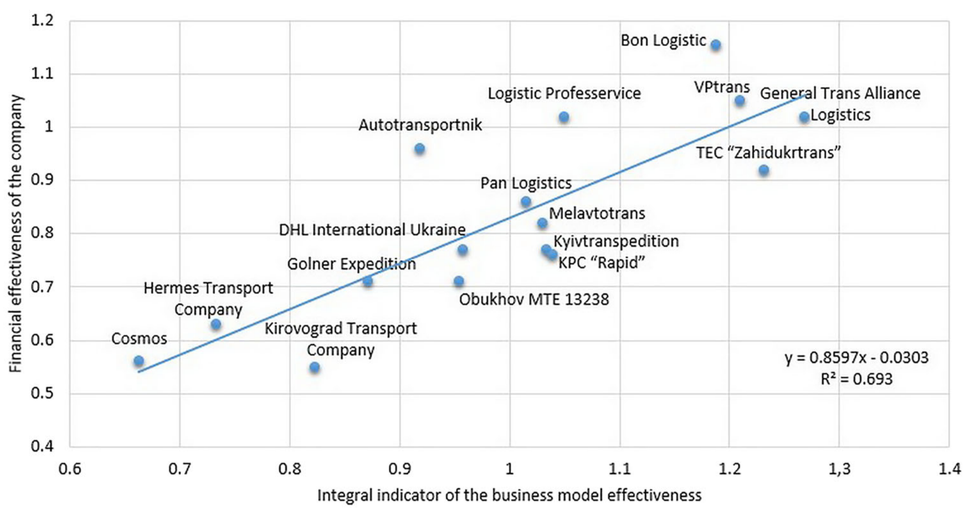

Figure 3. The connection between effectiveness indicators of business processes modelling and the financial efficiency of the companies under study under the COVID-19 pandemic.
Source: formed by the authors.

studied indicators. This is confirmed by the coefficient of determination that equals 0.693. This indicates the possible impact of improved business process modelling on the companies' financial efficiency. (Figure 4)

The leading companies in terms of the efficiency of business processes modelling and production efficiency are the same companies—enterprises 12, 7, 8, and 3. Enterprise 4 is clearly an outsider among the companies under study. In general,

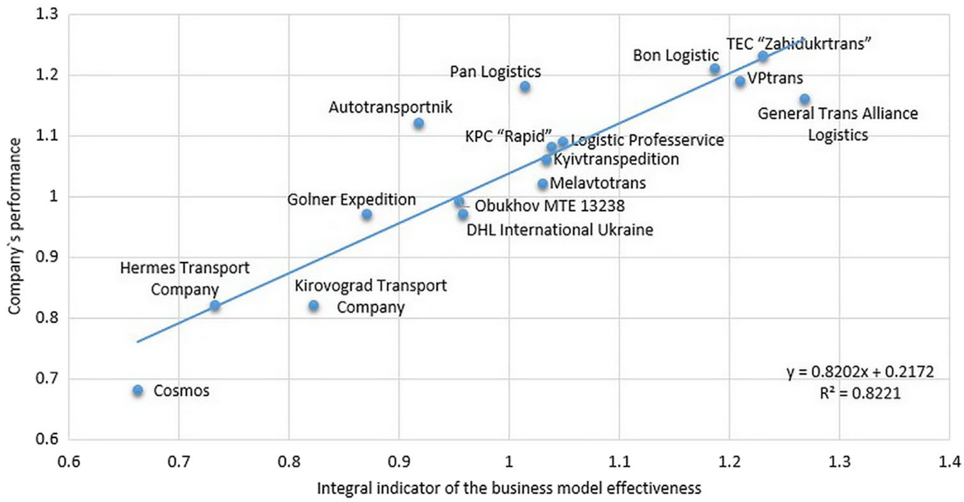

Figure 4. The connection between effectiveness indicators of business processes modelling and the production efficiency of the companies under study under the COVID-19 pandemic.
Source: formed by the authors.

there is a significant correlation between the indicators under investigation for the studied companies since R^2=0.822.

