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Analysis of Food Supply Chain Digitalization Opportunities in the Function of Sustainability of Food Placement in the Western Balkans Region

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Abstract: This paper aims to analyze and define incentives for the implementation of modern technology and digitalization of the Food Supply Chain (FSC) in the function of sustainability of the food retail sector of the Western Balkans (WB) region. The survey method was applied to a sample of 255 employees. We tested the importance of certain indicators for the implementation of the digitalization process, such as the application of Blockchain Technology (BT), the use of modern IT solutions for traceability, the implementation of the Internet of Things (IoT), the introduction of Artificial Intelligence (AI), development of a system for electronic food placement, implementation of standards, measures, and procedures for regulating the digitalization process, continuous training of employees and economic and financial measures and incentives. A special segment of research deals with the impact of the implemented digitalization process on the sustainability of food placement. The research was conducted among employees of SMEs, large-scale business entities, and retail chains. The research results showed significant deviations from the mentioned incentives to the digitalization process depending on the size of the FSC participants. The work has practical implications because the obtained results show the FSC management, trade policy makers, and competent institutions (ministries, chambers of commerce, professional associations) what measures to apply in order to improve a more efficient implementation of the digitalization process of food placement and lay the foundation for the sustainability of the FSC. Guidelines for future research are outlined in the paper.

Keywords: Food Supply Chain (FSC); Internet of Things (IoT); Blockchain Technology (BT); sustainability; digitalization; retail; Western Balkans (WB)



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1. Introduction

Numerous academic research on the topic of retail [1], logistics [2], sustainability [3], and supply chain in recent years emphasized the increasing necessity for complete digitalization of the Food Supply Chain (FSC) [2]. This process was influenced by the turbulence that occurred on the world market and the substantial gaps that appeared on the demand side for food products caused by the COVID-19 pandemic and the Ukrainian-Russian conflict [1]. There are problems regarding sustainability, the continuous placement of food, safety, and security of shipments, shortages of essential food products such as grains, meat and meat products, inflexibility and non-transparency of the FSC, etc. [4]. In addition, a growing number of FSC participants, especially in retail, emphasize the need for remote work, work from home, etc. [5].

Conventional FSC showed a lot of shortcomings and inflexibility to respond adequately to the resulting changes. There are frequent cases of losses in the food distribution system, stoppages and/or complete interruptions in production, distribution, and retail, gaps on the supply and demand side, poor flow of information and weak coordination of

cross-channel activities within the FSC [6], robustness, and non-transparency of information [7], dysfunctions caused by inadequately trained workers, etc. [8]. The existing FSC is not sustainable, and cannot absorb all the turbulence and sudden shocks that appear in the market. Timely collection of information, their processing, and integration within the chain are not at a level that will provide FSC management with an adequate response in terms of quickly finding alternative sources of supply, continuous replenishment of stocks, finding the most optimal routes, eliminating gaps, etc. [9].

Within the FSC, the most sensitive is the retail sector, which is in direct contact with end consumers on the one hand and with downward members of the supply chain on the other. Shortages of essential products lead to panic purchasing, creating large-scale gaps on the demand side and crowding in the retail stores themselves, which make it even more demanding to supply the market [10]. Not infrequently, late information from retailers goes to distributors and manufacturers, which causes reduced stocks, empty shelves, and an inadequate range of food products [11].

Previous experiences have shown that the speed with which uncertainties occur in the market is inversely proportional to the speed with which FSC management reacts and eliminates the consequences of those uncertainties [1]. Conventional FSC is robust, dysfunctional, and non-transparent, with weak information flow within the FSC itself and between the FSC and the environment [12], all this with a low rate of integrated digital systems and processes [13]. Hence, Zhao et al. [14] and Nurgazina et al. [15] often point to transforming the conventional FSC into a sustainable chain with fully digitalized business processes based on modern IT solutions for traceability.

In this context, the work aims to analyze and define incentives for the implementation of modern technology and digitalization of the FSC in the function of sustainability of the food retail sector of the Western Balkans (WB) region (Serbia, Bosnia & Herzegovina, North Macedonia, Albania, and Montenegro). The goal and subject of the research thus imposes the following research question RQ1: what is the actual importance of the mentioned indicators for the implementation of the digitalization process in food placement, and does implementing modern technologies and digitalized business processes contribute to the sustainability of food placement on the market? Based on empirical research, the importance of key indicators for the implementation of the digitalization process will be tested, such as the application of Blockchain Technology (BT), the use of modern IT solutions for traceability, the implementation of the Internet of Things (IoT), the introduction of Artificial Intelligence (AI), the development of systems for electronic food placement, implementation of standards, measures and procedures for regulating the digitization process, continuous training of employees and economic and financial measures and incentives. A particular segment of the research deals with the impact of the implemented digitalization process on the sustainability of food placement, which seeks to prove that digitalized business processes contribute to the sustainability of FSC. Given that FSC research so far indicates the existence of significant differences in food placement depending on the size of the participants [16], the impact of the indicators will be tested in particular in SMEs, large business entities, and retail chains. *The results* will show significant deviations from the stated incentives to the digitalization process depending on the size of the FSC participants. *The scientific contribution* of the work is multiple. By searching the keywords: Food Supply Chain AND Digitalization AND Western Balkans, Sustainability AND Digitalization AND Western Balkans, Sustainability AND Food Supply Chain AND Western Balkans according to the research bases WoS, SpringerLink, and Scopus, a vast number of hits was observed. Further filtering the hits according to paper title, abstract, and keywords, the number of direct hits was WoS 7 papers, SpringerLink 6 papers, and Scopus 12 papers. After a detailed reading of the papers, only 6 papers were identified covering the mentioned issue. There is a research gap in this area. It was also observed that previous studies dealing with FSC and food retailing in the territory of WB did not systematically cover all the indicators of the digitalization process and compare them. Hence, there is a need for this research that will fill the research gap in this area. In addition, since the research uses genuine data, a

wholesome picture of the impact of the mentioned indicators on the implementation of the digitalization process and the sustainability of FSC is obtained. *The practical significance* of the work is reflected in the fact that, based on the obtained results, a set of measures was proposed that trade policymakers and FSC management should implement to improve a more efficient implementation of the digitalization process of food placement and lay the foundation for the sustainability of FSC.

