SUSTAINABLE AGRI-FOOD SUPPLY CHAINS

CONTEMPORARY AND NEW CHALLENGES IN LOGISTICS TERMS

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Preface

One of the overarching objectives of the functioning of food supply chains, both nationally and globally, is to achieve sustainability. This is done by guaranteeing food security in terms of quantity and quality at national level while reducing adverse environmental impacts. In conditions of uncertainty caused by a number of factors (including random events such as the coronavirus pandemic or armed conflict), it becomes difficult, if not impossible, to meet the above assumptions. In addition to random factors, the future functioning of food supply chains will be affected in the coming years by increased environmental volatility resulting from growing social (migrations), economic (global shifts in economic power) and climatic (global warming) problems.

Recent events related to the COVID-19 pandemic, and the war in Ukraine, are leaving a lasting mark on supply chains, changing previous logistical paradigms. As a threat from outside the economic system, COVID-19 instantly transformed global supply chains: in addition to other issues, it became more difficult to transport, monitor and control products between different locations around the world. In turn, the war in Ukraine, one of the world's largest cereal producers, has dramatically reduced the supply of cereals in global markets. As a result, cereal supply chains (especially those destined to Africa) have been disrupted, causing significant shortages of these products. Also, from an economic perspective, this resulted in skyrocketing prices of raw cereals on global commodity exchanges.

Faced with temporary food shortages, consumers are beginning to appreciate what is local: accessible, safer, proven and tested. They are also changing their shopping habits, especially in terms of how they shop and what type of products they put in their basket. These changes are manifested by an increase in online sales and by the consumers buying more but less frequently. However, irrational shopping and increased food wastage are becoming a negative effect of these developments.

In view of these issues, and having in mind that policymakers can influence the regulatory environment, the first Chapter presents the link between the EU Green Deal policies and innovation in agribusiness. Innovation activities have implications all along the agricultural food supply chain. Environmental safety and food safety regulations are important for innovation in agribusiness; while adjusting these policies will be challenging, it is an important enabler of Green Deal objectives.

The next Chapter is about the Fair Trade movement which emphasizes the importance of responsible consumption because of the consequences it has for producers, the environment and the society. The Chapter identifies grounds for changes and checks the way they are determined by consumer attitudes and informed decisions to buy Fair Trade products.

The third Chapter presents a case study of the local production chain of '*Anadara tuberculosa*' shellfish, involving three links: shellfish gatherers, wholesalers and retailers, as well as restaurants, cevicherías, cocktail bars and the like. The Chapter concludes with recommendations that can improve sustainability, competitiveness and potential for production and commercialization in the international market.

The fourth Chapter presents the particularities of maritime transport of agricultural machinery and equipment as a link in the whole logistics supply chain of food. It presents the most widespread and most important principles for transporting machinery as containerized cargo.

Another key aspect for the sustainable development of supply chains is the proper education of human resources for the transport, forwarding and logistics (TFL) sector. The Chapter presents how human resources training evolves in response to advances in technology, IT and robotics and to environmental requirements.

The last Chapter indicates the role and place of logistics in the implementation of strategic sustainable development goals of an agricultural enterprise. Furthermore, it presents the author's methodological proposals for measuring the sustainability of logistics in agricultural businesses. As the next step, it evaluates the efficiency of transport processes in agricultural enterprises from the perspective of CO_2 emissions. A definition of agri-food logistics is also put forward based on LSR concept and on a new approach which proposes that the classical model of logistics be extended with one more aspect, the right environmental responsibility (7R → 8R).

Karol Wajszczuk
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Chapter I

Innovation in agribusiness: the European Green Deal and agriculture food supply chains

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Abstract
Innovation in the agribusiness sector depends on the irreversibility effect. The irreversibility effect depends strongly on the regulatory environment. Innovation in agribusiness will be important for achieving the objectives of the European Green Deal. Policy makers can influence the regulatory environment. This contribution shows the link between the EU Green Deal policies and innovation in agribusiness. The innovation activity has implications along the whole agriculture food supply chain. Thus, regulatory polices affect the whole supply chain as well. For innovation in agribusiness important regulatory policies are environmental safety and food safety regulations. Adjusting these policies will be a challenge, but important for achieving the Green Deal objectives.
Keywords: agribusiness, EU policy, innovation, irreversibility, supply chains, uncertainty
JEL: K, O, Q

Introduction

OECD countries have experienced substantial growth in the agribusiness sector since the Second World War. Similar developments were observed in China and other Eastern Asian countries when they started to open up their economies in the 1980s and 1990s, as well as in Africa and Latin America (Barrett et al., 2019). The development of the agribusiness sector was more successful in some countries than in others. This success was mainly driven by political factors that determined the extent to which the adoption of innovations was supported. Innovation is understood here as a new idea that can but does not necessarily result in something new, such as a new production method, a new product, a new business strategy, or a new way of organizing production.

The historical perspective tells us that political or institutional factors, in general, are important for the adoption of innovations, an important driver of eco-

nomic growth. This importance is underlined by the quest for sustainable development, where development (and not growth) has become important, while sustainable development does not exclude growth but includes a wider perspective that considers opportunity costs (Arrow et al., 2004).

The adoption of innovations assumes the availability of innovations. Innovations need to be generated to become available. The generation of innovations in the agribusiness sector is the focus of this chapter. This sector is understood as a sector that converts biological resources into products that serve human needs. This includes the whole supply chain, from primary production to final consumption, including forward and backward links with other sectors of the economy. There are no sharp boundaries within the sector. Depending on the question being asked, the focus can be on one part of the sector, such as farms in general or dairy farms in particular, food processors, food retailers, food consumers, organizational structures, business models, and more.

In this contribution, I do not present new empirical evidence or new descriptive statistics, but I do refer to them where they help illustrate my argument. Therefore, the aim of the chapter is to show the links between innovation in agribusiness and the European Union (EU) policies under the Green Deal. These policies have a strong impact on the agriculture and food sectors. As I will argue, achieving the objectives of the Green Deal requires innovation in agribusiness. The chapter is organized as follows. In the next section, I discuss the importance of uncertainty and irreversibility in innovation. In the third section, I link innovation in agribusiness with Green Deal policies. I conclude by discussing the research agenda emerging from the Green Deal for innovation in agribusiness.

Importance of uncertainty and irreversibility for innovation in agribusiness

An innovation is something that is new. Something that did not exist before. An innovation not only has to be new; it also has to be successful. It has to be better than what was there before. It not only has to be better; it has to be better for many. This "better for many" brings in the element of uncertainty. I might consider an idea to improve on what is already there, but others might or might not share this view. This is not a problem if all the costs I face in developing my new idea are completely reversible (i.e., I do not lose anything). A case in which all investments made are completely reversible is difficult to imagine. If time has opportunity costs, it is difficult to imagine how the time I spent developing an idea into an innovation can be reversible. This may apply to other resources. Arrow and Fisher (1974) introduced the

concept of quasi-option value into the literature. The example they used to illustrate quasi-option value was the conversion of a nature reserve into an area for development. Before the area is developed, there is uncertainty as to what extent the development will be successful. Another uncertainty is related to the preservation value of nature preserves. This uncertainty might change over time. If the nature preserve is converted into a development area, and it later turns out, for example, that not enough people are willing to buy houses, it would have been better to further preserve the nature preserve; converting the area back to its initial state is impossible. The area can be renatured, but not at zero cost, and not to its exact original state. Thus, developing the area has costs that can be considered irreversible. These costs weigh more than reversible costs if new information about the opportunity costs of development is expected to become available over time, uncertainty resolves, and decision makers can be flexible about the timing of the decision. This is basically always the case. Or, to put it differently, it is difficult to imagine a situation in which new information does not become available, and all costs are reversible. The higher weight of irreversible costs in comparison to reversible costs has been called the irreversibility effect in the literature.

The approach presented by Arrow and Fisher is similar to the one derived from the evaluation of financial options, the real option approach (see e.g. Dixit and Pindyck, 1994 or Trigeorgis, 1996). Linking this approach to innovations in agribusiness, the decision is not to innovate now or never but to innovate now or at a later point when more information becomes available. The trade-off is that while waiting for more information, benefits might be foregone (Wesseler and Zhao, 2019).

The irreversibility effect can explain a number of behaviors toward innovation in agribusiness. Commodity price uncertainty can be reduced by using forward contracts. Vertical integration in the supply chain has a similar effect. In particular, where the prices for new products are difficult to secure via forward contracts in the stock market, vertical integration via contracts with buyers can reduce uncertainty and increase incentives to innovate. Other examples include horizontal and vertical licensing agreements and leasing contracts. The irreversibility effect also gives rise to the hold-up problem. If contracts with buyers have been signed, and engaging in the contract requires substantial irreversible investments, the buyer may at a later stage reduce the price knowing that the supplier has almost no choice other than to comply to at least cover the fixed costs. Cases have been reported for contracts with retailers. For retailers, such behavior comes at reputational costs, with potential damage in the longer run (Karantininis et al., 2010).

Policies can also have a strong effect on incentives to innovate. Many of the innovations in the agribusiness sector are regulated for food and environmental safety. They often include costs for receiving approval for introducing new prod-

ucts. These approval costs can be considered irreversible (Wesseler et al., 2022). They include not only the direct costs for generating the information approval but also the time length of the approval process. Each additional month or year delay in approval time delays market entry. Approval policies can also differ by jurisdiction and either increase or decrease the size of the market. Studies have shown that the irreversibility effect of approval polices can be substantial (Wesseler et al., 2022). Approval must not only be seen as a cost. Approval of new products also provides a positive signal. The product complies with requirements, and in the case of safety assessments, it can be considered safe. This often reduces the costs of ex-post liability in case safety issues arise. The regulator and the agribusiness sector both face the problem of the right balance between ex-ante safety regulation and ex-post liability. Depending on the agribusiness company position in the market, some prefer more stringent regulations for innovation to keep competition out, while others might prefer less stringent regulations to keep the costs of innovation low. Wesseler et al. (2019) reported on the results of a survey of the Dutch seed industry in response to the judgment of the Court of Justice of the EU, in which the differences in assessment of the ruling depended on the position of the seed company in the market.

In general, one can think of modeling incentives to innovate by considering four stages: 1) research and development, 2) approval, 3) market, and 4) ex-post liability. All of these stages are characterized by uncertainty in costs and benefits and differences in time length, where the length of the different stages and related costs may overlap. A large share of the research and development costs and of the approval costs can also be considered irreversible. The research and development or improvement of a food product may take some time. Although this phase has not been completed, a company may start the approval process. While the approval process has not been completed under certain conditions, companies may have the right to sell their products under certain conditions, such as emergency authorization for plant protection products in the EU (European Commission [EC], 2021).

As several authors have pointed out (Boehlje et al., 2011), the agribusiness sector is characterized by complex supply chains, where the upstream sector includes many small and medium-sized actors (many small and medium-sized farms), while further down the supply chain, the number of actors decreases substantially to a few retailers dominating the market. This structure causes difficulties for innovations that rely on tracking and tracing products along supply chains from the retailer back to the producer, such as for organic-labeled products (ibid.). This increases the difficulties for innovations requiring such mechanisms.

In the historical context, one might be tempted to conclude that competition in the agribusiness sector has decreased over time as the number of food proces-

sors and retailers has declined. One might also conclude that this has increased downstream market power. A study by Acemoglu and Azar (2020) showed how innovation via network effects supports sustained economic growth. Their empirical evidence for the United States shows that the number of suppliers for inputs has increased over time. Supply chains have become more complex. Companies can choose from a wider range of input materials and input suppliers than they could in the 1960s. This suggests that competition has increased. This is also reflected in the sharp decline in the farm share of consumer expenditures on food in the United States (Barrett et al., 2019). The vertical organization of agriculture and food production has increased with economic growth, and agriculture and food supply chains have become longer measured by the number of agents involved. Moreover, the value added has moved along the supply chain and has to be shared by more than one agent. Relatively less value added remains on the farm and more with downstream agribusiness that operates beyond the farm.

Innovation in agribusiness and the EU Green Deal

The European Green Deal is a major policy objective of the van der Leyen Commission of the EU. The Green Deal includes a number of strategies for achieving its objectives. For the agribusiness sector, the farm-to-fork strategy and the biodiversity strategy are the most important, as they directly impact agricultural production. Nevertheless, other strategies also directly or indirectly impact the agribusiness sector. Table 1 lists some of the strategies and the specific objectives/interventions and implications for innovation.

Table 1. EU Green Deal policies and their opportunities and threads for agribusiness

Policy/Strategy	Interventions/Objectives	Agribusiness opportunity	Agribusiness thread
EU Green Deal Policy	No net emissions of greenhouse gases by 2050	Innovations reducing greenhouse gas emissions receive additional support. The Green Deal supports agribusiness in the bioeconomy. Alternatives to animal-derived products increase in comparative advantage.	Agribusiness emitting greenhouse gases face higher costs for compensating emissions. Comparative advantage of foreign competitors might increase, depending on the effectiveness of carbon border adjustment mechanisms.
	EU's climate, energy, transportation, and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.		

Table 1. Condt

Farm-to-fork Strategy	At least 25% of agricultural land is under organic farming management, and the uptake of agro-ecological practices is significantly increased.	Supports policies at the member state level for organic agriculture. Supports organic agriculture in general.	Decline in the prices for organic products via an increase in quantity.
	The risk and use of chemical pesticides are reduced by 50%.	Supports agribusiness developing non-chemical plant protection products such as biological control mechanisms. Supports organic agriculture.	Fewer opportunities for agribusiness involved in developing, producing, and trading chemical pesticides.
	The use of more hazardous pesticides is reduced by 50%.		
	The loss of nutrients from fertilizers is reduced by 50%, resulting in reduction in the use of fertilizers by at least 20%.	Supports agribusiness developing organic fertilizing compounds. Supports organic agriculture.	Fewer opportunities for agribusiness involved in the development of inorganic fertilizer.
	The overall EU sales of antimicrobials for farmed animals and in aquaculture are reduced by 50% by 2030.	Support agribusiness developing disease-resistant animals, animal health improving animal husbandry methods, and raising farm animals according to the organic standards.	Feed companies using antimicrobials in their supplies have to change their feed compounds. Agribusiness trading antimicrobials lose market share.
	Per-capita food waste at retail and consumer levels is halved by 2030.	Supports agribusiness developing waste reducing solutions. Supports just-in-time delivery models and food packaging companies.	Fresh food sector have to adjust their business models to reduce waste.

Farm-to-fork Strategy	At least 10% of agricultural area is under high-diversity landscape features.	Agribusiness developing eco-friendly solutions. Supports organic agriculture.	Agribusiness involved in maize production may face a decrease for their markets. Decline in areas for the use of chemical pesticides.
Biodiversity Strategy	By 2030, significant areas of degraded and carbon-rich ecosystems are restored; habitats and species show no deterioration in conservation trends and status.		
	At least 30% of degraded and carbon-rich ecosystems reach favorable conservation status or at least show a positive trend.		
Green Deal related: Rules for companies to respect human rights and environment in global value chains	All EU limited liability companies of substantial size and economic power (with 500+ employees and EUR 150 million+ in net turnover worldwide) must have a plan to ensure that their business strategy is compatible with limiting global warming to 1.5 °C, in line with the Paris Agreement.	Small companies are exempted, and their relative competitiveness can increase.	Large companies may have to change their mode of production, resulting in a cost increase. Foreign companies' comparative advantage may increase depending on the effectiveness of carbon border adjustment mechanisms.

Source: European Commission (2019a; 2019b; 2022).

These strategies affect the entire agriculture and food supply chain. This, for example, is illustrated by the requirements for reducing pesticide and fertilizer use as part of the farm-to-fork strategy, as well as the objective of reaching at least 25% of agricultural land under organic farming management. Important questions that arise out of the farm-to-fork and biodiversity strategies are to what extent this will affect the agriculture and food supply chains and related innovations.

All four models mentioned in Box 1 are affected by the Green Deal. The important question is to what extent the Green Deal policies contribute to the overall objective of reducing greenhouse gas emissions to 25% of the 1990 levels by 2030 and carbon neutrality by 2050. From the listed objectives and interventions, it is evident that changes in agribusiness will be necessary to achieve the Green Deal objectives. These changes not only require new ideas. New ideas must be translated into innovations that reach the market and are widely implemented.

Box 1. Agriculture and food supply chains

One view is that these chains start from agricultural production by processing agricultural products into food products sold to consumers via retailers. Another view of agriculture and food supply chains includes upstream sectors, such as those that produce inputs for the agricultural sector. Examples are the seed, pesticide, and fertilizer industry, the plant and animal breeding sector, and similar industries. A third view also includes the research and development sector and its contributions to agriculture and food production. A fourth view includes considering circularity in the agriculture and food supply chains, where some of the byproducts that originate from agricultural production and food processing are fed back into the production process. An example is the use of straw to generate biofuels or bioenergy. Other examples include the use of manure for bioenergy production and/or conversion into fertilizing products. A big difference is that the first three are linked to what has been called linear models, while the last example relates to circular models.

One possibility is to use innovations that have been implemented in one place and transfer them to other places. In the EU, substantial productivity differences exist in agriculture between member states. Reducing the difficulties of technology transfer has the potential to substantially increase food production. In organic agriculture, the standard output per unit of agricultural area in the Netherlands is three to four times above the EU average (Eurostat, 2016). There seems to be a large potential to increase output using existing technologies. Although other EU member states might not be able to achieve the same standard output as in the Netherlands, the huge differences illustrate the potential for innovation in the organic sector. Similar differences have been observed for other forms of agriculture. Often, institutional factors, such as access to land, regulations, or local infrastructure, are limiting factors (Ciaian and Swinnen, 2006; Larsson et al., 2013). While there is the potential to increase the output of organic agriculture, this often comes at the cost of the quantity produced per unit of land in comparison to other forms of agriculture. New developments in biotechnology are seen as one possibility for increasing the productivity of organic agriculture. Innovations by the agribusiness sector in this direction can contribute to increasing the share of land allocated to organic agriculture and reducing the potential decline in output (Purnhagen et al., 2021).

Innovation is not only needed in organic agriculture. In addition, other forms of agriculture must innovate to reach the objectives of the farm-to-fork strategy (see Table 1). Reducing pesticide and fertilizer use is expected to reduce agricultural output in the EU, as several studies have shown, if innovations are not made (Wesseler, 2022). Again, translating new developments in modern biotechnology into innovations by the agribusiness sector that reach the market can provide necessary adjustments. In general, enabling the agribusiness sector to develop the innovations needed can be stimulated by reducing the irreversible costs related

to developing innovations and increasing potential markets. In particular public-private-partnerships have increased in importance for reducing investment costs and stimulating investments for applications using modern biotechnology (Rausser et al., 2021). One of the major difficulties in the EU is adjusting regulatory policies to enable the application of modern biotechnology via public-private-partnerships (Purnhagen, 2019).

Proposals for innovative and regulatory action in agribusiness

Many of the new solutions that can contribute to achieving the objectives of the Green Deal rely on the use of modern biotechnologies. Many of these solutions are regulated by the EU. The level of regulation substantially increases development costs. In particular, the costs that are related to market approval. In the EU, they are relatively high compared to other jurisdictions (Jin et al., 2019). The approval costs not only include the direct costs by the agribusiness sector for generating the data required by the agencies assessing a new technology. Approval costs also include the time length related to approval. The shorter the time length, the earlier the product will enter the market, and the earlier agribusinesses offering the product will be able to generate income. The approval procedures also have an impact on the size of the market that can be reached. Depending on the approval process, agribusinesses might get approval for an individual member state, for some member states, or for the whole of the EU (Purnhagen and Wesseler, 2021). Therefore, the approval process has implications for incentives to invest in the development of new technologies. Unfortunately, as stated, the approval costs in the EU are much higher than the approval costs in other jurisdictions. This generates a disadvantage for the EU in attracting agribusiness investments for solutions that are important to the region.

If we look at the supply chains, including the aspects of circularity, we can observe that the farm-to-fork strategy as well as other European Green Deal strategies strongly support the development of the circular bioeconomy or circularity within agriculture and food supply chains (Kardung et al., 2021). The recycling and processing of byproducts have received substantial policy attention, as well as support for developing markets and solutions. There is also a strong interest in developing business models that support circularity in supply chains. This includes, for example, leasing equipment as well as support for developing organic fertilizing products. Nevertheless, the development of solutions will take many years. However, this provides new opportunities for agribusiness (ibid.).

An important trend in technological innovation is related to the development of alternatives to animal products, such as meat and milk. Alternatives include plant-based products, such as burgers from peas, oat milk, almond milk, and more. An increase in this market, particularly if it is related to substituting meat consumption and thus supporting dietary changes, can have a strong positive impact on sustainable development. The market for these products is strongly increasing, but in absolute numbers, the market share of these food products is still relatively small. The market share for plant based meat was below 1% of the total meat market for Germany measured by turn over in 2020 (Statista, 2022). On the positive side, there seem to be opportunities for the agribusiness sector to substantially increase the market for these products. The market also goes hand in hand with the demand for higher animal welfare standards. This trend is supported by innovative marketing tools directly linking consumers and producers, as well as the rise of home delivery. While this market is increasing, the agribusiness sector faces the challenge of translating the higher costs of complying with tougher environmental standards into higher prices (Venus et al., 2018). The design of the regulations for complying with higher standards and the organization of the supply chain are important driving factors for innovations (Castellari et al., 2018; Ghozzi et al., 2018; Smith et al., 2021).

Discussion and conclusion

Innovation in the agribusiness sector is important for achieving societal objectives. The EU Green Deal is one of the most important examples at the EU level. At the global level, the sustainable development goals and objectives of the United Nations (US) Food System Summit are significant examples (Singh et al., 2021). The innovations generated and the speed with which these innovations reach the market depend on the irreversible costs and uncertainties related to a specific innovation. The irreversible costs and uncertainties depend on the technical specificities of the innovation as well as the institutional environment, including policies. Policies can have a substantial impact on incentives to innovate. The approval costs for innovations to reach the market are an important driver. Policymakers can largely influence these costs via the policy choices made. In the agribusiness sector, food and environmental safety policies are perhaps the most important. Innovations that are very promising include information and communication technologies, such as artificial intelligence, precision agriculture, and block chains. Property rights, such as data ownership and security, deserve attention for securing accessibility and protection. Another very promising innovation

is the progress observed in modern biotechnology. Here, environmental safety and food safety are important. The views on the right level of property rights protection and environmental safety and food safety differ among policymakers, civil society, and the agribusiness sector, and between those groups. Although views also differ among scientists, there is wide consensus that innovations are necessary for achieving different societal objectives and, in particular, those related to food systems transformation. Policies that reduce the irreversible costs of innovation in the agribusiness sector can have a strong stimulus. Policies can also direct innovation. Legal requirements, such as those related to complying with sustainability objectives, can stimulate the agribusiness sector to direct innovations in this direction. Innovation in the agribusiness sector is related not only to technical change, as shown in the two examples above. New business models, including organizational design, are also important innovations. They include increasing the level of circularity in resource use. Examples include licensing and leasing agreements for the use of technologies, such as machinery or biotechnologies. New business models play an important role in renewable energy production and the use of modern biotechnology. Recent events, namely, the COVID-19 pandemic and the war in Ukraine, have highlighted the importance of the agribusiness sector for food and energy security. Long supply chains developed over time are vulnerable to external shocks. Increasing the resilience of the agribusiness sector to these shocks deserves attention. Innovations that increase the flexibility of the agribusiness sector in responding to these shocks deserve attention. Although the sector has its own incentives for developing solutions, the policy sector can also be supported by, for example, simplifying shifting trade via international trade agreements and ensuring diversity among suppliers. Policymakers can also stimulate innovations in agribusiness that shorten supply chains.