Scenario modelling of the efficiency of business processes under the COVID-19 crisis. Based on the conducted regression analysis, alternative scenarios for business processes modelling were developed, implying a 10% increase in the quality, cost, and speed of business processes, their double increase or simultaneous growth in the context of all three indicators. Thus, seven scenarios for business processes modelling have been formed. However, the seventh scenario, involving a simultaneous increase in all three indicators, was considered a reference one (Table 5).

For the majority of the companies under study (81%), the most effective (approximate to the reference) scenario is the concentration on the cost and speed of business processes. There is a priority to improve efficiency in terms of the quality and speed of business processes only for companies such as 6, 10, and 12. Each company can define a scenario that maximizes the efficiency of business process modelling. The conducted scenario confirms that companies do not need to achieve maximum efficiency for all three components of modelling efficiency in order to save resources. At the same time, there is a possibility of such a scenario, when with the help of asymmetry in the direction of quality, cost, and speed of business processes, it will be possible to maximize the efficiency of their modelling to a level close to the reference value. The average indicators for all scenarios for the companies under study are displayed in Table 6.

The connection between the generated regression equations, which were given earlier, can also be traced in this research. Focusing on the cost and speed of business processes is the most effective option for their modelling. It also contributes to improving financial efficiency and productivity for the investigated companies. Table 7 displays the results of the hierarchical synthesis of the obtained effectiveness indicators of business processes modelling for the financial and production efficiency of the companies' functioning concerning the designed scenarios.

Table 5. Effectiveness indicators of business processes modelling according to the obtained scenarios under the consequences of the COVID-19 pandemic.

	Business process improvement priority in the scenario						
Company	Quality	Cost	Speed	Quality-cost	Quality -speed	Cost-speed	Quality-cost-speed
Autotransportnik	0.8147	0.8404	0.8454	0.8484	0.8535	0.8792	0.8873
Pan Logistics	0.9356	0.9554	0.9567	0.9723	0.9737	0.9935	1.0105
General Trans Alliance Logistics	1.1939	1.1992	1.2212	1.2272	1.2492	1.2545	1.2825
Cosmos	0.5188	0.5411	0.5206	0.5501	0.5296	0.5519	0.5608
Hermes Transport Company	0.6898	0.6971	0.7077	0.7112	0.7218	0.7291	0.7432
Logistic Professervice	0.9702	0.9649	0.9801	0.9947	1.0100	1.0046	1.0344
Bon Logistic	1.0562	1.0883	1.0974	1.0987	1.1079	1.1399	1.1504
VPtrans	1.0982	1.1184	1.1088	1.1439	1.1343	1.1545	1.1800
KPC 'RAPID'	0.9734	0.9870	1.0006	1.0052	1.0189	1.0324	1.0507
Obukhov MTE 13238	0.8129	0.7933	0.8317	0.8197	0.8582	0.8386	0.8650
Kyivtranspedition	0.9717	0.9821	0.9912	1.0038	1.0128	1.0233	1.0450
TEC 'Zahidukrtrans'	1.1409	1.1376	1.1515	1.1720	1.1859	1.1826	1.2171
Golner Expedition	0.7506	0.7726	0.7905	0.7768	0.7948	0.8167	0.8210
Kirovograd Transport Company	0.7726	0.7825	0.7893	0.7988	0.8056	0.8155	0.8319
DHL International Ukraine	0.8774	0.8984	0.9035	0.9115	0.9166	0.9376	0.9507
Melavtotrans	0.9024	0.9332	0.9381	0.9408	0.9458	0.9766	0.9842

Source: formed by the authors.

Table 6. Average indicators of the modelling effectiveness according to scenarios for the studied companies under the consequences of the COVID-19 pandemic.

Regression models	a	b	–
Financial efficiency of the company (FE)	−0.0303	0.8597	–
Production efficiency of the company (PE)	0.2172	0.8202	–
Scenario modeling	x	y_{FE}	y_{PE}
Quality	0.9050	0.7477	0.9594
Cost	0.9182	0.7591	0.9703
Speed	0.9271	0.7668	0.9776
Quality-cost	0.9360	0.7743	0.9849
Quality-speed	0.9449	0.7820	0.9922
Cost-speed	0.9582	0.7934	1.0031
Quality-cost-speed	0.9759	0.8100	1.0200

Source: formed by the authors.