2. Literature Review

A key problem cited in many food marketing studies is inadequate cost control and poor flow of products and services along the conventional FSC. According to [16], 92% of the total costs related to food placement appear solely due to deficiencies and errors in transport from the place of production (processing) to the place of final consumption (retail). It is often stated that the FSC is disorganized in terms of inadequate connectivity between participants and that any lack of unity creates a market gap on the supply side (lack of supply relative to demand) [17]. The authors criticize the FSC for lacking communication between chain participants and final consumers [18]. There is almost no two-way communication going to downward members. Consequently, output prices of products often do not follow the purchasing power of a certain market segment, there are gaps on the demand side (offer of products that are not in demand), untimely reactions to consumer needs, etc. In addition, FSC, especially in transition countries, is burdened by the inadequate distribution of risks, profits, rewards, and losses between participants [13]. As a global problem, external factors (wars, infections, natural disasters) and increasingly expressed wastage (loss) of food appear [19], which seriously question the viability of the FSC.

When looking at the FSC sustainability concept, which implies the chain's ability to respond adequately to current market challenges, adapting to them through the rational use of available resources, thus eliminating gaps on the supply and demand side, the authors point to the following problems in the literature. In their 2017 study, Rezaei & Liu [20] bring attention to serious problems of the sustainability of food placement on the global market and point out that shortly, the need for food will increase by about 70% compared to the current FSC capacity. The same authors estimate a 30% loss of food intended for human consumption on the global market. In addition to all the existing challenges, the growth of the global population is a factor that further burdens the sustainability of the conventional FSC. This will be especially visible in urban city centers, which, on the one hand, will require the involvement of a large number of participants (direct, indirect) in FSC, which on the other hand, due to poor coordination between them, will cause problems in timely 7P delivery (7P: product, price, place, process, people, physical evidence and promotion), food quality, safety and consumer confidence. Similarly, Lemma, Kitaw, & Gatew [21] state that due to technical limitations and inconsistencies in the production-consumption relation, a huge amount of produced food is wasted and lost along the FSC. In absolute terms, this is about 1.5 billion tons of food products for human consumption.

The authors agree that conventional FSCs are unsustainable, non-transparent, centralized, robust, and asymmetric and, therefore, less and less instilling trust among consumers regarding the delivery of healthy foods [22]. Additionally, they have a hard time absorbing sudden global challenges such as the COVID-19 pandemic, the Ukrainian-Russian conflict, the conflict in the Middle East, increasing energy prices, etc. When global "health incidents" such as aflatoxin content in milk [23], GMO food [24], mad cow disease [25], horsemeat scandal [26], etc. are added, ensuring food traceability along the FSC based on modern technology becomes a priority task [22].

The advantages of digitalization are multiple. First of all, they are reflected in better optimization of the activities of all FSC participants, which leads to more efficient deliveries [27], reduction of market gaps, and faster response to global market fluctuations [28]. Digitalization ensures better control of business processes, more transparent and efficient exchange of information, and timely coordination of activities between key participants and end consumers [22]. The feedback link that forwards information from final consumers

through retailers to producers (processors) is especially crucial. In this way, the real needs of consumers are met in retail by providing sufficient quantities of quality products, safe and healthy food, and safe and complete stocks [29]. In addition, digitalized retail activities ensure more efficient waste management, faster reverse logistics, and lower rates of product returns and food waste [30]. Critical (control) points such as the risk of contamination, inadequate storage and preservation conditions, hygiene, etc., are crucial for the food placement. Without adequate management of the supply chain based on modern technology, it is not possible to fully control those critical points, and hence, it is not feasible to achieve the flexibility, efficiency, and sustainability of the FCS [31].

Overview of Key Indicators for the Implementation of the Digitization Process

Based on the literature review and analysis of academic studies, as the most significant indicators for the implementation of the FCS digitalization process, the following were identified: the application of Blockchain Technology (BT) [32], the use of modern IT solutions for traceability [33], the implementation of the Internet of Things (IoT) [34], the introduction of Artificial Intelligence (AI) [35], the development of a system for electronic food placement [36], the implementation of standards, measures, and procedures for regulating the digitalization process [37], continuous training of employees [38] and economic and financial measures and incentives [1].

Blockchain Technology is a database that is not located in one place but consists of smaller databases (blocks) that are digitally connected and contain information about digital transactions of any type [39]. As such, BT meets all the mentioned needs of FSC regarding sustainability, flexibility, transparency, and food traceability along the entire chain [32]. BT places a particular emphasis on sustainability in the sense that it minimizes the harmful impact on the environment, enables more effective control of working conditions, storage, and preservation of food, eliminates its wastage, ensures better quality control of raw materials and finished products, ensures fair distribution of profits and risks among FSC participants, etc. The authors [32] state that BT solves specific problems in the marketing of food, such as more efficient collection of information about food, collection of data on its nutritional composition and composition of substances, records of wrong and/or late orders, records of expiration dates of business contracts between FSC participants, recording information on the transportation of food and raw materials along the entire chain, transparency of the disposal or destruction of returnable packaging and non-use of food, creation of smart contracts, creation of databases, etc.

Modern IT solutions for traceability, include all those digital devices that are used for direct labeling of food products along the supply chain and contribute to their easier monitoring, control of storage and preservation conditions, time, place, and method of delivery, control of critical points (contamination, hygiene, temperature, pollution), etc. These include time-temperature indicators (TTIs), which can be chemical, physical, biological, etc., then RFID tags [40], bar codes, wireless sensors (WS), etc.

The authors [34] interpret *the IoT* as a centralized digital platform that, through interconnected computers and digital devices, can exchange and transfer data without the human factor. IoT processes information collected with the help of advanced technologies, such as RFID, cloud computing, AI, WS, TTIs, etc. The key advantage of digitalized IoT-based FSC is that the system collects data based on the input information, processes it, and makes timely decisions on its own [41].

