The Role and Importance of Logistics in Agri-Food Supply Chains: An Overview of Empirical Findings[1]

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This paper presents a survey of empirical literature on the role of logistics in the agri-food sector. The main objective of the paper is to systemise and comprehensively describe the knowledge and information derived from a large number of sources about the specifics of food supply chains in terms of logistics, with particular emphasis on agricultural enterprises. Moreover, taking into account the increasing environmental, social and ethical demands concerning Agri-Food Supply Chains, the article formulates challenges for logistics and future trends in its development. In conclusion, it proposes a definition of logistics for the agri-food sector.

Keywords: logistics in agriculture, LSR, logistics costs, definition of logistics, trends in AFSCs.

1. INTRODUCTION

The agri-food sector plays a significant role in the economy, being one of the main contributors to the GDP of many countries, particularly in developing countries, where the share of this sector in the GDP reaches even as much as 50%. On the other hand, in highly developed countries, such as the USA or the EU countries, it is not greater than 2% [5]. According to The World Factbook, in 2013 this index reached nearly 4% in Poland [41].

According to the European Commission, in 2008 slightly more than 48 million people were employed within the EU-27's food chain; they worked in nearly 17 million different holdings/enterprises [16].

In view of the fact that in agri-food supply chains (AFSCs) there are raw materials and products with short sell-by dates, and due to the fact that there are living organisms in the initial links of this chain, this sector is a logistic challenge. In contrast to all other sectors of the economy, apart from the requirement of efficient logistics, it must guarantee the delivery of safe food to final consumers. Apart from that, the transport of food products, especially livestock, requires the application of specialised logistic infrastructure.

At the same time, for a few years we have seen growing environmental, social and ethical concerns, and increased awareness of the effects of food production and consumption on the natural environment. These phenomena have led to increased pressure exerted by consumer organisations, environmental advocacy groups, policy-makers, and several consumer groups on agri-food companies to deal with social and environmental issues related to their supply chains within product lifecycles, from 'farm to fork' [23]. Therefore, effective and environmentally friendly logistics and production technologies are key success factors both for manufacturers and retailers in the AFSC.

The main goal of the article is to make a synthetic presentation of the role and significance of logistics in AFSCs based on an overview of empirical findings. The detailed objective is to present specific features of food supply chains in the logistic aspect, with a particular focus on agricultural enterprises.

Apart from that, in view of the increasing environmental, social and ethical demands concerning food supply chains, the article will

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formulate challenges for logistics and further trends in its development in the agri-food sector.

The article will also attempt to answer the question: *What is an adequate definition of logistics in the agri-food sector in view of the considerations presented in the article?*

2. THE LOGISTICS ASPECTS OF AGRICULTURAL PRODUCTION

Agricultural enterprises are an essential link in the AFSC. They produce raw materials for agricultural processing and make fresh products, which are directly or indirectly delivered to the consumer. Thus, the quality of raw materials and products and the costs generated by agricultural enterprises will have considerable influence on the final efficiency of the entire supply chain. Apart from that, the type of production technologies and logistics will significantly affect these costs and quality due to the direct contact with the environment and living organisms.

As Stachak [39] reports, specific traits of agricultural production can be divided into primary and secondary traits. Primary traits are mostly characteristic of plant production, but due to their connections with raw materials they influence the traits of animal production and the food industry. Primary traits result in secondary traits of production, such as: promptness and seasonality of outlay used and production gained, diversification in production between enterprises, etc. It is specific that agricultural production is characterised by combined application of all of these traits rather than exclusive application of each individual trait, because some of these traits are also important characteristics of forestry, building, the food industry and mining industry.

Primary traits include the following elements:

- close relation between agricultural production and land,
- dependence of agricultural production on climatic conditions,
- dependence of agricultural production on the genetic traits of plants and animals.

Secondary traits include the following elements:

- promptness of economic processes,
- seasonality of economic processes,
- high diversification of production in enterprises,
- versatility in the use of agricultural products.

