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APPLICATION OF DIGITAL TWINS IN LOGISTICS

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Abstract

The aim of this research is to explore the application of digital twins in logistics and their impact on the efficiency and optimization of logistic processes. The methodology involved analyzing existing instances of digital twin implementation in logistics, conducting expert interviews with representatives from logistic companies, and performing a comparative analysis of logistics process effectiveness before and after the integration of digital twins. The findings revealed that the incorporation of digital twins into logistic processes significantly enhances operational efficiency, reduces delivery times, optimizes routes, and improves inventory management. Additionally, there was a notable decrease in the risk of errors and an increase in transparency throughout the supply chain. One prominent outcome is the assertion that digital twins serve as a substantial tool for logistic companies, contributing to heightened competitiveness and adaptability to rapidly changing environments. In conclusion, the study underscores the relevance of integrating digital technologies into logistics for achieving more efficient and sustainable supply chain management.

Keywords: Biomonitoring devices, digital transformation of healthcare, digital ecosystem, integrated ecosystem, personalized medicine

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1. Introduction

The modern world has accelerated the processes of digitalization of the world economy, the development of the fourth industrial revolution and the transition to a new technological order. The world and the economic environment for business have become non-linear. Under these conditions, the adoption of managerial decisions based on past experience becomes ineffective, new approaches based on the use of data are required, which in turn becomes the basis for the digital transformation of companies (Z. M. Ilaeva et al., 2020; Z. Ilaeva et al., 2021).

Any commercial organization strives for a competitive advantage in the market. One way to achieve this is to design and shape your supply chains in the most efficient way possible. Making the right decisions is possible on the basis of an accurate assessment of the situation in the course of identifying shortcomings and deviations in the supply chains.

One of the competitive advantages that solve key problems is the introduction of modern information technologies in enterprises.

Technological advances like the internet of things, big data analytics, distributed cloud computing, artificial intelligence and VR have given impetus and revitalized previously static digital models, giving them the ability to predict and simulate the state of physical objects and even the behavior of the world around us in perspective (Makarova, 2021).

The integration of the physical and digital world is an inevitable trend to meet the rapidly growing demands of today's market. The transition process has a long way to go. One of the initial stages of the process is focused on creating the latest development – digital double.

The concept of using “doubles” originates in the 1960s from NASA's Apollo program, during which two identical spacecraft were built. One of the ships was a ground model, created to reflect all the conditions of the second ship sent into outer space. The ground model of the device was widely used for training in preparation for the flight. During the mission, the ground model was used to simulate flight conditions as accurately as possible and to assist astronauts in orbit in critical situations (Kaishev, 2013).

Currently, there is no one generally accepted and unique classification of digital twins. The difficulty lies in the dependence of the perception of a particular term. The authors in their works strive to give the most accurate definition of the digital twin in terms of their application in various situations, during which a large number of proposed classifications of the digital twin arise.

The first use of the term “Digital Twin” originated in a 2010 NASA report on modeling and simulation. The technique described in the report was developed in view of the need to construct an ultra-realistic spacecraft simulation during construction, testing and flight. The digital twin was a natural result of NASA's Mercury research, which has been creating twins since the late 1950s (Pashaev et al., 2021).

In the professional field of high technology, the use of “digital twins” can lead to high benefits for both individual users and large companies. Getting started with digital twins is not a difficult process, as there are many ways that you can apply with cloud technologies, or use your data mining experience. Working with digital twins requires the efforts of specialists from different fields, as teamwork leads to an effective solution of modern technological solutions. Digital twins are a new trend that will only grow and develop in the future.

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2. Problem Statement

The problem addressed in this study revolves around the financial and temporal challenges associated with traditional project development processes, emphasizing the critical role of digital twins in mitigating these issues. The conventional approach, where modifications and adjustments are made later in the project lifecycle, leads to escalating costs, and the subsequent redesigning incurs substantial financial and time expenditures. This situation, as indicated by Bignell et al. (2016) and Darsih et al. (2015), not only increases the overall expenses but also narrows the "window of opportunity" for the timely introduction of new products to the market.