Business processes modelling based on the concentration scenario on indicators of the cost and speed of business processes has the highest positive effect of their modelling, which contributes to increasing the financial and productive efficiency of the companies functioning. This effect differs from the reference version by 0.8%. Meanwhile, the efficiency with regard to this scenario exceeds the values under the scenarios of concentration only on quality, cost or speed by an average of 10%. Thus, the first hypothesis is confirmed since the cost and speed of business processes had the most considerable impact on the company's financial productivity under the COVID-19 crisis. At the same time, the second hypothesis requires rejection: quality is an essential parameter for the effectiveness of business process modelling, but under the COVID-19 pandemic, it is not a priority. All this conditions confirm the need for integrated business processes modelling, which takes into consideration different combinations of the resulting indicators and helps to increase both the efficiency of modelling business processes, and companies' financial and productive efficiency as well.

Table 7. Hierarchical synthesis of financial and production efficiency indicators of the studied countries based on business processes modelling according to designed scenarios under the consequences of the Covid-19 pandemic.

Criterion	Assessment	Quality	Cost	Speed	Quality-cost	Quality-speed	Cost-speed	Quality-cost-speed
Financial efficiency of the company (FE)	Initial	0.7477	0.7591	0.7668	0.7743	0.7820	0.7934	0.81
	Normalized	0.1376	0.1397	0.1412	0.1426	0.1440	0.1461	0.1489
	Weighted sum	0.9635	0.9782	0.9881	0.9979	1.0078	1.0224	1.0421
Production efficiency of the company (PE)	Initial	0.9594	0.9703	0.9776	0.9849	0.9922	1.0031	1.02
	Normalized	0.1389	0.1405	0.1416	0.1426	0.1437	0.1453	0.1474
	Weighted sum	0.9726	0.9836	0.9911	0.9984	1.0058	1.0168	1.0316
Hierarchical synthesis		0.9371	0.9622	0.9793	0.9963	1.0137	1.0397	1.0751

Source: formed by the authors.

5. Discussion

The findings are conceptually similar to studies demonstrating the effect of business process costs on a company's operational performance (Widarti et al., 2020). However, they do not confirm the findings of studies indicating the importance of business process quality and its improvement in the context of innovation and digitalization (Lüdeke-Freund et al., 2018; Viriyasitavat et al., 2019). This is due to the fact that they were conducted before the start of the pandemic. There has been a transformation of values and a shift in business development priorities as a result of the COVID-19 spread, as indicated in crisis impact studies (Lozada-Contreras et al., 2022). The lack of common characteristics for the surveyed companies, which confirms the impossibility of conducting the proper diagnostics for individual parameters, should also be considered. The conducted regression analysis made it possible to level out this limitation regarding the integral indicator of the efficiency of business processes modelling.

The study's benefit is the proposed integrated indicator of the business process modelling effectiveness incorporating the research of other scientists with due regard to assessing the quality of business processes (Garza-Reyes, 2018), the cost of business processes, and the corresponding investment to optimize them (Abeygunasekera et al., 2018), and the speed of business processes (Hartley & Sawaya, 2019; Wilson & Daugherty, 2018). This study suggests integrating approaches using an integrated indicator. Meanwhile, it can be modified to conduct research in other sectors while considering their functioning specifics.

Modelling business processes based on cost and speed indicators of business processes have the most significant positive impact, increasing the financial and productive efficiency of the surveyed companies. Previous studies have addressed the aspects of the link between business processes and company performance using a key indicators system (Brazier et al., 2017; Lederer et al., 2020). However, this research confirms the need for integrated business process modelling, which takes into account different combinations of resulting indicators and contributes to improving the efficiency of business process modelling (Baghiu, 2020) as well as the financial and productive efficiency of companies in the aftermath of the COVID-19 pandemic.

The benefit of this study is also the proposed methodological approach to evaluating the effectiveness of business process modelling, which enables not only assessing the level of companies' performance (Laguna & Marklund, 2018) but also anticipating it in the future. This is facilitated by including the prediction scenario in the methodological tools, which can also be observed in other studies (Oey et al., 2020; Zhang et al., 2021). However, the study demonstrated the ability to select the most effective alternative which is as close to the reference scenario as possible. Thus, this approach allows us to transform the asymmetry of the company's development into efficiency (Johnsen et al., 2020) and multiply it in the context of business processes modelling.

