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New dimension of logistics innovations development in agricultural enterprises in Slovakia

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Abstract: The research article's primary aim was to provide a comprehensive and systematic view of a new dimension of logistics in the form of logistics innovations in agricultural enterprises in Slovakia. The intention thereof was to define and then analyse selected logistics innovations in agricultural enterprises. The research object was formed by 95 agricultural enterprises in Slovakia. A questionnaire was used as the research instrument. MS Excel and IBM SPSS Statistics 20 were used to process the data in the questionnaire. The univariate descriptive statistics and multivariate descriptive statistics were used to interpret the data. The research results were tested and evaluated by means of Spearman's rank correlation coefficient. Medium-sized agricultural enterprises in Slovakia represented the largest segment (68%) of the study. The agricultural enterprises mostly understand the use of smart technologies as an innovation in logistics (mean = 4.43). The results of the research showed that the analysed agricultural enterprises intend to innovate mainly the production logistics (mean = 3.20). Out of the logistics processes, the agricultural enterprises want to innovate mostly the inventory management (mean = 4.55). Lean logistics is the most frequently implemented logistics innovation in agricultural enterprises (mean = 3.64). The hypothesis testing has proven that there is a statistically significant relationship between the utilisation of lean logistics and production logistics innovation. In addition, it was proven that there is a statistically significant relationship between the utilisation of radio frequency identification (RFID) and the logistics process innovation – inventory management.

Keywords: agricultural logistics; lean logistics; logistics outsourcing; quick response; radio frequency identification

Increasing investments, setting rationalised policies and methods in agriculture, improving innovation systems in agriculture and effective disposal of natural resources leads to an increase in efficiency and productivity of a country's agriculture as a result of successful strategy establishment.

In his study, Jeníček (2016) defines fundamental developmental constraints such as access to technology, foreign capital and international trade. Based on these constraints, the transition of current developing countries differs from current industrialised countries. Bielik et al. (2010) in their study dealt with fundamentals of technological changes and causal coherence of factors impacting technical efficiency. Research conducted in the Czech Republic shows that knowledge exchange is more and more focused on productive technologies

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and less on unproductive and multifunctional activities (Šťastná et al. 2019). Fang et al. (2020) in the study point to China, which because of the agricultural industrialisation has created a new model of internet and agriculture, company-to-farmer (C2F). They indicate the need to enhance rural internet infrastructure, support broadband access for villages and groups, reduce the digital divide between urban and rural areas, strengthen the information chain, and build a big data service platform to connect farmers and enterprises. Suitably chosen agricultural technology and innovative system approach directly impact agricultural production, which is aimed at increasing work productivity, decreasing production expenses, and decreasing risk related to implementing new technology (De Janvry and Sadoulet 2002; Nederlof et al. 2011). Implementation of innovations in logistics decreases cost, time reduction, increases the flexibility of logistics operations, and at the same time, innovations are among the important tools of differentiation and securing competitive abilities of an enterprise (Cichosz et al. 2017).

Logistics innovations in agriculture are used to improve logistics processes. We can divide them into individual improvement tools such as lean logistics – cost and waste reductions, logistics outsourcing – cost and waste reductions, radio frequency identification (RFID) – risk management, quick response (QR) – response time reduction. The implementation and application of selected logistics innovations in agriculture leads to a reduction in costs, time, and waste, risk reduction, simplification of decision-making processes, and progress in developing new products with an ecological aspect. Agricultural innovations developing in logistics as a result of technological development and technological changes in this sector are leading to extensive adoption of robotics and automation.

Crucial areas significant for lean management also include lean logistics. Bowersox et al. (2020) define lean logistics as the ability to design, manage and administrate materials and goods control system in securing the lowest possible expenses. Lean logistics is based on principle of increasing speed of operational activities and elimination of unnecessary elements, which are not providing any value. Lean manufacturing is also combined with other management programs, especially quality programs such as six sigma (Brown et al. 2006).

In the beginning of the 21st century, outsourcing has become one of the most discussed business activities. Logistics outsourcing is a crucial tool for strategic management, the implementation of which is carried out under time constraints, as the possibility of a return is often ruled out (Jabir and Jawab 2013). By correct implementation for the outsourcing of logistics activities, businesses could achieve savings, decrease financial risks, achieve effective utilisation of capacities, and secure better allocation of capital (Kalinzi 2016). The aim of business process outsourcing (BPO) is to decrease expenses for performing activities and decrease investments in resources used for the performing of internal activities in order to increase the flexibility in the entire enterprise (Ahimbisibwe et al. 2012). When restricting the basic benefits of outsourcing in production and logistics, it is necessary to focus on logistics because logistics outsourcing impacts service performance (Lee and Song 2015). In logistics outsourcing, we can also find seventh-party logistics (7PL) representing an innovation where one provider carries out activities of third-party logistics (3PL) and fourth-party logistics (4PL) providers. 7PL is an effective connection of physical options and professional skills of 3PL with professional consultant services and information-communication skills of 4PL (Li 2017).