Most of the traits listed above strongly affect logistic processes in an agricultural enterprise and the entire food supply chain. Studies which have been conducted for many years by different scientific centres resulted in a detailed list of specific traits of agricultural production, determining the logistics of agricultural enterprises. The following traits were distinguished [17, 43, 53, 4, 48, 26, 27]:

- *spatial character of agricultural production* (considerable costs of internal transport resulting from multiple journeys to individual fields within one season and travelling the distance of a dozen or more kilometres from the economic centre),
- *dependence on climatic conditions and seasons of the year* (seasonality often causes the need to make large reserves in a short time, which occupy a large warehouse area),
- *promptness of economic processes* (untimely harvest may cause a considerable loss in the yield or even its complete loss in extreme cases, interrupted transportation of some products, e.g. milk, may cause the loss of their properties and thus, the loss of their commercial value),
- *continuity of the production process at discontinuous labour processes* (it results from the seasonality effect and causes uneven demand for factors of production),
- *diversity of loads transported* (e.g. cereal grains, beetroots, potato tubers, dry and juicy roughages, milk, livestock) determines the need to have a wide range of different means of transport [15]. There are special requirements concerning animal transport, as described in applicable EU regulations[2],
- *outstandingly high total transport weight* (including both tonnage transported and the multitude of journeys). It is illustrated by the results of previous studies, which prove that

[2] The first EU directive on the protection of animals during transportation was agreed on in 1977 and new resolutions, which are applicable now, were passed in 1991 and 1995. According to these regulations, it is necessary to meet the following requirements before the beginning of animal transport: the carrier must be licensed to transport animals; only competent personnel with appropriate skills and know-how may transport livestock; animals must be appropriately loaded and provided with space on the means of transport; animals' basic needs for water, food and rest must be satisfied; animals must be fit for transport [46].

depending on the type of production and degree of intensity, there are 20-80 tonnes of weight transported per 1 ha of farmland [47, 49, 50, 53, 44].

- *one-way haulage in agriculture* (this burdensome trait can be eliminated from external transport on condition of good management – haulage of a product to be sold and return to the base with means of production purchased, but it is impossible to eliminate it from internal transport – between the base and field). Empty haulage is common in the agricultural sector and the load capacity utilisation level of vehicles is very low (it varies between 10% and 95%) [19].
- *short-distance haulage on poor-quality roads* (the poor quality of roads lowers the quality of agricultural products, especially juicy roughages – green forage, fruit, some vegetables, etc.)
- *low transport and storage capacity of numerous agricultural products*, resulting from their short shelf life and high perishability (it involves the risk of loss during too long-distance haulage and during too long storage period – the following plant products are particularly sensitive: green forage, fruit, vegetables, and the following animal products are perishable: milk, meat). If we take inappropriate transport, storage and processing technologies into consideration, the loss during and after harvest reaches 60-70% in developing countries [19, 40], whereas this index reaches only 1-2% in the USA [40].

Therefore, there was a good reason why as early as in 1813 Albrecht Thaer formulated his well-known statement that *... the farm is inadvertently a transport enterprise* [54].

3. LOGISTICS-RELATED CHALLENGES AND PROBLEMS IN AFSCs

In view of the progressing globalisation, the specific traits of agricultural production which were discussed above determine not only the logistics in agricultural enterprises but they also affect the functioning of entire AFSCs. They intensify and generate new determinants, which make them difficult to identify in AFSCs. Having analysed different publications, the following factors can be distinguished:

- the problem of *receiving aligned-quality products from various small farmers* results from variable weather and biological conditions affecting organoleptic traits such as: taste, aroma, consistence, etc.)
- *different sources of supply of raw material batches* (this factor is related to the previous factor, but it is intensified by the internationalisation of chains resulting from the search for new and cheap sources of supply of raw materials),
- many different supplies of raw materials contribute to *contamination (infection)* issues and difficulties in ensuring a fixed processing recipe upstream the AFSC,
- *continuous production* (production of milk, sugar, flour, etc. – it is difficult to trace the sources of supply of raw materials) is the predominant type of production in AFSCs in contrast to other sectors, where discrete manufacturing prevails (assembling cars, washing machines, etc. - it is easy to trace individual parts and subassemblies),
- *the presence of numerous and independent links in the entire supply chain* – 'from the farmer's field to the consumer's table' (it causes numerous disturbances in the information flow and in consequence, it generates excessive inventories increasing upstream the supply chain – 'the bullwhip effect'[3]) [11, 27]. Apart from that, the multitude of participants in the supply chain favours the presence of numerous formal and informal relations, which make difficulties in the desirable development of partnership and trust in the chain,
- the abovementioned problem leads to the *formation of long marketing channels, where an unequal balance of power appears within the supply chain*. This situation leads to business

[3] The *bullwhip effect*, *whiplash effect* or *whipsaw effect* consists in amplified transfer of demand changes in the supply chain. Relatively small deviations in the final consumer's demand increases as the information about the demand is transferred upstream the supply chain – to the producer and further to suppliers. The *demand amplification* effect was first identified and described by Jay Forrester in 1958. He thought that the main cause of this effect was the behaviour of managers, who made rational decisions and overestimated the increase or decrease in clients' demand and they assumed the change would continue. He also noted other sources of this effect, i.e. the time gap between the transmission of order, delivery and material flow as well as the influence of promotional actions on creating fluctuations in the demand [38].