The performed hierarchical synthesis is also frequently used in modern research in various directions: entrepreneurship (Trushkina et al., 2020), digitalization (Adomako et al., 2021; El Hamdi et al., 2019), competitiveness (Feng et al., 2020) and so on. In this study, hierarchical synthesis contributes to a comprehensive assessment of the impact of business process modelling on the companies' financial and production efficiency. This feature distinguishes our study from others, but at the same time, the application of this approach gives them a common characteristic.

6. Conclusion

The study's theoretical contribution is the expansion of the asymmetries theory of a company's development from the standpoint of business model efficiency. The approach to its diagnostics confirms that there must be asymmetries in business modelling that contribute to the company's development in practice. In this case, the complex model integrates three components of the business process efficiency assessment system (quality, cost, and speed), which significant performance can solely be achieved jointly. As a result, it enables the identification of the drivers of effective business models in the context of the COVID-19 crisis. Meanwhile, this allows determining the model transformation directions in response to changes in the COVID-19 economy.

The practical contribution of this research is the approbation of the proposed methodological approach to assessing the effectiveness of business process modelling based on diagnosing the impact of their quality, cost and speed with the implementation of regression analysis and the formation of alternative scenarios. The study demonstrates the approach's applicability in improving the efficiency of business process modeling and its impact on company performance under rapidly changing COVID-19 conditions. The identification of leaders and outsiders among the companies under study with due regard to set parameters was made possible using the definition of the effectiveness indicators of business process modelling based on their quality, cost, and speed. Leading companies with respect to quality typically have a higher speed level of business processes. Among the indicators under consideration, the cost of business processes has the lowest value for these companies. However, there are no common characteristics for the surveyed companies, demonstrating the impossibility of conducting adequate diagnostics based on individual parameters. This limitation was reduced to the minimum by the regression analysis, which took into account the integral indicator of the effectiveness of business process modelling. The results of the regression analysis are valuable, since the formed models are applicable to and appropriate for the operating conditions of the studied companies, which is confirmed by numerous control indicators. This analysis proves that the most significant factor in modelling efficiency for the companies under study is the speed of business processes.

According to the determination of the impact of the effectiveness of business processes modelling on the companies' financial and production efficiency, the diagnosis of the relationship between these indicators was carried out under the COVID-19 pandemic. The regression analysis provided an opportunity to develop alternative scenarios for the performance of business processes modelling, taking into consideration the reference option. The anticipation made it possible to determine that for most of the surveyed companies during a pandemic, the most effective scenario (close to the reference) is the one that focuses on the cost and speed of business processes. At the same time, the approach proposed in this study allows each company to identify a scenario that maximizes the efficiency of business process modelling. The conducted scenario modelling confirms that companies do not need to achieve maximum efficiency for all three components of modelling efficiency in order to save resources. At the same time, there is a possibility of such a scenario, when with the help of asymmetry in the direction of quality, cost and speed of business processes, it will be possible to maximize the efficiency of their modelling to a level close to the reference value against the background of the COVID-19 pandemic. Business processes modelling based on the concentration scenario on indicators of the cost and speed of business processes has the highest positive modelling effect, which contributes to increasing the companies' financial and productive efficiency. All this factors confirm the necessity for integrated business processes modelling, which takes into consideration various combinations of the outcome indicators and helps to increase both the efficiency of business processes modelling, and the companies' financial and productive efficiency under the Covid-19 pandemic.

The research conducted contains few limitations. The most important one is access to information about the company's business processes, which allows for its general performance and simulation diagnostics. Since the required information is not disclosed in the financial statements, the company's management must approve and consent to provide the necessary data for the baseline calculation. Another limitation of the study comes from the fact that it can only be conducted for companies in a specific economy's industry or sector. The inclusion of companies from various industries in the sample is not appropriate since they are specific, and the results obtained may differ considerably. As a result, it is possible to assert that the proposed methodological approach does not claim to be universal. However, it is still possible to compare the effectiveness of business process modelling by the level of an integral indicator for companies from differing sectors, allowing for competitive diagnostics in this direction.