High-frequency identification is a system utilising electronic labels to store data about items (Crandall and Crandall 2015). A concept model of management system in logistics automation based on internet of things (IoT) and RFID was established by Chen and Zhao (2018) and is aimed at accurate and effective information flow. Goudos et al. (2017) researched supporting technologies of IoT, logistics applications such as RFID, cloud computing and systems based on agents operating autonomously. RFID has different uses, including access, payment, and logistics management. Results of studies show that the application of these sensors grew between 2005 and 2012 by 20% per year, which is significantly more than the 7% growth of business flows with products (Raghu and Harrop 2014). According to Matulewski (2012) RFID technology applications are used in agri-logistics in Poland in the following sectors: animal identification, prevention of spreading of infectious diseases [e.g. mouth disease, foot and mouth disease, bovine spongiform encephalopathy (BSE)], process optimisation for animal breeding, forest resource management, localisation, and animal tracking.

Quick response is an inventory management strategy developed to reduce the lead time (Zhang et al. 2020). Christopher (2016) argues that quick response connects informational systems and logistics systems, resulting in a combination of transferring correct goods to the correct location at the correct time. Nuševa and Marić (2017) say that quick response

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is a strategy that basically involves focusing on a factor of time, includes all the activities of the enterprise along the supply chain.

MATERIAL AND METHODS

The research article's primary aim was to provide a comprehensive and systematic view of a new dimension of logistics in the form of logistics innovations in agricultural enterprises in Slovakia. The intention thereof was to define and then analyse selected logistics innovations in agricultural enterprises in Slovakia.

The research object was formed by 95 agricultural enterprises in Slovakia. In the structure of NACE Rev. 2 (statistical classification of economic activities in the European Community), the enterprises marked the following as the sector of their activity – Section A: Agriculture, forestry and fishing. Of the total number of respondents participating in the research, 68% of enterprises were in the category of medium-sized agricultural enterprise (50–249 employees). The second largest group of enterprises were large agricultural enterprises (250 or more employees), which accounted for the share of 21%. Small agricultural enterprises (10–49 employees) were represented in the lowest share (11%).

In the research, we identify the geographical location of agricultural enterprises in Slovakia. We used the Nomenclature of territorial units for statistics (NUTS) to divide the research sample by geographical location. In terms of NUTS 2, agricultural enterprises from western Slovakia were predominant in the sample (58.6%), with eastern Slovakia (21.6%) in the second place and Bratislava Region (11.2%) in the third. The least represented region in terms of agricultural enterprises participating in the research was central Slovakia (8.6%).

A questionnaire was used as the research instrument. The research using the questionnaire was conducted in agricultural enterprises in Slovakia from June 2019 to January 2020. The questionnaire contained various questions (open-ended, closed, semi-open, and rating scale questions). The rating scale questions included options on multi-point scale (strongly disagree – 0, disagree – 1, slightly disagree – 2, neutral – 3, slightly agree – 4, agree – 5, strongly agree – 6). MS Excel and IBM SPSS Statistics 20 were used to process the data in the questionnaire. Univariate descriptive statistics and multivariate descriptive statistics were used to interpret the data. The use of the univariate dimensional descriptive statistics made it possible to implement mean values and measures of variability. Arithmetic mean, median, and mode were used from the mean values. The arithmetic mean represents the ratio of the sum of values and their number. Median specifies the middle value in a set of data, and mode represents the value that occurs most frequently in the set. Standard deviation was used from the degree of variability. Standard deviation determines the average distance of all measured values from their arithmetic mean. Multivariate descriptive statistics was used to create parameter tables that contain several variables and indicators. In order to meet the aim of the article, it was necessary to establish scientific hypotheses. Their verification/falsification was performed using Spearman's rank correlation coefficient. This coefficient is a nonparametric statistical measure that measures the strength and direction (positive or negative) of the association between two ranked variables.