The problem is underscored by the recognition that delays and inefficiencies in the development stage can have cascading effects, negatively impacting the competitiveness and innovation capabilities of businesses. Consequently, there is a need for a transformative approach, such as leveraging digital twins, to shift the "center of gravity" to the early development stages, thereby minimizing costs and optimizing the product development timeline. Addressing this problem is crucial for businesses aiming to enhance their agility, reduce time-to-market, and maintain a competitive edge in the rapidly evolving landscape of product development and innovation.

3. Research Questions

i. How has the integration of digital technologies, specifically digital twins, addressed the challenges associated with late-stage modifications in project development, as highlighted by Bignell et al. (2016) and Darsih et al. (2015).
ii. In the realm of logistics, what specific benefits and efficiencies have been observed through the implementation of digital twins, and how do these benefits contribute to cost reduction and time optimization in project development?
iii. To what extent does the use of digital twins shift the "center of gravity" to the development stage, and how does this impact the overall product development lifecycle, particularly in terms of financial costs and time-to-market?

The literature review underscores the pivotal role of digital twins in revolutionizing project development methodologies. According to Bignell et al. (2016) and Darsih et al. (2015), the traditional approach of making modifications later in the project lifecycle incurs escalating costs and time investments. Digital twins offer a paradigm shift by enabling changes and adjustments at the development stage, reducing financial and temporal burdens and preserving the "window of opportunity" for timely product launches.

In the logistics domain, the implementation of digital twins has yielded tangible benefits. The efficiency gains are evident in streamlined processes, optimized resource utilization, and improved decision-making. These advancements not only contribute to cost reduction but also enhance the overall project development timeline. The ability of digital twins to simulate and analyze logistics scenarios enables organizations to proactively address challenges, ultimately leading to a more resilient and responsive supply chain.

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The fundamental shift in the "center of gravity" to the development stage is a key aspect of leveraging digital twins. This transformative approach ensures that modifications and adjustments are made early in the project lifecycle, minimizing the financial and time costs associated with later-stage changes. By embracing digital twins, organizations position themselves to navigate the complexities of modern project development, fostering agility and adaptability in an ever-evolving market landscape.

4. Purpose of the Study

The primary purpose of this study is to conceptualize and establish a startup dedicated to revolutionizing warehouse logistics through the implementation of digital twin technology. The aim is to develop an innovative warehouse architecture that leverages digital twins, thereby enhancing operational efficiency, real-time monitoring, and overall logistical processes. By introducing digital twins into warehouse logistics, the study seeks to address existing challenges and contribute to the evolution of modern, technologically advanced warehouse management systems (Taranova et al., 2021; Vorontsova et al., 2019).

5. Research Methods

In this study, the research methods employed were primarily focused on obtaining and analyzing data related to the technology of digital twins, existing solutions in the global and Russian markets, and the processes within the logistics system.

1. Literature Review:

i. Extensive review and analysis of scientific literature were conducted to establish the theoretical foundation for understanding digital twin technology, its applications, and advantages.

ii. Exploration of domestic and foreign practices in data management and data-based management provided valuable insights into current trends and best practices in the field.

2. Analysis and Synthesis:

i. The study employed methods of analysis and synthesis to systematically examine the technology of digital twins. This involved breaking down complex concepts into constituent elements for a comprehensive understanding and synthesis of key insights.

3. Market Analysis:

ii. An in-depth analysis of existing digital twin solutions was performed, encompassing both global and Russian markets. This involved studying available technologies, their features, and the advantages they offer in the context of warehouse logistics.

4. Logistics System Analysis

iii. The logistics system was scrutinized to identify key processes and pinpoint potential challenges. This analysis served as a foundation for understanding the dynamics of warehouse logistics and identifying areas for improvement.

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5. Time-Ordered Sequence Analysis:

iv. The study focused on the time-ordered sequence of logistics operations within a warehouse. This involved analyzing the functions of stocking, handling, and physical distribution of orders to gain insights into the intricacies of the logistics process.

6. Implementation of Digital Twins:

v. To fulfill the specified tasks, the implementation of digital twins in the logistics system was explored in detail. The technology's potential integration into various stages of the supply chain was investigated, and Figure 1 illustrates the key steps of warehouse logistics.