models that cannot be sustained by small and medium farms. The final price of food products can be almost 250-350% higher than the price at the farm level, especially in developing countries [45],

- *poor infrastructure and limited access to the required means* (technology, funds, innovation) to achieve high efficiency (suppliers from developing countries consider transport and post-harvest costs to be the most important challenge [34] and standards (e.g. ISO 22000[4] or FSSC 22000[5]) required by global markets) [18],
- there are *significant difficulties in establishing horizontal farm cooperation schemes and coordination mechanisms*, mainly due to the lack of trust and supporting means, mostly in developing countries (e.g. the lack of proven business models, modern storage infrastructure, ICTs, training, etc.).

4. LOGISTICS COSTS IN AGRI-FOOD SUPPLY CHAINS

The abovementioned specific traits of AFSCs affect the generation of a particular level of logistics costs and have influence on their structure. So far there have been few domestic and foreign reference publications concerning the level and structure of logistic costs in AFSCs (especially in agricultural enterprises) and the factors which influence them. The author's research on agricultural enterprises in Poland revealed that there was a high share of logistics costs in total costs of production, i.e. 42.2% [52]. Other studies conducted under the IGRE project analysed logistics costs in the production of silages from selected plants for biogas production. The studies were conducted in five groups of farms with average areas of 15 ha, 35 ha, 130 ha, 600 ha and 1500 ha of farmland. The scale of production had the greatest influence on the share of logistics costs in total costs. This index ranged from 51.1% to 54.2% on the smallest farms. This share was about 8.5% lower on the farms with 35 ha of farmland and it ranged from 42.9% to 45.7%. On the farms with 130 ha of farmland the share of logistics costs was lower by about 13% again and ranged from 30.1% to 32.1%. The share of logistics costs was slightly lower on the farms with areas of 600 ha and 1500 ha, where they ranged from 28.6% to 33.3% and from 29.6% to 32.2%, respectively. The lowest share of logistics costs was noted in Virginia mallow farming, whereas the highest share was noted in sorgo cultivation [37].

By comparison, as results from global data, the average share of logistics costs in total costs of manufacturing products in enterprises of different branches ranges from 10% to 25% [31].

Table 1 compares the structure of logistics costs in agricultural enterprises with the enterprises in other sectors.

Table 1. The share of basic components of logistics costs in agricultural enterprises vs enterprises of other branches.

Component of logistics costs	Percentage of basic components of logistics costs in total logistics costs (%)		
	Agricultural enterprises	Enterprises of other branches (Poland)	Enterprises of other branches (world)
Physical flow costs	86.5	44.2	31.5
Inventory costs	12.2	34.3	39.7
Costs of information processes	1.3	14.2	19.5

Source: 2013. *Model rachunku kosztów logistyki dla przedsiębiorstw rolniczych.* (*Logistics-based costing model for agricultural enterprises*). UP w Poznaniu, Poznań

As results from the data, in comparison with the enterprises in other sectors the predominant cost in the structure of logistics costs in agricultural enterprises is the cost of physical flow of raw materials, materials and products. It is mostly conditioned by the scale of outlay in internal transport, which results from the abovementioned specific traits of this type of enterprises.

As results from the research conducted in Thailand, the analysis of the structure of logistics costs in the production of mangos revealed that there was a high share of costs of transport in total logistics costs. The research findings proved that the mean costs of orders in this structure amounted to 9.74%, inventory costs – 2.24%, costs of information processes – 2.43%, whereas mean costs of transport reached 16.29% [35].

[4] The ISO 22000 standard for food safety and quality

[5] The FSSC 22000 standard was developed by the Confederation of the Food and Drink Industries in the European Union and by leading food producers; it is an extension of the ISO 22000 standard.

5. CURRENT TRENDS AND PROGNOSES IN AFSC LOGISTICS

In view of the considerations presented above, we can now discuss the current trends and prognoses concerning changes in the AFSC logistics.

Until recently there were two aspects of classic optimisation in logistics, i.e. costs and time. Such aspects as environmental costs or social problems were usually ignored [33]. Since the 1980s, when we saw the emergence of considerable influence of environmental protection on the functioning of enterprises, there has been increasing pressure on the optimisation of three aspects of logistics, i.e. costs, time and the environment.