AI technology in food placement is an entirely innovative way of Supply Chain Management (SCM) that involves intelligent planning of supply and demand levels, personalization in approaching the needs of end consumers, optimization of warehouse and storage space, intelligent planning of the most optimal routes, waste reduction in post-production stages, more efficient reverse logistics, etc. Such complex tasks AI achieves through specific techniques (Deep Learning DL, Convolutional Neural Network CNN, Belief-desire-intention BDI, Gaussian Mixture Model GMM, Support Vector Machine SVM) and disciplines (Machine Learning ML, Computer Vision CV, Knowledge Representation

KR, Automated Reasoning AR) [42]. At the same time, in the retail sector, in its food delivery segment, AI implies the application of drones, aircraft, and smart vehicles, which directly deliver food to the home address of final consumers [43].

Electronic food placement is becoming more and more prevalent in the overall structure of placement. Estimates are that after the COVID-19 pandemic, the percentage of food products ordered and purchased online has risen to 20% [44]. Delivery of ready-made products, ready-made meals, fast food, fresh fruits and vegetables, etc., is certainly leading here. An increasing number of retailers are transforming from classic brick-and-mortar facilities into click-and-brick or pure click-and-click electronic retailers. Food manufacturers often shorten the supply chain, bypassing distributors and retailers, by placing food directly through their electronic stores.

The adoption of standards, measures, and procedures for regulating the digitalization process is a sensitive area that involves the harmonization of national regulations with international standards. The digitalization of work and the digital economy have disrupted the traditional understanding of working conditions. They have led to the emergence of new forms and ways of working that are different from the traditional and must be regulated by appropriate acts [37]. The FSC management must adopt internal regulations, instructions, and procedures related to the digitalization of business processes, which will regulate the obligations and responsibilities of employees that arise from such digitalization, simultaneously create conditions, and remove bureaucratic obstacles to facilitate the implementation of digital systems.

In transition countries, such as most WB countries, *continuous training of employees* is a crucial issue for the success of the implementation of the FSC digitalization process. Simply put, digitalization requires new skills and competencies that will be in demand in the future [38]. Employees must have specific continuous training, and get familiar with special practices, etc. Despite this, there is always a concern about the deviation towards changes and the non-acceptance of new solutions and ways of working.

Economic and financial measures and incentives are related to finding financial means for modern digital systems implementation. The major disadvantage of digitalization is that it requires considerable investments, which are almost impossible without subsidies, loans, financial incentives, etc. It is common practice that responsible institutions should help FSC participants feel economically secure while providing the necessary funds for the transformation of their business activities. It includes a whole range of economic and financial measures and incentives for all those who invest in the digitalization of work processes, such as credit lines (lower interest rates, longer grace period, extended repayment period), direct benefits and incentives for employees and new hires, deferred payment, tax incentives (exemption from income tax, VAT on digitalization equipment), participation in national and international co-financing programs (IPA funds, national programs, EU projects), etc. [1].

The originality of the work lies in the fact that this way, in one place, the influence of indicators on the digitalization of business processes and sustainability of food placement in the WB region is analyzed and defined. It will fill the gap in research since only a few studies from the WB area have dealt with the issue of digitalization within the FSC so far. The analysis will specifically address retail as the most sensitive and final segment of food placement. The influence of the size of FSC participants on the implementation of the digitalization process will be tested since previous studies have indicated the existence of vast differences in the acceptance of innovative solutions between small and independent retailers (SMEs) and retail chains [41]. Defining the impact of these indicators is essential for proposing adequate measures for improving working conditions and more efficient digitalization of business processes and achieving sustainability along the entire FSC.

3. Methodology

3.1. Objective and Hypotheses

The objective of the research is to define the importance of key indicators for the implementation of modern technology and digitalization of FSC in the function of sustainability of the food retail sector of the WB region. The objective thus set will be operationalized through empirical research in which the individual influence of the following indicators on the introduction of the digitalization process will be tested: the application of BT, the use of modern IT solutions for traceability, the implementation of IoT, the introduction of AI, the development of systems for electronic food placement, the implementation of standards, measures and the procedure for regulating the digitalization process, continuous training of employees and economic and financial measures and incentives.

Previously cited studies have analyzed the impact of individual indicators, considering them crucial for modern technology implementation and the improvement of FSC functioning. In order to obtain a thorough picture of how to digitalize business processes in FSC, it is necessary to measure and define the impact of the mentioned indicators in a mutual comparison. Accordingly, to answer the RQ₁ the first group of research hypotheses H_{1a}–H_{1h} was set.

H_{1a}—the application of BT is statistically significant in the implementation of modern technology and digitalization of business processes in food placement; H_{1b}—the use of modern IT solutions for traceability has a statistically significant effect on the implementation of modern technology and the digitalization of business processes in food placement; H_{1c}—the implementation of IoT has a statistically significant effect on the implementation of modern technology and the digitalization of business processes in food marketing; H_{1d}—the introduction of AI is statistically significant in the implementation of modern technology and the digitalization of business processes in food placement; H_{1e}—developing a system for electronic food placement has a statistically significant effect on the implementation of modern technology and digitalization of business processes in food placement; H_{1f}—the implementation of standards, measures, and procedures for regulating the digitalization process has a statistically significant effect on the implementation of modern technology and the digitalization of business processes in food placement; H_{1g}—continuous training of employees is statistically significant in the implementation of modern technology and digitalization of business processes in food placement; H_{1h}—economic and financial measures and incentives have a statistically significant effect on modern technology implementation and the digitalization of business processes in food placement.

Based on the hypotheses set in this way, the conducted testing will precisely define which indicators have greater importance and influence for the digitalization of FSC in the WB region. Given that in the food distribution system, retail is the final link in the chain where the finished product ends up and connects final consumers with other FSC participants, it is of high importance to focus particularly on researching the potential of digitalization in this sector. As stated in the results of the cited studies there is no effective placement without timely feedback from the market, from final consumers to downward-chain participants. Bearing in mind that previous studies, Zorić et al. [1] and Končar et al. [41], primarily in the WB region, indicated the existence of seizable differences in the adoption of innovative solutions between small and medium enterprises (SMEs) and retail chains, it is necessary to test whether the differences in the influence of indicators in digitalization of business processes differ depending on the size of the FSC participants. In this sense, the second research hypothesis, H₂, states that the differences in the size of FSC participants are statistically significant for predicting the differences appearing in the influence of indicators on the digitalization of food placement.