In the future, the study can be expanded in terms of applying the proposed approach in other branches of the economy, as well as in different countries and regions, transforming the indicator system, considering the business functioning specificity. Meanwhile, it is possible to deepen the study by clustering the studied companies, determining their general characteristics and the possibilities of applying scenario modelling to the formed clusters. Another area of subsequent research can be the identification, assessment, and minimization of the company development risks, taking into consideration alternative forecast scenarios and diagnostics of the flexibility level of the business process model in the context of eliminating the consequences of the COVID-19 pandemic. This can contribute to developing a new direction in the theory of asymmetries concerning business development based on the process approach, its features, considering the transformation of values and the generation of new opportunities under the COVID-19 economy.

Disclosure statement

The authors declare that they have no conflict of interest.

Data availability

Data will be available on request.

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References

Abeygunasekera, A. W. J. C., Bandara, W., Wynn, M., & Yigitbasioglu, O. (2018). Nexus between Business Process Management (BPM) and accounting: A literature review and future research directions. *Business Process Management Journal*, *24*(3), 745–770. https://doi.org/10.1108/BPMJ-12-2016-0235

Adomako, S., Amankwah-Amoah, J., Tarba, S. Y., & Khan, Z. (2021). Perceived corruption, business process digitization, and SMEs' degree of internationalization in sub-Saharan Africa. *Journal of Business Research*, *123*, 196–207. https://doi.org/10.1016/j.jbusres.2020.09.065

Araz, O. M., Choi, T. M., Olson, D. L., & Salman, F. S. (2020). Role of analytics for operational risk management in the era of big data. *Decision Sciences*, *51*(6), 1320–1346. https://doi.org/10.1111/deci.12451

Bag, S., Wood, L. C., Mangla, S. K., & Luthra, S. (2020). Procurement 4.0 and its implications on business process performance in a circular economy. *Resources, Conservation and Recycling*, *152*, 104502. https://doi.org/10.1016/j.resconrec.2019.104502

Baghiu, M. C. (2020). Analysis of business model innovation in the post-Covid economy: Determinants for success. *Journal of Public Administration, Finance and Law*, (17), 7–24.

Baiyere, A., Salmela, H., & Tapanainen, T. (2020). Digital transformation and the new logics of business process management. *European Journal of Information Systems*, *29*(3), 238–259. https://doi.org/10.1080/0960085X.2020.1718007

Brazier, J., Ara, R., Rowen, D., & Chevrou-Severac, H. (2017). A review of generic preference-based measures for use in cost-effectiveness models. *PharmacoEconomics*, *35*(Suppl 1), 21–31. https://doi.org/10.1007/s40273-017-0545-x

Burström, T., Parida, V., Lahti, T., & Wincent, J. (2021). AI-enabled business-model innovation and transformation in industrial ecosystems: A framework, model and outline for further research. *Journal of Business Research*, *127*, 85–95. https://doi.org/10.1016/j.jbusres.2021.01.016

Chatterjee, S., Ghosh, S. K., & Chaudhuri, R. (2020). Knowledge management in improving business process: An interpretative framework for successful implementation of AI–CRM–KM system in organizations. *Business Process Management Journal*, *26*(6), 1261–1281. https://doi.org/10.1108/BPMJ-05-2019-0183

El Hamdi, S., Oudani, M., & Abouabdellah, A. (2019). Towards identification of the hierarchical link between Industry 4.0, smart manufacturing and smart factory: Concept cross-comparison and synthesis. *International Journal of Supply and Operations Management*, *6*(3), 231–244.

Erasmus, J., Vanderfeesten, I., Traganos, K., Keulen, R., & Grefen, P. (2020). The HORSE project: The application of business process management for flexibility in smart manufacturing. *Applied Sciences*, *10*(12), 4145. https://doi.org/10.3390/app10124145

Feng, B., Sun, K., Chen, M., & Gao, T. (2020). The impact of core technological capabilities of high-tech industry on sustainable competitive advantage. *Sustainability*, *12*(7), 2980. https://doi.org/10.3390/su12072980

Fischer, M., Imgrund, F., Janiesch, C., & Winkelmann, A. (2020). Strategy archetypes for digital transformation: Defining meta objectives using business process management. *Information & Management*, *57*(5), 103262. https://doi.org/10.1016/j.im.2019.103262