This will be a challenge for the European Union. The Green Deal has very ambitious objectives. The reduction in pesticide and fertilizer use without additional innovations in agribusiness is expected to reduce the food supply in the EU. Not only the quantity of food produced but also the variety is expected to decline. Several authors (e.g. Noleppa and Cartsbug, 2021; Smyth and Wesseler, 2021) have pointed out that recent developments in modern biotechnology are important for innovation needed in the agriculture and food sector to attain the objectives of the Green Deal without increasing food and bioenergy prices. Reducing the regulatory hurdles for innovations in animal and plant breeding and the use of microorganisms has high potential for developing solutions that allow us to achieve the Green Deal objectives. There are valid concerns related to the implications this may have for environmental and food safety. These concerns need to be considered. Several authors (Smith et al., 2021) have suggested that

regulatory hurdles can be reduced without reducing the level of safety. Examples include harmonizing safety assessments that increase the market for innovation and reducing time delays that do not contribute to increased safety.

Although I have stressed the importance of regulatory policies for agribusiness incentives to innovate driven by their strong impacts on the irreversibility effect, there are still a number of open questions. Acemoglu and Azar's (2020) contribution to endogenous production networks predicts endogenous growth via horizontal and vertical spread of technical change. They assessed endogenous production networks for the United States at a relatively high level of aggregation. Investigating this for different sectors, and, in particular, for the agribusiness sector across countries, can provide important insights into how fast and wide innovations spread within an economy. The authors included distortions caused by regulations, taxes, and more. A more detailed treatment of regulations, such as those facing the agribusiness sector, might provide more detailed insights into their impact on endogenous growth, as well as if the agribusiness sector is impacted differently from other sectors and if within the agribusiness sector differences exist and what might cause these differences. This requires a more detailed data set than the one Acemoglu and Azar used for their study. The improvement in data availability should allow us to conduct more differentiated assessments. More detailed empirical studies on the impact of the irreversibility effect on incentives to innovate in the agribusiness sector are rare. In particular, studies that allow comparison of the effects are lacking. The methodology for conducting such studies from the theoretical as well as empirical perspective is only starting to emerge. More research in this direction will be promising, as this will allow us to get better insights into the effects of agriculture policies and Green Deal – related policies in particular on sustainable development. The transformation of the food system toward a higher level of sustainability has been emphasized not only by the European Commission but also by the UN at the Food System Summit. Thus, research on stimulating innovation in the agribusiness sector will not only deepen our scientific knowledge but may also provide important insights for policy.

References

Acemoglu, D., Azar, P.D. (2021). Endogenous production networks. Econometrica 88(1), 33–82.

Arrow, K.J., Fisher, A. (1974). Environmental preservation, uncertainty and irreversibility. Quar. J. Econ., 88(2), 312–319.

Arrow, K.J., Dasgupta, P., Goulder, L.H., Mumford, K.J., Oleson, K. (2012). Sustainability and the measurement of wealth. Env. Dev. Econ., 17(3), 317–353.

Barrett, C.B., Reardon, T., Swinnen, J., Zilberman, D. (2019). Structural transformation and economic development: insights from the agri-food value chain revolution. Working paper, Dyson School of Applied Economics and Management, Cornell University.
Boehlje, M., Roucan-Kaneb, M., Bröring, S. (2011). Future agribusiness challenges: strategic uncertainty, innovation and structural change. Int. Food Agribus. Manag. Rev., 14(5), 53–82.
Castellari, E., Soregaroli, C., Venus, T., Wesseler, J. (2018). Food processor and retailer non-GMO standards in the US and EU and the driving role of regulations. Food Policy, 78, 26–37. https://doi.org/10.1016/j.foodpol.2018.02.010.
Ciaian, P., Swinnen, J.F.M. (2006). Land market imperfections and agricultural policy impacts in the new EU member states: a partial equilibrium analysis. Am. J. Agricult. Econ., 88(4), 799–815.
Dixit, A.K., Pindyck, R.S. (1994). Investment under uncertainty. Princeton: Princeton University Press.
European Commission (2020a). A farm-to-fork strategy for a fair, healthy and environmentally-friendly food system. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020)381. Brussels: EC.
European Commission (2020b). EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020)380. Brussels: EC.
European Commission (2021). Guidance on Emergency Authorisations According to Article 53 of Regulation (EC) No 1107/2009. SANCO/10087/2013 rev. 1. Brussels: EC.
European Commission (2022). Proposal for a Directive of the European Parliament and of the Council on Corporate Sustainability Due Diligence and Amending Directive (EU) 2019/1937. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2022)71 final. Brussels: EC.
Eurostat (2016). Farm structure survey. Available at: https://ec.europa.eu/eurostat/web/microdata/farm-structure-survey#:~:text=In%20the%202016%20farm%20structure,between%20250%20and%20400%20variables.
Ghozzi, H., Platoni, S., Tillie, P., Soregaroli, C. (2018). TCE determinants and governance forms in the EU "Non-GMO" Soybean Supply Chain. Food Policy, 78: 68–80.
Jin, Y., Drabik, D., Heerink, N., Wesseler, J. (2019). Getting an imported GM Crop approved in China. Trends in Biotech. 37(6), 566–569. https://doi.org/10.1016/j.tibtech.2019.02.004.
Kardung, M., Cingiz, K., Costenoble, O., Delahaye, R., Heijman, W., …, Zhu B.X.(2021). Development of the circular bioeconomy: drivers and indicators. Sustainability 13(1), 413. https://doi.org/10.3390/su13010413.
Karantininis, K., Sauer, J., Furtan, W.H. (2010). Innovation and integration in the agri-food industry. Food Policy 35(2): 112–120. https://doi.org/10.1016/j.foodpol.2009.10.003.
Larsson, M., Morin, L., Hahn, T., Sandahl, J. (2013). Institutional barriers to organic farming in central and eastern European countries of the Baltic Sea Region. Agricult. Food Econ., 1, 5. https://doi.org/10.1186/2193-7532-1-5.
Noleppa, S., Cartsburg, M. (2021). The socio-economic and environmental values of plant breeding in the EU and for selected EU member states. Berlin: HFFA Research GmbH.
Purnhagen, K.P. (2019). How to manage the Union's diversity: the regulation of new plant breeding technologies in Confédération Paysanne and others. Common Mark. Law Rev., 56, 1379–1396.

Purnhagen, K.P., Clemens, S., Eriksson, D., Fresco, L.O., Tosun, J. …, Zilberman, D. (2021). Biotechnology and organic farming: conflicting or complementary goals? Trends in Plant Sci., 26(6), 600–606.
Purnhagen, K.P., Wesseler, J. (2021). EU Regulation of new plant breeding technologies and their possible economic implications for the EU and beyond. Appl. Econ. Perspect. Policy, 43(4), 1621–1637.
Rausser, G., Foster, W., Zilberman, D. (2021). The search for smart governance in agriculture and natural resources. Appl. Econ. Perspect. Policy, Forthcoming, Available at SSRN: https://ssrn.com/abstract=3890476 or http://dx.doi.org/10.2139/ssrn.3890476.
Singh, B.K., Arnold, T., Biermayr-Jenzano, P., Broerse, J., Brunori, G.…, Wesseler, J.(2021). Enhancing science-policy interfaces for food systems transformation. Nature Food, 2, 838–842. https://doi.org/10.1038/s43016-021-00406-6.
Smith, V., Wesseler, J., Zilberman, D.(2021). New plant breeding technologies: an assessment of the political economy of the regulatory environment and implications for sustainability. Sustainability, 13(7), 3687. https://doi.org/10.3390/su13073687.
Statista (2022). Fleischersatz auf dem Vormarsch. Available at: https://de.statista.com/infografik/26536/geschaetzter-umsatz-mit-fleischersatzprodukten-im-dach-raum/.
Trigeorgis, L. (1996). Real options: managerial flexibility and strategy in resource allocation. Cambridge: MIT Press.
Venus, T., Drabik, D., Wesseler, J. (2018). The role of a German multi-stakeholder standard for livestock products derived from non-GMO Feed. Food Policy, 78, 58–67. https://doi.org/10.1016/j.foodpol.2018.02.009.
Wesseler, J., Politiek, H., Zilberman, D. (2019). The economics of regulating new plant breeding technologies – implications for the bioeconomy illustrated by a survey among dutch plant breeders. Frontiers in Plant Sci., 10: 1597. https://doi.org/10.3389/fpls.2019.01597.
Wesseler, J. (2022). The EU's F2F Strategy – an assessment from the perspectives of agricultural economics. Appl. Econ. Perspect. Policy. https://doi.org/10.1002/aepp.13239.
Wesseler, J., Kleter G., Meulenbroek, M., Purnhagen, K. (2022). EU regulation of genetically modified microorganisms in light of new policy developments: possible implications for the EU bioeconomy. Appl. Econ. Perspect. Policy. https://doi.org/10.1002/aepp.13259.
Wesseler, J., Zhao J. (2019). Real Options and Environmental Policies – the Good, the Bad, and the Ugly. Annu. Rev. Res. Econ., 11, 43–58.

Chapter II

Local action, global thinking and the Fair Trade movement

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Abstract
The Fair Trade movement emerged in contradiction to a traditional approach to economic considerations dominated by classical and neoclassical schools. Fair Trade places emphasis on responsible consumption because of the consequences it has for the producers, the environment and the society. The purpose of this chapter is to identify grounds for changes and see how they are determined by attitudes of consumers who make informed decisions to buy Fair Trade. The values meets the postulates of sustainable development concept, which call for thinking of global consequences of local actions (*act locally, think globally*). The market analyses carried out in this paper suggests that demand for Fair Trade products can be expected to continue to rapidly grow in the next years as an accompanying process to economic growth. Moreover, contrary to the initial meaning of the movement to the countries of the South, continued growth in global demand can be generated by new players of the worldwide market in both the North and the South. This is accompanied by economic growth of the South being much faster than in developed countries and by sustainable development goals being strongly promoted in political programs of the global society. The new responsible consumption patterns are also seeping faster into the consciousness of those consumers who emulate the consumption patterns and lifestyles of developed countries.
Keywords: Fair Trade movement, sustainable development, Fair Trade market, Fair Trade consumers
JEL: F13, F63, Q01

Introduction

The Fair Trade movement emerged in contradiction to a traditional approach to economic considerations dominated by theoretical assumptions of classical and neoclassical schools. Seemingly, their underpinning ideas did not consider morality to be part of economic analyses because the assumption was made that the market makes an optimum allocation of resources when the consumers and the producers maximize their own selfish interests. However, the foundations of these assumptions are laid down by a common acceptance of individualist ethical systems and utilitarianism—the prevailing concepts of the British culture at the

time of consecutive industrial revolutions (Pieńkowski, 2013). It can therefore be only concluded that when it comes to economic activity, Fair Trade breaks with those generally accepted criteria for assessing market behaviors and with institutions supporting individualist ethical systems. Instead, it places emphasis on responsible consumption because of the consequences it has for the producers, the environment and the society. As another key aspect, Fair Trade does not reject free-market trade mechanisms but only identifies other grounds for decision making both at consumer and producer levels. Hence, Fair Trade is consistent with sustainable development principles as it shows the global impact of day-to-day local actions and the role of responsible consumption in sustainable development from a "global village" perspective.

The liberalization of economic activity (including trade), an idea advocated by classical economists, was accompanied by a general belief that free trade is the most efficient and fair mechanism of resource distribution based on mutual benefits to all parties. However, in practice, it faces two kinds of restrictions used in this scenario. On the one hand, without directly challenging the classical concepts, free trade involves a number of imperfections that neoclassical economists converted into formal assumptions or conditions for trade efficiency. As a consequence, in order for trade to be efficient, a number of difficult conditions must be met, such as the infinite number of producers and consumers which prevents single market players from having an impact on prices; the freedom of entry to and exit from the market; complete information; and homogeneity of products offered (Pieńkowski, 2013). Nicholls and Opal (2005) extend the above list with a few political and economic instruments which in practice supported trade imbalance to the advantage of developed countries. This includes access to loans; the inability to freely transform one's production business to seek other, more beneficial market activities; and legal systems which poorly protect the employees and local communities. On the other hand, the fact itself (which lays the foundations for these theoretical considerations) that trade is based on mutual benefits to all parties does not make it a fair activity. In other words, from the perspective of both fairness and efficiency, a situation where one party earns several times more than the other one can give rise to doubts. These are the very problems taken into account when considering trade between developing and developed countries.

The purpose of this chapter is to identify grounds for changes and see how they are determined by attitudes of consumers who make informed decisions to buy Fair Trade. There is sharp growth in demand for Fair Trade products; in countries such as Switzerland, the market for these goods represents a large share in the total product range of all producers. According a to a number of analyses, this is the consequence of growing household incomes. However, what also matters is the

considerable increase in consumer awareness and new trends which break with a classical approach to consumer behavior based on individualist ethics.

As an important factor in shaping new trends for responsible consumption (which are consistent with the Fair Trend movement), the sustainable development concept – based on adopting a global perspective in assessing local behaviors – has become a generally accepted part of political considerations (Kefalas, 1998). The values accompanying the development of the Fair Trade movement are a good illustration for the now-widespread motto which calls for thinking of global consequences of local actions (*act locally, think globally*). Daily consumer choices are believed to carry axiomatic attributes which are not pleasure and pain (in accordance with utilitarian moral criteria) but good and evil acts towards other communities living thousands miles away or towards the natural environment and climate change which are the common responsibility of humans. That concept also involves new management forms where producers' and consumers' interests are longer viewed solely from an antagonistic and individual perspective (Belk et al. eds., 2019) and calls for changing consumption and production patterns due to social and environmental consequences of today's lifestyle for a modern global society (Fairtrade International, n.d.-c; Pieńkowski et al., 2018).

Therefore, the following section will present the grounds for the emergence of the Fair Trade movement and the basic assumptions that underpin it from a perspective of sustainable development requirements. Next it will be presented the institutionalized forms of trade regulations in light of values that accompany the Fair Trade movement. Finally, there is indicated the market for Fair Trade products and the trends followed by consumer purchases. The chapter concludes with a summary of key topics addressed in it, and shows the potential vectors of change in developing responsible consumption.

Genesis of the Fair Trade concept from a perspective of sustainable development requirements

Fair Trade results from a bottom-up social movement believed to be inspired by the activity of Christian charitable organizations, by the emergence of cooperatives and by the formation of consumer movements. These considerations are based on economic morality and consumers' responsibility for their decisions from the perspective of how they affect producer behaviors (Nicholls and Opal, 2005).

Anderson (2015) sees the foundation of the Fair Trade movement in works by Thompson (1971) on the politicization of consumption and of consumer obligations from the perspective of England in the 1700s, and in Ruskin's papers (1862)

criticizing the industrial transformation and market trade. Ruskin claimed that the then-existing conditions for production and market trade failed to reflect the true value of goods offered and of the labor involved in their manufacturing, and therefore were breaking the relationship between the consumer and the producer. Supplementing the above considerations, the concepts of the cooperative movement were initially developed in England by Owen. In early 1800s, they provided an answer to these problems and an attempt to cut through these antagonistic, separated interests of consumers and producers (Anderson, 2015). Although seen as idealistic and utopian, Owen's views are in practice a foundation for and a good example of how to develop the cooperative movement and corporate responsibility.

The first activities which directly refer to modern Fair Trade principles can be found in the suggestions and actions of Christian movements witnessed in late 1700s / early 1800s. They called the consumers to boycott products made in developed countries with the use of slave labor. Market practices promoted by NGOs after the end of World War II became key in forming the modern Fair Trade movement. A particular role in this respect was played by *Oxfam*, a British charity organization which imported artisanal products from Eastern European countries to support the recovery of their economies. Similar practices could be observed in the activity of *SelfHelp Crafts of the World* (currently called *Ten Thousand Villages*), a U.S.-based organization which imported goods from Puerto Rico (Anderson, 2015).

Later on, the first British (*Tradecraft*) and German (*Gepa*) enterprises became interested in trading directly with producers with no intermediaries who had a considerable downward impact on prices obtained by producers in international trade arrangements. Note that their intent was not only to shorten the supply chain and get lower retail prices but also to support and develop the local communities. In a similar vein, a large number of cooperatives emerged in developed countries (U.S. and UK) to reinforce trade with developing countries, whereas the Fair Trade movement itself started to attract interest not only from such alternative trade organizations but also from politicians and scientists. The social debate on fair trade and economic relationships between developing and developed countries became a topic of theoretical considerations that accompany the consumption paradigm shift away from classical and neoclassical schools. Also, these changes were consistent with the sustainable development concept as they extended the initial charity framework with an environmental dimension and a global perspective for the development of a modern society (Anderson, 2015, 2018; Fairtrade Foundation, 2020; WFTO and FI, 2018).

The problem behind the imperfection of liberalized international trade consists in an uneven distribution of information on and control over the trade pro-

cess. From a market perspective, this is referred to as the *bottleneck* (Slob, 2006; WFTO and FI, 2018). On the one side, there is a large number of small raw material producers based in developed countries; on the other, there is an even greater number of consumers in developing countries. Between them, there are several global corporations that control most trade flows and the production based on raw materials offered in developed countries. These uneven trade conditions are underpinned by specific development conditions of local communities who undertake production activities in developing countries which deliver goods manufactured by numerous small farms and factories. As a consequence, prices obtained in such trade flows often fail to satisfy the basic needs of producers in developing countries while allowing international corporations to generate incommensurable profits derived from products sourced from these very producers.

Hence, having regained their independence after long years of colonization, many developing countries continue to be economically dependent. This leads to aggravated poverty, political destabilization and environmental degradation. In such cases, trade liberalization is not accompanied by development processes as defined by sustainable development requirements.

List (1909), a representative of the German national historical school who largely contributed to the development economics, placed strong emphasis on issues related to trade liberalization from a perspective of fair and efficient international trade (Pieńkowski, 2009). The key issue addressed by List was the economic development gap between trade partners and the liberalization of trade called for by British representatives of classical schools. According to List, less economically developed and politically unstable countries are not an equal trade partner. Thus, trade liberalization will only be beneficial to countries at highest development levels, pushing less developed countries further into poverty. Trading with developed countries is a perfect example that corroborates List's analyses from a perspective of today's conditions for the relationships between developed and developing countries. As a matter of fact, List himself never denied the benefits derived from trade liberalization. Instead, he only indicated that such trade flows boost the economic efficiency and development of both parties provided that each of them is at a similar level of economic development.

From a global perspective, the sustainable development concept provides a modern theoretical and political framework for the formation of fair and efficient trade patterns. Already in the Preamble, the International Fair Trade Charter (WFTO and FI, 2018) states that focus needs to be placed at fairness, equality and sustainable development. The definition of sustainable development is embedded in that of Fair Trade, as proposed in 2001, which views it as a trade partnership "*based on dialog, transparency and respect, that seeks greater equity in international*

trade. It contributes to sustainable development by offering better trading conditions to, and securing the rights of, marginalized producers and workers—especially in the South. Fair Trade Organizations, backed by consumers, are engaged actively in supporting producers, awareness raising and in campaigning for changes in the rules and practice of conventional international trade" (Milczarek, 2016, p. 129).

The *Fair Trade and Ethical Fashion* report (Fairtrade Foundation, 2020) presented at the completion of a project implemented from 2017 to 2020 indicates the relationships between the Fair Trade movement and the *Sustainable Development Goals* (United Nations, 2017). Specifically, this includes fighting poverty and taking measures to ensure gender equality, decent work and sustainable consumption. These actions are directly called for in 8 out of the total of 17 sustainable development goals (Fairtrade International, n.d.-d). The objectives identified in the project refer, respectively, to: fighting poverty (1) and famine (2), good health and life quality (3), gender equality (5), clean water and sanitation (6), economic growth and decent work (10), less inequalities (11) and responsible consumption and production (12). However, a direct reference to these selected goals in that project does not mean the Fair Trade movement does not contribute to meeting a number of other objectives such as climate action (13), clean and available energy (7) and terrestrial and aquatic life (15 and 14).

The abovementioned Charter points out to several essential goals related to the activity of the Fair Trade organization (WFTO and FI, 2018):

- inclusive economic growth,
- decent work and increase in wages and incomes,
- strengthening the rights of women,
- food security,
- protecting children's rights and investing in future generations,
- development of local communities,
- support for biodiversity and environment,
- involvement of citizens in the creation of a fair world,
- impacting the business and government policy to make Fair Trade values widespread.

In practice, these measures are implemented in two essential areas of the supply chain (consumers and producers), enabling the achievement of the following (Auroi, 2003):

1. Producers:
   - ensuring higher prices for goods and services offered,
   - avoiding intermediaries,
   - financial support for production activities,
   - establishment of diverse forms of producer collaboration based on demo-

cratic principles,
- involvement of women in decision-making processes,
- responsible management,
- creation of social and investment funds,
- support for environmentally-friendly and qualitative production standards.

2. Consumers:
- greater transparency of transformation procedures,
- awareness of socioeconomic differences between the *poor South* and the *rich North*[1],
- mechanisms that increase solidarity from a global perspective,
- production of certified high-quality products,
- awareness of labeling and inspection processes.

The Fair Trade concept is a middle path between economic interventionism and full economic liberalization. On the one hand, non-government organizations have an impact on prices and play a guardian-like role in controlling the fairness of trade agreements; while this is indisputably a kind of economic interventionism, it does not involve the government. On the other hand, emphasis is placed on the consumers' ability to make choices and decide of the extent of support which lays the foundations for Fair Trade certification.

Fair Trade certification: institutionalized action taken to promote Fair Trade

Today, the Fair Trade movement has been institutionalized and is based on certificates granted by different organizations which specify the principles for production, trade and ways of spending profits derived from certification. Also, they provide a form of support for certified producers and promote the concept of fair trade. Certification, as directly related to today's Fair Trade movement, emerged in late 1980s when the Max Havelaar coffee certificate was issued in the Netherlands.

[1] That delineation was initially proposed in works by Brandt, the former chancellor who split the globe into two parts (for the sake of convenience), taking the differences in development pace and socioeconomic problems as a criterion. The context for this was the geopolitical situation in the 1970s. The (*rich*) *North* is mostly represented by European and North American countries and Australia while the (*poor*) *South* means Africa, Latin America and a number of Asian countries (Brandt, 1980). These terms continue to be used to this day in the public debate showing the differences between developing and developed countries, even though the situation in some of them is no longer consistent with the Brandt's initial delineation from the 1970s. In the considerations regarding sustainable development, the North is viewed as having improper consumption and production patterns and a misalignment between technology and environmental requirements. In turn, the South is characterized by rapid population growth and poverty.

It was named after a famous eponymous book that criticized the Dutch colonialism, and was followed in early 1990s by similar certificates developed in France, Germany, Switzerland, UK, Italy, Denmark and Sweden. The European certification was soon emulated by American, Canadian and Japanese organizations and, in early 2000s, by their Australian and New Zealand peers (Anderson, 2015). *International Federation for Alternative Trade* (IFAT), an international organization of producers and other parties related to fair trade with the South, was established in 1989 and is currently known as the *Word Fair Trade Organization* (WFTO) with 429 members from 76 countries (including 377 enterprises, 27 fair trade networks and 25 supporting organizations) (Milczarek, 2016; WFTO, n.d., 2020). In turn, *Fairtrade International* (FI) was set up in 1997 with 3 producer networks and 19 national organizations (Fairtrade International, n.d.-b). Established in 2003, *Fair Trade Labeling Organizations International* (FLOCERT) represents one of the key activity areas related to FI and plays an important role in certifying Fair Trade products. In 2004, FI together with WFTO and WFTO-Europe launched the *Fair Trade Advocacy Office* (FTAO) to promote Fair Trade values, coordinate international cooperation and collaborate with the European Union (Fair Trade Advocacy Office, n.d.; Sinigaglia and Corbalan, 2019). Although *TransFair USA* exited FI in 2011 having indicated certain discrepancies in certification strategies, they did not renounce the organization's key values. The core of the dispute was that TransFair USA wanted to certify small producers and large plantations in the same way whereas FI placed emphasis on the former. Other issues included the intent to keep an independent certification logo for the U.S. and some more tensions which ultimately led TransFair USA to exit FI (Raynolds and Murray, n.d.). Fair Trade certification is related to a clearly defined producer support scheme which is based on 3 dimensions (Fairtrade International, n.d.-a):

1. Economic:
   - minimum price: a fixed guaranteed price that enables long-term production planning, covers costs of production and ensures profits irrespective of market price fluctuations,
   - premium: additional money allocated to developing the community of local producers and businesses,
   - placing emphasis on long-term trade partnerships and ensuring pre-financing by buyers in order to guarantee capital availability and stabilize production operations.
2. Environmental:
   - production practices compliant with environmental requirements and environmental resource efficiency (e.g. less pesticides, appropriate waste management, preserving biodiversity, ban on production operations based

on genetically modified organisms or on particularly dangerous substances as defined in the certification process),
- setting higher minimum prices to promote fully organic production.