As far as the environmental aspect is concerned, initially optimisation only concerned the optimisation of transport routes, maintenance of means of transport, consumption of non-sustainable raw materials, emission of exhaust gases and noise, traffic congestion on roads, disposal of dangerous waste [6]. Research on these issues contributed to the development of the term 'green logistics', which began to be used in publications. Green logistics originated in the mid-1980s as a concept characterising logistics systems and approaches that use advanced technology and equipment to minimise environmental damage during operations [10, 42].

Studies show that a considerable number of consumers prefer purchasing products from the companies which take care of environmental protection and build good models of civic behaviours. Apart from that, these preferences are reflected in investments – consumers more often invest their money (purchase shares) in such companies [3, 21].

The abovementioned phenomena concerning logistics are closely related with the CSR concept, which has been elaborately described in many publications [8, 32, 12]. Due to the AFSC traits described in the aspect of logistics and its significant influence on the environment, in recent years there have been many attempts to adapt the CSR concept to assess logistic actions in the aspect of social responsibility. The new concept was called Logistics Social Responsibility (LSR) [7]. As results from the research conducted so far, the LSR concept encompasses 47 practices classified in five areas: Purchasing Social Responsibility (PSR), Sustainable Transportation (ST), Sustainable Packaging (SP), Sustainable Warehousing (SW) and Reverse Logistics (RL) [12]. In view of the increasing consumers' demand for food quality and safety (fresh, palatable, nutritious and safe food) and animal welfare, and in view of increasing social expectations and legal requirements concerning environmental protection, the LSR concept will continue to develop, especially in food supply chains.

In view of the large number of intermediaries in AFSCs and especially due to the high fragmentation among producers of agricultural raw materials, there will be progressing concentration of farms, processing plants and wholesalers so as to reduce their number and simultaneously, to increase their size. These changes will favour greater integration within the chain and they will help to build partner relationships between all links. Such solutions in AFSCs may be a chance for small producers to operate on global food markets.

However, in order to guarantee that they can compete successfully it will be necessary to implement systems certifying the quality of supplied raw materials and products. The best-known standards in AFSCs are as follows:

IFS - International Featured Standards[6] [24]. It is a group of international standards which provide a fully objective image of food quality and safety thanks to the application of appropriate mechanisms. Apart from that, the IFS may be a tool for traders to assess the quality of a supplier. Above all, it may ensure continuous improvement of producers and enable them to define the weak points of their organisation. There are different varieties in this group of standards. The following standards concern logistics:

- *IFS Food* – its main goal is to standardise the rules of evaluation and auditing procedures, standardise the rules of qualifying suppliers and to make periodical, independent and objective assessments of food distributors. Today the IFS is a ticket to cooperation with leading trade companies from Western Europe. IFS Food was the first of the IFS

[6] The IFS is a requirement in all German retail chains associated in the HDE, such as: Metro AG, Rewe, Tegut, Edeka, Aldi Tengelmann, Ava, Lidl, Spar, Globus, Markant, COOP and Migros (Switzerland). It is also a requirement of French retail chains, such as: Auchan, Carrefour, EMC, Groupe Casino, Metro, Monoprix, Picard Surgeles, Provera (Cora, Match), System U. It is estimated that today the IFS is recognised by 65% of entities involved in food trade. Apart from the United Kingdom, the IFS is the most important standard for suppliers of large retail chains.

family. The standard underwent consecutive modifications, which started in 2003 and continued until 2010. The modified system of assessment enables even better identification of the companies applying good practice of food production and distribution [25]:

- Much more *qualitative requirements* concerning e.g. weight and nutrient control and information provided on labels;
- The guidelines concerning food safety meet the latest version of the document '*GFSI Guidance*[7]*'* on the assessment of risk and legal regulations which are applicable in a particular country;
- New criteria for products released on the market;
- Extended requirements concerning packages.