Fletcher, G., & Griffiths, M. (2020). Digital transformation during a lockdown. *International Journal of Information Management*, *55*, 102185. https://doi.org/10.1016/j.ijinfomgt.2020.102185

Gandhi, A., & Sucahyo, Y. G. (2021). Architecting an advanced maturity model for business processes in the gig economy: A platform-based project standardization. *Economies*, *9*(4), 176. https://doi.org/10.3390/economies9040176

Garza-Reyes, J. A. (2018). A systematic approach to diagnose the current status of quality management systems and business processes. *Business Process Management Journal*, *24*(1), 216–233. https://doi.org/10.1108/BPMJ-12-2016-0248

Hameed, N. S. S., Salamzadeh, Y., Rahim, N. F. A., & Salamzadeh, A. (2022). The impact of business process reengineering on organizational performance during the coronavirus pandemic: Moderating role of strategic thinking. *foresight*, *24*(5), 637–655. in press. https://doi.org/10.1108/FS-02-2021-0036

Hartley, J. L., & Sawaya, W. J. (2019). Tortoise, not the hare: Digital transformation of supply chain business processes. *Business Horizons*, *62*(6), 707–715. https://doi.org/10.1016/j.bushor.2019.07.006

Johnsen, R. E., Lacoste, S., & Meehan, J. (2020). Hegemony in asymmetric customer-supplier relationships. *Industrial Marketing Management*, *87*, 63–75. https://doi.org/10.1016/j.indmarman.2020.01.013

Kharazishvili, Y., Kwilinski, A., Grishnova, O., & Dzwigol, H. (2020). Social safety of society for developing countries to meet sustainable development standards: Indicators, level, strategic benchmarks (with calculations based on the case study of Ukraine). *Sustainability*, *12*(21), 8953. https://doi.org/10.3390/su12218953

Kolpak, E., Borisova, V., & Panfilova, E. (2022). Vector model of digital economy in the process of increasing the competitiveness of countries and regions. *Journal of Globalization, Competitiveness and Governability*, *15*(2), 104–121. https://doi.org/10.3232/GCG.2021.V15.N2.05

Laguna, M., & Marklund, J. (2018). *Business process modeling, simulation and design*. Chapman and Hall/CRC.

Lamine, E., Thabet, R., Sienou, A., Bork, D., Fontanili, F., & Pingaud, H. (2020). BPRIM: An integrated framework for business process management and risk management. *Computers in Industry*, *117*, 103199. https://doi.org/10.1016/j.compind.2020.103199

Lederer, M., Heider, L., & Maier, J. (2020). A multidimensional indicator system for quantifying business process interface problems. *International Journal of Management Practice*, *13*(3), 295–320. https://doi.org/10.1504/IJMP.2020.10028119

Lozada-Contreras, F., Orengo-Serra, K. L., & Sanchez-Jauregui, M. (2022). Adaptive customer relationship management contingency model under disruptive events. *Journal of Advances in Management Research*, *19*(2), 198–219. in press. https://doi.org/10.1108/JAMR-12-2020-0347

Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L., & Breuer, H. (2018). The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation. *Sustainable Production and Consumption*, *15*, 145–162. https://doi.org/10.1016/j.spc.2018.06.004

Mendling, J., Pentland, B. T., & Recker, J. (2020). Building a complementary agenda for business process management and digital innovation. *European Journal of Information Systems*, *29*(3), 208–219. https://doi.org/10.1080/0960085X.2020.1755207

Nuseir, M. T. (2021). Designing business intelligence (BI) for production, distribution and customer services: A case study of a UAE-based organization. *Business Process Management Journal*, *27*(4), 1275–1295. https://doi.org/10.1108/BPMJ-06-2020-0266

Oey, E., Wijaya, W. A., & Hansopaheluwakan, S. (2020). Forecasting and aggregate planning application–a case study of a small enterprise in Indonesia. *International Journal of Process Management and Benchmarking*, *10*(1), 1–21. https://doi.org/10.1504/IJPMB.2020.104229

Perboli, G., Musso, S., & Rosano, M. (2018). Blockchain in logistics and supply chain: A lean approach for designing real-world use cases. *IEEE Access*. *6*, 62018–62028. https://doi.org/10.1109/ACCESS.2018.2875782