3. Social:
   - democratic self-organization of production, transparency and non-discrimination (including with respect to gender): producers and farmers are expected to have a share of at least 50% in enterprise ownership and management (usually, this means cooperative forms of ownership and management of organizations),
   - where hired labor is used, non-discrimination with respect to employment or wages, ensuring the freedom of association for the employees and complying with occupational health and safety standards,
   - various forms of democratic producer organizations are promoted that might boost their bargaining power in the market,
   - ban on child and forced labor.

Certification is subject to a fee which also has an additional impact on production costs related to production requirements, the minimum price and the premium. At the same time, the certification process involves inspections and monitoring of adopted production standards, and includes measures taken to support production efforts and access investment funds or finance the education on and knowledge of growing or production techniques which meet the defined socioeconomic and environmental goals.

Market for Fair Trade products

According to Anderson (2015), only one year after the Max Havelaar certificate was introduced in the Netherlands in 1998, certified products had a 3% share in the domestic coffee market. Early 2000s saw an important increase in interest in Fair Trade Products; today, many trends suggest that their share will continue to grow as the standards of living in the North improve. As shown in a 1997–2002 market survey by FLOCER, the share of selected certified products grew at an average rate of 18% whereas some products, such as orange juice, reached a growth rate of nearly 40% over that period (Nicholls and Opal, 2005, p. 143).

According to FI, in 2020, the production of certified products provided jobs to nearly 2 million employees in over 70 countries which sold their produce to more than 130 countries. The premium earned on the sale of over 37,000 certified products accounted for EUR 180 million in 2020 (Fairtrade International, 2021). The market for certified products was worth EUR 9.0 billion in 2017 (Fairtrade Inter-

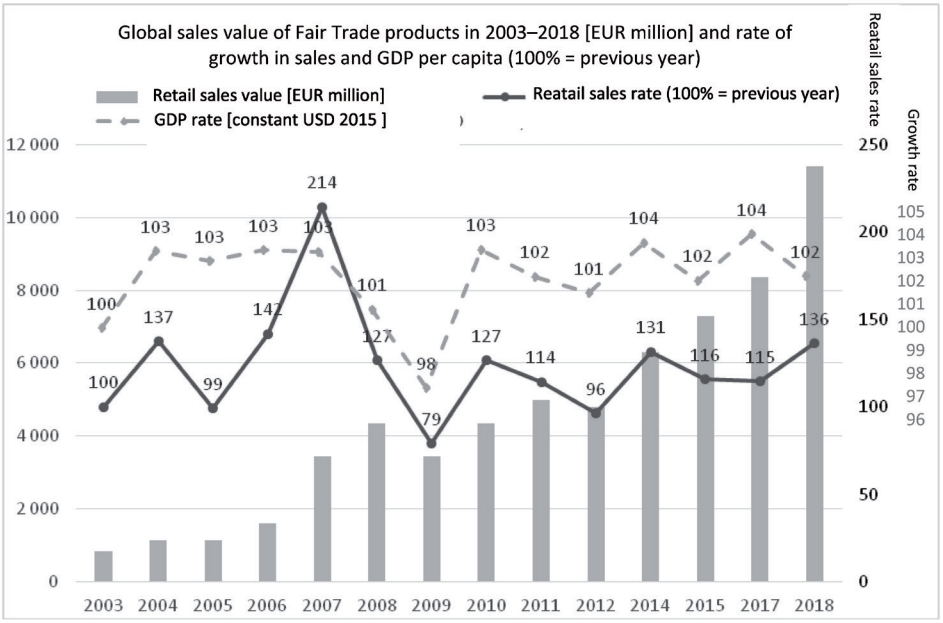

Fig. 1. Retail sales value (EUR) in 2003–2018 as estimated by Fairtrade International; growth rates for the sales value and global GDP per capita at 2015 constant prices in USD (100% = previous year). No data for 2013 and 2016 is available

Source: own study based on: Fairtrade International (2015, 2018); Faitrade America (n.d.); FLO International (2005, 2006, 2009, 2010, 2011, 2013); The World Bank Data (n.d).

national, 2018), with some products reaching a share of as much as 15% in their respective global markets (Fiedoruk, 2021). As shown in analyses by Willer and Lernoud (2017), certified products held a share of 1–2% in the largest consumers' markets in 2015. The biggest market shares were recorded in Switzerland (1.7%) and Sweden (1.5%), followed by Finland (1.3%) and UK and Ireland (1.2% each). In Europe, the region of the world's most active shoppers, Fair Trade products had a share of 1.1%. At the same time, the shares reported in the U.S. and Canadian markets were barely 0.1% and 0.3%, respectively.

Figure 1 illustrates growth in demand for Fair Trade products between 2003 and 2018. Characteristically, there was an abrupt deceleration of growth in demand for Fair Trade products during the 2007–2008 financial crisis. Nevertheless, the consumption of Fair Trade products keeps growing. Over the study period, it grew at an average annual rate of 25% whereas the average GDP growth rate was over 2% globally and below 1.5% in developed (high-income) countries (The World Bank Data, n.d.).

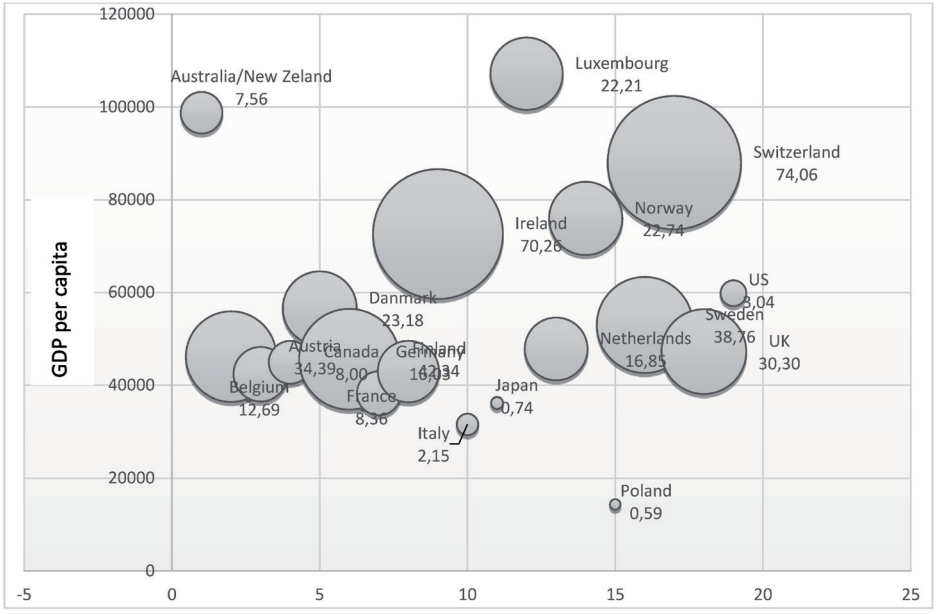

Fig. 2. Average worth of Fair Trade purchases per capita (ball diameter: purchase value per capita, EUR) and GDP per capita (at 2015 constant prices in USD) in 2017

Source: own study based on: Fairtrade International (2018); Fairtrade Polska (2021); Faitrade America (n.d.); The World Bank Data (n.d.).

Ironically, Fair Trade leaders are those countries which do not have a record of colonial conquest and are historically less related to specific geographies of Fair Trade producers. In 2017, Fair Trade spending of Swiss and Irish residents was ca. EUR 70 per capita (EUR 74 and EUR 70, respectively). Significant shares are also recorded in the Nordics, with EUR 20 to EUR 40 per capita, compared to less than EUR 20 spent by average French, Dutch and German nationals. Only the Britons consume relatively more, and have the world's largest Fair Trade market with a sales volume in excess of EUR 2 billion in 2017. Ranked second, the German market was worth only over EUR 1.3 billion. In the U.S., one of the world's largest markets and the third largest Fair Trade market, the sales volume did not exceed EUR 1 billion in 2017, and per capita spending was at a level of EUR 3. Figure 2 shows the average per capita spending on Fair Trade products and GDP per capita in 2017. As it can be seen, the level of economic development is not the sole determinant of demand for Fair Trade products. Although countries such as Finland or Sweden are less economically developed than Australia and New Zealand (or even than neighboring Norway), their population spends much more on Fair Trade products.

Also, there is accelerated growth in demand for Fair Trade products in countries where producers are the main target of the Fair Trade movement (so far, these have been the representatives of the poor South). As a consequence of their rapid economic development, South Africa, Kenya, Brazil, India and many other southern hemisphere countries witnessed increased consumer interest in new trends related to responsible consumption and production. Furthermore, even if the share that new consumer group holds in the Fair Trade market is relatively small compared to total consumption in their respective countries, it represents a considerable part of the world population, which translates into rapid growth of demand for Fair Trade products. This is accompanied by economic growth being much faster than in developed countries and by sustainable development goals being strongly promoted in political programs of the global society. As a consequence, new consumption patterns are also seeping faster into the consciousness of those consumers who emulate the consumption patterns and lifestyles of developed countries but as they form their consumption behaviors, they realize the mistakes these countries made in their development process.

Today, these markets demonstrate huge potential for production growth, even though their shares in the domestic sales volume continue to be marginal. For instance, the sales of Fair Trade products in Brazil in 2017 are estimated to be worth over EUR 10 million and are getting closer to what is recorded in less populated countries such as Luxembourg (EUR 14 million) (Fairtrade International, 2018). At the same time, on an annual per capita basis, the above translates into an average of EUR 0.5 for Brazil vs. EUR 22 for Luxembourg. Similarly, in South Africa, Fair Trade sales grew at an average annual rate of over 160% between 2009 and 2015, from nearly EUR 0.5 million to almost EUR 19 million, with EUR 0.3 of per capita spending in 2015 (Fairtrade International, 2015, 2018; Fairtrade Polska, 2021; Faitrade America, n.d.; FLO International, 2005, 2006, 2009, 2010, 2011, 2011, 2013; The World Bank, n.d.). The most successful products in 2017 were bananas (641,727 metric tonnes), cocoa (216,662 metric tonnes), coffee (214,106 metric tonnes), Cane sugar (207,222 metric tonnes), as well as cotton (8,311 metric tonnes), tea (10,724 metric tonnes), and flowers and plants 834,750 items). The sales of the products account for 90% of producers in the Fairtrade system. The sale of some products such as coffee rose even by 57% on the previous year. The sale of the rest products rose by 1–30%, while only the sale of tea dropped by 12% (Fairtrade International, 2018).

Things look similar in many new markets of post-socialist countries which, after completing their political transformation and joining the European Union's common market, quickly shifted to production and consumption patterns of other member states. These actions are accompanied by the Union's common

policy which lays down the development priorities and defines the frameworks for socioeconomic development at member state level. For instance, according to Fairtrade Polska data (Fairtrade Polska, 2021), retail sales in Poland grew at an average annual rate of nearly 150% in 2015–2020, reaching ca. EUR 120 million in 2020, which means a more than fivefold increase in the per capita purchasing volume. As can be seen in Figure 2, only 3 years earlier (in 2017) the per capita amount was EUR 0.6 but went above EUR 3 in 2020. Over that period (from 2015 to 2020), growth in Polish GDP per capita was only 16% at 2015 constant prices in USD (The World Bank Data, n.d.). Czech Republic, Lithuania, Latvia and Estonia experienced similar rapid developments in their markets. Already in 2015, Estonian and Czech residents spent an average of nearly EUR 2.5 on certified products (Fairtrade International, 2015, 2018; Fairtrade Polska, 2021; Faitrade America, n.d.; FLO International, 2005, 2006, 2009, 2010, 2011, 2011, 2013; The World Bank, n.d.).

According to an analysis of retail sales of certified products based on Fairtrade International data and on global GDP per capita at 2015 constant prices in USD (Fairtrade International, 2015, 2018; Fairtrade Polska, 2021; Faitrade America, n.d.; FLO International, 2005, 2006, 2009, 2010, 2011, 2011, 2013; The World Bank, n.d.), there is strong income elasticity of demand for Fair Trade products (with an income elasticity ratio of 6). Hence, as corroborated by a number of studies, interest in ethical consumption becomes disproportionately greater as incomes grow (which is characteristic of luxury products) (Balineau, 2019). The analysis of the relationship between retail sales and economic development at country level suggests that incomes are not the sole determinant of interest in buying Fair Trade. Countries with the highest incomes are not the largest consumers of Fair Trade products at the same time. Actually, a number of consumer surveys carried out in different countries (Andorfer and Liebe, 2012; Schenk et al., 2021) indicates a variety of non-economic grounds for decision-making.

Conclusions

The Fair Trade movement is largely consistent with modern trends related to changes in how consumer and producer roles are viewed in the economic processes. First, this is a bottom-up initiative that generally relies on active citizenship and attempts to redefine the relationships between producers and consumers which are based on antagonistic motivations for action and on individualist ethics. Second, it also goes hand in hand with the liberal narration which views the market as an efficient mechanism for resource allocation. Fair Trade is not a form of state interventionism;

from the perspective of its goals, it places key emphasis on how to shape consumer behaviors so they may contribute to establishing fair relationships between all people around the world. Thus, it is a way to go beyond nationalist and egoistic views on the development of one's own community, and to adopt a global perspective that takes solidarity criteria and long-term benefits to everyone into account. Finally, the Fair Trade movement is in keeping with the assumptions of the sustainable development concept as regards meeting a number of development goals for a global society. From the perspective of developed societies, this mostly means changing their consumption and production patterns as called for under goal 12. The consumers' responsibility for their own development, the environment and other humans is the key requirement and mission of developed countries. These measures are manifested in a number of ways, including by ethical requirements becoming part of the decision-making process of consumers who adopt a broad perspective on the global consequences of what they do.

Greater interest of consumers from the North is an obvious finding in the light of how the Fair Trade movement emerged. The interviewees also suggest that interest in these products is viewed from a perspective of how higher-order needs are addressed in accordance with patterns characteristic of buying luxury products. However, the increase in incomes should only be considered a precondition for a stable functioning of households, and the same is true for producers' profits. In their decision-making and economic processes, the consumers and the producers face different objectives which are postulated to be met through corporate social responsibility and the consumers' global responsibility for their market decisions. Irrespective of many potential motivations behind such actions (e.g. the companies building their image to reap certain benefits; or individuals feeling responsible for their local actions from the perspective of global consequences), the Fair Trade movement established attractive ethical grounds and market support mechanisms to reinforce fair and sustainable production and consumption.
As a consequence of analyses carried out in this chapter, demand for Fair Trade products can be expected to continue to rapidly grow in the next years as an accompanying process to economic growth in both developed and developing countries. As regards the latter, it seems crucial that their governments support the promotion of Fair Trade products while taking market mechanisms into account. Moreover, contrary to the initial meaning of the movement to the countries of the South, continued growth in global demand can be generated by new players of the worldwide market in both the rich North and the poor South. Indeed, as their incomes grow and their socioeconomic situation improves, southern countries tend to emulate the consumption patterns of the North and are more willing to accept Fair Trade products.

References

Anderson, M. (2015). A history of fair trade in contemporary Britain. London: Palgrave Macmillan UK.

Anderson, M. (2018). Fair trade and consumer social responsibility: Exploring consumer citizenship as a driver of social and environmental change. Manag. Decisi., 56(3), 634–651. https://doi.org/10.1108/MD-01-2017-0013.

Andorfer, V.A., Liebe, U. (2012). Research on Fair Trade consumption – A Review. J. Bus. Ethics, 106(4), 415–435.

Auroi, C. (2003). improving sustainable chain management through Fair Trade. Greener Manag. Int., 43, 25–35.

Balineau, G. (2019). Engel Curves for Fair Trade Consumption and Development Perspectives for Producers: Evidence from Data on Real Fairtrade Purchases. J. Dev. Stud., 55(5), 894–916. https://doi.org/10.1080/00220388.2018.1499894.

Belk, R.W., Eckhardt, G.M., Bardhi, F. (eds.). (2019). Handbook of the sharing economy. Cheltenham: Edward Elgar Pub.

Brandt, W. (1980). North-South, a Programme for Survival: Report of the Independent Commission on International Development Issues. Cambridge: MIT Press.

Fair Trade Advocacy Office (n.d.). What we do. Fair Trade Advocacy Office. Retrieved 1 April 2022, from https://fairtrade-advocacy.org/what-we-do/.

Fairtrade Foundation (2020). Trade Fair, live fair. State of progress report (p. 17). London: Fairtrade Foundation.

Fairtrade International (n.d.-a). How Fairtrade differs from other labels. Fairtrade International. Retrieved 1 April 2022, from https://www.fairtrade.net/about/how-fairtrade-differs.

Fairtrade International (n.d.-b). How Fairtrade works. Fairtrade International. Retrieved 1 April 2022, from https://www.fairtrade.net/about/how-fairtrade-works.

Fairtrade International (n.d.-c). Sustainable Development Goals (SDGS). Fairtrade International. Retrieved 14 January 2021, from https://www.fairtrade.net/issue/sdgs.

Fairtrade International (n.d.-d). Trade fair, live fair. Fairtrade International. Retrieved 1 April 2022, from https://www.fairtrade.net/about/projects/trade-fair-live-fair.

Fairtrade International (2015). Global change, local leadership. Annual Report 2014–2015 (p. 24). London: Fairtrade International.

Fairtrade International (2018). Working together for fair and sustainable trade. Annual report 2017–2018 (p. 20). London: Fairtrade International.

Fairtrade International (2021). The future is fair. Annual report 2020–2021 (p. 28). London: Fairtrade International.

Fairtrade Polska (2021). Fair Trade Polska. 2020 in review (p. 11). Cracow: Fairtrade Polska.

Faitrade America (n.d.). *Home*. Fairtrade America. Retrieved 2 April 2022, from https://www.fairtradeamerica.org/.

Fiedoruk, M. (2021). Fair Trade: Shortcomings and contemporary challenges. Ekonomia – Wroclaw Econ. Rev., 27(4), 37–51.

FLO International (2005). Delivering opportunities. Annual Report 2004–2005 (p. 28). Bonn: FLO International.

FLO International (2006). Building trust. Annual Report 2005–2006 (p. 28). Bonn: FLO International.

FLO International (2009). Faitrade. Leading the way. Annual Report 2008–2009 (p. 15). Bonn: FLO International.

FLO International (2010). Growing stronger together. Annual Report 2009–2010 (p. 17). Bonn: FLO International.
FLO International (2011). Challenge and opportunity. Annual Report 2010–2011 (p. 6). Bonn: FLO International.
FLO International (2013). Unlocking the power. Annual Report 2012–2013 (p. 20). FLO International.
Kefalas, A.G. (1998). Think globally, act locally. Thunderbird Int. Bus. Rev., 40(6), 547–562.https://doi.org/10.1002/(SICI)1520-6874(199811/12)40:6<547::AID-TIE3>3.0.CO;2-F.
List, F. (1909). The National System of Political Economy. London: Longmans, Green and Co.
Milczarek, E. (2016). Polityka handlowa Unii Europejskiej na podstawie implementacji założeń ruchu sprawiedliwego handlu (European Union's trade policy based on the implementation of Fair Trade assumptions). In: Reviewed Proceedings of the International Scientific Conference on Pravni Rozpravy 2016. International Scientific Conference on Law and Law Studies „Theory, Evolution, Practices of Law" (p. 128–135), vol. VI, February 22–26. Hradec Kralove: Magnanimitas.
Nicholls, A., Opal, C. (2005). Fair trade: Market-driven ethical consumption. Thousand Oaks: SAGE.
Pieńkowski, D. (2009). The Paradigms War and the Two Ways of Economy Liberalising by F. List. In R.O. Bailly (ed.), Emerging Topics in Macroeconomics (pp. 97–125). New York: Nova Science Publishers.
Pieńkowski, D. (2013). *Sprawiedliwość dystrybutywna w świetle optimum Pareto i idei zrównoważonego rozwoju* (Distributive equity in the light of the Pareto optimum and of the sustainable development concept). Białystok: Wydawnictwo Uniwersytetu w Białymstoku.
Pieńkowski, D., Murawska, A., Zaremba-Warnke, S. (2018). Zrównoważona konsumpcja. Wyzwanie dla społeczeństwa w dobie globalizacji (Sustainable consumption. A social challenge in the era of globalization). Warsaw: Texter.
Raynolds, L.T., Murray, D.L. (n.d.). Fair Trade USA's split from FLO: issues and implications. Center for Fair & Alternative Trade. Retrieved 2 April 2022, from https://cfat.colostate.edu/2012/04/fair-trade-usas-split-from-flo-issues-and-implications/.
Ruskin, J. (1862). Unto this last: four essays on the first principles of political economy. London: Smith, Elder, and Co.
Schenk, P., Rössel, J., Weingartner, S. (2021). It's all about distinction: the lifestyle embeddedness of fair trade consumption. Sustainability, 13(19), 10997.
Sinigaglia, A., Corbalan, S. (2019). EU trade and development policies: how has Fair Trade been used as a tool to achieve sustainability for people and planet? In: S. Bilal, B. Hoekman (eds.), Perspectives on the Soft Power of EU Trade Policy (pp. 193–202). London: CEPR Press.
Slob, B. (2006). A fair share for coffee producers. In A. Osterhaus (ed.), Business unusual: Successes and challenges of Fair Trade (pp. 121–139). Brussels: Fair Trade Advocacy Office.
The World Bank. (n.d.). Population. The World Bank Data. Retrieved 3 April 2022, from https://data.worldbank.org/indicator/SP.POP.TOTL.
The World Bank Data. (n.d.). GDP per capita (constant 2015 US$). The World Bank Data. Retrieved 2 April 2022, from https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?end=2018&start=2003.
Thompson, E.P. (1971). The Moral Economy of the English Crowd in the Eighteenth Century. Past & Present, 50, 76–136.

United Nations (2017). *Sustainable Development—Goals*. United Nations Sustainable Development. Retrieved 3 April 2022, from http://www.un.org/sustainabledevelopment/energy/.
WFTO (n.d.). The Global Community of Fair Trade Enterprises [Text]. World Fair Trade Organization. Retrieved 1 April 2022, from https://wfto.com/who-we-are.
WFTO (2020). Annual Report 2020 (p. 38). Culemborg: WFTO.
WFTO & FI (2018). The International Fair Trade Charter. Brussels: Fair Trade Advocacy Office.
Willer, H., Lernoud, J. (2017). The world of organic agriculture—Statistics & emerging trends 2017. London: IFOAM & FIBL.

Chapter III

Description of the bivalve mollusk *Anadara tuberculosa* production chain

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Abstract
This research aims to describe the production chain of the bivalve mollusk "*Anadara tuberculosa*." In this sense, a bibliographic research methodology was applied. This production chain comprises three links: the shellfish collectors; wholesalers, and retailers; finally, restaurants, cevicherías, cocktail bars, and the like. This specimen or fruit of the sea is highly desired for fresh and raw consumption but is mainly consumed cooked in coastal areas in tourist and recreation sites and homes. Extending the investigation into those key factors that can improve sustainability, competitiveness, and production and commercialization potential for the international market is recommended.
Keywords: shellfish collectors, traders, restaurants, mangroves, competitiveness
JEL codes: D24, Q22, Q56

Introduction

The concept of production chains arises from the perspective of the producer of the raw materials, in this case, the shellfish collector, to respond to the problem related to the fact that the producer understands that to reach the final consumer the product must be processed previously. It also has to go through several links, which generally obtain better returns or profit margins, with less risk in their operations.

The concept of the production chain has been evolving and adapting to the new realities of the local, national and global markets, integrating the categories of final customer satisfaction, process efficiency, and harmonization of interests. Another definition points to the production chain as a system made up of the harmonious interaction between various participants, who intervene directly or indirectly in producing and consuming products and services (López, 2003).