6. Findings

The comprehensive analysis and detailed study of warehouse logistics processes have revealed critical issues within warehouses, primarily centered around the inefficiencies in the receipt and retrieval of goods and materials. The identified problems include:

1. Protracted Goods Receiving Process:

vi. The examination of warehouse operations highlighted a prolonged duration in the process of receiving goods and materials. Delays in this phase contribute to bottlenecks in the overall logistics timeline.

2. Inefficient Storage Leading to Picking Challenges:

vii. The long search times for required goods and materials during the order picking process emerged as a significant challenge. This inefficiency is attributed to inadequacies in storage practices, hindering the swift retrieval of items and subsequently extending shipping times.

Expected Results:

Building upon the identified issues, the implementation of Digital Twins in Distribution Centers (DCs) is anticipated to yield the following outcomes:

1. Enhanced Recruitment Productivity:

viii. By reordering the sequence of sending orders to work and optimizing the placement of goods, a notable increase in recruitment productivity is expected. This improvement directly addresses the protracted goods receiving process.

2. Attraction of Warehouse Design Companies:

ix. The findings recommend attracting companies involved in warehouse design, modernization, or optimization. The optimized warehouse model, facilitated by digital twin integration, becomes an attractive proposition for these entities.

3. Consumer Attraction Strategies:

x. To enhance consumer engagement, various promotion channels are suggested, including e-mail marketing, contextual advertising, and utilization of specialized portals. Establishing a dedicated website with a presentation and demo version of the product is recommended to attract and inform potential consumers effectively.

The findings underscore the urgency of addressing inefficiencies in warehouse logistics, particularly in goods receiving and order picking processes. The proposed solutions, rooted in the integration of digital twins, offer a pathway to not only rectify these issues but also to create a more

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streamlined and attractive environment for warehouse design companies and consumers alike. The anticipated results align with the overarching goal of optimizing warehouse operations and improving overall logistics efficiency.

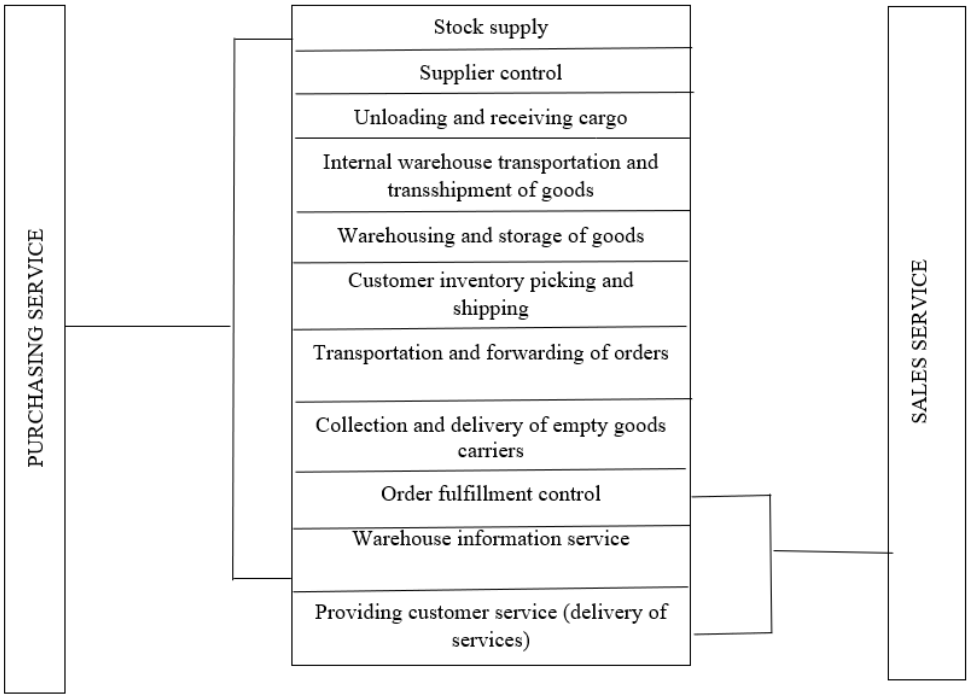

Figure 1. Logistics processes in the warehouse

For a more detailed study of warehouse logistics and identifying its problems, we will reproduce the business processes of organizing warehouse logistics.

