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# RETRACTED: Energy Efficient Digital Omnichannel Marketing Based on a Multidimensional Approach to Network Interaction

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Digital Omnichannel marketing is viewed the answer to future marketing however, the concept is mired with problems related to the energy and carbon footprinting. Therefore, this study proposed energy efficient network of a complex topology of data access and marketting, where the nodes function as an objects with unique characteristics and create digital customer value network. It is believed that competition has transformed into a contest of online platforms in energy efficency as well in economic efficiency. It is emphasized that there is no alternative to multichannel interaction at the present stage of implementing digital business solutions. In this study, authors have developed omnichannel interaction algorithms based on mathematical models. The proposed approach supplements the digital twin model with economic indicators and methods. Results and analysis of multidimensional structures allows for omnichannel network digital interaction and improves the digital marketing approach. To consider the formation of a network configuration of customer service, developing the idea of digital interaction between participants in consumer value chains. The study conclude and recommend to expand the methodology of digital marketing involving alternative channels of interaction and energy efficency by including a mathematical apparatus for analyzing multidimensional structures (n-D structures).

**Keywords: omnichannel interaction, sales network, multi-dimensional structures, green economy, digital development, digital marketing**

## INTRODUCTION

The principle of any economic activity is based on the an energy efficicy and carbon foorprint reduciton is the challenge of the in the recent decades. However, management considers energy efficiency as the essential factors of interaction in the commercial process and the level of rationality of the company's divisions (Al Asbahi et al., 2019). Sustainable energy is the route to any economic activies in the world (Ahmad et al., 2019). Additionally, the consolidation of business into network structures has been the dominanted trend in the last decade. Moreover, this trend is typical for goods and manufacturing and service sector enterprises, which occupy an overwhelming market share in developed countries as well in the energy efficency The search for a strategy that maximizes the company's business potential correlates with the desire to expand the reach of the potential client pool. The covid-19 pandemic has become a powerful driver for the development of digital technologies (Bai et al., 2021). The postive and negative aspects of the pandemic especially in the context of the digitlizaiton and bossting omnichannelinig business resulted online business grew rapidly across the world; the online shopping tread among the general public particulary and in business segment has grown many times over (Farah et al., 2018; Donida et al., 2021). When determining the options for enterprise interaction in the Web 4.0 environment, it is necessary, first of all, to rely on the achievements of Internet technologies, primarily mobile, supplied by 4G and 5G networks. The availability of equipment YO and multiple platforms allows for organizing several alternative interaction channels. Digital interaction was facilitated by the device-to-device option and the high speed of data exchange in any format, including geolocation. Additionally, the implementation of IoT technologies has become much more manageable. Hossain et al. (2020) the term omnichannel means an integrated sales experience that melds the advantage of physical stores with the information-rich experience of online shopping.

Omnichannel business interaction has emerged in the digital economy (Cui et al., 2021). The ability to integrate XaaS solutions in cloud service SIM solutions, including mobile interaction, brings corporate CRM (Customer Relationship Management) and ERP (Enterprise Resource Planning) classes to the global level (Rajganesh and Ramkumar, 2016; Alemzero et al., 2021). These integration raises the problem of developing appropriate algorithms for creating the algorithmic basis of digital platforms based on omnichannel interaction based on the digital twin defintion (Barykin et al., 2020). it is possible to expand the scope of the application of optimization methods in making managerial decisions. At the same time, the indices of business process excellence and economic indicators remain the optimization criteria (Golosnoy et al., 2019). Algorithms developed for digital platforms have shown high conversion, promotional activity, and scaling due to the optimal use of these corresponding digital interaction surfaces (Barykin et al., 2021a). There is no alternative to omnichannel interaction at the present stage of introducing digital business solutions. When creating such virtual business platforms, a mathematical basis is needed to complement the technology of single-channel digital twins (Barykin et al., 2020). Podvalny et al. (2017) considered the formation of a network configuration of customer service, developing the idea of digital interaction between participants in the chains of consumer value formation. The mathematical model is proposed to complements the digital twin model with economic indicators (Barykin et al., 2020) using the adopted methods (Barykin S. Y. et al., 2021). Past studies did not address the possibility of taking into account the time spent by the consumer in buying through online or offline channels.