Pérez-Álvarez, J. M., Gómez-López, M. T., Eshuis, R., Montali, M., & Gasca, R. M. (2020). Verifying the manipulation of data objects according to business process and data models. *Knowledge and Information Systems*, *62*(7), 2653–2683. https://doi.org/10.1007/s10115-019-01431-5

Querini, P. L., Chiotti, O., & Fernádez, E. (2020). Cooperative energy management system for networked microgrids. *Sustainable Energy, Grids and Networks*, *23*, 100371. https://doi.org/10.1016/j.segan.2020.100371

Rodionov, D. G., Konnikov, E. A., & Nasrutdinov, M. N. (2021). A transformation of the approach to evaluating a region's investment attractiveness as a consequence of the COVID-19 pandemic. *Economies*, *9*(2), 59. https://doi.org/10.3390/economies9020059

Shogrkhodaei, S. Z., Razavi-Termeh, S. V., & Fathnia, A. (2021). Spatio-temporal modeling of pm2. 5 risk mapping using three machine learning algorithms. *Environmental Pollution (Barking, Essex: 1987)*, *289*, 117859. https://doi.org/10.1016/j.envpol.2021.117859

Sott, M. K., Furstenau, L. B., Kipper, L. M., Rodrigues, Y. P. R., López-Robles, J. R., Giraldo, F. D., & Cobo, M. J. (2021). Process modeling for smart factories: Using science mapping to understand the strategic themes, main challenges and future trends. *Business Process Management Journal*, *27*(5), 1391–1417. https://doi.org/10.1108/BPMJ-05-2020-0181

Stević, Ž., & Brković, N. (2020). A novel integrated FUCOM-MARCOS model for evaluation of human resources in a transport company. *Logistics*, *4*(1), 4. https://doi.org/10.3390/logistics4010004

Taymouri, F., La Rosa, M., Dumas, M., & Maggi, F. M. (2021). Business process variant analysis: Survey and classification. *Knowledge-Based Systems*, *211*, 106557. https://doi.org/10.1016/j.knosys.2020.106557

Trushkina, N., Abazov, R., Rynkevych, N., & Bakhautdinova, G. (2020). Digital transformation of organizational culture under conditions of the information economy. *Virtual Economics*, *3*(1), 7–38. https://doi.org/10.34021/ve.2020.03.01(1)

Viriyasitavat, W., Da Xu, L., Bi, Z., & Pungpapong, V. (2019). Blockchain and internet of things for modern business process in digital economy—the state of the art. *IEEE Transactions on Computational Social Systems*, *6*(6), 1420–1432. https://doi.org/10.1109/TCSS.2019.2919325

Vještica, M., Dimitrieski, V., Pisarić, M., Kordić, S., Ristić, S., & Luković, I. (2021). Multi-level production process modeling language. *Journal of Computer Languages*, *66*, 101053. https://doi.org/10.1016/j.cola.2021.101053

Widarti, W., Desfitrina, D., & Zulfadhli, Z. (2020). Business process life cycle affects company financial performance: Micro, small, and medium business enterprises during the Covid-19 period. *International Journal of Economics and Financial Issues*, *10*(5), 211–219. https://doi.org/10.32479/ijefi.10516

Wilson, H. J., & Daugherty, P. R. (2018). Collaborative intelligence: Humans and AI are joining forces. *Harvard Business Review*, *96*(4), 114–123.

Zahedi, J., Salehi, M., & Moradi, M. (2022). Identifying and classifying the contributing factors to financial resilience. *foresight*, *24*(2), 177–194. in press. https://doi.org/10.1108/FS-10-2020-0102

Zamarreño-Aramendia, G., Cruz-Ruiz, E., & Ruiz-Romero de la Cruz, E. (2021). Sustainable economy and development of the rural territory: Proposal of wine tourism itineraries in La Axarquía of Malaga (Spain). *Economies*, *9*(1), 29. https://doi.org/10.3390/economies9010029

Zhang, H., Song, H., Wen, L., & Liu, C. (2021). Forecasting tourism recovery amid COVID-19. *Annals of Tourism Research*, *87*, 103149. https://doi.org/10.1016/j.annals.2021.103149