Prasetyawan and Ibrahim (2020) argue that respect for lean principles is not only in the production area, but also in all processes that are in the enterprise. Wronka (2017) says that the application of lean logistics also uses tools and concepts used in production such as Kanban, 5S (sort – set in order – shine – standardise – sustain), total productive management (TPM), or value stream mapping (VSM). Zhang et al. (2016) conducted a survey among enterprises in the Singapore Logistics Association, where 37.5% of enterprises applied lean tools in business processes. Li et al. (2014) conducted a research on lean logistics in China. They focused on the production of engines, in the research they characterised in detail the logistics of engine production with the design of a lean logistics system.

Theoretical knowledge and foreign research dealing with lean logistics offers a baseline for defining and examining the null and alternative hypothesis:

H_{0a}: There is no significant positive relationship between utilisation of lean logistics and production logistics innovation.

H_{1a}: There is a significant positive relationship between utilisation of lean logistics and production logistics innovation.

Kirch et al. (2017) say that the use of RFID in logistics processes creates smart logistics. Lanko et al. (2018) combine the implementation of blockchain in building materials logistics with RFID technology. Wang (2014) advocates that RFID is a modern way of managing information in a material flow. Alfian et al. (2017) emphasise that RFID is used to track goods and control inventory. Tao et al. (2017) found that if the enterprise implements RFID technology, its inventory management policy will improve. With RFID, it is possible to get a perfect and immediate overview of the inventory status.

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Based on the findings, we state that RFID is a very frequent term in the literature, but there is no research in this area in Slovakia. These backgrounds and facts were the basis for the formulation of these hypotheses:

H_{0b}: There is no significant positive relationship between utilisation of RFID and logistics process innovation – inventory management.

H_{1b}: There is a significant positive relationship between utilisation of RFID and logistics process innovation – inventory management.

RESULTS AND DISCUSSION

The average values were calculated out of the aggregated data and the order was determined. The enterprises mostly understand the use of smart technologies as an innovation in logistics. This option reached the highest average value (4.43). The use of logistics strategies as innovation in logistics reached the second-highest average value (4.16). The use of logistics methods achieved the average value of 3.48. Table 1 shows the descriptive statistics according to the respondents' answers.

The results of the research show that the analysed agricultural enterprises intend to innovate mainly the production logistics with the highest average value of 3.20. The distribution logistics reached the second-highest average value of 3.06. What the enterprises want to innovate the least is the procurement logistics with an average value of 2.95.

Research results show that agricultural enterprises are inclined to innovate production logistics as inputs represent a considerable part of the benefits for enterprises. The intention is to simplify and ensure production preparation by making the flow of material and raw materials from the warehouse of the business unit into the production process transparent. The second area that agricultural enterprises have identified as the potential for innovation is distribution logistics. Enterprises aim to reduce and clarify flow of products from the warehouse to the customer. Table 2 shows the descriptive statistics based on the respondents' answers to the question on which business logistics fields they intend to innovate.

The research sample was asked if they intended to innovate the logistics processes they used in their enterprises. Agricultural enterprises would like to innovate inventory management. This option reached an average value of 4.55. Inventory management consists of the management flow of raw materials, materials and finalised products, and their storage. It is a form of management of the supplier chain, including demand forecasting, stock control, and reverse logistics security. It is critical for agricultural enterprises to create security supplies, especially for needs of animal production. Generally, in agricultural enterprises dealing with animal and plant production, it is vital to manage turnover of supplies within the enterprise's internal environment. The outputs of transformation process represent inputs in other areas of business activities for the enterprise. Outputs of plant production become inputs for animal production of a given entity. The above-mentioned cycle of supplies and its management represent an important attribute in the inventory management. Traffic and transportation came second with the calculated average value of 4.36. With an average value of 4.22, warehousing and storage

Table 1. Descriptive statistics based on the respondents' answers

Statistics	Mean	Median	Mode	SD
Use of smart technologies	4.43	5.0	6	1.628
Use of logistics strategies	4.16	4.0	5	1.578
Use of logistics methods	3.48	5.0	6	1.844

N – the number of valid observations for the variable; *N* (missing) = 0; *N* (valid) = 95
Source: Authors' own processing

Table 2. Descriptive statistics based on the respondents' answers

Statistics	Mean	Median	Mode	SD
Production logistics	3.20	4.0	4	1.890
Distribution logistics	3.06	3.5	4	1.814
Procurement logistics	2.95	3.0	3	1.664

N – the number of valid observations for the variable; *N* (missing) = 0; *N* (valid) = 95
Source: Authors' own processing

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is another innovative logistics process. Table 3 shows the descriptive statistics according to the respondents' answers to a question on which logistics processes they use in their enterprises.