The proposed dynamic programming allows for improving the principles of making managerial decisions for a long planning horizon. By conducting reasoning and derivation of mathematical formalisms for a limited channel dimension to show that the obtained relations are fully scalable and allow any increase in the number of interaction channels available in an actual situation.

## LITERATURE REVIEW

The idea of deeveloping digital marketing based on omnichannel network interaction refers to the conceipt Porter's value chain stemming from his book (Porter, 1985) and his earlier ideas about competitiveness (Porter, 1980) as well as his recent publication about creating shared value (Porter and Kramer, 2019). Researchers suppose that future topics could spread over the supply chains transforming to the digital supply networks, incorporating ecosystem partners (Scherbakov and Silkina, 2019). In the modern literature, logistics and supply chain management are considered one of the priority areas of the ongoing digital transformation (Burroughs and Burroughs, 2020). Several authors have considered the digital modifications of logistics, marketing channels, and supply chain management (Mohsin et al., 2015; Matsuda et al., 2019; Cai and Lo, 2020). Researchers couldn't find studies based on the database of the journal of theoretical and applied research on e-commerce by the keywords "Digital omnichannel marketing", "Integration of marketing and logistics", "Dimensions marketing", "Dimension methodology". The work of Lee (2020) considered an omnichannel retail approach and authoer has investigated the influence of omnichannel characteristics on customer satisfaction. Lee (2020) defined omnichannel as a cross-channel retail model that firms use to improve customer experience and maximize firm productivity. Logistics is considered from the position of delivery and return of goods. The perspective of integrating marketing and logistics, the paper notes that an omnichannel approach strategy allows retailers to overcome inefficient organizational barriers that separate retailers from their suppliers and increase transparency for all participants in the supply chain network (Gao and Fan, 2021). Hajdas et al. (2020) considered the consistency of omnichannel concerning customer experience. Attention is paid to customer satisfaction when interacting with the brand through online and offline channels. The study results highlight the importance of consistency between online and offline channels for customers in equal proportions. Consistency denotes the communication between channels. However, the mentioned work considers no integrating marketing and logistics however, example is given for goods related to luxury goods. For clients seeking exclusivity, an omnichannel distribution strategy can be challenging. The most appropriate in this case would be a selective or exclusive distribution strategy. In the analyzed study, attention is also paid to the efficiency of logistics, which refers to the factors associated with the product. The next block of factors related to the market emphasizes the importance of analyzing the needs and attitudes of customers. As an example, a situation is considered in which the company's main target audience does not have sufficient digital skills. It will be challenging to consider the digital channel as an alternative to shopping in such a situation. The next set of drivers relates to competition factors. New business models based on digital technologies are intensifying competition. As more companies begin to move to an omnichannel approach, more other market participants will follow the same path to remain competitive. The list is completed by a group of factors relating to legality. Tariffs and taxes are seen as an obstacle to implementing an omnichannel strategy. It is also necessary to take into account legal restrictions in the process of implementing an omnichannel approach.

Hossain et al. (2020) studied the barriers firms face in implementing of omnichannel approach. It is noted that both customers and brands show interest in omnichannel. Customers are ready to be active participants in the buying process of omnichannel environment. Brands are equally interested in this approach and admit that they are not as an effective at integrating channels as they would like. Despite the interest, Hajdas et al. (2020); Hossain et al. (2020) and Gao and Fan (2021) omnichannel theory is not well developed in the past stuide. In Hajdas et al. (2020) the omnichannel approach should be considered the next channel integration level. Barriers to applying the omnichannel approach are presented in the form of cases illustrating the factor. Sets of factors are called omnichannel industry drivers. Depending on the industry, they can help or hinder the adoption of omnichannel. One of the blocks is devoted to the factors associated with the product being produced. Product characteristics can either help implement an omnichannel strategy or make it completely unrealistic.