As cited studies have shown a direct correlation between modern technologies and the sustainability of FSC, it is necessary to test within the existing research whether the implemented digitization process contributes to the sustainability of FSC and food placement. At the same time, to complete the response to RQ₁, the third research hypothesis,

H₃, states that implemented modern technologies and digitized business processes have a statistically significant effect on the sustainability of food placement.

The set objective of the research and the predicted research hypotheses H_{1a}–H_{1h}, H₂, and H₃ are presented in the following research model (Figure 1).

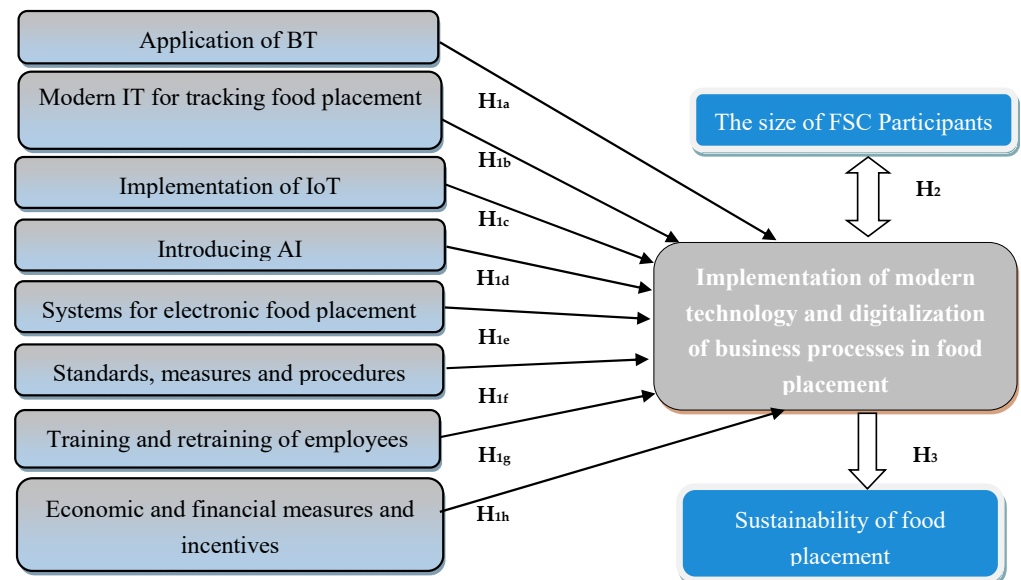


Figure 1. Research model.

3.2. Research Variables

The set subject of the research dictates the need to realize the research based on two dependent and a higher number of independent variables. The dependent variables are represented by implemented modern technologies and digitalized business processes in food placement and sustainability of food placement. The dependent variables were assessed using a standard Likert scale (0-disagree; 5-strongly agree) through three statements. Independent variables of the interval type of measurement are the application of BT; modern IT solutions for traceability, IoT implementation; introduction of AI; systems for electronic food placement; standards, measures, and procedures; continuous training of employees, and economic and financial measures and incentives. The impact of each of these variables on the implemented FSC digitalization process was also assessed based on a Likert scale. The grouping independent variables include the size of FSC participants (SMEs vs. Large-scale business entities and retail chains), demographic characteristics (gender, education), and hierarchical position of respondents (middle-level management, operational management, administration).

3.3. Research Sample

The research was carried out electronically using a Microsoft Teams questionnaire. It included a sample of 255 employees working in the food distribution market of the WB region and was conducted from July to September 2023. The representativeness of the sample is confirmed by the fact that the surveyed employees are directly responsible for the placement of food and have experience working with modern IT platforms and technologies. To obtain as objective data as possible, the sample was uniform in terms of demographic characteristics, the hierarchical position of the respondents, and the size of the FSC participants (Table 1).

Table 1. Research sample.

Gender	n	Structure (%)
Female	141	55.29%
Male	114	44.71%
Education level	n	Structure (%)
High school education	75	29.41%
Higher education	65	25.49%
University degree	115	45.10%
Hierarchical level	n	Structure (%)
Middle-level management	85	33.33%
Operational management	102	40.00%
Administration	68	26.67%
FSC participants' size	n	Structure (%)
SMEs	144	56.47%
Large business entities/Retail Chain	111	43.53%

Source: Author's calculation.

Through the coefficients of Cronbach's alpha, Skewness, and Kurtosis (Table 2), the validity of the selected scales was confirmed. Cronbach's alpha coefficient values for all indicators are above 0.750, while statistically significant deviations are not observed in Skewness and Kurtosis. These values show that the questions asked describe an identical problem and can be used to examine employees in FSC regarding the implementation of modern technologies and the process of digitalization of food placement.

Table 2. Cronbach's Alpha, Skewness, and Kurtosis coefficient.

Indicators	Cronbach's Alpha *	Skewness	Kurtosis
Application of BT	0.752	0.070	−1.030
Modern IT for traceability	0.828	−0.339	−0.227
Implementation of IoT	0.883	−0.553	−0.993
Introducing AI	0.802	−0.618	−1.262
Systems for electronic food placement	0.751	−0.323	−1.125
Standards, measures, and procedures	0.823	0.089	−1.208
Continuous training of employees	0.812	−0.227	−0.616
Economic and financial measures and incentives	0.817	0.582	−0.772

Note: * Minimum value for Cronbach's alpha to confirm validity is 0.700 [45]. Source: Author's calculation.

3.4. Research Procedure and Data Analysis

The research was conducted from July to September 2023. The online questionnaire was forwarded via the Microsoft Teams platform to FCS employees experienced in working with modern technologies and IT platforms. In the sample, all categories of respondents are equally represented, except for the top management of FSC, who did not show interest in participating in this type of research.