Processing and evaluating various logistics innovations and their mutual comparisons have not been processed in any research either abroad or in Slovakia. Hence, we have decided to pay increased attention to selected innovations in logistics and examine them in agricultural enterprises in Slovakia.

Table 4 contains the selected logistics innovations and the order of their utilisation in agricultural enterprises in Slovakia. Lean logistics achieved the highest average value of 3.64. We can conclude that lean logistics is widely implemented and utilised in almost every enterprise. The most utilised methods of lean logistics include just in time (JIT) and material request planning (MRP). Successful implementation of JIT and RFID technologies in agricultural businesses leads to combination of two innovations that allow for further potential innovations that create value for the enterprise. The implementation of a lean solution should not end the innovation curve. The needs of agricultural enterprises are evolving and it is ideal to adapt lean solutions to changing conditions. The specific feature of logistics in agriculture is the large multitude of transported and stored material items and various agricultural primary production products. Lean logistics in agriculture is represented in terms of technical implementation measures to handle a large number of material items with the lowest operating costs. These include saving people, material, time and costs, faster supply of production workplaces, reducing stocks of production inputs, higher safety and cleanliness at the workplace, freeing up production area, reducing waiting, and simplifying inventory differences.

The results show that agricultural enterprises most often use JIT in the implementation of lean logistics. In contrast, in their study, Brown et al. (2006) present the implemented six sigma method, which allows to manage the system of material and goods flow control by minimising costs.

The respondents use quick response with the average value of 2.20 and logistics outsourcing with the average value of 2.07. Quick response represents one of the simplest means of providing customers or other subjects with information, allowing for obtaining information about the product by a quick scan, such as identifying the seed origin of crops throughout their life cycle. At the same time, it ensures security via password and hence prevent sharing information with third parties. radio frequency identification reached the average value of 1.99. According to the research analysis, the RFID logistics technology has an irreplaceable position among implemented innovations in agricultural enterprises. Utilisation of RFID in the agri-logistics sector results in many advantages such as transparency and ensuring effective flow of information, materials, products, more effective localisation, and elimination of risks arising from goods handling before, during, and after delivery from point A to point B within internal and external environments of the enterprise.

Table 3. Descriptive statistics based on the respondents' answers

Statistics	Mean	Median	Mode	SD
Inventory management	4.55	5.0	6	1.59
Traffic and transportation	4.36	5.0	6	1.68
Warehousing and storage	4.22	5.0	5	1.66

N – the number of valid observations for the variable; *N* (missing) = 0; *N* (valid) = 95

Source: Authors' own processing

Table 4. Descriptive statistics based on the respondents' answers

Statistics	Mean	Median	Mode	SD
Lean logistics	3.64	4.0	6	1.95
Quick response	2.20	1.0	0	2.33
Logistics outsourcing	2.07	1.0	1	1.87
Radio frequency identification (RFID)	1.99	1.0	0	2.28

N – the number of valid observations for the variable; *N* (missing) = 0; *N* (valid) = 95

Source: Authors' own processing

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Table 5. Results of Spearman's rank correlation coefficient

Spearman's rho		Utilisation of lean logistics	Production logistics innovation
Utilisation of lean logistics	correlation coefficient	1.000	0.266**
	sig. (2-tailed)	0.000	0.000
Production logistics innovation	correlation coefficient	0.266**	1.000
	sig. (2-tailed)	0.000	0.000

**Correlation is significant at the 0.01 level (2-tailed); N – the number of valid observations for the variable (N = 95); sig. (2-tailed) – two-tailed P-value

Source: Authors' own processing

Table 6. Results of Spearman's rank correlation coefficient

Spearman's rho		Utilisation of RFID	Logistics process innovation – inventory management
Utilisation of RFID	correlation coefficient	1.000	0.289
	sig. (2-tailed)	0.000	0.000
Logistics process innovation – inventory management	correlation coefficient	0.289	1.000
	sig. (2-tailed)	0.000	0.000

N – the number of valid observations for the variable (N = 95); sig. (2-tailed) – two-tailed P-value; RFID – radio frequency identification

Source: Authors' own processing

Furthermore, it is the path tracking materials, raw materials, components, agricultural machine accessories, fuel consumption monitoring, extent of utilisation, service jobs, measurement of cultivated land and increasing quality of production and provided services. Based on the research results, RFID is primarily used to ensure the efficient flow of information, handling of materials and products, with the aim of more efficient localisation. According to Raghu and Harrop (2014), RFID is more significantly applied in the area of trade flows with products.