Authors agreed with the point of view of a customer-centric business (Hossain et al., 2020) considering omnichannel marketing as integration between channels to provide a consistent service experience for customers. Several channels are spread over physical stores, websites, direct mail and catalogs, social media sites, review sites, call centers, mobile devices, kiosks, home services, and networked appliances. Saghiri et al. (2017) described the main building blocks and enablers to operationalize the omnichannel system. Verhoef et al. (2015) optimized the customer experience across channels and the performance over channels using numerous available channels and customer touchpoints through synergetic management. Lazaris and Vrechopoulos (2014) supported the view that omnichannel integrates all available channels but not just simultaneous use of channels. The optimization of economically significant indicators of the functioning of the consumer value chain, including those related to the interaction of network participants (Borisoglebskaya et al., 2019) makes it possible to develop a customer-centric business based on multichannel technology. Based on the analyzed sources, we emphasize no approach to forming "seamless" ways of interaction through available communication channels in the presented works. This article proposes to expand the methodology of digital marketing based on multichannel interaction by including the mathematical apparatus for analyzing multidimensional structures.

The main feature of the omnichannel approach is the integration of various channels allowing retailers to glean consumer opinions instantly. The second feature could be a coordinated offering to provide a seamless customer

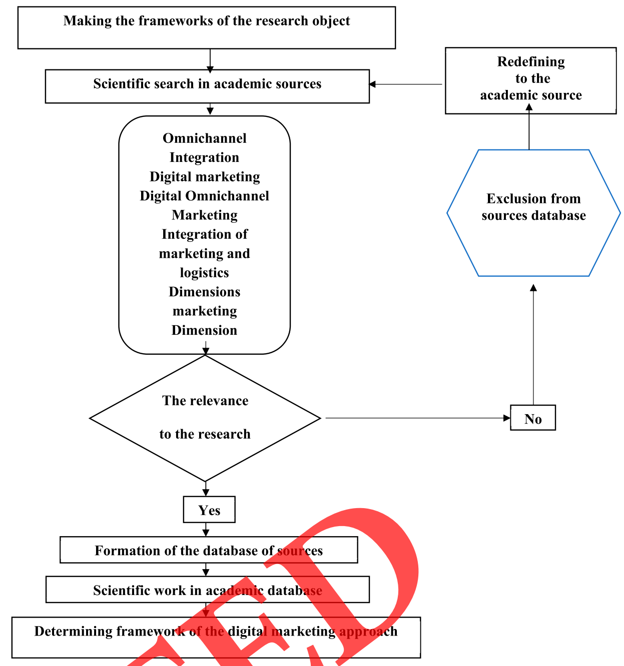


**FIGURE 1** | Digital omnichannel marketing framwrok.

experience. The third feature regards diminishing the distinction between online and offline channels *via* omnichannel marketing (Hossain et al., 2020). In the comprehensive review it is understood past studies has agreeed ommninchannel integration quality as a higher-order multidimensional construct however most of the authors have presented in the simmulaiton form and lack of development in the mathemathical expression has found in the work. In this study we aimd to develop the idea of the following four dimensions of Omnichannel Integration Quality described in Hossain et al. (2020) research study. Implementation of the concept of a customer-centric business depends entirely on the level of coordination of enterprises, organizations, and the general consumer pool. Herein, proposed the considering such interaction as a network of complex topology, where the nodes function as objects with unique characteristics. Topology objects characterize participants in the digital customer value creation network. Algorithms preprogrammed in cloud servers of the nodes determine the quality of the implementation of system interaction in omnichannel marketing.

## MATERIALS AND METHODS

The idea of deeveloping digital marketing based on omnichannel network interaction refers to the concept Porter's value chain stemming from his book (Porter, 1985) and his earlier ideas about competitiveness (Porter, 1980) as well as his recent publication about creating shared value (Porter and Kramer, 2019). In the study, we attempted to develop the idea of the logistics system and marketing instruments which was previosuly studid (Aslam et al., 2020; Bag et al., 2020; Giordano, 2020). Research frame as shown in **Figure 1** has developed from the literature analysis as the research methodology was applied for the selected keywords and main characteristics were determined which is the part of the secondary data. In this study we aimd to develop the idea of the following four dimensions of Omnichannel Integration Quality described in Hossain et al. (2020) research study.