The questionnaire was created based on similar questionnaires that were used in related studies [1,41]. It was structured in such a way that after general demographic information about the respondents, they were asked to rank on a Likert scale the influence of each of the mentioned indicators on the implementation of the digitalization process. Each indicator was evaluated through three statements. The first dependent variable—implemented modern technologies and digitalized business processes in food placement, was also assessed based on three statements on a Likert scale: (1) implemented modern technology based on BT, IoT, AI, etc.; (2) implemented modern technology based on RFID, TTI, bar codes, sensors, etc.; (3) implemented modern technology based on GPS, RS, etc. To test the second dependent variable, sustainability of food placement, the following statements were applied: (1) balance between used resources and timely satisfaction of the

needs of end consumers; (2) compliance with the needs of environmental protection and improvement; (3) satisfaction with the existing way of functioning of the FSC. The total number of questions in the questionnaire is 19. The questionnaire was sent to a total of 550 addresses, which shows a return rate of filled questionnaires of 46.36% (255/550).

The collected data were analyzed and tested with the help of the SPSS 20 statistical package. The Descriptive Statistics method was used to describe the fundamental characteristics of the sample, while the Path Analysis Method (PAM) was used to define the influence of independent variables on dependent variables. The Multiple Regression method was used to determine the connection (correlation) between the size of FSC participants and differences in the influence of indicators on the implemented digitalization process.

4. Research Results

The average answers of respondents (M) to the claim that independent variables (indicators) have a statistically significant effect on the implementation of modern technologies and digitalization of business processes in food placement are shown in the following table (Table 3). In addition to the average rank, descriptive statistics (SE, SD, Min., Max.) are presented.

Table 3. The most important indicators of Descriptive statistics of the influence of independent variables on the digitalization of business processes in food placement.

Order No.	Indicators	Mean (M)	Min.	Max.	Standard Error (SE)	Standard Deviation (SD)
1	2	5	3	4	6	7
1	Application of BT	4.23	1.00	5.00	0.0703	0.9513
2	Modern IT for traceability	4.01	1.00	5.00	0.0517	0.9170
3	Implementation of IoT	4.31	2.00	5.00	0.0672	0.7003
4	Introducing AI	3.87	1.00	4.00	0.0561	0.8117
5	Systems for electronic food placement	4.25	1.00	5.00	0.0660	0.9271
6	Standards, measures, and procedures	3.44	1.00	4.00	0.0821	1.1309
7	Continuous training of employees	3.56	2.00	5.00	0.0774	1.0426
8	Economic and financial measures and incentives	4.22	1.00	5.00	0.3276	0.7290

Source: Author's calculation.

Respondents mostly agree with the statements that the key indicators for the implementation of the FSC digitalization process are the implementation of IoT (M = 4.31), the development of a system for electronic food placement (M = 4.25), and the application of BT (M = 4.23). FSC employees believe that the good connectivity of all participants, products, and activities of FSC through BT and IoT contributes to more efficient output services and timely food placement. Also, they particularly emphasize the transition from traditional stores in favor of e-retail, online ordering, and food delivery. In two of these three indicators, a high degree of agreement is also noticeable (BT: SD = 0.9513; e-placement systems: SD = 0.9271), which speaks in favor of respondents being uniform in their attitude to these statements. In the case of IoT implementation, the agreement is somewhat weaker (SD = 0.7003), probably because some food distribution systems are not based on IoT yet, and the respondents are not familiar with their benefits. Employees assign significant influence to modern IT solutions for traceability (M = 4.01; SD = 0.9170), which coincides with some previous studies that better connection of participants, products, and FSC processes is achieved by using TTI, RFID, WS, etc. [33]. The slightest importance is attached to standards and procedures (M = 3.44; SD = 1.1309) as well as continuous training of employees (M = 3.56; SD = 1.10426). It is interesting to note that a relatively low ranking was given to the statement regarding the introduction of AI (M = 3.87; SD = 0.8117), which is not in accordance with the results of related studies [42]. The probable reason is that AI

systems have not been implemented sufficiently in food supply chains on the WB market, and as such, they remain unknown to FSC employees.

The testing of the first group of research hypotheses H_{1a} – H_{1h} primarily requires determining the degree of correlation between independent variables and implemented modern technologies and digitalized business processes in food placement. The Multiple Regression Analysis method was applied to determine the correlation between the analyzed variables. Table 4 shows the test results.

Table 4. Contribution of independent variables.

Indicators	Stand. Coefficient		<i>t</i>	Sig.
	Beta	St. Error		
(const.)	0.897	1.272	3.457	0.000
Application of BT	0.838 **	0.862	0.812	0.008
Modern IT for traceability	0.724 *	0.703	1.042	0.033
Implementation of IoT	0.841 **	0.620	1.125	0.001
Introducing AI	0.664 *	0.870	0.584	0.028
Systems for electronic food placement	0.745 **	0.869	1.125	0.000
Standards, measures, and procedures	0.551	0.972	0.584	0.080
Continuous training of employees	0.352	0.733	0.970	0.334
Economic and financial measures and incentives	0.679 **	0.814	1.042	0.001

Note: ** Significant at the level 1%; * Significant at the level 5%, Source: Author's calculation.

The resulting model shows statistical significance ($F(120;8) = 2.663$; $p < 0.01$), which implies that the set of independent variables is statistically significant and predicts the implementation of modern technology and digitalization of business processes in food placement. The resulting model describes 52.6% of the criterion variance. By reviewing the individual contributions, it is noticeable that among the indicators that statistically significantly predict the implementation of the digitalization process the following indicators stand out: implementation of IoT ($\beta = 0.841$; $p < 0.01$), the application of BT ($\beta = 0.838$; $p < 0.01$), developed systems for electronic food placement ($\beta = 0.745$; $p < 0.01$) and economic and financial measures and incentives ($\beta = 0.679$; $p < 0.01$). Such results confirm the results of cited studies that consider these independent variables as the most significant for FSC digitalization. A significant correlation is also present with the developed IT systems for traceability ($\beta = 0.724$; $p < 0.05$) and the introduction of the AI systems ($\beta = 0.664$; $p < 0.05$), while no statistically significant deviations are observed for the other variables.