The effective work of the personnel of logistics transport companies primarily depends on the conditions set for them and the requirements that must be met.

The formation of transport systems in the field of transport logistics is a cross-cutting for the basic functional areas of the logistics system - supply, production, distribution.

Economic efficiency in transport logistics (carriers, freight forwarders, terminals) can be obtained from the commissioning, and the entire delivery system as a whole, based on the coordination of the interests of all participants in the process of joint planning. The purpose of transport logistics is to optimize the material flow, as well as related information and finances that arise during the transportation process; transport logistics carries out the planning of the transportation process of delivery in coordination with the warehouse and production (Seifert & Gams, 2011).

Warehouses and distribution centers make up only a small part of the entire logistics infrastructure chain, since the flow of goods to the destination depends on the organization of the entire logistics supply chain, primarily on the human factor, as well as ships, trucks and aircraft, order systems and information. This complex system, which consists of many stakeholders, is clearly observed in major global logistics centers such as airports and container ports. Today, we can observe in these facilities that the problem of efficient operation is complicated by imperfect information exchange systems, and as a rule, many

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stakeholders are forced to rely on offline processes that can lead to errors and delays in deliveries. If we talk in detail about the implementation of digital twins in the logistics system, now the technology can be integrated into almost every step of the supply chain (Wen-Hai & Chih-Shan, 2000).

Let us consider the evolution of the definition and presentation of the concept of a digital twin through a review of the literature on technology definitions. As mentioned earlier, the development of advanced information technologies has led to the emergence of the concept of digital twins.

In logistics, the digital twin will be a model of the entire network, including not only logistics assets, but also oceans, rail lines, highways, streets, as well as customer homes and workplaces. The idea of such a comprehensive twin is now largely an aspiration for the logistics industry (Elbuzdukaeva et al., 2019).

Figure 2 shows the work of the authors of The New Age of Manufacturing: Digital Twin Technology & IoT1, which reflects the evolution of the digital twin.

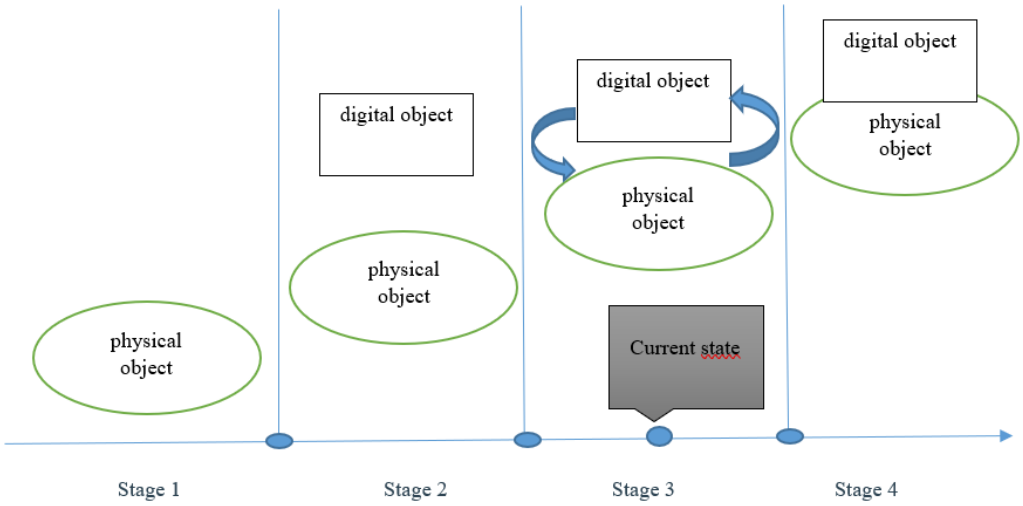

Figure 2. The evolution of the concept of digital twins (Ilyasov, 2018)

This approach makes it possible to take into account at the design stage a much larger number of characteristics of the future product than is possible with the traditional approach to design.