1. Channel-service configuration (breadth of channel, transparency of channels, and appropriateness of channels)
2. Content consistency (information consistency and transaction data integration)
3. Process consistency (system consistency and image consistency)
4. Assurance quality and sub-dimensions: privacy, security, and service recovery accessibility.

Our approach includes at least one additional dimension (a fifth dimension). Hornik (2021) considered time value functions and customer time spent in online and traditional offline stores, they propose creating and developing an environment to encourage patrons to stay longer doing their shopping. The sixth dimension refers to the value chain's digital interaction based on the marketing and logistics approach (Barykin et al., 2021c). The rapid development of digital platforms in various business segments is a driver for maintaining a high share of online business after the pandemic. Alexander and Kent (2020) stated technology redefines the store space and experience through consumer-facing technologies and tech-enabled services. However, achieving the objectives of a customer-centered business needs some improvement in the logic of interaction with a client. We suppose that the analysis of the n-D structure expands the scope of digital marketing methods.

### Basic Formalisms

Analyzing multidimensional (n-D) structures allows for omnichannel network digital interaction and improves the digital marketing approach. Let us introduce the definition of a trade network that combines $s$ many nodes. Each of them has a set of types of interaction with counterparties. Let us define their number as $M$.

The entire planning horizon is divided into $N$-many planning periods. This can be either a period when the results of activities are summarized or a period convenient for settlements, as a rule, synchronized with counterparties. Before the planning period, it is necessary to determine the optimal distribution of investments for each type of interaction.

According to statistical data (Barykin et al., 2021c) and business intelligence, the dependencies (Barykin S. Y. et al., 2021) of the planned profit $P_k(z_{kj})$ can be obtained by including similar information on other network players, here denoted as $z_{kj}$ (amount of investment in the network node $j$ for $j = 1, 2, ..., s$ in the direction of $k$ for $k = 1, 2, ..., M$). The problem statement is formulated as follows:

It is necessary to optimize investments in network divisions to determine their volume with the allocation of amounts for types of interaction. The condition is the amount of allowable costs. The expression for the quality functional $\Omega$ then takes the form written in **Eq. 1**

$$\Omega = \max\left[\sum_{j=1}^{s}\sum_{k=1}^{M} P_k(z_{kj}\}\right] \quad (1)$$

The development of an appropriate algorithm with the application of the dynamic programming method makes it possible to reduce the problem's solution to a set of recursive formulas. The advantage of this method is mainly the ability to use the results to create software applications embedded in the shell of digital platforms.

## ANALYSIS AND RESULTS

Let us consider a network structure with the dimension of $s$ nodes. For most real types of omnichannel interaction, their number $M$ is somewhat limited. We construct a solution for the clarity and convenience of creating formulas for $M = 3$. Thus, it will be immediately apparent that formulas are scalable. It will also become clear that the number $M$ can be set arbitrarily, while the main result will remain the same, only the dimension of the formulas will change. Study of Alexander and Kent (2020), Zhabko et al. (2019), Pilipenko et al. (2019) has shown statistical data in business intelligence software solutions. Using similar techniques, based on the information flow data, dependencies are created to convert investments into profit.

Investing the amount $z_{1j}$ in the network node $j$ (where $j = 1, 2, ..., s$) will result in profit described by the function $F_{1j}(z_{1j})$. Similarly, dependencies can be created between $z_{2j}$ and $F_{2j}(z_{2j})$, and the function $F_{3j}(z_{3j})$ can be used for $z_{3j}$.

Next, we propose to set a limit amount considering the restrictions on possible costs for each enterprise participating in the network—$L_j$, where $j = 1, 2, ..., s$. Moreover, in the mathematical model, the entire network consolidated budget shall be placed in the amount of $N$.

The problem comes down to finding the optimal distribution of investments. Here, investments are calculated between enterprises integrated into the network and for each of the three interaction channels. If, for example, less than three channels are used between nodes, then the corresponding value will be zero.