Other authors mention that production chains are groups of social actors, such as agricultural production systems, fisheries, and aquaculture agroforestry, service and input providers, processing and transformation industries, distribution and marketing, as well as final consumers of the product and by-products (Gomes de Castro et al., 2002).

In the food sector, for the Institute of Cooperation for Agriculture, the agrifood chain is a concept that involves the set of economic activities and actors that intervene from the primary activity to the final consumer, incorporating processes of industrialization of products, their packaging, and distribution (Herrera, 2004). For its part, the Undersecretary of Rural Development of Mexico (2010) defines production chains as the itinerary or process followed by an agricultural, livestock, forestry, or fishery product, through production, transformation, and exchange activities, until it reaches the final consumer.

Likewise, for the Ministry of Production of Peru (2007), the production chain is defined as a fishing, aquaculture, or mixed system that brings together the economic actors interrelated by the market with articulated participation in activities that generate value around a good or service. It includes the provision of inputs, production, conservation, transformation, distribution, marketing, and consumption in both internal and external markets. The production chain starts from the production or extraction phase (Fig. 1).

The concepts presented above focus on the long and complex continuum of production processes and transactions, from the agricultural establishment or primary production to the consumer, identified by scholars from the Institut Nationale de Recherche Agronomique (INRA) of France back in the 1960s as an object of study. At that time, the analysis center ceased to be the isolated agricul-

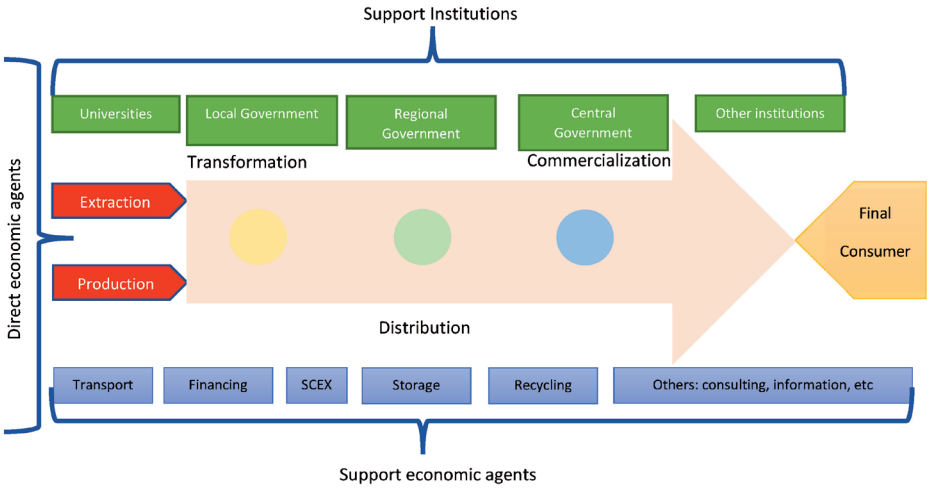

Fig. 1. Components of a fishing-aquaculture production chain
Source: Ministerio de la Producción del Perú (2007).

tural production unit (Fishing or Aquaculture), and the systemic approach was privileged (Castro and Gutman, 2002).

The studies influenced this French approach to filiére, or agrifood chain carried out on agriculture in the United States in the 1950s, which went beyond the agricultural production unit (Aquaculture or Fisheries) due to the importance of the stages earlier and later in value creation Raikes et al. (2000), Zylbersztajn (1996), Bencharif and Rastoin (2007). Among the pioneering works are those of Goldberg and Davis at the Harvard Business School, based on the conceptual framework developed for the Agribusiness course of the MBA program. All the concepts presented above account for the itinerary approach that goes from the primary producer to the final consumer.

This research focuses on the production chain of the bivalve mollusk *Anadara tuberculosa*, an endemic species of the eastern Pacific coast and distributed from southern Mexico to northern Peru, associated with the mangrove ecosystem. *A. tuberculosa* receives different common names in the different countries where it is produced. In the Republic of Ecuador with the common name „concha Prieta." It is also known as „arca negra" (from the translation from English to Spanish), in French as „arche noire" and in English as „pustulose ark or black ark" Prado-Carpio et al., (2018a, 2018b), Prado-Carpio (2020).

The importance of studying the production chain lies in the social, environmental, and economic aspects. Socially, it is a source of food, culinary culture, and work for thousands of families in the extensive areas where it is extracted. Environmentally, it represents one of the activities that allow the sustainable use of the

mangrove ecosystem, whose surface has been drastically reduced in the last 20 years, reducing its capacity to produce blue carbon due to deforestation and urban tourist aquaculture activities. Finally, economically, *A. tuberculosa* is an aquatic resource marketed and in great demand in the producing countries. Therefore, it has great export potential to the United States, Europe, and China, once its production increases. Production and compliance with the safety regulations required by them. Taking the above into account, and based on a case study of the bivalve mollusk *Anadara tuberculosa* production chain, the aim of this chapter is to provide recommendations that can improve the sustainability, competitiveness, commercialisation and production potential of such a supply chain in the international market (Prado-Carpio, 2018b).

To this end, Gómez-Vargas et al. (2015) point out that a qualitative-documentary bibliographic research methodology of a critical-interpretative nature has been applied to review the studies produced by people in their bibliographic representation.

Development of legislation concerning the production chain of the bivalve mollusc *Anadara tuberculosa*

In Peru, according to article 3 of Ministerial Resolution No. 209-2001-PE, of the Ministerio de Pesquería de Perú (2001), the links in the fishery production chain are the following: extraction, reception, transport, processing, and marketing. This resolution includes *A. tuberculosa.*

In Nicaragua, the Ministry of the Environment and Natural Resources, MARENA, published the technical standard to regulate the extraction, cultivation, and sustainable use of the *A. tuberculosa* and other bivalves within protected áreas. According to Lazarich Gene and Gabriel Argüello (2009), it is important to note that this standard introduces the category of cultivation for the production of *A. tuberculosa* and the traditional extraction of this hydrobiological resource.

In the Republic of Ecuador, the Ministerial Agreement No. 005, issued by the Ministry of Foreign Trade, Industrialization and Fisheries (2005), Undersecretary of Fisheries Resources, indicates that the links in the production chain of the *A. tuberculosa* are the extraction and commercialization.

Based on the Ecuadorian legal norm that regulates the shellfish activity and the productive reality of *A. tuberculosa* in the Jambelí archipelago, in the Province of El Oro, Republic of Ecuador, the locality where this study has been carried out, three links for the production chain have been established. They comprise the extraction, harvesting, commercialization tasks, and the preparation and sale of dishes in restaurants and cevicherías (Fig. 2).

Fig. 2. The bivalve mollusk *Anadara tuberculosa* production chain
Source: own study.

Characteristics of the mollusc harvesting stage Collection task: operational aspects

Extraction of *A. tuberculosa* is carried out through fishing trips (tasks) that fluctuate between 3 to 4 hours, depending on the tide levels and the inclines of the banks. In banks with slight slopes, the tide fills more quickly than others with steep slopes, reducing work time. For Marín Abanto (2013), the shellfish collectors move to the banks in canoes in a number of two or more. Some spend the night in the mangrove for several days to take advantage of the low tide. The extraction of the shell is carried out by introducing the hands in the mud and extracting the shell on contact.

The working conditions in the extraction of the *A. tuberculosa* are very demanding since it is collected among the mangroves, digging with the hands in the mud. The collectors are usually trapped in the mud, which slows down their activity and makes it more difficult. In some cases, the extractors use jackets, pants, gloves, and cloth shoes made by themselves, to not injure themselves in the extraction process. It is usually collected for about 4 hours a day, and the start time is adapted each day to the tidal cycle. The shells are collected at low tide, when the muddy surfaces of the marshes are exposed and can be walked on. After the harvest, the fishermen separate 1 or 2 dozen shells for personal consumption, and the rest are sold to intermediaries (Mackenzie, 2001). The only processing given to the product is its packaging in twine bags. They are kept in mud to lengthen their conservation (Lazarich, 2009).

According to OSPESCA (Organization of the Fishing and Aquaculture Sector of the Central American Isthmus, 2018), this activity is carried out by people with limited economic resources as a source of employment and subsistence purposes.

In Colombia, fishing for *Anadara tuberculosa* and *Anadara similis* is an artisanal activity carried out mainly by women and children. Borda and Cruz (2004a) indicate that the increase in demand for this hydrobiological resource, mainly due to its commercialization to Ecuador, has caused the incorporation of men to this work, especially when other activities such as fishing are not profitable. According to Espinosa (2010), the average extraction of one person per day is approximately 162 specimens.

Sustainable management improvements

In some coastal sectors where *A. tuberculosa* is extracted, some strategies have been established to conserve them. Such measures include the designation of periods in which they are not collected, the rotation of extraction sites, the capture of shells with sizes above the minimum size established, and the mangrove reforestation (Borda and Cruz, 2004b). Still, it is considered that these efforts have not given the expected results. In addition, no strategies have been established to preserve the product's safety.

In Central America, *A. tuberculosa* is a mollusk collected in large quantities, which is why some of its populations have drastically decreased. Currently, there are closed seasons in several Central American countries, and crops are being developed in controlled farms to repopulate or stop the pressure on natural populations. In addition, for OSPESCA Organization of the Fisheries and Aquaculture Sector of the Central American Isthmus (2018), the research carried out in the region to cultivate *A. tuberculosa* through spawning and fattening induction techniques in coastal communities is essential.

The *A. tuberculosa* production is carried out almost entirely through artisanal extraction fishing. However, technological processes of aquaculture production are being developed that offer an innovative and sustainable alternative that is technically viable. These initiatives may represent an option to sustain and increase the production of this crucial marine resource, preserving the natural resource, favoring the shellfish collectors socially, and generating economic and food resources.

According to the Food and Agriculture Organization of the United Nations (FAO, 2012) since the 1980s, aquaculture projects have been proposed for *A. tuberculosa*, such is the case of the project for its production in the Pacific estuaries in Costa Rica.

In El Salvador, the Chávez Fisheries and Aquaculture Development Center (2007) published a guide on cultivating mollusks of the *Anadara* genus. It indi-

cates that the cultivation of mollusks on a productive scale implements a structure that facilitates their management and does not significantly alter the mangrove ecosystem since the nurseries are considered „natural protected areas" directly in the mangrove area or in the nearby beaches. The culture of *A. tuberculosa* does not need a food supply since these are developed in these species' natural growth areas.

In Ecuador, with the sponsorship of the Ministry of Agriculture, Livestock, Aquaculture, and Fisheries (2015), projects have been developed that, based on biotechnology, offer alternatives for seed production projects in artificial laboratory conditions for the following purposes:

- repopulation by massive sowing of seeds in the natural environment,
- as an alternative aquaculture species that families could cultivate due to its low production cost.

The experiences mentioned above represent an indication of how there is an interest in the scientific, business, and government sectors to manage the production of *A. tuberculosa* in a sustainable and innovative way, whether at the level of traditional fishing, improved fishing from an extractive activity to the breeding of *A. tuberculosa* in the same mangrove or the aquaculture activity per se.

For Lazarich Gene and Gabriel Argüello (2009), some important aspects that can influence the favorable evolution of the production and therefore of the supply *of A. tuberculosa* are the following:

- Greater sanitary and closed season control. Extraction under legal and environmental regulations could increase the volume offered in the medium term.
- Expansion of installed capacity by current producers through reproduction and cultivation techniques. Improving reproduction and growth in semi-natural enclosures or non-extraction areas, where the ideal population density is guaranteed, could sustainably increase the supply.
- Restore habitats through reforestation of mangrove forests. The habitat improvement will suppose the conservation of the existing resources and its possible expansion to new recovered areas. Reforestation could mitigate the impact that extraction activity causes on plant communities, mainly the Rhizophora mangle species, closely linked to the development of *A. tuberculosa* species.
- Diversification and improvement of economic opportunities through the search for sustainable economic alternatives for the populations of coastal areas, which complement the controlled extraction of bivalves.

Sanitary controls

Concerning sanitary control, it should be noted that *A. tuberculosa*, once extracted, is sold to traders, without any treatment, beyond cleaning the mud with water from the beach in some cases. Therefore, *A. tuberculosa* with a safety guarantee requires safe handling processes from its extraction to its sale to the final consumer. The adequate selection of the mollusk cultivation or extraction site reduces the risk of product contamination.

Subsequently, the shell extracted from the mangrove should be submerged in purification tanks that eliminate the contaminating substances that it could retain. The actors present in the commercialization process must ensure that the product is not exposed to new contaminants and that adequate measures are taken for its conservation. In the same way, Lazarich Gene and Gabriel Argüello (2009) points out that these measures will allow obtaining a safer, higher quality, value-added, more competitive product that can offer higher profits to producers and traders and their incursion into the international markets of North America, Europe, and Asia.

Some problems in the production chain

Most of the domestic supply of *A. tuberculosa* in Nicaragua comes from artisanal fishing. Most of the people dedicated to the extraction on the coast of the Pacific Ocean do not have the permit for the extraction, commercialization, and export. In some cases, the first sale of the product can take place on the beaches, at the moment the boat leaves the sea, and it is usually directly to consumers or intermediaries. In this first sale, products with lower commercial value are marketed. For Lazarich Gene and Gabriel Argüello (2009), sometimes a member of the collecting family (generally women) travels to the communities surrounding the extraction areas to directly market the product not sold to intermediaries, even bartering for food or necessary items for their homes.

Finally, the market structure from the suppliers' side presents a high level of competition since the entry into the market is free and generally only depends on physical access to the extraction zones. The relationship between shellfish collectors and their buyers, mostly intermediaries, is characterized by informality. Lazarich Gene and Gabriel Argüello (2009) indicates that extractors are usually subjected to a dominant position, sometimes even monopsonistic, by intermediaries. However, there are some initiatives to organize and improve working conditions, income sustainability, and bargaining position in the collectors' market through the formation of cooperatives or community marketing networks.

Marketing of *A. tuberculosa*

In the Republic of Ecuador, the main ports of landing and commercialization of *A. tuberculosa* (Table 1) are San Lorenzo and Muisne (Province of Esmeraldas), El Morro (Province of Guayas), Puerto Jelí, Puerto Bolívar and Puerto Hualtaco (Province of de El Oro), in addition to other ports in Colombia such as La Tola, Imbiti, Tumaco, Mosquera and San Francisco, from which the resource enters the Ecuadorian market (Cabanilla, 2010).

The primary forms of marketing are in bulk (counted in units of 100 specimens), in bags (3,000 to 3,500 shells per bag), and packed in bags or vacuum containers of 50 shellfish per bag. These are generally marketed mixed at the level of shellfish collectors, without classifying between large, medium, and small shellfish. The function or task of classification is under the responsibility of the traders.

In Ecuador, the largest number of shellfish collectors is found in El Oro province and then in the Esmeraldas province. The purchase price at the shellfish collector level ranges from $0.092/shell in the Esmeraldas province to $0.165/shell in the Guayas and El Oro provinces.

The price trend for *A. tuberculosa* at landing ports between 2004 and 2010 was upward, going from $4 to $10 per hundred shells in 2004 (0.04 to $0.10/shell), at 15 to 18 $ per hundred shells in 2010 (0.15 to 0.18 $/shell), which represents a 135% increase in prices at the level of shellfish collectors, during the study period. Likewise, it occurred at the level of the Guayaquil and Durán markets, whose prices registered an increase of 42.86% for purchase and 52.17% for sale in the period between 2004 and 2010. Likewise, it should be noted that Fridays, Saturdays, and holidays are when there is greater demand and commercialization, and prices also tend to increase.

Much of the *A. tuberculosa* produced in Ecuador is consumed locally in the main cities, such as Guayaquil, Quito, Cuenca, Loja, Machala, Tulcán, and Huaquilla (Table 1).

However, the entry of *A. tuberculosa* from Colombia to Ecuador, and the exit from Ecuador to Peru, some of which may be of Colombian origin, have been reported (Cabanilla, 2010). Traders in these ports of the province of Esmeraldas, once or twice a week, go to the shellfish collectors in their homes to remove the shell, while some merchants additionally buy Colombian shellfish.

Likewise, it was estimated that in the department of Nariño (border with Ecuador), there is the extraction of around 300 million shells per year with a value between 0.04 and 0.05 USD per unit, which represents a potential annual income of more than USD $7 million (Borda et al., 1998). In this area of Colombia, the production sold in Colombia represents only between 15 and 20% of the total

Table 1. Main landing ports of *A. tuberculosa* and commercialization indicators

Location	Collectors / Traders	Type of Commercialization / Average Price Paid to Collector in 2021 [$/shell]	Final Destination
San Lorenzo (Prov. Esmeraldas)	1878 / 21	in 3000 to 3500 shells sacks / 0.10 $ per shell	Guayaquil, Quito and Tulcán
Muisne (Prov. Esmeraldas)	1526 / 12	in 3000 to 3500 shells sacks / 0.10 $ per shell	Guayaquil, Quito and Tulcán
Puerto El Morro (Prov. Guayas)	30 to 40 / 10	retail in 100 shells units / 0.165 $ por concha	Guayaquil (Mercado General Villamil Playas)
Puerto Bolívar (Prov. El Oro)	133 / 10 to 15	retail in 100 shells units / 0.165 $ por concha	Huaquilla, Perú and Machala
Puerto Jelí (Prov. El Oro)	44 / 2	retail in 100 shells units / 0.165 $ por concha	Loja and Cuenca
Hualtaco (Prov. El Oro)	177 / 10 to 13	100 shells units / 0.165 $ por concha	Hualtaco (Restaurants) and Peru (Sorted)

Source: own study.

production, while the rest, 80 to 85% of the captures, is sold in Ecuador (Borda and Cruz, 2004b).

No records of this commercial flow of shells between Colombia, Ecuador, and Peru have been found. In this same sense, in Nicaragua, Lazarich (2009) indicates that some producers and intermediaries might not be interested in a more regulated (or transparent) market, since it would limit illegal commercialization, especially exports, mostly directed to El Salvador and, to a lesser extent, to Honduras, and which, according to government officials, can account for up to 50% of the product extracted in some areas of the northwest of the country.

In Ecuador, in Puerto El Morro, in the province of Guayaquil, the price of *A. tuberculosa* varies from the merchant to the final consumer according to its size and quantity. Similarly, in Puerto Bolívar, in the Province of El Oro, the largest amount of shellfish is taken to Huaquilla (border with Peru) and Peru, while others sell the product in restaurants and food markets, in the Oro Province.

In Puerto Jelí, El Oro Province, Ecuador, the shellfish is distributed mainly to the mountains, specifically to the cities of Loja and Cuenca. Finally, in Puerto Hualtaco, due to the importance of trading shellfish in the neighboring country of Peru, merchants classify them according to their size into large, médium, and small shellfish. The Port of Hualtaco is the place that is perceived as having the best quality and price of the product. The *A. tuberculosa* that does not go to Peru is distributed among the restaurants of this port in El Oro province.

From all the information outlined above, based on the study by Cabanilla (2010), it can be inferred that the majority of the shellfish collectors sell to wholesalers. These in turn to retailers and the latter to restaurants, cevicherías and final consumers. However, this marketing chain can have variants, when some shellfish collectors at the landing ports sell directly to restaurants and cevicherias or some wholesalers sell to restaurants, ceviche shops, and final consumers.

Regarding the marketing margin of *A. tuberculosa* in the main markets of the Guayaquil province (Table 2), based on authors' calculations, it was estimated that it has a range between 51.67% and 94.44%, which will depend on the place in which the traders buy the shellfish if it is directly from the collectors.

Table 2. *A. tuberculosa* commercialization margins in the main markets of the Guayaquil Province, Ecuador

Market	Type of Commercialization / Average purchasing price 2021 [$/shell]	Type of Commercialization / Average sale price 2021 [$/shell]	Commercialization margin [%]	Observations
Durán	hundred units / 0.12 $ per shell	hundred units / 0.20 $ per shell	66.66	purchases directly in stores in Esmeralda
Portete	hundred units / 0.12 $ per shell	hundred units / 0.20 $ per shell	66.66	purchases directly in stores in Esmeralda
Caraguay	hundred units / 0.12 $ per shell	hundred units / 0.18 $ per shell	50.00	purchases in Esmeralda (20 %) and Colombia (80%) directly from collectors

Source: own study.

Finally, it should be noted that in this study by Cabanilla (2010), it is reported that in Ecuador there are initiatives to sell the processed *A. tuberculosa* pulp in vacuum-packed bags, the amount of which is not specified. In this sense, it should be noted that the reported price of *A. tuberculosa* pulp in the casings ($0.09/shellfish) was lower than that of live and raw shellfish ($0.14/shell) in the same market. This may be explained by the market's preference for consuming live and raw shellfish over fresh processed pulp.

Many producers sell the harvested shellfish to large traders who do not have authorization and are located in urban centers near the coast. In some cases, before being packed in sacks, *A. similis* and *A. tuberculosa* are separated since the latter is larger and is sold at a higher price. The distribution from the product collection is controlled by intermediaries who geographically divide the buying and selling areas. The product does not receive any processing during most of the marketing chain.

Intermediaries supply the product to retailers located in popular markets, street vendors, restaurants, and seafood restaurants. This form of commercialization is conditioned mainly by the actors' opportunities at the time of sale and not by established regulations or formalized markets. On some occasions, the product is delivered to retailers in the morning through a credit system, to be canceled after the day's sales.

The market sale is carried out in stalls specializing in fish and shellfish. In the markets, the shell is offered closed or open and clean of mud, which in many cases involves the first handling of the product (Table 3). It is not sold in supermarkets, which have a limited tradition of selling this type of product generally demanded fresh. In the last phases of the commercialization chain, the most significant manipulation of the product is carried out.

Table 3. *A. tuberculosa* presentation forms for its commercialization

Outlets	Presentation forms
Collection centers	unwashed closed
Markets	open and closed / washed and unwashed
Cocktail bars	open and semi-prepared in ceviches and cocktails
Restaurants	open and semi-prepared in ceviches and cocktails

Source: Lazarich Gene and Gabriel Argüello (2009).

The distribution of the national production is carried out through intermediaries or by some companies that have collection centers that supply the rest of the traders: popular markets, street vendors, restaurants, and seafood restaurants. Finally, the commercialization of *A. tuberculosa* with a guarantee of innocuousness is an essential condition for expanding markets and incorporating new segments of the population to shellfish consumption of, targeting markets in countries of the European Union, North America, and Asia.

Restaurants and cevicherias

In restaurants and cevicherías, the *A. tuberculosa* is cleaned, the product and the shell is opened to later sell raw in one of the shells or processed in cocktails and ceviches to final consumers. The most significant percentage of the income generated by the *A. tuberculosa* production chain remains in the hands of the collectors and some final sellers (restaurants).

A. tuberculosa is one of the most used mollusks for food purposes on the South American Pacific Ocean coasts. The muscle used to make more elaborate dishes such as cocktails, stuffed shells (well-washed empty shells full of muscle with rice, potato and wrapped in egg), cakes (muscle with potato and egg), rice with shellfish, and black soup with beer or wine. According to Lazarich Gene and Gabriel Argüello (2009), calcium carbonate ($CaCO_3$) is extracted and used in micro-painting or to make crafts and ornaments by grinding the shells.

The limitations in the processing and the widespread culture of consumption of the raw product mean that the demand is poorly segmented. The majority of consumers belong to the lower-middle-income segment. Among regular consumers of the product, 88% perceive it as a product of good or excellent quality. More than 50% consider that the relationship between quality and price is good or excellent. There are opportunities to expand demand to segments of the population with high incomes, traditional consumers of other more valued seafood. To achieve greater segmentation and expansion of the market, improvements in terms of quality and presentation are necessary.

The consumption of *A. tuberculosa* occurs mainly in restaurants, cevicherias, cocktail bars, or on the beaches near the extraction sites and is only rarely consumed in homes. Generally, its consumption is linked to leisure and, on many occasions, to alcohol intake. It is usually served as a typical dish of the country in some of the most visited restaurants by tourists. Its consumption is marked by seasonality, with Easter and December being the times of greatest demand, coinciding with festive dates with a long tradition of consuming fishery products. These data show the important sociocultural aspect that characterizes the demand and preferences in the forms of consumption of *A. tuberculosa*.