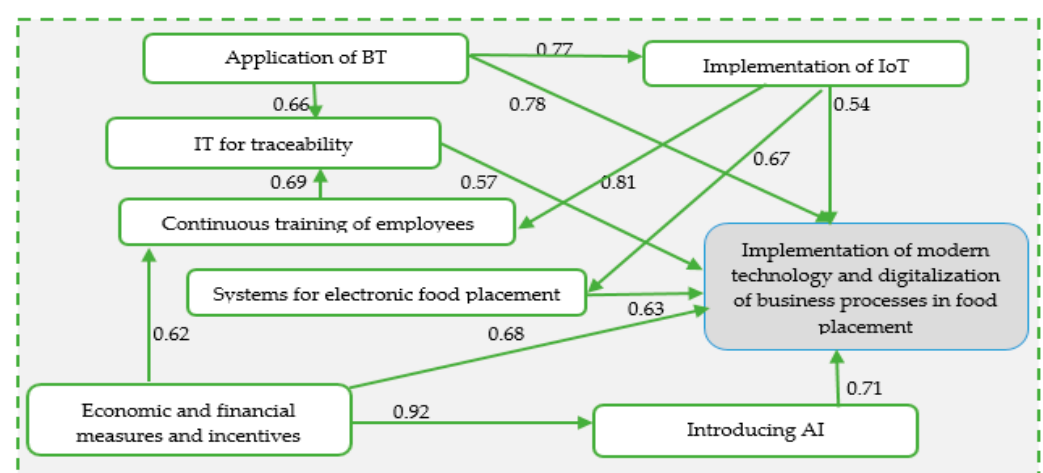
As the conducted testing confirmed the existence of a significant correlation between the observed variables, the application of the Path Analysis Method (PAM) will precisely define the impact of each independent variable on the implementation of modern technology and digitalization of business processes in food placement. The statistical significance of the model is confirmed by the following parameters: NFI = 0.976, RFI = 0.937, IFI = 0.966, TLI = 0.961, CFI = 0.988, RMSEA = 0.029, CMIN/DF = 1.387. Table 5 presents the results of testing the hypotheses H_{1a} – H_{1h} , as well as the confirmed statistical significance that appears in the mutual influence of the analyzed variables.

The results of the PA method show that the variables BT application, modern IT for traceability, IoT implementation, the introduction of AI, implementation of systems for electronic food placement, and economic and financial measures and incentives have a statistically significant impact on the implementation of modern technology and the digitalization of business processes in food placement. We conclude that the research hypotheses H_{1a} , H_{1b} , H_{1c} , H_{1d} , and H_{1h} are accepted, which means that any increase in the influence of the mentioned independent variables is positively reflected and gives incentive to the digitalization of the FSC. No statistically significant influence was observed in the remaining independent variables, and those hypotheses were rejected. The following structural model illustrates the paths of influence of the analyzed variables, and their mutual influence (Figure 2).

Table 5. Results of Path Analysis Method.

Ord. No.	Path	Path Coefficient	t Value	Result
1	2	5	6	7
1	Application of BT » Implementation of modern technology and digitization of business processes in food marketing	0.776	15.221	Support
2	Modern IT for traceability » Implementation of modern technology and digitization of business processes in food placement	0.566	3.077	Support
4	Implementation of IoT » Implementation of modern technology and digitization of business processes in food placement	0.539	10.030	Support
5	Introduction of AI » Implementation of modern technology and digitization of business processes in food placement	0.706	15.174	Support
6	Systems for electronic food placement » Implementation of modern technology and digitization of business processes in food placement	0.530	3.587	Support
7	Standards, measures, and procedures » Implementation of modern technology and digitization of business processes in food placement	0.176	1.835	Reject
8	Continuous training of employees » Implementation of modern technology and digitization of business processes in food placement	0.152	1.213	Reject
9	Economic and financial measures and incentives » Implementation of modern technology and digitization of business processes in food placement	0.678	3.077	Support
10	Application of BT » Modern IT for traceability	0.657	8.323	Support
11	Application of BT » Implementation of IoT	0.774	15.221	Support
12	Implementing IoT » Introducing AI	0.812	10.030	Support
13	Implementation of IoT » Systems for electronic food placement	0.671	9.070	Support
14	Economic and financial measures and incentives » Introduction of AI	0.922	15.174	Support
15	Economic and financial measures and incentives » Continuous training of employees	0.620	8.078	Support
16	Continuous training of employees » Modern IT for traceability	0.691	9.022	Support

Source: Author's calculation.

**Figure 2.** Structural model.

Bearing in mind that cited studies have shown that the acceptance of modern technologies differs depending on the size of FSC participants and that it is an extremely sensitive issue in the retail sector, which represents the last place in FSC where numerous information, data, products, and services intersect between downward chain participants and final

consumers, it is necessary to examine whether the size of the FSC participant affects the application of modern technology. As in the case of the first group of research hypotheses, the Multiple Regression Analysis method will first test whether there are differences in the influence of independent variables on the implementation of modern technologies and digitalization of business processes in food placement in both strata (SMEs, large business entities/retail chains). Testing confirmed that the regression model is significant for both SMEs and large business entities/retail chains. For SMEs, the obtained model shows the following statistical significance: $F(120;8) = 2.663$; $p < 0.01$ and predicts 48.4% of the criterion variance, while for large business entities/retail chains, it is $F(100;8) = 2.663$; $p < 0.05$ and predicts 57.1% of the criterion variance. Table 6 shows the test results for both strata.

Table 6. The individual contribution of independent variables observed by FSC participant size.

Indicators	SMEs		Large FSC Participants	
	Beta	Sig.	Beta	Sig.
(const.)	0.924	0.002	0.855	0.012
Application of BT	0.742 **	0.000	0.804 **	0.002
Modern IT for traceability	0.411	0.073	0.714 *	0.013
Implementation of IoT	0.7884 *	0.020	0.841 **	0.000
Introducing AI	0.270	0.980	0.554 **	0.022
Systems for electronic food placement	0.952 **	0.001	0.683 **	0.000
Standards, measures, and procedures	0.481	0.582	0.551 *	0.040
Continuous training of employees	0.461 *	0.033	0.352	0.733
Economic and financial measures and incentives	0.679 **	0.814	0.114	0.294

Note: ** Significant at the level 1%; * Significant at the level 5%, Source: Author's calculation.