Despite the variety of terminology, the basic concept has remained virtually unchanged over the past years, but interest in it has increased significantly (Klishina et al., 2017; I. M. Podkolzina, A. I. Belousov et al., 2021; I. M. Podkolzina, I. V. Taranova, et al., 2021)

The authors in their works strive to give the most accurate definition of the digital twin in terms of their application in various situations, during which a large number of proposed classifications of the digital twin arise. Since the most important characteristic of a digital twin is that it continues to exist at all stages of the life cycle of a particular product. Table 1 shows the number of search results for the “digital twin” in different databases (Shmatko et al., 2016).

Thus, one can observe the growth and interest in the concept of digital twins in both industry and academia, especially since 2015. A fixed definition of a digital twin does not yet exist - the interpretation of the term in different sources is different.

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The conceptual model of the digital twin consists of three main parts: a) a physical object in real space, b) a virtual object in virtual space, and c) data and information links that link virtual and real objects together (Barzaeva & Ilyasov, 2022).

Table 1. Definitions of the digital twin - the interpretation of the term in different sources differs

Rosen et al.	2015	Highly realistic models of the current state of the process and its behavior when interacting with the environment in the real world.
Schluse and Rossman	2016	Virtual substitutes for real world objects, consisting of virtual representations and communication capabilities that make up intelligent objects that act as intelligent nodes within the Internet of things and services.
Talkhestani et al.	2018	A digital twin is a virtual model of a physical asset that can fully reflect its characteristics and functions throughout its entire life cycle. It is an approach to managing all generated digital data of a component or system throughout its life cycle and extracting it as needed through modeling or optimization functions to solve any problems that arise.
ISO/ISO-AWI 23247	2019	A virtual representation of manufacturing elements such as people, products, assets, and process definitions, a live model that is constantly updated and modified as the physical counterpart changes to provide a synchronous representation of status, operating conditions, product geometry, and resource status.
Stark and Damerau	2020	A digital twin is a digital representation of an active unique product (a real device, object, machine, service or intangible asset) or a unique product-service system (a system consisting of a product and a related service), including its selected characteristics, properties, conditions and behavior through models, information and data within one or even several phases of the life cycle.

Digital twins allow you to reduce costs by shifting the “center of gravity” to the development stage: the later changes are made to the project, the more expensive the product becomes, and redesigning and repeatedly making adjustments to the project significantly increases both financial and time costs, thereby closing “window of opportunity” for bringing new products to market.

Due to the fact that the work carried out an analysis of the introduction of digital twins in warehouse logistics, we will dwell in more detail at this stage of the supply chain. The logistics process in a warehouse is a time-ordered sequence of logistics operations that integrates the functions of stocking, handling, and physical distribution of the order. For a more detailed study of warehouse logistics and identifying its problems, we will reproduce the business processes of organizing warehouse logistics. Optimization of business processes of an enterprise involves a description at the first stage of existing procedures (business process model “AS IS”) with subsequent optimization to the “TO BE” model (“as it should be”). The first step is to describe warehouse logistics processes using the “AS IS” notation. The process management is regulatory documents, the company's warehouse regulations, standards and directives of the management, the mechanism for ensuring the process is warehouse personnel, warehouse infrastructure, suppliers of goods and materials, and the bundling department. At the input, the supply plan for goods and materials, inventory items, sales plan, commodity distribution documents are taken into account; at the output, the required reports, the shipped order and the list of commodity distribution documents (Sugaipova & Gapurov, 2018).

Regulatory documents, regulations on the company's warehouse, standards and directives of the management act as management for all processes, the mechanism for ensuring the process is the

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warehouse staff and its infrastructure. At the input, the process takes into account the supply plan of goods and materials, the sales plan, goods and materials, and distribution documents. At the output, it has an ED waiting for acceptance. As an input, the process takes into account the acceptance waiting OD. The output has a shipped order.