A large part of specialized fish restaurants and shellfish shops sell *A. tuberculosa*. They tend to be demanding regarding the quality of the product purchased and offered. They generally respect the conditions for the conservation and hygiene of the product, which is stored in refrigerators at a controlled temperature. It is a product frequently demanded in these establishments, although its profit margin is low, so it is not usually crucial to the financial stability of these businesses. In most restaurants, *A. tuberculosa* is offered as an aperitif, raw or in cocktails, depending on its seasonal availability and the activities of the establishment. Restaurants and cevicherías are the link in the production chain of *A. tuberculosa*, which add higher value to the product (processing, quality, and service) and, therefore, those that sell it at a higher price.

For their part, cevicherías tend to satisfy the demand for the product in segments of the population with fewer resources that have difficult access to other restaurants due to their high prices. By having lower prices, they tend to reduce

the costs of handling, preserving, and presenting the product, offering fewer safety guarantees. The consumption routine of *A. tuberculosa* in cocktail bars intensifies on weekends. The location of these establishments is usually strategic for the sale of these products since most of them are located near companies, markets, and leisure centers. In cocktail bars or cevicherías the culture of consumption of this shellfish is linked to leisure and combined with the intake of alcoholic beverages, and influenced by the aphrodisiac properties attributed to the shellfish.

In Ecuador, in El Oro Province, a ceviche dish that is prepared with approximately 15 shells, has a price of 10 to 12 USD in a restaurant or cevichería of the upper range (in commercial premises and residential areas) and from 3 to 5 USD in a low-end restaurant or cevichería (popular and street markets). This price variation depends on the shellfish size, the accompanying appetizers, the type of service, and the commercial establishment, reaching a marketing margin in a range of 50 to 350% for the restaurant.

Conclusions and recommendations

Based on the objective of this research, which is to describe the production chain of the bivalve mollusk "*Anadara tuberculosa*," the following conclusions and recommendations have been reached:

1. The production chain of the bivalve mollusk "*Anadara tuberculosa*" comprises multiple social and economic actors, mainly integrated into the links of the collection, marketing, and preparation of dishes at the level of restaurants, cevicherías, and cocktail bars. It begins on the mangrove coasts of the eastern Pacific of the American continent between southern Mexico and northern Peru. Its activity is predominantly artisanal and economically informal. However, it is the basis of food, economic, and labor support for thousands of families in its geographical area of development.
2. The first link or primary production, collection, or extraction of the shellfish consists fundamentally in transferring the shellfish collectors in boats to the mangrove forest areas and estuaries when the tides go down and leave the soil of the mangroves uncovered. Next, go through them and insert their hands into the mud to extract the live shellfish, store them in bags or sacks, and move them to the trading areas primarily found in the shipping ports. Among the primary production practices of the shellfish collectors are selecting shells larger than 4.5 cm and cleaning them of the mud at the time of collection.
3. The second link is commercialization, which consists of the reception and purchase of live shellfish at the collection centers for physical cleaning and classi-

fication into large, small and medium-sized. The next step is the separation of the shellfish of the species *Anadara tuberculosa* (of greater demand and commercial value) from the shells of the species *Anadara similis*. This process also usually occurs on the islands or in the mangroves themselves, especially with that shellfish product that will be sold in neighboring countries. After purchasing, cleaning, selecting, and grading, the shellfish are sold live and fresh to retailers, restaurants, or end consumers who prepare them at home.

4. The third link is restaurants, ceviche bars, cocktail bars, and the like, commercial establishments that buy live shellfish and offer them fresh to their customers. These establishments open the shells at preparation and deliver them in single or mixed dishes to their customers. This link is where greater value is added to the product, offered alone or mixed with other seafood and accompanied by rice, popcorn, salad, and other side dishes depending on its preparation, which is very diverse.
5. It should be noted that in the production chain, the product, in most cases, is offered live and fresh and is only slaughtered at the time of preparation. Hence, its sanitary management and handling are vital to preserving its quality. For freshness, the aim is to maintain the captured shellfish alive as long as possible.
6. It is recommended to expand the study on the subject related to the factors that can influence making this production chain more competitive and sustainable and transforming it into a value chain with export possibilities.

References

Bencharif, A., Rastoin, J.L. (2007). Concepts e Méthodes de l'Analyse de Filières Agroalimentaires: Application para la Chaîne Global de Valeur au cas des Blés en Algérie. Working Paper N° 7/2007, Unité Mixte de Recherche, Marchés Organisations Institutions Stratégies d'Acteurs. Montpellier, France.

Borda, C.A., Cruz, R. (2004a) Pesca Artesanal de Bivalvos (*Anadara tuberculosa* y *A.similis*) Y Su Relación Con Eventos Ambientales. Pacífico Colombiano. Rev. Invest. Mar., 25(3), 197–208.

Borda, C.A., Cruz, R. (2004b). Reproducción y reclutamiento del molusco *Anadara tuberculosa* (Sowerby, 1833) en el Pacífico colombiano. Rev. Invest. Mar., 25(3): 185–195.

Borda, R., Carlos, A., Edgar, G., Portilla, M. (1998). Talla de captura, madurez sexual, comercialización y recomendaciones para el manejo de la *Anadara tuberculosa* en la ensenada de Tumaco (Nariño) Pacífico colombiano. Retrieved from: https://www.academia.edu/.../TALLA_DE_CAPTURA_MADUREZ_SEXUAL_COME, accessed on 07.05.2019.

Cabanilla, C. (2010). Comercialización de la concha prieta (*Anadara tuberculosa* y A. símilis) en los principales puertos de la costa ecuatoriana. Retrieved from http://www.oceandocs.org/bitstream/handle/1834/4796/4.%20comercializaci%d3n%20de%20la%20concha%20prieta-c.%20Cabanilla.pdf?sequence=1, accessed on 12.03.2020.

Castro, A.C.Y., Gutman, G. (2002). Análisis de Subsistemas Agroalimentarios. Manual de Capacitación. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Documento de Trabajo de TCAS, 46.

Chávez, A., José, I. (2007). Guía Para Los Pescadores Sobre El Cultivo de Moluscos Del Género Anadara. Retrieved from: https://www.jica.go.jp/project/elsalvador/2271029E1/materials/pdf/.../2007_02.pdf, accessed on 09.06.2019.

FAO (2012). Proyecto Para El Cultivo de Concha de Burro (*Anadara Tuberculosa*) En Los Esteros Del Pacifico, http://www.fao.org/docrep/field/003/AC587S/AC587S07.htm, accessed on 09.06.2019.

Gomes de Castro, A., Valle Lima, S., & Pedroso Neves, C.. (2002). Cadena productiva: Marco conceptual para apoyar la prospección tecnológica. Revista Espacios. Asociación para el Desarrollo de la Ciencia y la Tecnología, DECITEC, 23(2), 2.002, https://www.revistaespacios.com/a02v23n02/02230214.html, accessed on 09.06.2019.

Gómez-Vargas, M., Galeano-Higuita, C.Y., Jaramillo-Muñoz, D. (2015). El estado del arte: una metodología de investigación. Revista Colombiana de Ciencias Sociales, 6(2): 423–442. https://doi.org/10.21501/22161201.1469.

Herrera, D. (2004). El IICA y las cadenas agroalimentarias. Avances y tareas pendientes. Costa Rica: Instituto de Cooperación para la Agricultura, Área Comercio y Agronegocios.

Lazarich Gene, R., & Gabriel Argüello, F. (2009). Estudio de mercado de la concha negra (Anadara similis y *Anadara tuberculosa*) en Nicaragua. Comercialización con garantía de inocuidad. http://www.bvsde.org.ni/Web_textos/GOLFONSECA/CIDEA/0002/2009 Estudio mercado final de moluscos.pdf.

López, C. (2003). Redes Empresariales: Experiencias en la Región Andina. Perú: Editorial Minka, Cooperación Italiana y CEPAL.

Mackenzie, J., Clyde, L. (2001) The Fisheries for Mangrove Cockles, Anadara spp., from Mexico to Peru, With Descriptions of Their Habitats and Biology, the Fishermen's Lives, and the Effects of Shrimp Farming. Mar. Fish. Rev., 63(1), 1–39.

Marín Abanto, Pablo Martín (2013). Evaluación de concha negra (*Anadara tuberculosa* y Anadara similis) en los manglares de Puerto Pizarro, Tumbes – Perú, mediante un modelo de biomasa dinámica. Lima, Perú. Tesis Para optar el título de Biólogo con mención en Hidrobiología y Pesquería.

Ministerio de la Producción del Perú (2007). Cadenas productivas de la acuicultura peruana. Perú: Despacho Viceministerial de Pesquería, Dirección General de Acuicultura.

Ministerio de Pesquería del Perú (2001) Tallas mínimas de captura y tolerancia máxima de ejemplares juveniles de principales peces marinos e invertebrados. RESOLUCION MINISTERIAL Nº 209-2001-PE. Retrieved from: https://tarwi.lamolina.edu.pe/lico-chea/pesca/tallas/rm209-2001-pe.doc, accessed on 07.05.2019.

Organización de las Naciones Unidas para la Agricultura y la Alimentación – FAO (2012). La situacion de la pesca y acuicultura en Guatemala y los lineamientos para su desarrollo futuro. Obtained from https://www.fao.org/3/AC587S/AC587S07.htm#anx2

OSPESCA – Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (2018). *Anadara tuberculosa*. Retreieved from: http://climapesca.org/2018/09/06/anadara-tuberculosa/, accessed on 03.05.2019.

Prado-Carpio, E. (2020). Gestión de agronegocios y el desempeño de la cadena de valor de la Concha Prieta *Anadara tuberculosa*. Tesis Doctoral, Doctorado en Ciencias Agrarias, Universidad del Zulia, Venezuela. Retrieved from https://www.researchgate.net/publication/353352826_Tesis_Doctoral_en_el_Doctorado_de_Ciencias_Agrarias, accessed on 04.08.2021. https://doi.org/10.13140/ RG. 2.2.20107.62242.

Prado-Carpio, E., Quezada-Abad, C., Martínez-Soto, M.E., Rodríguez-Monroy, C., Morris-Díaz, A. (2018a). An approximation to agribusiness development in the value chain of the bivalve mollusk (*Anadara tuberculosa*) (Sowerby, 1833) (Arcidae). Proceedings in Food System Dynamics: 382–393. Retrieved from: http://centmapress.ilb.uni-bonn.de/ojs/index.php/proceedings/article/view/1831, accessed on 21.09.2019.

Prado-Carpio, E., Martínez-Soto, M.E., Urdaneta De Galué, F., Morris-Díaz, A.T., Rodríguez-Monroy, C., Borja-Herrera, A. (2018b). Modelo Teórico de Relaciones entre la Gestión de Agronegocios y el Desempeño de la Cadena de Valor de la Concha Prieta "*Anadara tuberculosa*". Retrieved in http://www.laccei.org/LACCEI2018-Lima/meta/FP396.html, accessed on 04.06.2019.

Raikes, P., Jensen, M.F., Ponte, S. (2000). Global Commodity Chain Analysis and the French Filière approach: Comparison and Critique. Working Paper Subseries on Globalisation and Economic Restructuring in Africa, IX.

Subsecretaría de Desarrollo Rural de México (2010). Las cadenas productivas agroalimentarias, https://www.academia.edu/9245637/Sagarpa_Sagarpa_1_1_Las_Cadenas_Productivas_Agroalimentarias_Direccion_General_De_Estudios_Para_El_Desarrollo_Rural, accessed on 09.06.2019.

Zylbersztajn, D. (1996). Governance Structures and Agribusiness Coordination: A Transaction Cost Economics Based Approach. Res. Domestic and Int. Agribus. Manag., 12: 245–310.

Chapter IV

Possibilities and limitations in the carriage of agricultural machineries by maritime transport as a containerized cargo

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Abstract
In recent years in Poland it has been recorded a large share of agricultural machinery exports to overseas countries, therefore this chapter presents the issues of the transport of agricultural machinery, both new and already in operation, from the sender to the recipient, with particular emphasis on maritime transport. The chapter includes conclusions, that are mainly addressed to agricultural machinery carriers using maritime transport services and for producers of agricultural machineries.
The main aim of the research included in the chapter is to present possibilities and limitations in carriage of the agricultural machineries and equipment, as containerized cargoes by maritime transport. The possibilities and limitations were taken into account on the basis of international regulations and from the technological point of view resulting from the specifications of the containers. The paper also addressed the issues related to the preparation of the machine by the manufacturer and shipper for containerization and transport, resulting from maritime regulations in order to ensure the safety of transport and delivery of the device undamaged to the recipient.
Keywords: agricultural machinery supply chain, maritime transport, agrotechnology, containerization, CTU
JEL: R320, R410, Q160

Introduction

Observing the long-term trends on the agricultural machinery market in Poland, it can be noticed that producers of agricultural machinery in Poland, mainly provide the demand for the domestic market, strive to ensure that their devices are designed in such a way as to meet the expectations of users, are safe, functional, economical in operation and cheap to buy. On the other hand, those producers of agricultural machinery, whose devices reach foreign markets, try to design the device in such way to increase their resistance to factors during transport, proposing additional security solutions to enable road, rail and maritime carriage to the recipient. According to the producers of agricultural machinery in Poland, these devices are exported to such countries, as Romania, Lithuania, Latvia, Estonia,

Greece, Ireland, Hungary, Slovenia, Belgium, the USA, Portugal, Bulgaria, and also to the countries of North Africa. As can be seen, machines can be delivered to most countries by road or rail means of transport, but knowledge of the possibility of transporting machines by sea transport may in the future extend their sales to new export markets, especially outside Europe.

Therefore, this chapter indicates the factors that may affect the agricultural machines transported by sea, with particular emphasis on container transport. These factors are sometimes quite specific due to the specific conditions of the sea transport, and therefore knowing them may contribute to strengthening the resistance of machines to these factors and to protect transported equipment for destruction during transport and handling processes.

Research methodology

Research on the issue discussed in this chapter was carried out taking into account the following stages:

- Stage 1: Overview of legal regulations regarding the carriage of machinery by sea transport – in this stage, has been carried the overview of main regulations regarding the carriage of cargo by sea and established by the International Maritime Organization (IMO), the provisions of Classification Societies and the ISO standards, especially regarding cargo transportation in containers,
- Stage 2: The specificity of sea transport of cargoes– in this stage has been identified hazards that may affect cargo during sea transport,
- Stage 3: Overview of agricultural machineries produced in Poland – in this stage, the type and models of agricultural machinery produced in Poland were reviewed, with particular emphasis on their dimensions and the manner of their preparation for transport by the producer. The directions of exports of these machines to European and non-European countries were also analyzed. During this stage, agricultural machinery was also selected for further detailed analysis,
- Stage 4: Determining the susceptibility of agricultural machinery to containerization – in this stage, the selection of agricultural machinery was carried out due to their dimensions, enabling them to be placed in a container.
- Stage 5: in this stage has been selected the types of containers in which agricultural machinery can be transported for safety reasons and analyzed the methods of securing loads in the container were indicated.

The overview of legal regulations and technical standards concerning maritime transport and covering agricultural machineries

Safety regulations for maritime transport are established by one of the United Nations Agencies, International Maritime Organization (IMO) with headquarters in London, by established Resolutions, Conventions, Codes and Circulars. This chapter covers the IMO legal acts that deal with the carriage of cargo in containers.

One of the most important legal instrument of IMO legislation is The *International Convention for the Safety of Life at Sea* (SOLAS, 1974). It is the Convention on the wide broad approach to the safety of maritime shipping, with particular reference to Chapter VI – "Cargo Carriage". According to Rule 5 in Chapter VI – Stowage and securing of cargo – cargoes, cargo units and cargo transport units carried on or below deck should be loaded, stowed and secured in such a way as to prevent damage to or endanger the ship and people during the voyage. on it, as well as loss of cargo.

Next very important legal act is *The International Convention For Safe Containers* (CSC, 1972). It is the Convention relating to the safe carriage of containers by sea. The Convention defines the requirements that must be met in order a container to be considered as a sea container and allowed to carry by sea transport. It can be concluded that the provisions in this Convention apply to persons designing and operating sea containers.

Moreover, he legal act relating to the safe stowage and securing of loads inside the container is the CTU Code (*IMO / ILO / UNECE Code of Practice for Packing of Cargo Transport Units*). As its name suggests, it was developed with the participation of the International Maritime Organization (IMO), International Labor Organization (ILO) and The United Nations Economic Commission for Europe (UNECE). The CCC Sub-committee of IMO, consisting of experts from around the world and other UN Agencies, e.g. ILO, FAO and NGOs involved in the development of safety standards, e.g. ISO, ITF, ICHCA, WSC, BIMCO, etc., works on the development of the CTU Code (ICHCA International, n.d.). On the base of The CTU Code containers are classified as Cargo transport unit (CTU), and CTU is definied as: "A freight container, swap body, vehicle, railway wagon or any other similar unit in particular when used in intermodal transport". This means that agricultural machinery transported inside a sea container or swap body or inside a truck trailer or inside a rail car - is treated as a multimodal or bimodal unit, goes to the sea-going vessel and is covered by the rules and guidelines for cargo securing in these units. Additional information material on the CTU Code is *Informative material related to The IMO / ILO / UNECE CODE of Practice for*

Packing of Cargo Transport Unit published by IMO in MSC.1 / Circ.1498 Circular 16 December 2014.

In addition to the IMO regulations, which relate directly to sea transport, it is also worth taking into account the recommendations and guidelines for transport safety contained in ISO standards. It is worth quoting here the most important standards that directly relate to containerization, such as: PN-ISO 830: 2001 Cargo containers – Vocabulary, PN-ISO 668: 2018-05 – EN – Series 1 cargo containers – Classification, dimensions and maximum gross masses, PN – ISO 3874: 2000 – PL – 1 Series Loading Containers – Handling and securing.

Another very important and useful document is the set of rules contained in INCOTERMS®2020 developed by the International Chamber of Commerce (ICC, n.d.). Knowledge of the INCOTERMS®2020 rules makes it possible to ensure the continuity of the supply chain of agricultural machinery from the manufacturer to the recipient and to facilitate the contracting of transport contracts in international trade. Rules mainly define responsibilities between buyers and sellers with regards to costs, risks, responsibilities for cargo insurance and regulatory compliance (DHL, n.d.).

The legal acts presented above are important for many participants of the sea-land supply chain of agricultural machinery, such as shippers of machinery for containers, forwarders, land carriers, combined transport carriers, sea carriers, sea ports, and machine manufacturers.

General specification of container transport by sea

During carriage by sea the ships can perform such movements on wave (Grzybowski et al., 1997): rolling (Fig. 1a), pitching (Fig. 1b), yawing (Fig. 1c).

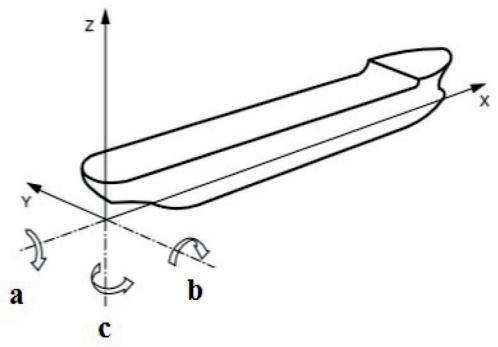


Fig. 1. Movements of ship during carriage by sea
Source: Grzybowski et al. (1997).

These movements cause the acceleration acting on the hull, containers and cargoes located inside the containers and located on a ro-ro or a ferry ship. During the carriage by sea cargoes may have the following three types of acceleration (Grzybowski et al., 1997; LRS, 2021; PRS, 2012; CTU Code, n.d.):

a) vertical accelerations – generated during the pitching – most rocking occurs at the bow, amidships and the smallest,
b) longitudinal accelerations – generated during the rolling,
c) lateral accelerations – generated during – the highest value reach in middle ships and the smallest at the fore and aft.

The size of this accelerations, and thus the degree and type of wear is affected by many factors, such as: the number of layers of containers on board to the right of metacentric height, hull shape, weather conditions, frequency, and direction of the waves, and above all, the ability of operations the vessel on waves and the region of shipping (CSS Code, 2021). Another disadvantageous phenomenon that can occur during shipping is hitting the wave portion of the bow of the vessel, which also affects the impact of cargoes and the angular acceleration resulting from the movement of the vessel, depending on the angular velocity and the distance from the center of rotation of the container ship.

One of the solutions to limit the intensity of results of climatic and mechanical conditions is certainly the ability of the crew to drive the ship, especially the bow section with respect to wavelength, which can eliminate a sleming (i.e. hits by a wave) and eliminate flooding a deck with salt seawater. In addition, the increased speed of the vessel and to map out the wrong kata exchange rate may trigger a wave hitting the hull of the deck and flooded with seawater. (Grzybowski et al., 1997) The second important solution is proper arrangement and lashing of cargoes, containers and vehicles on ships and proper forming of cargoes inside containers.

These solutions can be made by the sea carrier and the container shipper, but can the designer of the device design the device in such a way as to increase the resistance of the device to the factors described above?

The safety of sea transport of containers begins not only in the port itself, but much earlier, in the place where the container is formed. This site could be, for example, a factory that produces agricultural machinery or a distributor. The shipper of the container is most often a company providing land transport services (road or rail), the main task of which is to choose the right type of container to which the machine will go, as well as its proper arrangement and lashing in the container. In order to perform the above activities, it is worth knowing the specificity of sea transport in order to eliminate the risks and their effects that may damage the machines during transport and cause a serious hazard.

In recent years in Poland., have been established many companies dealing in the formation of containers especially for sea transport These companies are often located near seaports and provide packing services, especially those which, due to their dimensions or weight, cannot be formed on euro-pallets. The process takes place in such a way that the load on truck trailers arrives at the company from cargo producers, there is packed, secured, and then loaded into the container, properly lashed in the container and labelled appropriately. The important advantage of these companies is their excellent knowledge of the regulations on the principles of forming sea containers and securing the cargo. (DANPOL Skrzynie transportowe, n.d.; Cordstrap, n.d.).

The IMO regulations cited in this chapter are aimed at increasing the safety of maritime navigation and eliminating the human factor, and are addressed mainly - but not only - to participants in maritime transport (container shippers, sea carriers, ports, freight forwarders) and designers of sea-going ships.

However, the knowledge of potential threats that may occur during sea transport and the specificity of sea transport and container handling in seaports may contribute to increasing the awareness of machine producers on how to increase their resistance to external factors and their effects, and in particular, which result from the laws of physics accompanying transport processes. On the other hand, threats caused by human error should also be included in the analysis, but they are not always predictable enough.

Nowadays, in sea transport, containers are transported on ships called container ships. Currently, the largest container ships in the world are approx. 400 m long, 61.5 m wide and, when fully loaded, can carry approx. 24,000 TEU. All containers on the ship are arranged according to a previously prepared loading plan, which takes into account many factors, e.g. the order of unloading the containers in the port, the gross weight of the container, the type of container, the length of the container, or the container power needs. In addition, the containers are secured to ensure the ship's stability during the voyage. Examples of container ships are shown in Figure 2.

In maritime transport technology, a sea container is classified as a cargo unit (CTU), but from the point of view of transport safety, it also plays a protective role in relation to the cargo, i.e. it protects the cargo against external factors, but also protects the environment against cargo (if it can have the properties of harmful to the environment). Despite this, it is necessary to know the specificity of sea transport and the behaviour of the ship in a wave.

Due to the place where the exposures arise throughout the ship's voyage, exposures to the containers may occur during the loading of the container onto the ship, during the sea transport and during the container unloading in the port.

a) 13.360 TEU / L=365,9 m, W=51,2m

b) 13.344 TEU / L=365 m, W=51,2m

c) 4.402 TEU / L=294m, W=32,26m

d) 1.678 TEU / L=178m, W=28m

Fig. 2. Examples of containerships

Source: own photoes made on the North Sea (2015).