Mathematically, this is written as finding the maximum functionality $\omega$ in the form in **Eq. 2**.

$$\omega = \max\left[\sum_{j=1}^{s}\sum_{k=1}^{3} F_{kj}(z_{kj}\}\right] \quad (2)$$

with restrictions: for the budget of a network subdivision

$$\sum_{k=1}^{3} z_{kj} \le L_j; \quad (3)$$

the total amount of investment across the entire network structure:

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$$\sum_{j=1}^{s}\sum_{k=1}^{3} z_{kj} \le N. \tag{4}$$

Additionally, it shall be taken into account that the values of $z_{1j}$, $z_{2j}$, and $z_{3j}$ must conform to the inequalities $z_{kj} \ge 0$ for all values of $j = 1, 2, ..., s$ and $k = 1, 2, 3$.

To construct a sequence for solving the problem according to the principle of dynamic programming, we introduce an additional auxiliary function $g_j(w)$. Its value is defined as the maximum profit gained when placing investments $w$ between $j = 1, 2, ..., s$ enterprises of nodes of a commercial network. Further, for a rigorous statement, we consider that inequality 1) reflects a restriction on all arguments of the mathematical model, and restriction 2) has a local meaning and is imposed only on the $j$ th subdivision of the network.

In such a formulation, the recurrence relation based on the Bellman principle is written as follows:

$$g_j(w) = \max\left[\sum_{k=1}^{3} P_k(z_{kj}) + g_{j-1}\left(w - \sum_{k=1}^{3} z_{kj}\right)\right] \tag{5}$$

where $j = 1, 2, ..., s$ and is denoted by $n = 0, 1, 2, ...., N$, and only nonnegative integer values $z_{1j}$, $z_{2j}$, and $z_{3j}$ that satisfy the restrictive inequality $\sum_{k=1}^{3} z_{kj} \le \min(L_j, w)$ participate in the optimization.

The set problem shall also be solved under the conditions of uncertainty of the market environment Due to the scalability of unified distribution solutions, such complex business entities as a commercial network need management support systems much more than usual. In turn, the set problem is classified as a discrete optimization problem, for which methods and algorithms of finding the optimal solution already exist.

Let us represent this problem of choosing the distribution of investments in communication channels in terms of the concept of a discrete controllable system. This allows us to formulate an algorithm and formalize the corresponding recurrent relations. The main advantage of such a solution is the readiness to embed the resulting algorithm for finding the optimal solution in digital platforms. Moreover, the possibility appears to integrate with manufacturing resource planning, enterprise resource planning for optimization of demand-driven techniques/logistics, and widespread customer relationship management solutions that are the core of the Industry 4.0 concept. Next, to solve the multidimensional optimization problem, we transform the obtained expressions of the mathematical model. Let us represent the above equations as finding the maximum sum:

$$F_{1j}(z_{1j}) + F_{2j}(z_{2j}) + F_{3j}(z_{3j}) \tag{6}$$

subject to the following restriction:

$$z_{1j} + z_{2j} + z_{3j} \le y \tag{7}$$

and nonnegativeness of $z_{1j}$, $z_{2j}$, and $z_{3j}$ which are natural numbers.

We search for a solution for each of the values of the auxiliary variable $y$ taking the values: $y = 0, 1, ...., L_j$. For these purposes, we then introduce the function

$$f_{1j}(y) = F_{1y}(z_{1j}),\ y = 0, 1, ...., L_j \tag{8}$$

and apply the recurrent method to the problem (5.6). We transform **Eq. 4** into the form:

$$f_{2j}(y) = \max_{z_{2j}}\left[F_{2j}(z_{2j}) + f_{1j}(y - z_{2j})\right],\ y = 0, 1, ...., L_j \tag{9}$$

where finding the optimal solution is carried out only by the values $w_j \le y$, $z_{2j} \le y$ and the condition:

$$f_{3j}(y) = \max_{z_{3j}}\left[F_{3j}(z_{3j}) + f_{2j}(y - z_{3j})\right],\ y = 0, 1, ...., L_j \tag{10}$$