The results obtained by strata show certain deviations. It is evident that independent variables such as the introduction of AI, standards, measures, and procedures, and the application of modern IT solutions for traceability do not have a significant impact in the stratum of SMEs, while the variables, first of all, the introduction of the AI systems ($\beta = 0.554$; $p < 0.01$), is especially prominent in large FSC participants. The reason for the obtained results lies in the fact that small FSC participants consider the introduction of AI in their business systems too abstract and complex a problem, and at the same time, they believe that they do not have enough capacity to implement a system for electronic monitoring of food placement. In addition, we are talking about small, organized systems that hold that the introduction of additional standards, procedures, and regulations to the existing ones would further burden the already complicated administration. On the other hand, it is noticeable that SMEs consider economic and financial measures and incentives to be important ($\beta = 0.679$; $p < 0.01$), and without them they cannot implement expensive systems for digitizing business processes. Contrary to this, for the large-scale FSC participants, financial resources are not a crucial problem for the introduction of modern technologies. The remaining variables have an equally significant impact in both strata. These results confirmed the second research hypothesis H_2 —that the differences in the size of FSC participants are statistically significant in predicting the differences appearing in the influence of indicators on the digitalization of food placement. This fact confirmed the findings of some previous studies [1,41].

The precise influence of independent variables by stratum will be defined using the PA method. PA testing shows that both obtained models are statistically significant (SMEs: NFI = 0.987; RFI = 0.913; IFI = 0.944; TLI = 0.923; CFI = 0.956; RMSEA = 0.024; CMIN/DF = 1.384; retail chains: NFI = 0.957; RFI = 0.940; IFI = 0.961; TLI = 0.926; CFI = 0.935; RMSEA = 0.031; CMIN/DF = 1.257). Figure 3 (structural model) presents the paths of influence of independent variables on the implementation of modern technology and digitalization of business processes in food placement by strata (SMEs, large-scale participants in FSC).

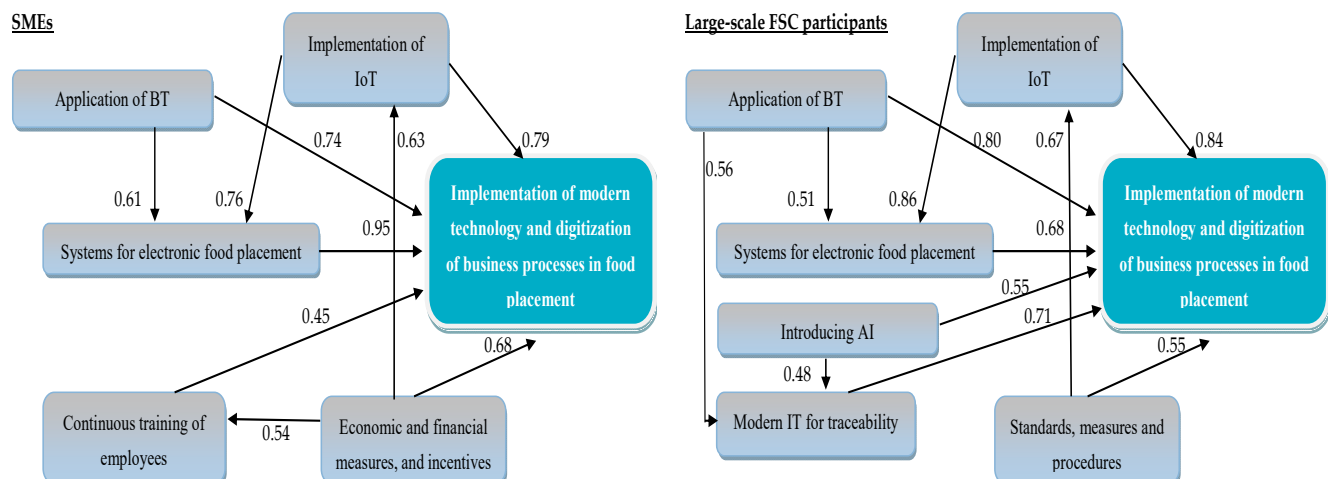


Figure 3. Structural models by strata.

Finally, it is necessary to clearly define the need for digitalization in terms of whether the implemented digitization process contributes to the sustainability of the FSC. To test the third research hypothesis H_3 , the impact of implemented modern technologies and digitalized business processes on the sustainability of food placement will be precisely defined using PAM. The statistical significance of the model is confirmed by the following parameters: NFI = 0.992, RFI = 0.916, IFI = 0.980, TLI = 0.951, CFI = 0.985, RMSEA = 0.034, CMIN/DF = 1.276. Table 7 presents the test results.

Table 7. The test result of the impact of implemented modern technologies and digitalized business processes on the sustainability of food placement.

Ord. No.	Path	Path Coefficient	t Value	Result
1	2	5	6	7
1	Implementation of modern technology and digitization of business processes in food marketing » Sustainability of food placement	0.812	15.221	Support

Source: Author's calculation.

The obtained result shows that the use of modern technology has a statistically significant effect on the sustainability of FSC and food placement. This confirms the results of previous related studies [41], as well as hypothesis H_3 , and it is concluded that implemented modern technologies and digitalization of business processes have a statistically significant effect on the sustainability of food placement. The correlation is positive and strong, which means that as the intensity of the impact of digitalization increases, the sustainability of the entire food chain and placement increases as well.