Moreover, due to the type of exposure, one can distinguish climatic and mechanical exposures. Climatic hazards affecting the containers and the loads placed in them (especially when it comes to open containers) result from the impact of climatic conditions, such as: wind, sunlight, rainfall, snowfall, salt fog, sea water. The effects of the impact of climatic exposures have already been discussed in greater detail in publications (Szyszko, 2014; 2016) how they can have a destructive effect on the packaging, as well as accelerate the corrosion processes of steel elements, both on the ship's equipment, as well as on the transported steel loads. The second type of exposure is static and dynamic mechanical exposures. Static exposures result mainly from the weight of loads and containers placed on top of each other as a result of the force of gravity. On the other hand, dynamic exposures result from accelerations resulting from physical phenomena in the sea transport process and as a result of physical phenomena in the process of lifting and lowering containers into the holds.

Types of containers via types of sea containers

There are many types of containers on the market, but not all of them can be used to transport cargo by sea. Below has been presented main type of containers that are currently on the market (ANGA Kontenery, n.d.):

- office containers – designed to suport office facilities, often of a temporary places, e.g. at construction sites, terminals, temporary seasonal sales points, guarded car parks, etc.,
- storage containers – intended for temporary storage of private goods, e.g. as a result of renovation of a house or apartment, for commercial companies for the safe storage of goods unsold in a given season, for storage of devices, equipment and tools of a seasonal time of operation,
- gastronomic and commercial containers – often called pavilions intended for gastronomic or commercial purposes,
- habitable containers – intended for habitation, they are often used as holiday homes or hostels,
- sanitary containers – constituting sanitary facilities for public places, such as beaches, swimming pools, playgrounds, exhibition fairs, concerts, etc.,
- social containers – constituting social facilities for employees of construction sites and other places,
- guardhouse containers – providing social facilities for property protection services,
- technical containers – intended for the installation of various types of technical, electric, pneumatic and hydraulic devices, e.g. power generators or pumping stations *and*
- ***sea containers*** – intended for the transport of cargo by sea after obtaining the appropriate certificates.

As can be seen above, there are many types of containers, but only sea containers are dedicated to the transport of cargo by sea.

In Poland, the entity that issues the approval of a container for sea transport is Polish Register of Shipping (PRS) based in Gdańsk. Each container that goes to a seaport is verified in terms of correct labelling, and above all, whether it has the so-called CSC SAFETY APPROVAL plate. A container, when it obtains such a plate, means that it meets the requirements for containers so that they can be intended for sea transport in accordance with the requirements of the CSC Convention and the provisions of the Polish Register of Shipping regarding the construction and operation of sea containers (PRS, 2014).

Types of sea containers, that enable to carry agricultural machineries

Then, the existing types of sea containers were overview on the basis of the CSC Convention, ISO Standards and PRS regulations, and a subjective selection was made for those types that allow for safe placement and lashing of agricultural machineries in the container (Group A), those types were indicated where there are restrictions, but may be used only for selected machines (Group B) and the third group are containers in which it is not possible to use for transport agricultural machinery due to their specialized purpose for specific loads (Group C).

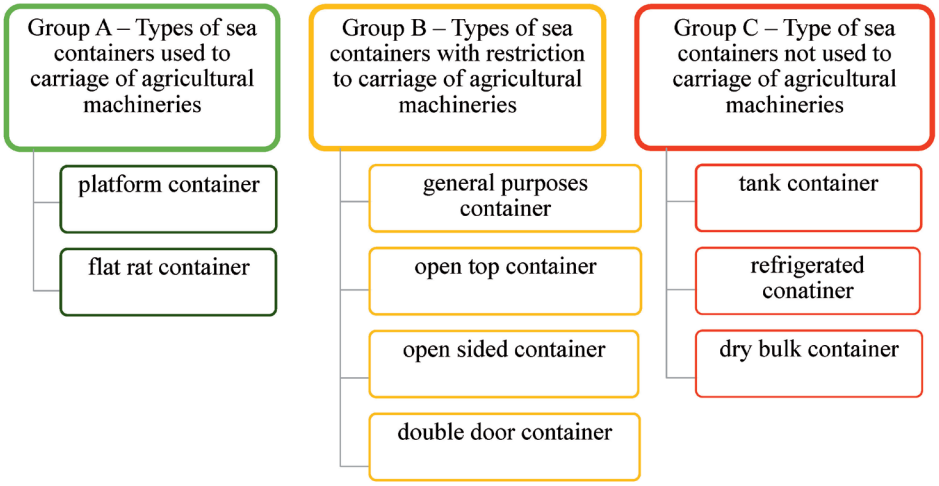


Fig. 3. Types of sea containers used and not used to carry agricultural machineries

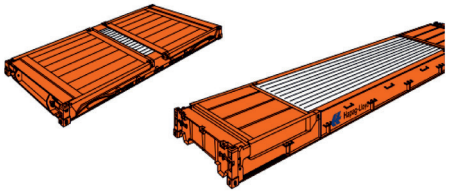
Source: own study based on legal regulations.

Figure 3 presents types of containers according to their purpose, divided into those in which they are adapted to transport agricultural machinery, types of sea containers in which the transport of agricultural machinery is limited and those in which it is not allowed.

Figure 4 presents only those sea containers that can be used to transport agricultural machineries. With regard to the division shown in Figure 3, they apply to the types of containers from group A and group B. However, the restrictions in transport that occur in group B will be discussed in case studies.

Group A

a) Platform container



b) Flat rat container

Group B

c) general purposes container

d) open top container

e) open sided container

f) double door container

Fig. 4. Sea containers enable to carry agricultural machineries

Source: photoes from Ecocontainers (n.d.) and Hapag Lloyd (n.d.).

Moreover, PN-ISO 668: 2018-05 – Freight containers series 1 – Classification, dimensions and maximum gross masses, defines the types of containers according to their dimensions, introducing into the international circulation the markings presented in Table 1.

Table 1. Containers markings according to ISO 668 and CSS Code

The length of the container	The high of the container			
	< 8′	8′	8′6″	9′6″
10′	1DX / 18	1D / 10	-	-
20′	1CX / 28	1C / 20	1CC / 22	-
30′	1BX / 38	1B / 30	1BB / 32	1BBB / 35
40′	1AX / 48	1A / 40	1AA / 42	1AAA / 45
45′	-	-	1EE / L2	1EEE / L5

Source: PN-ISO 668:2018-05 – Freight containers series 1 – Classification, dimensions and maximum gross masses.

Results of the Research

Case Study 1 – agricultural machinery's elements – a flat pallet or a wooden box-pallet – general purposes or double door sea container – a container ship
Case Study 1 concerns a situation when small size element of agricultural machinerieselements are placed on a pallet or a wooden box-pallet, and then loaded into a general purposes container.

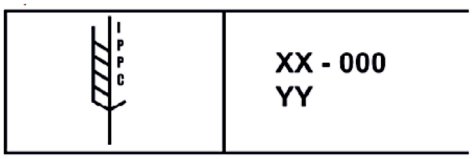
Figure 5 presents examples of wooden box-pallets or pallets with wooden pads, especially adapted to the transport of machine parts, such as: enginees, drive's elements, gears, valves, electric motors, etc., with dimensions corresponding to the 1200 × 800 euro pallet or the 1200 × 1000 industrial pallet.

Fig. 5. Examples of box-pallet and pallets with wooden pads
Source: RAJA (n.d.).

An important aspect during applying such types of wooden box-pallets or other wood elements and wooden stevedoring materials used for securing cargoes inside the containers is that wood materials must be certified for the use of a given type of wood in this pallet for international exchange trade according to the provisions of the International Plant Protection Convention (IPPC, 1957), established by Food and Agriculture Organization (FAO) in Rome. In order to effective elimination of spreading of pests in international trade has been developed International Standards for Phytosanitary Measures (ISPM 15, 2009). The standards includes general rules for the recognition of new methods, rules for supervision by the relevant national services, the performance of preventive treatments, rules for labelling confirming the fact, that phytosanitary treatment has been carried out in accordance with the recommendations and recommended procedures, including destruction of packaging wood materials if found by authorized authorities of the National Plant Protection Organizations of the importing country that there are traces of live pests on them. (Noskowiak, 2010).

In the document – related to ISPM 15, 2009 – *Regulation of wood packaging material in international trade* represent the guidelines, which cover all forms of wood packaging materials, like: crates, boxes, packing cases, flat pallets, cable drums, spools/reels, and box-pallets, and dunnage wood used to securing cargoes in CTU (Euroshipping, n.d.).

On the other hand, wooden packaging does not include packaging made entirely of wood-based materials such as plywood, particle board, oriented strand boards or veneer boards made of glue, heat and pressure (such packages are considered to have undergone sufficient treatment to eliminate the risks associated with raw wood) and raw wood packaging with a thickness of 6 mm or less (Euroshipping, n.d.). The example of marking of wooden material applied in transport has been presented on the Figure 6.



Where: XX – the code of the country
000 – number of the producer
YY – Treatment code (HT, MB, DH, SF)

Fig. 6. The example of marking of wooden materials used in transport

Source: ISPM 15 (2009), ROTOM (n.d.).

The ISPM 15 standard (also called fumigation and IPPC) describes the treatment of wooden and wood packaging. It ensures the elimination of all organisms that can harm ecosystems in the countries to which wooden packaging is transported. According to this standard, most of the packaging made of wood in international traffic must be treated in this way. The thermal treatment of the wood must be performed at 56°C for 30 minutes and made in special certificated drying room in which the heat treatment process takes place (ROTOM, n.d.).Table 2 includes internal dimensions of selected containers.

Table 2. Internal dimensions of general purposes sea containers

Type of the sea container	ISO Symbol		Internal dimentions of the container [mm]			Internal dimentions of the container doors [mm]	
	1	2	length	width	high	width	high
General purpose container	1AAA	45GP	11998	2330	2684	2286	2566
	1AA	42GP			2395		2261
	1A	40GP			2356		2134
	1BBB	35GP	8931		2684		2566
	1BB	32GP			2395		2261
	1B	30GP			2356		2134
	1CC	22GP	5867		2395		2261
	1C	20GP			2356		2134
	1D	10GP	2802		2356		2134
	1EEE	L5GP	13542		2694		2566
	1EE	L2GP			2684		2261

Source: PN-ISO 668:2018-05 – Freight containers series 1 – Classification, dimensions and maximum gross masses, CTU Code (n.d.) and Hapag Lloyd (n.d.).

Table 3. The most important and specific features included in case study 1

Advantages	Special precautionary measures	Limitations	Types of carrying agricultural machineries
easy loading of a pallet into a container	provide IPPC certification for wood materials used inside the container	the limitation as to the size of the load resulting from the dimensions and load of the pallet	components and spare parts for agricultural machineries

Source: own study.

Case Study 2 – agricultural small machineries or components – wooden frames or small wooden transport box – general purposes container, double door, open sided – a container ship

Case Study 2 concerns a situation when medium size element of agricultural machineries or small machineries are placed into wooden frame or small wooden transport box and then loaded into a general purposes container, double door, opened sided orf lat rack type of container and loaded on container ship. This example refers to situation when machinery does not have special – originally designed by producer – attachment points intended for lashing it in the container.

Wooden transport boxes can be totally closed (Fig. 7b) for special protection of inside cargoes against the impact of bad weather conditions, like rain or snow fall. But very important role play also such solutions, where boxes can be partly opened o constituting a wooden frame construction to protecting cargoes with irregular shape for movement during transport (Fig. 7a).

a) wooden construction frame

b) closed small wooden transport box

Fig. 7. Examples of wooden transport boxes
Source: DANPOL Skrzynie Transportowe (n.d.).

Figure 7 presents examples of wooden transport boxes, especially designed and adapted to the transport of machine parts, such as: large engines, cabins, small machineries, which due to their dimensions and weight cannot be loaded on a euro-pallet.

The most important aspects to consider in this case:

1. the issue of using certified wood – those topic has been discuss in the case study 1 (discussed in case study 1),
2. the issue related to the preparation of the transport box and the distribution and securing of the cargo in it,
3. the issue of loading the box into the container,
4. the issue of the arrangement of the box inside the container,
5. the issue of lashing the box inside the container.

An important aspect to take into account is the permissible load on the container floor. In the case of the general purposes container, the values are presented in Table 4.

Table 4. Maximum load of the permissible on the floor of general purposes container

The length of GP container	Mass of cargo per 1 m [t]			Mass of cargo per 1 m^2 [kg]		
	30480	32500	34000	30480	32500	34000
45′	1,93	2,08	2,19	828	892	939
40′	2,21	2,38	2,50	947	1019	1073
20′	4,80	5,15	5,40	2061	2209	2319

Source: Informative material (2016).

On the basis of the information in the table 4, it can be seen there is a wide variation in the strength of the floor of containers. The highest floor strength has 20' container. Those type of containers are very often applied for heavier loads formed in pallets, but 45' are mainly applied for lighter loads formed into pallets, as well.

Whereas for containers open sided minimum door openings reduced internal height and load distribution and planning guide approximately 10% lower than GP container (CTU Code, n.d.).

Table 5. The most important and specific features included in case study 2

	Advantages	Special precautionary measures	Limitations	Types of carrying agricultural machineries
General purposes container	easy loading of a transport box into a container	provide IPPC certification for wood materials used inside the container	limited load distribution	components and spare parts for agricultural machinineries, small machines, like: small fertilizer spreader, baling press, swath tedders, bale wrappers
Double door container	easier and faster loading and unloading boxes from container in compare in gp container	provide IPPC certification for wood materials used inside the container	limited load distribution	
Open sided container	easy loading and unloading long cargoes into the container it is not necessary for a forklift to enter the container	provide IPPC certification for wood materials used inside the container	load distribution and planning guide approximately 10% lower than gp container.	

Source: own study.

Case Study 3 – small and medium sizes agricultural machineries or components – open top sea container – a container ship / semi-container ship

Case Study 3 concerns main two situations, like: small size agricultural machineries are roll on into the container and small sized agricultural machineries or components that are non-propeller are loaded by lift on – lift off system. In the container vecicles are lashing and loaded on the container ship or semi-container ship.

Open top containers are very often used to transport cars, machines, by the system roll on-roll of or other specific non-propelled devices, that can be loaded by lift on – lift off system. They can be also used to transport small and medium sized agricultural machineries. Table 6 includes internal dimensions of open top containers.

Table 6. Internal dimensions of open top sea containers

Type of the sea container	ISO Symbol		Internal dimentions of the container [mm]			Internal dimentions of the container doors [mm]	
	1	2	length	width	high	width	high
Open top	1AAA	45UT	11998	2350	2649	2338	2570
	1AA	42UT			2344		2280
	1CC	22UT	5895				

Source: PN-ISO 668:2018-05 – Freight containers series 1 – Classification, dimensions and maximum gross masses, CTU Code (n.d.) and Hapag Lloyd (n.d.).

Vehicles are driven into the container by a small ramp and should be small sizes and make enough space has to be left for the driver to get out of the vehicle and for setevedor enable lashing.

Securing cargo in open-top containers needs a mixture of lashing and chocking system. Chocking protects the cargo against slipping. To secure lengthwise, wooden beams are to be laid-out between cargo and corner posts of the container. Chocking crosswise should be done as far below as possible against the side walls. The forces must be distributed over an area as large as possible by horizontal timbers. Side and front walls are not designed for selective stresses. Whereas, lashings prevent cargo tipping and increase the friction on the floor. All open-top containers have small lashing eyes on the corner posts, as well as on the floor and on the roof rails, each with a Maximum Securing Load (MSL) of 12 t. (CTU Code, n.d.).

Open top container is very similar to a general purpose container, with regard to general structure and dimensions, but the only exception is the lack of a roof. During transport containers are covered by canvas, plastic or reinforced plastic material often referred to as a tarpaulin, "tarp" or "tilt" (CTU Code, n.d.).

Table 7. The most important and specific features included in case study 3

	Advantages	Special precautionary measures	Limitations	Types of carrying agricultural machineries
Open top container with doors	easy and fast loading and unloading vehicles by roll on – roll off system, availability to carriage of cargoes that are overhight it is not necessary for a forklift to enter the container	provide IPPC certification for wood materials used inside the container	limited load distribution	small size rolling machineries (agricultural tractor for fruit growing) small sizes non-propeller machineries with special lifting hooks for lift on – lift off system (small fertilizer spreader, baling press, swath tedders, bale wrappers)

Source: own study.

Case Study 4 – agricultural machinery – a platform or a flat rack container – a container ship or a semi-container ship

Case Study 4 concerns a situation where a small size agricultural machinery is loaded into a flare rack or platform container and then loaded on a ship. Such situation may concern several variants, e.g. the machine is previously loaded into a wooden transport box, the machine is loaded on a wooden base and shrink-wrapped or the machine is loaded directly into a flat rack container.

The platform or flat rack containers and flatrack are especially dedicated to cargoes that cannot be transported in other containers due to its weight or height.

Rating and load distribution flat rack maximum gross mass values have increased over the past years 45,000 kg. Securing cargo on a flatrack must involve a combination of lashing and chocking, but the preferred by shippers lashing method is cross lashing (Hapag Lloyd, n.d). Figure 8 presents a few solution that can be applied to agricultural machineries.

During transport cargoes into flat rack containers, especially vehicles, are applied solutions for protection against environmental influences. Examples include wooden shipping crates or heat-shrinkable foil. In the case of using wooden boxes, their must be certified as is described in case study 1.

Professional packaging of machines and devices in heat-shrinkable foil for machines and devices will enable the protection of cargo against harmful external factors that may occur during container sea transport. The use of modern heat-shrinkable films with UV filters and an additional coating with volatile corrosion inhibitors will effectively protect steel elements (DANPOL Skrzynie Transportowe, n.d.).

This is especially important as the load is also exposed to salty seawater, salt MIST and rainfall.

a) closed wooden transport box

b) wooden construction frame + heat-shrinkable foil heat-shrinkable foil

c) agricultural machineries directly in the platform container

Fig. 8. Examples of using a flat rack containers

Source: a, b – DANPOL Skrzynie Transportowe (n.d.); c – Cargo RestTraint Systems (n.d.).

Table 8 includes internal dimensions of flat rack containers.

Table 8. Internal dimensions of selected sea containers

Type of the sea container	ISO Symbol		Internal dimentions of the container [mm]			Internal dimentions of the container doors [mm]	
	1	2	length	width	high*	width	high
Flat rack	1AA	42PC	11652	2245	1953 / 6'5"	-	-
	1CC	22PC	5638	2194	1953 / 6'5"	-	-

* – refers to the high of front/rear walls

Source: PN-ISO 668:2018-05 – Freight containers series 1 -–classification, dimensions and maximum gross masses, CTU Code (n.d.) and Hapag Lloyd (n.d.).

Table 9. The most important and specific features included in case study 4

	Advantages	Special precautionary measures	Limitations	Types of carrying agricultural machineries
Cargo inside the wooden transport box and loaded on the flat rack container	easy loading of a transport box into a container	provide IPPC certification for wood materials used inside the container	the limitation of the wodden transport box sizes	components and spare parts for agricultural machines, like: grippers, lawn mowers
Cargo on the wooden frame and covered by heat-shrinkable foil	additional procection of machines by foil	provide IPPC certification for wood materials used inside the container	the limitation of the flat rack sizes	small agricultural tractors with or without cabins
Cargo directly in the platform or flat rack container	is applied to overhigh cargoes	machineries require specialized lashing	the limitation of the flat rack sizes	for machines resistant to weather conditions, i.e. small agricultural tractors with cabins

Source: own study.

Conclusions

1. Very important property of agricultural machineries as the cargo in sea container transport system is that they are classified as a dynamic cargo. It means that the machines able to change their positions and able to change the position of the centre of gravity during carriage. Proper securing of the machine is required to prevent the machine from moving or overturning during carriage. Therefore it is essential that the machine has originally designed by producer special handles to facilitate its attachment in the container.
2. Knowledge of the rules for securing rolling loads (which include agricultural machinery) on ro-ro ships in accordance with the requirements of the CSS Code may contribute to the consideration of introducing additional reinforcements in order to increase the resistance to mechanical stress that may arise during sea transport and during unloading from land transport in port and loading onto the ship.
3. Increasing the following parameters of machines, such as the grade ability and the lower ground clearance, may have a positive effect on increasing the level of safety when loading and unloading machines from various means of transport, especially when using access ramps for containers.

References

ANGA Kontenery (n.d.). www.anga.pl, accessed on: 04.05.2022.

Cargo RestTraint Systems (n.d.). www.cargorestraintsystems.com.au (accessed on 07.05.2022).

Cordstrap (n.d.) .www.cordstrap.com, accessed on: 09.05.2022.

CSC (1972). International Convention For Safe Containers. London: IMO.

CSS Code (2021). Code of Safe Practice for Cargo Stowage and Securing. London: IMO.

CTU Code (n.d). IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units. London: IMO.

DANPOL Skrzynie Transportowe (n.d.). www.skrzynietransportowe.eu, accessed on 02.05.2022.

DHL (n.d.). www.dhl.com/pl-pl/home/nasze-dywizje/spedycja-miedzynarodowa/obsluga-klienta/incoterms-2020.html, accessed on:10.05.2022.

Eco Containers (n.d.). www.ecocontainers.com, accessed on: 04.05.2022.

Euro Shipping (n.d.). www.euro-shipping.com.pl, accessed on:12.05.2022.

Grzybowski, L., Łaczyński, B., Narodzonek, A., Puchalski, J. (1997). Kontenery w transporcie morskim. Gdynia: TRADEMAR.

Hapag-Lloyd (n.d.). www.hapag-lloyd.com, accessed on: 12.05.2022.

ICC (n.d.). www.iccwbo.org, accessed on:11.05.2022.

ICHCA International (n.d.). www.ichca.com, accessed on: 04.05.2022.

Informative material related to the IMO/ILO/UNECE code of practice for packing of cargo transport units (CTU Code).(2016). London: IMO.

IPPC (1957). The International Plant Protection Convention (IPPC), established by Food and Agriculture Organization (FAO), in Rome (with last amendment in 2011).

ISPM 15 (2009). Regulation of wood packaging material in international trade. Rome: FAO.

LRS (2021). Rules and regulations for the classification of ships by Lloyd Register of Shipping. London: Lloyd's Register.

MSC.1/Circ.1498 (2014). Circular 16 December 2014. London: IMO.

Noskowiak, A. (2010). Znowelizowano standard IPPC/ISPM 15. Gazeta Przemysłu Drzewnego, vol. 6/16: 22–23.

PN-ISO 668:2018 – Freight containers series 1 – Classification, dimensions and maximum gross masses.

PN-ISO 830:2001 – Freight containers – Vocabulary.

PN-ISO 3874:2000 – Freight containers series 1 – Handling and Securing.

PRS (2012). Rules for the Inspection of Freight Containers in Service. Gdańsk: Polish Register of Shipping.

PRS (2014). Rules of Construction of Freight Containers. Gdańsk: Polish Register of Shipping.

RAJA (n.d.). www.rajapack.pl, accessed on: 07.05.2022.

ROTOM (n.d.). www.rotom.pl, accessed on 06.05.2022.

SOLAS (1974). International Convention for the Safety of Life at Sea. London: IMO.

Szyszko, M. (2014). Physico-Mechanical Wear Processes of Cell Guides in Container Ships. In: Phenomenology. Solid State Phenomena, vol. 225, 145–150. doi.org/10.4028/www.scientific.net/ssp.225.145.

Szyszko, M. (2016). Issues of Container Handling Modelling in the Aspect of Generating the Corrosion and Mechanical Wear. Solid State Phenomena, vol. 252, p. 91–100. doi.org/10.4028/www.scientific.net/ssp.252.91.