- ***IFS Global Markets*** – is a standardised programme for food safety assessment by retailers and wholesalers from the food industry. It is based on the GFSI Global Markets checklist. The programme is chiefly addressed to new and developing enterprises.
- *IFS Cash & Carry / Wholesale* – is a standard which encompasses all handling procedures concerning loose products sold by food wholesalers. It also encompasses the process of production in small amounts, e.g. meat. The requirements of this standard are the same as those in IFS Food but additionally, it includes the guidelines which describe how to handle specific requirements on the market of food wholesalers.
- *IFS Logistics* – is applied both for food and non-food products. It encompasses all logistic actions, such as loading, unloading, storage, distribution and transport. The standard can be applied to all types of transport, ranging from lorries, trains and ships to aeroplanes or any other type of transport (both frozen products and products transported without cooling).
- *IFS PACsecure* – is a safety standard for package systems based on the HACCP system. It was developed in conjunction with the Canadian Food Inspection Agency and a broad spectrum of representatives working in the branch. The aim of the standard is to ensure food safety through guidelines for packaging materials establishing a common, uniform evaluation system ensuring comparability and transparency in the entire supply chain to reduce manufacturers and retailers' costs and time. PACsecure was accepted by the American Food Safety Alliance for Packaging (FSAP), which associates organisations such as: General Mills, Kraft, Nestle, Conagra Foods, Unilever, Sara Lee and Campbell Soup.
- *SAI Global* is a world leading standard used for the evaluation of suppliers. The standard is applied to each supplier, regardless of the country of production or origin and it sets the standards for food producing enterprises.
- *BRC Global Standard for Food Safety* – is an international food standard developed by the British Retail Consortium. Like the IFS, the BRC sets requirements concerning the food safety management system for food producers and suppliers and it specifies auditing rules. The system combines the GMP and GHP rules and the HACCP requirements with elements of the management system. A BRC certified system is a requirement to supply products to British international retail chains.

To sum up the above considerations concerning the specific character of AFSCs/agricultural enterprises, we should make a reference to the definition of logistics. Since the Council of Supply Chain Management Professionals defined logistics[8] in 1998 [14], the differences between individual sectors of the economy and progress in logistics technologies allowing for the specific character of a particular branch have caused the identification of many definitions of logistics, which are adequate to the particular sector. Having overviewed the definitions of logistics for the

[7] The GFSI defines the process where food safety management systems may gain recognition through the GFSI. The Global Food Safety Initiative (GFSI) is managed by the Consumer Goods Forum and it was established in May 2000. It is a non-profit organisation established under Belgian law. It provides knowledge and guidelines concerning food safety management systems, which are necessary for safety in the entire supply chain [20].

[8] **CSCMP's Definition of Logistics Management:** *Logistics (management) is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements*.

agri-food sector presented in selected publications [44, 22, 1, 55, 2, 9, 19, 30, 36, 51, 28, 29], the following definition is suggested:

Agri-Food logistics is an important part of the economy and an integrated system which controls, coordinates and organises different flows of logistics (physical flows of agri-food materials, raw materials and goods, flows of accompanying information, law and finance) ranging from the places of production through points of storage, processing and trade to the final consumer. The aim of agri-food logistics is to provide the final consumer with uninterrupted supplies of safe food and non-food products[9] with minimum logistics costs and under environment-friendly conditions.

In this light, in relation to AFSCs, the classical logistics approach with '7Rs': *right product*, *right quantity*, *right condition*, *right place*, *right time*, *right customer*, *right price* (Coyle et al., 2002) does not exhaust the range and requirements for logistics in agri-food supply chains and should be supplemented with another 'R' - *right environmental responsibility.*

Thus, the modified rule with 8Rs defines eight requirements for procedures concerning the flow of materials, raw materials, animals and agri-food products and it defines appropriate implementation of the essential logistic tasks in AFSCs. It mostly concerns:

- improved control of the processes of product flow and storage and in consequence, it satisfies the material demands of people participating in logistics processes;
- the inclusion of aspects concerning the construction of food supply chains in the development strategy of an enterprise;
- subordination of actions related with logistics processes to the requirements concerning customer service;
- increasing the efficiency of the flow of materials and products to reduce the flow costs and in consequence, to reduce the costs of all logistics processes;
- appropriate organisation of logistics processes so that they can be friendly to the environment (including animals) and so that they can guarantee the supply of safe food products to consumers.

6. CONCLUSIONS

1. The study of reference publications showed the specific traits of food supply chains which should be taken into consideration in the planning of these systems.
2. We can observe an increasing pressure to optimise three aspects of logistics, i.e. costs, time and the environment.
3. In view of the increasing consumers' demand for food quality and safety and for animal welfare and in view of increasing social expectations and legal requirements concerning environmental protection, we can expect that the LSR concept will continue to develop, especially in food supply chains.
4. There will be progressing concentration of farms, processing plants and wholesalers so as to reduce their number and simultaneously, to increase their size.
5. These phenomena will favour greater integration within the chain and they will help to build partner relationships between all links.
6. In order to guarantee that agri-food supply chains can compete successfully it will be necessary to implement systems certifying the quality of supplied raw materials and products and the methods of their delivery.
7. The article proposed the definition of agri-food logistics which allows for recommendations of the LSR concept.
8. It is postulated that the classic approach to logistics should be extended with the issue of due responsibility for environmental protection (7Rs →8Rs).

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