Regulatory documents act as management for all processes, the mechanism for ensuring the process is the warehouse staff represented by the manager or shift foreman. In short, this process consists in manual verification of documents and the availability of products, as a result of which the goods and materials in full, after a qualitative and quantitative check, are sent to the warehouse. Also at this stage, the weight of the goods is determined, the etiquette with the name of the goods and materials and the barcode is printed and pasted. An acceptance certificate is created and transferred to the next stage.

7. Conclusion

This paper has undertaken a comprehensive exploration of the implementation of digital twins, shedding light on its current stage of development and its interaction between the physical and digital realms. The analysis encompasses a thorough examination of various interpretations of the term, ranging from broad conceptual frameworks with limited practical application to more restrictive definitions challenging to achieve with existing technologies.

Within the study's framework, a meticulous analysis of logistics warehouse activities was conducted, focusing on the existing procedures delineated by the business process model "AS IS." This analysis laid the foundation for proposing a startup model geared towards developing a product for the implementation of digital twins in the logistics system.

The proposed startup holds the potential to significantly impact the design, operation, and optimization of logistics infrastructure, particularly within warehouses and distribution centers. By leveraging digital twin technology, the startup aims to introduce effective solutions that address existing challenges and enhance overall logistical efficiency.

The analysis conducted reveals a notable evolution in the concept of digital twins, transitioning from an abstract idea to a mature technology widely applied in various domains of transport logistics. The endorsement and utilization of digital twins by global industry leaders underscore its practicality, resulting in elevated levels of system automation, improved data utilization, and informed decision-making.

In conclusion, the findings of this study affirm the growing significance of digital twins in the field of logistics. As the technology continues to evolve and gain practical traction, it is poised to play a pivotal role in shaping the future of logistics infrastructure, contributing to increased efficiency and informed decision-making on a global scale.

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References

Barzaeva, M., & Ilyasov, R. (2022). Sustainable development of the global labor market in the context of the transformation of the industrial complex of the digital economy. *Baku: Reliability: Theory and Applications*, 152-164. https://doi.org/10.24412/1932-2321-2022-470-476-484

Bignell, E., Cairns, T. C., Throckmorton, K., Nierman, W. C., & Keller, N. P. (2016). Secondary metabolite arsenal of an opportunistic pathogenic fungus. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1709), 20160023. https://doi.org/10.1098/rstb.2016.0023

Darsih, C., Prachyawarakorn, V., Wiyakrutta, S., Mahidol, C., Ruchirawat, S., & Kittakoop, P. (2015). Cytotoxic metabolites from the endophytic fungus Penicillium chermesinum: discovery of a cysteine-targeted Michael acceptor as a pharmacophore for fragment-based drug discovery, bioconjugation and click reactions. *RSC Advances, 5*(86), 70595-70603. https://doi.org/10.1039/c5ra13735g

Elbuzdukaeva, T. U., Gelagaeva, A. M., & Sugaipova, A. M. (2019). Migration Processes In The Chechen Republic At The Turn Of Xx Century. In D. K. Bataev (Ed.), Social and Cultural Transformations in the Context of Modern Globalism. *European Proceedings of Social and Behavioural Sciences* (Vol. 58, pp. 2690-2696). Future Academy. https://doi.org/10.15405/epsbs.2019.03.02.313

Ilaeva, Z. M., Alikhadjieva, D. S., & Bekmurzaeva Elizaveta, S. (2021). Digital Education To Provide Investment And Construction Sectors With Human Resources. In D. K. Bataev, S. A. Gapurov, A. D. Osmaev, V. K. Akaev, L. M. Idigova, M. R. Ovhadov, A. R. Salgiriev, & M. M. Betilmerzaeva (Eds.), Social and Cultural Transformations in The Context of Modern Globalism. *European Proceedings of Social and Behavioural Sciences* (Vol. 117, pp. 721-728). European Publisher. https://doi.org/10.15405/epsbs.2021.11.96

Ilaeva, Z. M., Alikhadzhieva, D. S., & Askhabova, Z. R. (2020). Application of Digital Technologies in the Sphere of Organic Production in the Agribusiness: Experience of the Chechen Republic. *Proceedings of the 2nd International Scientific and Practical Conference on Digital Economy (ISCDE 2020) Series: Advances in Economics, Business and Management Research* (pp. 402-406). Atlantis Press. https://doi.org/10.2991/aebmr.k.201205.067