Chapter V

Human resources education for the transport, shipping and logistics sector: a framework for vocational training in Poland

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Abstract
This paper addresses some issues related to human resources education for the transport, shipping and logistics (TSL) sector. The analysis covered both the sector's evolution in response to progress in technical solutions, computer science and robotics, and the stereotypic views on how people work in it. The authors presented certain aspects related to the labor market, including the differences in wage levels and the persisting trend of employment growth despite the difficulties faced during the COVID-19 pandemic. Other topics discussed are the reasons for introducing and adjusting secondary and tertiary education systems in Poland with a view to address the changing needs of the logistics labor market. Emphasis was placed on how attractive this industry is (especially in terms of wages) but also on the barriers to hire, including the generation Z lacking confidence in their skills and competences as they enter the labor market. This paper also presents the existing education qualifications and standards at different levels, and the fields of university studies offered in Poland for future TSL managers.
Keywords: transport, shipping, logistics, TSL industry, human resources education, labor market for logisticians, challenges in the logistics labor market
JEL: I25, O15, J24

Introduction

Over the recent years, the labor market in the broadly defined logistics sector has been among the most stable employers for graduates of both secondary schools and specialized university programs (holders of a bachelor, engineering or M.Sc.

diploma). It demonstrates certain particularities, has some requirements that adequately match the needs of enterprises both at local and global levels, and witnesses growing interest from employees. The can be explained by the logistics evolving from its traditional forms (usually related to haulage and storage) to increasingly modern solutions which include procurement planning and management of sourcing and distribution processes. The two first decades of the 21st century witnessed dynamic development of the logistics sector which underwent considerable changes and extended its scope of impact. This translated into redefining the profile of employees being sought (Żurek, 2019).

Logistics and to be more precise, the sector for transport, shipping and logistics (TSL) services is no longer composed only of drivers and freight forwarders. Now, it also includes specialists dealing with new technologies, such as automation, digitization, strategic planning and management, and a number of other domains. Hence, most of them are "digitally advanced" employees referred to as technology talents (Deloitte, 2017) which are continuously sought after in other sectors, too. As a consequence, state-of-the-art logistics (especially digital logistics) faces certain limitations in accessing competent human resources; this situation also partly results from the potential candidates having a quite traditional vision of the sector. For many of them, TSL heavily relies on transport, and offers jobs primarily to truck drivers and warehouse employees. In practice, logistics is an industry that requires technologically advanced solutions, including artificial intelligence, the Internet of Things, robots, automation and predictive analytics (Bujak, 2007; 2014; Blaik, 2019). However, this view continues to be shared by only a small number of students and graduates (potential employees). As a consequence, although generation Z believed to be multitaskers who cannot do without their computers (Kubera, 2021) enters the labor market, it is still difficult to address the TSL sector's demand for workforce (KDS, 2021). As shown by recruitment practice, generation Z generally lacks social skills, which means they do not trust their digital skills, lack self-confidence and cannot communicate directly in interpersonal relations. This considerably deteriorates their performance in many industries, whether or not related to state-of-the-art technologies. Also, already at the recruitment stage, a discrepancy emerges between what they learned in schools and universities and what is expected by the employers (TTR, 2021). Such a multitude of restrictions largely result from an inadequate education system, and make it extremely difficult to address the demand for employees in the transport, shipping and logistics sector on an ongoing basis. In turn, in an effort to be more efficient in looking for employees, the representatives of that sector enter into relationships with educational establishments by requesting and supporting the creation of specialized fields of study and by letting interns work onsite with cutting-edge equipment etc.

The purpose of this Chapter is to provide a synthetic description of the system for human resources education for the TSL industry and to show the market elements, i.e. supply, demand and prices (wages) for graduates entering the labor market related to transport, shipping and logistics. It follows a monograph approach and relies on document analyses and observation methods. Factual materials were sourced from available literatures, including reports and forecasts by international organizations monitoring the labor market (ManPower, Deloitte), data from the Central Statistical Office and information from industry web portals. An in-depth analysis was carried out of formal and legal documents and legislative acts relating to the area of education concerned.

A desk research was performed to thoroughly analyze the information and capture the changes witnessed in the TSL sector. This served as a basis for determining the professional requirements for candidates and identifying market demand for labor in that industry.

The way modern logistics evolves

As the volume of good offered grows, there is increased demand for services related to their transport and storage. This can be explained by a number of factors, including worldwide socioeconomic changes due to processes such as population growth and widening income gaps. Irrespective of where they live and how wealthy they are, the societies expect logistics operations to become more and more efficient this is when digitization comes into play. In other words, there is need both for technologies to accelerate the processes themselves and for an adequate number of duly skilled employees to handle the technologies. As there is a growing dearth of highly qualified human resources, the expectation for the near future is that intensified measures will be taken to streamline some warehousing tasks by using robotization processes, employing drones to take over courier services, and implementing numerous new solutions driven by progress in AI (artificial intelligence). However, contrary to what the futurologists believe, humans will not be replaced by robots (Frey and Osborne, 2013; Dominiak, 2020); this can be explained by the processes being operated at large scale, on the one hand, and by the growing need for personalization (e.g. gift packing etc.), on the other. According to updated forecasts, it is also necessary to adjust some warehouses to the needs of the ageing workforce (a concept referred to as silver warehouses) (Kohlbacher et al., 2011; Brdulak, 2014).

In other words, "the logistics changes because… it has no other option" (Lewicki, 2021). The above statement is the fullest possible description of changes

which take place in that sector and make it possible to keep pace with modern megatrends. They are driven by economic factors, including the virtually unlimited availability of communication and transport networks, by technological aspects, i.e. emergence of new technologies (also in the construction industry) which provide advantages such as enabling dynamic development of state-of-the-art storage facilities, and by social processes from the changing preferences of customers (and of future employees) through to education, healthcare and leisure (Bujak, 2021).

A lot of things have changed since the 1950s which are believed to mark the beginning of modern-era logistics. In the 2020s, the TSL sector reached a stage described as revolutionary. Logistics have naturally evolved from retail operations related to replenishing stocks by sourcing goods directly from manufacturers or wholesalers (in the 1970s), through to distribution centers controlled by stores (in the 1980s) and to a global economy which needs international distribution centers (at the turn of the millennium) (Laskowska-Rutkowska, 2014). Today's stage can be described as shifting to activity robotization and process automation. In this reality, logistics operators become fully-fledged business partners and are no longer only outsourcers of transport, storage and redistribution services. Increasingly often, they offer next-level quality of services related to: developing logistics processes; designing storage facilities; selecting a warehousing location; inventory storage and management; packing and repacking; labeling; and more and more frequently small repairs; B2B and B2C order fulfillment; handling returns and complaints; or even ordering marketing materials and packaging (Laskowska-Rutkowska, 2014; Lewicki, 2021).

The evolution of the logistics model entails both quantitative and qualitative changes in demand for staff, which are reflected in a number of ways, including by supply and demand aspects of the labor market. The type of professional tasks gradually becomes wider and more complex. Also, there is increase in demand for essential social competences, including foreign language skills, ability to work in multi-cultural teams, communication skills etc. It becomes necessary to make rapid decisions, think flexibly and be generally self-reliant in action. Many of these characteristics turn out to be barriers preventing the employees, especially fresh graduates, from accessing that sector.

Labor market for logisticians

The development pace of the TSL labor market can be inferred both from the analyses of information coming from this market and from periodic reports published by associations of economic analysts. The periodic publications include

the "ManpowerGroup Employment Outlook Survey" which provides a basis for a synthetic description of changes taking place in specific sectors of the economy. The analysis of subsequent editions of the Survey from 2018 to 2021 suggests there is relative stability in the development trends witnessed in the Polish TSL sector. Despite the negative forecasts for the whole trading sector (related to the introduction of a nearly total ban on Sunday trading in 2018), the sector continued to develop. Importantly, unlike many other parts of the economy, it avoided stagnation brought by the COVID-19 pandemic (early 2020 and next years). Most undertakings in this industry fulfilled their recruitment plan, and some of them even reported being understaffed due to the situation prevailing in the labor market (Barometr, 2021). Indeed, it turns out that immediately before the pandemic and right after it broke out (March 2020), the labor market experienced shortage of warehouse employees, drivers and some more specialized logistics staff. This was directly related to the candidates having insufficient knowledge of today's requirements and tasks faced by TSL employees, and to educational services still being not developed enough to prepare people to work in that sector. Furthermore, the workstations, their equipment and the scope of professional and personal competences expected from potential candidates evolved as the technology progressed. Irrespective of actual limitations to supply, employment in the TSL sector has dynamically grown over the last two decades at a rate of ca. 94,000 per year. Wages have undergone a similar evolution (Fig. 1).

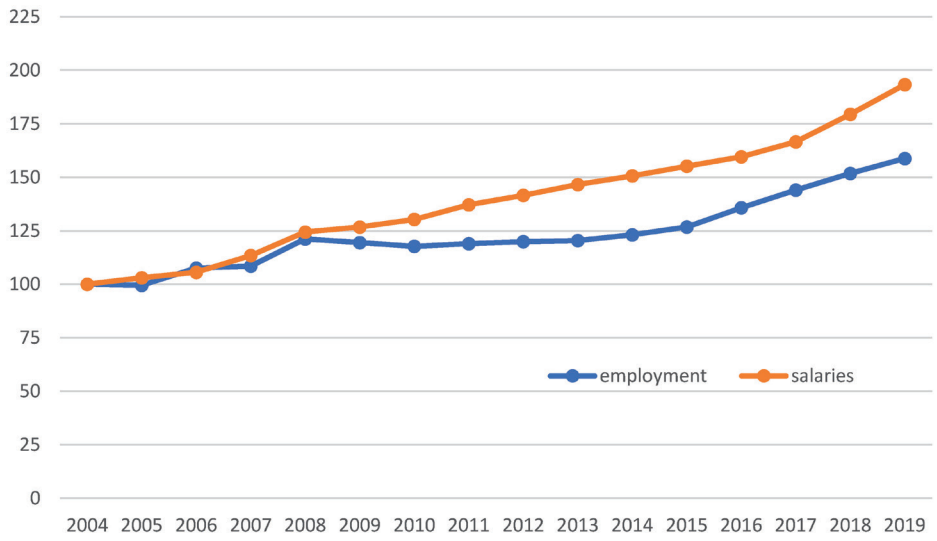

Fig. 1. Changes in employment and salaries in the Polish TSL sector (2004 = 100).

Source: GUS (2020).

It needs to be emphasized that wages are highly diversified across the Polish TSL sector depending on the job specification, the scope of duties and, often, employee age (Pecold, 2022). The extent of these gaps can be illustrated by a comparison of three jobs (forwarder, international forwarder and logistics specialist) in two age brackets (18–25 and 26–30 years old) (Fig. 2).

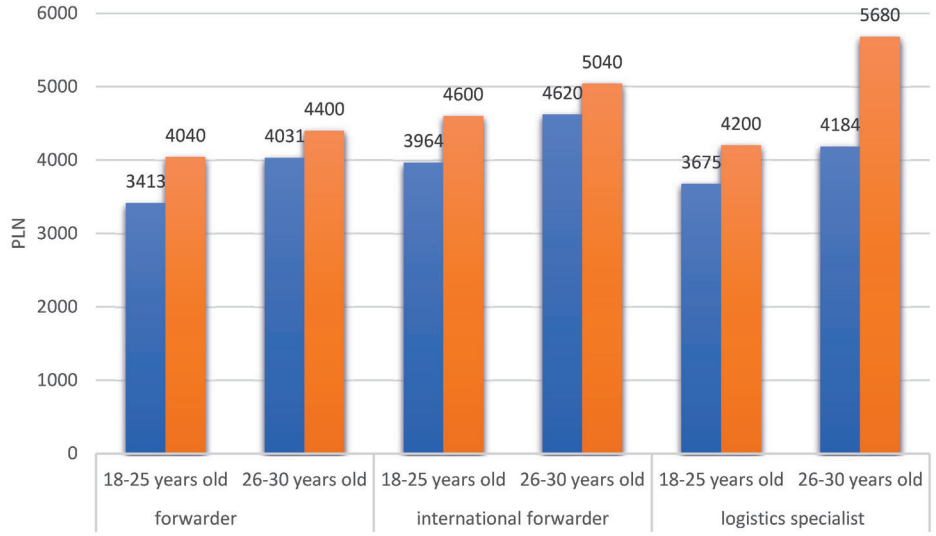

Fig. 2. Differences in salaries between selected TSL jobs depending on age
Source: GUS (2020).

Despite the wages being relatively high (for Polish conditions) and growing, the logistics sector is expected to witness increased competition for work candidates in the near future. The way the labor market is affected by the pandemic plays a decisive role in that process, although the situation was viewed as difficult even before the pandemic. The employers will face new challenges, including the need for developing a new teamwork model and the issues involved in employee motivation and engagement. The flexibility and security of work and the responsiveness to changes become key challenges in the post-pandemic reality, especially as the world's geopolitical stability increasingly often gets perturbed (as demonstrated by the Russian aggression against Ukraine in March 2022, for instance). The location of offices, the working mode (remotely or onsite), the ability to shift to a hybrid system, taking the wellbeing into account, and the employers' efforts taken to keep their employees in a good mental condition are the consequences of the pandemic experience which will grow in importance. Also, the ability to collaborate with people from remote locations (previously quite rare due to technical reasons) will become more and more widespread.

In the coming years, employment in the TSL sector is forecasted to keep growing at a rapid annual rate of ca. 10% (Survey, 2021). Hence, the sector will continue to experience increased demand for employees. However, the differences in expectations between employees and employers are a distinct question which will be decisive for the employment. According to studies, 53% of TSL companies report demand for hard-skilled employees. This mostly means having skills such as IT system management, risk analysis, inventory optimization, continuity planning in the supply chain, certifications granted by the Office of Technical Inspection, WMS operation, ability to handle machinery and equipment, forklift operator license, knowledge of e-Commerce processes and tools, knowledge of artificial intelligence and process automation topics, and forecasting skills (Rynek logistyki, 2020). The above does not mean the logistics sector does not expect the candidates to demonstrate soft skills (the acquisition of which is viewed as difficult by 47% of companies), primarily including transparency, team management skills, reliability and responsibility. Also sought after are the willingness to learn and improve one's qualifications and (as a key aspect during the pandemic) the ability to work remotely; work under pressure and embrace change; adaptability, flexibility, mobility and self-reliance in action. Not all of these competences can be acquired during the education process, some of them are the consequence of the candidates' personality traits.

In addition to lack of expected competences in job candidates, the barriers to hiring are excessive wage expectations (reported by as much as 61% of operators) as well as lack of job candidates (58%) and insufficient professional experience (44%) (Rynek logistyki, 2020).

Education for the TSL sector

While logistics does not form a separate scientific discipline in the Polish education system, both secondary and tertiary establishments try to educate candidates for the TSL sector. For more than ten years now, there has been renewed interest in education fields related to it. Meanwhile, a discussion is ongoing on how to combine essential general knowledge of students/graduates with their future specialization. It results in reaching a consensus according to which the education of human resources for logistics should be of a complementary nature, i.e. it should combine social science content (subjects such as management, economy and law) with hands-on skills of how to operate a computer, use programs etc. (Pawlisiak, 2014). The practical implementation of that concept is reflected in the emergence of numerous secondary and tertiary fields of education. However, the

goals pursued by universities which launch logistics-related fields of study remain debatable. Some of them use logistics as an incentive in their "fight for students" while not paying attention to their graduates' professional skills and future career paths. Others try to change their teaching methods and argue for a process-based approach to logistics studies by pointing to its role in enterprise management (at micro and macro levels), in building a competitive edge, in the financial standing of enterprises, in creating business strategies, in supply chain management and, generally, to how important logistics is to the national and global economy (Kurasiński, 2014).

Secondary vocational education for the TSL industry

Although wrongfully underestimated, vocational education is an important part of the Polish education system, primarily of the system for human resources education for the economy as a whole. In Poland, vocational education has for many years undergone a series of major reforms designed mostly to improve the quality and efficiency of education and to better align the professional background of young people with the needs of the labor market and employers (Sztanderska and Drogosz-Zabłocka, 2019). From an organizational point of view, prior to September 1, 2017, the Polish educational system was mostly composed of basic vocational schools with a 3-year curriculum and 4-year technical schools. Currently, the vocational education system comprises the following types of schools:

- three-year stage 1st sectoral vocational schools-specific schools for students aged 15 to 18,
- two-year stage 2nd sectoral vocational schools-specific schools for students aged 19 to 21,
- five-year technical secondary schools for students aged 15 to 20,
- three-year schools preparing for employment (Eurydice, 2022).

Additionally, professional skills can be acquired in post-secondary schools with a program duration of one to two and half years. They are strictly professional and do not include general educations. The candidates are required to be graduates of a general or industry-specific secondary school.

Vocational education is based on a system of identified professional qualifications which the pupils and students acquire and demonstrate throughout the education process (rather than just at the end of the education program). The applicable classification of vocational education paths includes a list of 245 occupations attributed between 32 industries (ORE 2019). The qualifications mean numerous skills that the graduates of a specific school are expected to demonstrate

and which are verified during an exam taken to validate a qualification identified for the occupation concerned. Starting from school year 2019/2020, every occupation has up to two qualifications attributed for which an exam needs to be taken (previously, this was not unified; for instance, the "logistics technician" was the only occupation to have as much as 3 qualifications attributed to it).

The dynamic growth of the TLS sector and the increasing demand for labor in related occupations are the reasons behind the growing number of schools offering dedicated education programs. In 2011, there were 594 of them vs. 694 in 2017 (according to Bujak and Rajczakowska, 2019). As regards vocational education for the TSL industry, the logistics technician was the leading occupation, followed by: the forwarding technician, the port and terminal operation technician, the rail transport technician and the road transport technician. In turn, the warehousing logistician is the relatively youngest of the logistics occupations offered, and is an education path that can be followed in 1st cycle industry-specific schools. Upon validating their qualifications classed as SPL.01 (AU.22.) "Warehousing operations," graduates of a school for warehousing logisticians can also obtain a logistics technician vocational diploma, provided that they validate their qualifications classed as SPL.04 "Transport organization" and have a secondary or industry-specific secondary education (Bujak and Rajczakowska, 2019).

The subsequent reforms to the vocational education system resulted in changing the core curriculum for certain occupations. This mostly involved modifications to what is referred to as the teaching schedule for each occupation and to professional qualifications required from graduates. Tables 1, 2 and 3 provide a summary of qualifications broken down by occupations introduced under consecutive reforms to the core curriculum.

Being granted a professional title, including a technician, depends on passing a written and hands-on exam for all qualifications required in the occupation concerned. This means reaching the required score, i.e. no less than 50% and 75% of the maximum score in the written part and in the hands-on part, respectively. Note that the acquisition of a certain qualification can be validated at any point during (and at different stages of) the education process. Usually, this is done during the summer or winter examination sessions (June/July and January/February, respectively), with the latter generally being a retake session. In practice, e.g. in the case of a 5-year educational program in a secondary technical school, the pupils validate their first and second qualification in the third and in the fifth grade, respectively. Note that in order to graduate, they are not required to validate their qualifications for the occupation concerned. A person who took the exam and successfully validated every qualification identified for his/her occupation obtains a professional diploma, i.e. is granted the title of technician. The exams intended to validate the pupils' occupa-

tional qualifications are organized and supervised by the head of the Central Examination Committee together with 8 Regional Examination Committees (supervised by the head of the Central Examination Committee).

Table 1. Qualifications – occupational core curriculum (2012)

Occupation name and numeric ID	Qualification designation	Qualification name
Forwarding technician 333108	A.28 A.29	Transport organization and management Customer and contractor support
Logistics technician 333107	A.30 A.31 A.32	Organizing and monitoring the resource and information flow in production, distribution and warehousing processes Managing technical resources in the course of transport processes Organizing and monitoring the resource and information flow in organizational units
Port and terminal operation technician 333106	A.33 A.34	Supporting travelers in ports and terminals Organizing and carrying out works related to transshipment and storage of goods and cargo in ports and terminals
Rail transport technician 311928	A.44 A.45	Organizing and managing rail traffic Planning and managing rail transport
Road transport technician 311927	A.69 A.70	Operating road vehicles Operating road vehicles

Source: own study based on ORE (2017a).

Table 2. Qualifications – occupational core curriculum (2017)

Occupation name and numeric ID	Qualification designation	Qualification name
Warehousing logistician 432106	AU.22.	Warehousing operations
Forwarding technician 333108	AU.31.	Organizing transportation and supporting customers and contractors
Logistics technician 333107	AU.22. AU.32.	Warehousing operations Transport organization
Port and terminal operation technician 333106	AU.33. AU.34.	Supporting travelers in ports and terminals Organizing and carrying out works related to transshipment and storage of goods and cargo in ports and terminals
Rail transport technician 311928	AU.46. AU.47.	Organizing and managing rail traffic Planning and managing rail transport
Road transport technician 311927	AU.04. AU.69.	Operating road vehicles Organizing transportation by road vehicles

Source: ORE (2017b).

Table 3. Qualifications—occupational core curriculum (2019)

Occupation name and numeric ID	Qualification designation	Qualification name
Warehousing logistician 432106	SPL.01.	Warehousing operations
Forwarding technician 333108	SPL.05.	Organizing transportation and supporting customers and contractors
Logistics technician 333107	SPL.01. SPL.04.	Warehousing operations Transport organization
Port and terminal operation technician 333106	SPL.02. SPL.03.	Supporting travelers in ports and terminals Handling cargo in ports and terminals
Rail transport technician 311928	TKO.07. TKO.08.	Organizing and managing rail traffic Planning and managing rail transport
Road transport technician 311927	TDR.01. TDR.02.	Operating road vehicles Organizing transportation by road vehicles

Source: ORE (2019).

The situation in the education market and the growing interest in logistics are the reasons why some secondary and upper-secondary schools turned their attention to the possibility of educating forwarding technicians and logistics technicians. In turn, the employers reported a shortage of employees with a vocational or secondary education in the field of transport, shipping and logistics, and witnessed strong fluctuations in these two occupational groups. The Ministry of National Education and Sport addressed these expectations by enhancing the Polish vocational education classification with two occupations referred to as "forwarding technician" and "logistics technician." The above was confirmed by the Regulation of the Minister of National Education and Sport of May 8, 2004 on the classification of vocational education occupations (Journal of Laws [Dz.U.] No. 114, item 1195). The Regulation provided a basis for organizing education in the field of logistics-related occupations, defined in a much broader sense than before. Examples of measures taken to address this problem include the Eugeniusz Kwiatkowski Technical School Complex (TSC) in Grodzisk Wielkopolski. From school year, 2007/2008, the TSC has been educating logistics technicians, a profession of great interest to graduates of primary schools located in the district and in neighboring communes. An interesting finding from the experience of the logistics technical school is that the group of candidates is predominantly feminine. The vocational training program for logistics technicians came to supplement and boost the attractiveness of the educational offering not only in

the Grodzisk Wielkopolski TSC but also in many other secondary schools. It is reasonable to guess that it managed to fill the gap left by the declining interest in vocational training for economy technicians. Because of the growing popularity of this field of vocational training and the demand for duly qualified logisticians from local employers, the TSC management decided to open another section for logistics technicians starting from school year 2016/2017, namely a uniformed section as part of the Certified Military Uniformed Sections project supported by the 5th Lubusz Artillery Regiment based in Sulechów (ZST, 2022).

Tertiary education for the TSL industry

A modern knowledge economy needs well-prepared professionals, including not only holders of a secondary school diploma but also university graduates capable of assuming managerial functions in the TSL sector. In a context of demographic decline and growing competition in the market for education services, addressing that sector's demand for human resources becomes an interesting alternative for tertiary schools which often must seek new, attractive fields of study in order to recruit students. However, this can only be done by the best universities which, on top of theoretical classes, can provide the students with an opportunity to enroll in internships and acquire additional certifications and qualifications. In the Polish realities, educating human resources for the TSL sector continues to be a relatively new proposal, even though logistics (as an interdisciplinary science) has many points of contact with technical, computer, management and economic sciences. In practice, the above means that logisticians can be graduates of a business, general or technical university (Świekatowski 2014). In Poland, the concept itself of logistics education is not new; for many years now, it has been supposed to be based on three domains:

– Business Logistics: educating specialists that address the needs of the business, and are prepared to carry out strategic analytics and economic assessments across the global supply chain,
– Logistics Management: educating specialists prepared to control logistics systems for supply, production and distribution,
– Technical / Industrial Logistics: educating specialists prepared to systemically analyze, design, implement, deploy and operate logistics systems and to manage them in a specific area (Korzeń, 1996).