The result will be the use of the value $f_{1j}(y)$ from **Eqs 7, 8** for each $j$ in the process of finding $f_{2j}(y)$. Accordingly, for values $f_{3j}(y)$ at $y = 0, 1, ...., L_j$, the search is carried out by the values of the functions $f_{2j}(y)$ and the condition **Eq. 9**. We transform **Eq. 4** and obtain the result from the solution of the relation:

$$g_j(w) = \max\left[f_{3j}(y) + g_{j-1}(w - y)\right],\ j = 1, 2, ..., s, \quad \text{where } n = 1, ..., N. \tag{11}$$

The variables are also subject to a condition in the form of a restrictive inequality: $y \le \min(L_j, w)$ at $j = 1, 2, ..., s$.

The proposed algorithm, formulated for a restricted value of $M = 3$, is easily scalable. The process of its calculation can be continued for an arbitrary value of interaction channels. Additionally, from the construction of mathematical formalisms, it can be noted that this model can also be transferred entirely to the cases of nonlinear constraints. This precisely follows the principle of dynamic programming. Practical implementation in software applications also does not cause any difficulties.

To do this, it is necessary to associate the interface of this algorithm with the results of the work of the BI business intelligence module of the corresponding digital platform subsystem in the M2M technology and supplement it with data on cost restrictions. The further calculation is carried out using the available application packages. **Table 1** indicate the results of econimical model of digital ommichannel.

**Table 1** indicated the digital ommnichannel forecasted the digitalized marketting efficiency in the emerging economies in this study. It shows that in the emerging countries internet economy is the potential to achieve green growth and an efficient digital ommanichannel maketting. To achieve long-term growth, the digital economy must be completely integrated. Digitalization should be promoted to increase existing economies' production and efficiency. Second, a generational split may reduce the digital economy's eco-efficiency.

**Table 2** shows the robustness results that show the reliability of the analysis. The DDF-ML method is used to measure the green, efficient development, which is the standby exogenous variableSecond, Principal component analysis and entropy are utilized to measure the digital economy as the explanatory variable. Third, marginal effects are studied using quantile regression. The table clearly shows that the digital economy still considerably promotes developing high-quality green development while marginal benefits decline. It confirms prior findings and research theories. The results can be used to analyze evolutionary

**TABLE 1** | Descriptive statistics.

| Variables | Symbol | Interpretation | Obs | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Explained variable | Gtfp | High-quality green development | 2,259 | 0.9937 | 0.2656 |
| Explanatory and threshold variable | Del | Digital ommnichaneel | 2,259 | 1.5433 | 0.7500 |
| Mediating variables | As | Assurance quality | 2,259 | 0.9835 | 0.5846 |
| | Gtech | Green technology innovation | 2,259 | 0.9424 | 0.6237 |
| Control variables | EE | Energy efficity | 2,259 | 10.4660 | 0.0634 |
| | PC | Process consistencey | 2,259 | 5.5718 | 0.8765 |
| | CC | Content consistency | 2,259 | 2.4784 | 2.3492 |
| | Gov | Government intervention | 2,259 | 2.8786 | 1.8573 |

**TABLE 2** | Robustness check.

| Variables | lnGtfp | lnGtfp | lnGtfp | lnGtfp | lnGtfp | lnGtfp |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Empty cell | Empty cell | Empty cell | τ = 0.1 | τ = 0.5 | τ = 0.9 |
| Del | 0.0793** | 0.1211** | 0.0948** | 0.1177*** | 0.0788*** | 0.0465** |
| | (0.0344) | (0.0500) | (0.0417) | (0.0241) | (0.0112) | (0.0187) |
| Constant | 5.4127 | 5.9227* | 5.5969 | 2.7370 | 1.8013 | 7.4751*** |
| | (3.6601) | (3.5616) | (3.6423) | (2.4913) | (1.1573) | (1.9311) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,529 | 2,529 | 2,529 | 2,529 | 2,529 | 2,529 |
| R-squared | 0.0307 | 0.3075 | 0.3072 | | | |
| F-statistic | 37.93 | 38.46 | 38.26 | | | |

and differential-difference systems with boundary conditions of the second and third types. For this, it is sufficient to set the second or third boundary condition instead of the Dirichlet boundary condition for the boundary value problem.