Ilyasov, R. K. (2018). Spline modeling and analysis of relationships in the economy with the possible presence of regression switching points. *St. Petersburg State Polytechnical University Journal, Economics, 11*(4), 165-175. https://doi.org/10.18721/JE.11412

Kaishev, V. K. (2013). LéVy Processes Induced By Dirichlet (B-)Splines: Modeling Multivariate Asset Price Dynamics. *Mathematical Finance, 23*(2), 217-247. https://doi.org/10.1111/j.1467-9965.2011.00504.x

Klishina, Y. E., Glotova, I. I., Uglitskikh, O. N., Tomilina, E. P., & Podkolzina, I. M. (2017). Peculiarities of the financial policy of non-profit organizations in the macroeconomic unstable environment. *Espacios, 38*(34), 34.

Makarova, A. V. (2021). Actual problems of cybercrime investigation in the Russian Federation. Actual problems of disclosure and investigation of crimes committed using the Internet: *Collection of materials of the All-Russian Scientific and Practical Conference* (pp. 149-153). Belgorod National Research University.

Pashaev, M. Y., Ilaeva, Z. M., & Alikhadzhieva, D. S. (2021). Transport and logistics dimension of Russian-Chinese cooperation within the framework of the One Belt, One Road project. *Bulletin of the Altai Academy of Economics and Law, 12*(2), 359-362. https://doi.org/10.17513/vaael.2008

Podkolzina, I. M., Belousov, A. I., Uzdenova, F. M., Romanko, L. V., & Chernikova, O. A. (2021). Forms of financial fraud and ways to minimize risks. *Modern Global Economic System: Evolutional Development vs. Revolutionary Leap. Institute of Scientific Communications Conference, 198*, 2197-2205. https://doi.org/10.1007/978-3-030-69415-9_241

Podkolzina, I. M., Taranova, I. V., Paytaeva, K. T., Revunov, S. V., & Abrosimova, T. F. (2021). Innovative approaches in financial support for regional economic security. *The Challenge of*

Sustainability in Agricultural Systems. Lecture Notes in Networks and Systems, 205, 549-558. https://doi.org/10.1007/978-3-030-73097-0_62

Seifert, K. A., & Gams, W. (2011). The genera of Hyphomycetes - 2011 update. *Persoonia - Molecular Phylogeny and Evolution of Fungi, 27*(1), 119-129. https://doi.org/10.3767/003158511x617435

Shmatko, S. G., Agarkova, L. V., Gurnovich, T. G., & Podkolzina, I. M. (2016). Problems of increasing the quality of raw material for wine in the stavropol region. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7*(2), 725-730.

Sugaipova, A. M., & Gapurov, S. A. (2018). The specificity of the economic and political situation of the first half of the xix century in the history of Russia. *All-Russian Scientific and Practical Conference of Students, Young Scientists and Postgraduates Science and Youth* (pp. 675-679). Kadyrov Chechen State University.

Taranova, I. V., Podkolzina, I. M., Uzdenova, F. M., Dubskaya, O. S., & Temirkanova, A. V. (2021). Methodology for assessing bankruptcy risks and financial sustainability management in regional agricultural organizations. *Lecture Notes in Networks and Systems, 206*, 239-245. https://doi.org/10.1007/978-3-030-72110-7_24

Vorontsova, G. V., Chepurko, G. V., Ligidov, R. M., Nalchadzhi, T. A., & Podkolzina, I. M. (2019). Problems and perspectives of development of the world financial system in the conditions of globalization. *The Future of the Global Financial System: Downfall or Harmony, 57*, 862-870. https://doi.org/10.1007/978-3-030-00102-5_93

Wen-Hai, L., & Chih-Shan, L. (2000). Associations of fungal aerosols, air pollutants, and meteorological factors. *Aerosol Science and Technology, 32*, 359-368. https://doi.org/10.1080/027868200303678