5. Discussion

The need for research arose from the need to digitalize food flows in FSC as more and more academic studies emphasized. It is a complex task, especially in transition regions such as the WB region, where the supply chain is not yet ready and open to the digitization of its business processes [41]. The research and the results obtained confirmed the findings of previously cited studies that some indicators such as the application of BT, the use of modern IT solutions for traceability, the implementation of IoT, the introduction of AI, the development of systems for electronic food placement, the implementation of standards, measures, and procedures for regulating the digitalization process, continuous training of employees, and economic and financial measures and incentives significantly affect the implementation of the digitalization process. That influence varies depending on the size of economic entities as FSC participants. This finding is understandable because business

conditions, organization, and economic and financial strength differ depending on the size of FSC participants [1]. The study confirmed the direct connection and impact of the implemented digitalization process on the sustainability of FSC and food placement.

The results obtained and the tests carried out show that it is necessary to take the following set of measures that the trade policy makers and FSC management should implement in order to improve the working conditions in FSC and lay the foundation for a more efficient implementation of the digitalization process of food placement.

Technical measures—they imply the ensuring of adequate infrastructure that will be able to absorb and accept digital technologies and modern devices. It means that the following three types of modern technologies must be implemented along the entire FSC: (1) modern technological solutions based on information technologies such as BT, BDA, IoT, AI, etc.; (2) modern technological solutions based on sensors and identification systems such as RFID, TTI, bar codes, bio-sensors, etc.; (3) modern technological solutions based on location technologies such as RTLS, GPS, RS, WS, etc. In addition, FSC participants, and especially retailers as the last link in the chain, should develop systems for electronic food placement (e-stores, e-retail, web ordering applications, etc.) and work to increase food placement through these channels up to 20 to 30% in the structure of the total placement.

Organizational measures—include the employees' training to work with modern technologies and the complete reorganization of business processes in the direction of the gradual introduction of digitalization. Since digitalization requires new skills and qualifications that employees were not familiar with until now, specific programs of retraining, special internships, professional training, seminars and lectures, specialized courses, etc., must be provided to them. It is up to the FSC management to respond to these requests promptly, transparently inform employees about the advantages of digitalization, and provide retraining for all those who want to work with new technology. Only with such an approach will FSC not feel the gap that occurs when moving from a conventional to a modern way of functioning [2]. Organizational measures also include the obligation to harmonize national regulations with international standards. In that context, it is the responsibility of the FSC management to pass internal acts, regulations, instructions, and procedures related to the digitalization of business processes, which will regulate and define the obligations, responsibilities, conditions, and employees' work.

Economic and financial measures and incentives—include all types of financial, credit, tax, and other economic benefits and incentives that would encourage FSC participants (primarily SMEs) to commence the digitization of their business processes. It is the responsibility of competent institutions, commercial banks, and national and international financial organizations to provide all crediting and investment tools for FSC participants who decide on such a change in business philosophy. It is surely part of the responsibility of the FSC management to be informed and apply to national, regional, and international funds that co-finance the implementation of modern technologies such as IPA funds, EU funds, etc. Economic and financial incentives include: (1) all types of credit incentives (lower interest rates, extended grace and repayment period), (2) direct compensation and incentives for employees and new hires, (3) various types of deferred payment, (4) tax benefits (exemption from income tax, exemption from VAT on digitization devices and equipment), (5) participation in national and international co-financing programs (funds of chambers of commerce and ministries, EU funds, etc.).

The inclusion of the mentioned measures in the regular operations of FSC leads to the digitization of all business processes in food placement, which will enable FSC to be sustainable, more transparent, and flexible. As such, FSC will more efficiently perform its primary function, which is a timely and continuous supply of food to the market, regardless of the influence of external factors and market gaps. Digitization is becoming the present, and only those FSCs that approach digitalization in time will survive in the increasingly fierce competitive battle on the global market.

6. Conclusions

The research showed that key indicators that determine and influence the implementation of modern technologies and the digitalization of business processes in food placement are the application of BT, the application of modern IT solutions for traceability, the implementation of IoT, the introduction of AI, development of a system for electronic food placement and economic and financial measures and incentives. The research showed that there are also significant differences in the influence of the mentioned indicators among FSC participants. For example, in addition to the above mentioned, a significant impact of continuous training of employees is also noticeable with SMEs, while with large business entities and retail chains, it is the introduction of standards, measures, and procedures related to the digitization of business processes. No statistically significant impact is read with economic, financial measures, and incentives. The obtained results also confirm the justification of the implementation of the digitalization process because the testing showed the strong impact of the implemented digitization process on the sustainability of FSC and food placement. In this way, the answers to the research questions were obtained. RQ₁: the importance of each of the mentioned indicators for the implementation of the digitalization process in food placement was clearly defined and the implemented modern technologies and digitalized business processes contribute to the sustainability of food placement on the market.

Practical implications. The obtained results signaled the FSC management (e.g., production directors, warehouse managers, retail and wholesale managers), trade policymakers (e.g., line ministries and secretariats), and competent institutions (e.g., professional associations, and chambers of commerce) which concrete measures should be implemented to improve a more efficient implementation of the digitalization process of food placement and lay the foundations for the sustainability of the FSC.

Research shortcomings. The study has several shortcomings that do not diminish its quality, and do not call into question the obtained findings and the conducted tests. The first shortcoming concerns the research sample, which is limited to FSCs operating in the WB market. The authors opted for this approach due to their familiarity with the regional FSC participants, knowledge of the functioning of food placement in the WB region, and facilitated organization of the employee examination procedure itself. Another drawback is the weak motivation and incentive of the top management of FSC to participate in the conducted research. Finally, in the very structure of the questionnaire, pre-given statements appear, with which respondents expressed their degree of agreement using a Likert scale. This approach could lead to unintentionally guiding respondents to agree with some statements.

Recommendations for future research. The most important guidelines and suggestions for further research concern the following: (1) extend the research to FSC participants from Southeast and Central Europe and compare the obtained results; (2) it is important to find a way to motivate and encourage at least some of the FSC top managers to join this kind of research; (3) open-ended questions should be dominant in the structure of the questionnaire; (4) include a larger number of independent variables in the analysis, (5) consider the application of different statistical methods, such as Factor analysis, which would group a large number of variables into a smaller number of factors, and thus possibly look at the research from a different angle. By applying this approach to future research, the scientific contribution to the issue of implementing modern technology and the digitalization of business processes in food placement would be completed.

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