Table 4 shows the descriptive statistics of the utilisation of selected logistics innovations.

Based on Table 5, we can see the evaluation of the hypotheses using IBM SPSS Statistics 20. We used Spearman's rank correlation coefficient to validate determined hypotheses.

We thus found a statistically significant relationship between the utilisation of lean logistics and the production logistics innovation (r = 0.266; P < 0.001). We reject hypothesis H_{0a} and accept hypothesis H_{1a}.

The second pair of hypotheses was evaluated by Spearman's rank correlation coefficient in the statistical software (IBM SPSS Statistics 20). The results are shown in Table 6.

We thus found a statistically significant relationship between the utilisation of RFID and the logistics process innovation – inventory management (r = 0.289; P < 0.001). We reject hypothesis H_{0b} and accept the hypothesis H_{1b}.

CONCLUSION

Nowadays, acquiring new knowledge, abilities, and skills is crucial in the agricultural sector to support individuals, businesses, regions, and countries. It is not only knowledge that is morally obsolete, but the technologic equipment as well. The application of new technologies has been developing fast, albeit with different levels of progress across the world.

In the past several years, as one of the oldest sectors, agriculture has been impacted by technological progress in different forms by trends in modernisation, digitalisation, and innovations. Innovation can be perceived as a well-organised system reducing risks. Farmer approaches to innovations differ. Some users seek opportunities for innovations aiming at reducing risk and penetrating the market. At the same time, the majority of farmers are not interested in innovations and concentrate on the management of their farms and the resolution of daily challenges utilising proven methods without taking any risks.

Based on the results of research conducted in agricultural enterprises in Slovakia, it was found out that

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agricultural enterprises mostly understand the use of smart technologies as the innovation in logistics (mean = 4.43). The results of the research showed that the analysed agricultural enterprises intend to innovate mainly the production logistics (mean = 3.20). The objective is to simplify and secure production preparation by means of clarification of materials and raw materials flow from the warehouse of the enterprise unit to the production process. Of the logistics processes, agricultural enterprises intend to innovate mostly inventory management (mean = 4.55). Inventory management consists of management flow of raw materials, materials, finalised products, and their storage. Lean logistics is the most frequently implemented logistics innovation in agricultural enterprises (mean = 3.64). We believe that lean logistics is widely implemented and utilised in almost every enterprise. The most utilised lean logistics methods include just in time (JIT) and material request planning (MRP). The hypothesis testing has proven a statistically significant relationship between the utilisation of lean logistics and the production logistics innovation ($r = 0.266$; $P < 0.001$). Besides, it was proven that there is a statistically significant relationship between the utilisation of RFID and the logistics process innovation – inventory management ($r = 0.289$; $P < 0.001$). Based on research results, we can establish that in case of an effective selection and correct implementation of innovation into processes of agricultural enterprises, the given entity might save approximately 30% in expenses on entire operations.

From the perspective of strategic objectives of agricultural enterprises in the area of innovation development, in the future, there is space for innovations in the department of process optimisation by means of modern procedures and breeding practices, production of sufficient amounts of agricultural products in the correct quality, implementation of information technologies securing long-lasting sustainability, and technology efficiency.

The basic element of Industry 4.0 is the extensive expansion of smart technologies which offer new opportunities to save costs, increase work efficiency, and minimise the burden on the environment. In connection with the implementation and use of innovations in agriculture, when individual machines and agricultural techniques are connected to an intelligent network connected to data, the use of the latest smart technologies in agricultural practice is identified as Agriculture 4.0. At present, in addition to the implementation of innovations in agricultural enterprises, the emphasis is placed on environmental aspects in the form of environmental protection and achieving environmental savings.

Nowadays, in the implementation of innovations, it is key to consider green technologies and enable the utilisation of renewable resources in agriculture and efficient utilisation of secondary resources. From the environmental perspective, agricultural innovations increase productivity and effectiveness of water use for crops while at the same time protecting the environment by reducing emissions of greenhouse gases from agriculture. Agriculture is one of the first sectors that has been utilising the principles of circular economy and waste hierarchy within their operations for a long time.

On the one hand, the implementation of modern technologies leads to cost reduction, and on the other, it leads towards more efficient system operation. Although logistics efficiency is growing, there are still potential social consequences in the form of the threat of losing millions of jobs in agriculture. It is precisely this threat arising from the development of technology that agriculture and other industrial sectors face. The challenge lies in finding solutions on how to balance out these factors, as the human intelligence is an indelible part of functioning artificial intelligence.

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