## DISCUSSION

The implications of the proposed approach for some practical cases. The growing role of digital technologies against the background of the pandemic of a new coronavirus infection actualizes the use of the concept of omnichannel in the activities of airlines. Considering the report Lu et al. (2020) concluded that from the perspective of air carriers, the pandemic caused increased competition. The restrictions caused by COVID-19 have led to a decrease in global demand for air transport. Such a decrease particularly affected small private airlines. Restructuring measures have aimed to reduce costs during the pandemic, which include:

– The cancellation of flights;
– The use of vouchers for future trips instead of refunds for canceled flights;
– Introduction of unpaid leave and freezing of staff salaries;
– No dividend or share repurchase programs; and
– Aircraft grounding.

Even though borders are reopening and several restrictions have ceased to apply, social distancing requirements cause airlines' losses in passenger transportation. We are sure that the increased competition due to the market's oversaturation requires new approaches in interacting with consumers. Omnichannel is a solution to the actual problem of attracting consumers to aviation services. The use of an omnichannel approach improves the interaction with the target audience. We believe that airlines that can apply this approach in their activities to increase the individual focus of their services. A distinctive feature of omnichannel is a "seamless" experience of interaction between the consumer and the enterprise. Digital marketing based on omnichannel technologies allows for interaction through all communication channels, including offline and online. The researchers find different approaches to implementing digital twins in logistics (Booyse et al., 2020; Marmolejo-Saucedo, 2020) and trade networks (Sacks et al., 2020). Study investigated the boundaries of the stability of an evolutionary parabolic system and a differential-difference system with distributed parameters on a selected graph. A computational complexity analysis to demonstrate the computational performance of the proposed solution methodologies could be a topic for future research because of the limitation on the size.

In this study, the development of classical approaches to the study of the sustainability of solutions obtained by using mathematical modeling based on systems of differential equations is carried out. The complex topology of logistics networks within which supply chains are built makes it necessary to apply deeper methods in the study of the dynamics of logistics flows. Based on the real conditions of logistics activities, it was assumed that this functionality is not always continuous in terms of movement and time parameters. The complexity of solving the problems of forming effective supply chains has increased under the influence of the trend of the consolidation of business into network structures. The application of the results obtained in this work is not limited to the analysis of the sustainability of solutions. Their use is relevant in assessing investment risks, the sustainability of the business.

## IMPLICATIONS AND CONCLUSION

Currently, intense competition characterizes the sharply increased segment of the network business. The need to raise an enterprise's competitiveness marks a high demand for software and hardware solutions to support management decisions. In addition, processes within network structures are also becoming more complex due to the growth of types of interaction. One of the decisive drivers of this was the pandemic. The concept of omnichannel business interaction allows the integration of all types of cloud solutions XaaS, SIM solutions, CRM, and ERP. The proposed algorithms allow for choosing the optimal multichannel interaction. The digital twin concept provides the mathematical basis for business optimization and application development in the digital platforms economy. Touching upon the issue of optimizing passenger air transportation, we believe that the concept of omnichannel is relevant to the possibility of increasing the individual focus of air services. The ability to improve the efficiency of demand forecasting also plays an important role.

The practical contribution of the study includes representation of the workflow framework for a comprehensive digital energy efficient ommanichannel marketting informaiton system. This paper details review and developed mathemathical model based on the Porter, 1980, Porter, 1985 and recent studies Porter and Kramer, 2019. The paper contributes to and extends the existing understanding of digital multidimensional ommanichannel networking interaction to overcome on the marketting and future energy issues and conducting reasoning and derivation of mathematical formalisms for a limited channel dimension to show that the obtained relations are fully scalable and allow any increase in the number of interaction channels available in an actual situation.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## AUTHOR CONTRIBUTIONS

Conceptualization & Writing, SEM and SMS methodology; VVP software; KKL; validation, TLK and AVK, drafting, edtiting, and reviewing. All authors have read and agreed to the published version of the manuscript.

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