In accordance with the above concept, Business Logistics should be taught by economic universities and faculties of economics at general universities, whereas Logistics Management programs should be offered both by economic universities

and universities of technology. In turn, technical universities should teach Technical / Industrial Logistics since they are in a position to deliver sophisticated technical know-how which is essential in working as a logistician. However, it turned out in practice that because of growing market demand for TSL specialists and the interest from pupils and students in learning logistics, a new discussion started in early 2000s on what is the desired education profile for that occupation. Since 2004, on the initiative of the Polish Logistics Association, a working debate has been ongoing to tell if "a logistician is an engineer or an economist?" That question was answered by the General Council of Higher Education who adopted the "tertiary education standard for logistics" in 2006, with an engineering or a bachelor diploma as the two possible education paths. The engineering path included more hours spent on learning math, system engineering, system analytics and commodity science. Also, it provided for physics or chemistry courses which were not covered by the standard bachelor path. Conversely, the bachelor program included content related to marketing and professional ethics. Graduates of the bachelor program could continue their education by enrolling to second-cycle studies no shorter than 4 semesters whereas graduates of the engineering program could select a second-cycle program with a duration of no less than 3 semesters (Journal of Laws [Dz.U.] No. 164, item 1166, Appendix 61).

The adoption of a dedicated education standard resulted in making logistics the leading field of study for TSL human resources. Another reason for it being so popular was the 2010 redefinition of the classification of occupations and specializations for the purposes of the labor market. It included occupations directly dedicated to graduates of tertiary programs, such as logistics director, logistics department manager, logistics specialist (Journal of Laws [Dz.U.] No. 82, item 537).

Education for TSL human resources is offered by both public and non-public establishments. In the Polish education market, there are two tertiary schools directly dedicated to logistics, namely the Poznań School of Logistics (WSL) and the International University of Logistics and Transport in Wrocław. In addition to academic teaching, the first one (WSL) is active in educating secondary level teachers, including by offering postgraduate programs and organizing the Teachers' Forum and the National Logistics Contest intended to disseminate modern logistics knowledge.

In academic year 2021/2022 in Poland, education for TSL human resources was offered by as many as 115 establishments, and there will be 116 of them in the next academic year (2022/2023). The existing group of schools will be joined by the University of Warmia and Mazury which announced the launch of an engineering program in logistics. In previous years, there was much less interest in fields of study related to logistics; in academic year 2007/2008, education for logisticians

was offered by 61 tertiary establishments (including 21 public and 40 non-public). However, that number grew to reach 110 (38 public vs. 72 non-public) in academic year 2011/2012. While the universities offered education in logistics mainly as part of the eponymous field of study, they also launched specialization fields in logistics as part of existing fields of study such as management, economy, finance and accounting or international relations (Stawiarska, 2014; Świekatowski 2014; Kacperska 2021). The growing number of specialization fields was undeniably a way to address the needs of the labor market. However, in some universities, it resulted from marketing efforts rather than from knowing what the labor market needs (Świekatowski, 2014).

The logistics education standard adopted in 2006 by the General Council of Higher Education provided a precise definition of the education profile and the characteristics of graduates of fist-cycle and second-cycle programs. The changes in higher education, especially the implementation of the National Qualifications Framework for Higher Education (KRK, 2010), provided the universities with autonomy in their programs, thus enabling the launch of unique fields of study other than what was provided for in the education standard. This considerably accelerated the emergence of new fields of logistics education. The implementation of the Qualifications Framework was underpinned by the Bologna process designed to ensure mutual recognition of qualifications and periods of studying abroad, and resulted in the need for defining the education profiles for the fields of study concerned. Hence, the existing tertiary programs can have a general academic or a practical profile. Table 4 presents the list of fields of study currently in place, broken down by cycle and education profile.

It turns out that the largest group of universities is formed by those offering first-cycle and second-cycle programs in the field of logistics and those offering long-cycle M.Sc. programs. Note that the latter are almost entirely new fields of study with a practical profile launched in 2019–2021 by military universities (Military University of Technology, Polish Air Force University, Polish Naval Academy of the Heroes of Westerplatte).

The autonomy the universities have in defining their programs resulted in launching new fields of study which referred to logistics already in their names. Twenty of them were created by academic year 2021/2022, but this number is highly likely to grow in the future. While most of the newly established fields of study were first-cycle engineering programs, some second-cycle programs also emerged, e.g. Logistics in the economy, Logistics and administration in the media, Manufacturing and logistics engineering.

Table 4. Fields of study for the TSL industry

No.	Field of study	Number of universities	Studies			
			first-cycle programs		second-cycle programs	long-cycle programs
			bachelor degree	engineering degree	M.Sc. / M.Sc in engineering	M.Sc.
1	Logistics	63	33	32	30	3
2	Transport	27	1	26	19	-
3	Transport and logistics	6	-	6	4	
4	Business logistics	2	1	-	2	
5	Logistics in the agri-food sector	1		1	1	
6	Logistics in the economy	1	-	-	1	
7	International logistics	1	-	1	-	
8	Economic logistics	1	-	-	-	1
9	Engineering logistics	1	-	1	-	-
10	Logistics and transport	1	-	1		
11	Logistics and freight forwarding	1	-	1		
12	Logistics and administration in the media	1	1	-	1	-
13	Rail transport	1	-	1	-	-
14	Transport, shipping and logistics security	1	1	-	-	-
15	Vehicle engineering	2	-	2	2	-
16	Logistics engineering	1	-	1	-	-
17	Transport and logistics engineering	1	-	1	-	-
18	Manufacturing and logistics engineering	1	-	-	1	-
19	Manufacturing logistics and engineering	1	-	1	-	-
20	Transport engineering	1	-	1	1	-
21	Logistics engineering*	1	-	1	-	-

Source: own compilation based on data published at the POLon site.

The fields of study that address the demand from the TSL industry are popular not only because of their interesting program content, but mostly due to the graduates not encountering any problems in the labor market (which means, in practice, an opportunity to earn a good to excellent salary). The information on the graduates' earnings is provided by numerous rankings that track their careers, including the Polish Graduate Tracking System (GTS) established on the orders of the Ministry of Education and Science. The GTS is the Europe's most innova-

tive system in its class because it provides data originating from the Social Insurance Institution and POLon (the Integrated System of Information on Science and Higher Education, https://polon.nauka.gov.pl/siec-polon). GTS presents data on people who graduated two years ago, and allows to rank the fields of study by such criteria as wages, unemployment rates and time to find employment. Also, it enables developing infographics that show the earnings and professional activity of graduates of specific tertiary establishments (ELA, 2022).

In order to demonstrate how attractive it is to work in the TSL industry, a detailed analysis was carried out of gross salaries earned during the first year after graduation[2]. The analysis relied on data for Logistics since it is the most popular field of study related to the TSL industry. Gross salaries are shown in a tabular form (Table 5).

Table 5. Total gross salary of Logistics graduates in PLN

Specification		Years					
	2017	2018	2019	2017	2018	2019	
	general academic profile			practical profile			
Full-time first-cycle studies	min	1762.00	1840.62	1990.31	1375.93	1261.22	1628.09
	max	3575.45	3751.50	3548.96	2947.85	3093.22	4039.20
Extramural first-cycle studies	min	2635.15	2116.62	2947.37	2196.68	2277.79	2875.00
	max	3622.11	4692.51	5108.46	3277.68	5144.41	4905.17
Full-time second-cycle studies	min	2653.14	2253.09	1677.86	2062.50	1857.62	2817.01
	max	3495.03	4431.27	3931.59	3247.44	3209.43	3675.73
Extramural second-cycle studies	min	2762.61	4340.63	3755.88	3415.06	2683.07	3594.59
	max	5136.36	4768.68	5718.29	4013.30	4553.75	4828.18

Source: own study based on Polish Graduate Tracking System (ELA, 2022).

As corroborated by the above data, Polish graduates of Logistics programs earn high wages which encourages students even more to enroll in that field of study. The amount of salaries earned by graduates grew consistently from one year to another (this is true for both the minimum and the maximum wages), and depended on the form and profile of studies (general academic / practical). However, a decisive role is played by previous professional experience, as testified by the fact that irrespective of their profile, higher wages can indeed be expected by graduates of extramural programs who usually can boast longer working expe-

[2] Gross salary data from a GTS survey presents the median of mean salaries from all income streams in the fist year after graduation

rience than full-time students. Interesting findings can be derived from 2019 data which clearly shows a significant difference in both the minimum and maximum amounts of gross salary between the forms of studying. Graduates of first-cycle programs could expect a maximum wage varying in the range of PLN 4905 to PLN 5108 compared to PLN 4828–PLN 5718 for second-cycle graduates (with the monthly salary in the transport and storage sector averaging at PLN 4512 in June 2019).

The information on wages encourage the students to continue studying the same or a similar field of study in a second-cycle program. In addition to becoming an M.Sc., holders of a second-cycle diploma are provided with an opportunity to earn even more and to further develop their professional career in the TSL industry.

Another clear conclusion from GTS data is that the employers become more and more interested in the profile of studies. It would seem that the TLS sector should in principle give preference to graduates of programs with a practical profile. However, it follows from the above data that higher wages are paid to graduates of general academic programs. This can be reasonably explained by such programs being widely available (as the general academic profile is taught by large academic centers with adequate authorizations, highly-qualified staff etc. whereas the practical profile is usually offered by smaller academic establishments) rather than by how the students themselves view the quality of their education.

Conclusion

The evolving industry of transport, shipping and logistics is increasingly eager to embrace new emerging solutions in both the technological and the organizational area. Once implemented, the novelties quickly set a standard for the operators active in the industry who, as a consequence, report growing demand for qualified workforce. As the deficiency of talents is widespread in the 21st century labor market (both in Poland an beyond), the undertakings must take urgent measures to source "tailored" human resources. This can be done through a coordinated collaboration between educational institutions and establishments, local government entities and the relevant stakeholders. In Poland, such measures have actually been taken since early 2000s, including the definition of separate occupational qualifications for logisticians and the amendments to the core curriculum for tertiary establishments which provided them with the ability to launch new fields of study (often in response to practical demand). As shown by previous experience, there is persistent interest in learning broadly defined logistics, both at sec-

ondary (logistics technician, forwarding technician) and tertiary levels (bachelor, engineering and M.Sc. degrees). However, a discussion is still ongoing on how to optimize the education of human resources so that their qualifications be the best possible match for expectations of TSL businesses.

References

Barometr (2021). Barometr ManpowerGroup Perspektyw Zatrudnienia Polska, Raport z badania ManpowerGroup I kwartał 2021 roku. Available online: https://www.manpowergroup.pl/wp-content/uploads/2020/12/Barometr_ManpowerGroup_Perspektyw_Zatrudnienia_Q1_21_PL_WWW.pdf (accessed on 12.03.2022).

Blaik, P. (2019). O wymiarach współczesnej logistyki i potrzebie ich kompleksowego wdrażania w praktyce przedsiębiorstw. Gospodarka Materiałowa i Logistyka. Tom LXXI, nr 16, 11–18.

Brdulak, H., (2014). Megatrendy ich wpływ na branżę TSL. Dziennik Gazeta Prawna, Magazyn Transport, Spedycja, Logistyka, nr 1.

Bujak, A. (2007). Współczesna logistyka i jej wyzwania. Zeszyty Naukowe Wyższej Szkoły Oficerskej Wojsk Lądowych im. gen. T. Kościuszki, 158–170.

Bujak, A. (2014). Współczesna logistyka i kierunki jej rozwoju. Logistyka, 4: 1693–1704.

Bujak, A. (2021). „Rewolucja przemysłowa – 4.0" i jej wpływ na logistykę XXI wieku. Autobusy, 6, 1338–1344.

Bujak, A., Rajczakowska, E. (2019). Skuteczność procesu kształcenia zawodowego w Polsce dla branży transportowej oraz logistycznej w odniesieniu do procesu egzaminowania zawodowego na poziomie szkół średnich. Gospodarka Materiałowa i Logistyka, 12, 23–31.

Deloitte (2017). Rewriting the rules for the digital age, 2017, Deloitte Global Human Capital Trends. Available online: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/HumanCapital/hc-2017-global-human-capital-trends-gx.pdf, accessed on 30.11.2021.

Dominiak, M. (2020) Technologie tworzące rynek pracy przyszłości. Available online: https://enkyconsulting.com/innowacje/technologie-tworzace-rynek-pracy-przyszlosci/, accessed on 12.03.2022.

Dz.U. nr 114, poz. 1195. Rozporządzenie Ministra Edukacji Narodowej i Sportu z dnia 8 maja 2004 r. w sprawie klasyfikacji zawodów szkolnictwa zawodowego.

Dz.U. nr 164 poz. 1166. Rozporządzenie Ministra Nauki i Szkolnictwa Wyższego z dnia 12 lipca 2007 r. w sprawie standardów kształcenia dla poszczególnych kierunków oraz poziomów kształcenia, a także trybu tworzenia i warunków, jakie musi spełniać uczelnia, by prowadzić studia międzykierunkowe oraz makrokierunki. Załącznik nr 61 Available online: http://www.wsps.nazwa.pl/docs/61_logistyka.pdf, accessed on 01.04.2022.

Dz.U. nr 82, poz. 537. Rozporządzenie Ministra Pracy i Polityki Społecznej z dnia 27 kwietnia 2010 r. w sprawie klasyfikacji zawodów i specjalności na potrzeby rynku pracy oraz jej stosowania.

ELA (2022). Ogólnopolski system monitorowaniaEkonomicznych Losów Absolwentów Szkół Wyższych. Available online: https://ela.nauka.gov.pl/pl, accessed on 01.04.2022.

Eurydice (2022). Organisation of vocational upper secondary education. Available online: https://eacea.ec.europa.eu/national-policies/eurydice/content/organisation-vocational-upper-secondary-education-35_en, accessed on 28.03.2022.

Frey, C.B., Osborne, M.A. (2013) The Future of Employment: How Susceptible are Jobs to Computerisation? Working Paper, Oxford Martin Programme on Technology and Employment, University of Oxford. Available online: https://www.oxfordmartin.ox.ac.uk/downloads/academic/future-of-employment.pdf, accessed on 15.02.2022.
GUS (2020). Transport – wyniki działalności w 2019 r., Informacje statystyczne GUS, Warszawa–Szczecin.
Kacperska, K. (2021). Rynek pracy w sektorze logistyki, Available online: https://omnipack.com/pl/blog/rynek-pracy-w-sektorze-logistyki (accessed on 28.02.2022).
KDS (2021). Dlaczego młodzi nie garną się do pracy w logistyce. Są dwie przyczyny. Available online: https://www.pulshr.pl/rekrutacja/dlaczego-mlodzi-nie-garna-sie-do-pracy-w-logistyce-sa-dwie-przyczyny,81715.html (accessed on 21.12.2021).
Kohlbacher, F., Gudors, P., Herstatt, C. (2011). Japan's growing silver market – An attractive business opportunity for foreign companies? In: S. Kunisch, A. Boehm, M. Boppel (eds.), From grey to silver. managing the demographic change successfully (p. 189–205). Berlin, Heidelberg: Springer.
Korzeń, Z. (1996). Logistyka w edukacji inżynierów. Założenia koncepcyjne i propozycje realizacyjne. I Forum Dyskusyjne Edukacji Logistycznej w Polsce, Polskie Towarzystwo Logistyczne. Poznań: Instytut Logistyki i Magazynowania.
KRK (2010). Krajowe Ramy Kwalifikacji dla Polskiego Szkolnictwa Wyższego, Ministerstwo Nauki i Szkolnictwa Wyższego. Available online: http://www.mnisw.gov.pl/krajowe-ramy-kwalifikacji-dla-szkolnictwa-wyzszego/krajowe-ramy-kwalifikacji-dla-polskiego-szkolnictwa-wyzszego.html, accessed on 01.04.2022.
Kubera, G. (2021). Pokolenie Z nie będzie w stanie wypełnić luki w umiejętnościach cyfrowych. Available online: https://www.computerworld.pl/news/Pokolenie-Z-nie-bedzie-w-stanie-wypelnic-luki-w-umiejetnosciach-cyfrowych,433195.html, accessed on 01.12.2021.
Kurasiński, Z (2014). Profesjonalna logistyka szansą gospodarki polskiej w czasach kryzysów, chaosu i zmian. Przedsiębiorczość i Zarządzanie, XV, 5 (I), 9–19.
Laskowska-Rutkowska, A. (2014). Logistyka, jej ewolucja i interdyscyplinarność – próba syntezy. Studia i Prace Kolegium Zarządzania i Finansów/Szkoła Główna Handlowa, 136, 33–46.
Lewicki, M. (2021). Współczesna logistyka – co to tak naprawdę oznacza? Available online: https://trans-moto.pl/spedycja-i-logistyka/centra-logistyczne/wspolczesna-logistyka-co-to-tak-naprawde-oznacza/, accessed on 21.12.2021.
ORE (2017a). Podstawa programowa kształcenia w zawodach – 2012. Ośrodek Rozwoju Edukacji. Available online: https://www.ore.edu.pl/2017/03/podstawa-programowa-ksztalcenia-w-zawodach2012/, accessed on 25.01.2022.
ORE (2017b). Podstawa programowa kształcenia w zawodach – 2017. Ośrodek Rozwoju Edukacji. Available online: https://www.ore.edu.pl/2017/03/podstawa-programowa-ksztalcenia-w-zawodach/, accessed on 25.01.2022.
ORE (2019). Podstawy programowe kształcenia w zawodach – 2019. Ośrodek Rozwoju Edukacji. Available online: https://www.ore.edu.pl/2019/08/podstawa-programowa-ksztalcenia-w-zawodach-2019/, accessed on 25.01.2022.
Pawlisiak, M. (2014), Komplementarność w kształceniu specjalistów logistyki.W: Przedsiębiorczość i Zarządzanie, XV, 5(I), 21–32.
Pecold, M. (2022). Wynagrodzenie osób zatrudnionych w logistyce w 2021 roku. Available online: https://wynagrodzenia.pl/artykul/wynagrodzenia-osob-zatrudnionych-w-logistyce-w-2021-roku, accessed on 02.03.2022.
Rynek logistyki (2020). Available online: https://log24.pl/news/rynek-logistyki-2020/, accessed on 04.04.2022.

Stawiarska, E. (2014). Kształcenie logistyków na poziomie szkół wyższych w kierunku społecznie odpowiedzialnych przedsiębiorstw/pracowników. Organizacja i Zarządzanie, 3, 125–141.
Świekatowski, R. (2014) System kształcenia logistycznego – inżynier czy ekonomista – dylematy edukacji. Przedsiębiorczość i Zarządzanie, XIV, 5(I), 35–44.
Sztanderska, U., Drogosz-Zabłocka, E. (2019). Wykształcenie zawodowe. Perspektywa systemu edukacji i rynku pracy. Warszawa: Wydawnictwo FRSE.
TTR (2021). 14th Annual Edition 2021 Tech Trends Report, Future Today Institute. Available online: https://olc.worldbank.org/content/future-today-institutes-2021-annual-tech-trends-report, accessed on 01.12.2021.
ZST (2022). Available online: https://zst-grodzisk.pl/certyfikowane-wojskowe-klasy-mundurowe-przekazanie-mundurow-w-ramach-realizacji-projektu/, accessed on 04.2022.
Żurek, J. (2016). Logistyka kiedyś i dziś. Ewolucja czy rewolucja? Available online: https://blog.arvato.pl/logistyka-kiedys-i-dzis-ewolucja-czy-rewolucja/, accessed on 30.11.2021.

Chapter VI

Different aspects of logistics sustainability in the agri-food sector

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Abstract
This Chapter presents different aspects of making logistics sustainable in the agri-food sector, especially in farms. The analysis was based on a study of the literature on the subject and on the author's own research. The first Subchapter indicates the role and place of logistics in the pursuit of strategic goals of sustainable development of an agricultural enterprise. The second one discusses Logistics Social Responsibility, a relatively new concept, by identifying its role in managing sustainable food supply chains. The next Subchapter presents the author's unique propositions for methodologies to be used in measuring the sustainability of logistics in agricultural enterprises, and illustrates them with case studies. The efficiency of transportation processes in the light of making them sustainable in agricultural enterprises is another topic addressed in this Chapter. The relevant analysis was carried out from the perspective of CO_2 emissions. The last Subchapter summarizes the role and importance of logistics in food supply chains; it identifies the particularities of and challenges faced by logistics in this kind of supply chains. Also, it proposes a definition of agri-food logistics by taking account of LSR guidelines and presents a new approach to the classical logistics model which is suggested to be enhanced with the right responsibility for environmental protection (7R → 8R).
Keywords: Farms, Agri-Food Logistics (AFL), LSR concept, Logistics Sustainability(LS), Methodologies for Measuring LS, definition of AFL, Transport Efficiency
JEL: Q56; Q590

Introduction

The implementation of sustainable development of societies started in late 1900s and became one of the major steps in agricultural development (Ryszkowski, 1998; Ziętara, 2000). The concept of sustainable development was first presented at the 1972 Conference on the Human Environment in Stockholm. In turn, "Our common future," a report published in 1987 by the UN World Commission on Environment and Development, defined sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (Runowski, 2000). Although the concept of sustainable development refers to all types of economy, it was triggered

by the adverse impacts of farming on the environment. Hence, the recommendations included reducing the intensity of agricultural production (simplifying the technologies, using less fertilizers and pesticides), taking part of the land out of farming; engaging the farms in non-food production activities; increasing food safety etc., so as to drive internal harmony in implementing the processes of an agricultural enterprise.

This could be attained, for instance, by enhancing the management practices with the concept of logistics which generally focuses on optimizing material and information flows both within the enterprise and throughout the supply chain (Christopher, 2000). Logistics is indeed the driving force behind planning, handling, implementing and controlling the transformation of products in time and space. When harmonized, these actions launch the flow of physical and information streams. It follows from the above that as logistics coordinates and integrates the phases and processes taking place both in a single enterprise and in the whole supply chain (to guarantee that the buyer receives the right product at the right time and place), it should naturally be viewed as a tool which offers features that could be potentially used in making development a sustainable process (Skowrońska, 2006).

Another finding is that the implementation of the sustainable agriculture concept cannot be limited to seeking an environmental balance. Instead, it should be placed in a broader context and refer to social wellbeing in general terms (Woś and Zegar, 2002; Michna, 2000). Therefore, in implementing that concept, efforts should be made to look for management methods that could ensure the attainment of production, economic, environmental and social goals (Runowski, 2004).

Taking the above into consideration, the purpose of this Chapter is complex, the purpose of this Chapter is complex, as the following issues related to making logistics a sustainable process in the area of food production were presented:

- the role and place of logistics in the pursuit of strategic goals of sustainable development of an agricultural enterprise,
- the role the concept of logistics social responsibility plays in managing sustainable food supply chains,
- methodologies for measuring the sustainability level of logistics in agricultural enterprises: case studies,
- efficiency of transport processes vs. how to make them sustainable in agricultural enterprises,
- the role and importance of logistics in food supply chains: particularities, challenges, definition of agri-food logistics.

Role and place of logistics in the pursuit of strategic goals of sustainable development of an agricultural enterprise

Efforts made to define a sustainable development strategy for agricultural enterprises resulted in identifying three strategic goals consistent with that concept, namely: (i) agri-environmental sustainability, (ii) improvements in the quality of human labor, (iii) increase in revenue.

In view of the above, the purpose of research conducted by Wajszczuk (2008) was to identify logistic processes which affect the formation of sustainable development of agricultural enterprises and, when optimized, can contribute to strategic goals of the concept contemplated in this Chapter.

Research on these aspects was carried out with large agricultural enterprises engaged in typical agricultural production activities but differing in their field arrangement patterns. All processes and related costs were identified based on fundamental logistic processes, i.e.: (i) processes related to physical flow of materials, raw materials, semi-finished products, finished products, machinery and humans, (ii) stockholding management processes, (iii) information flow processes.

The research resulted in identifying three types of logistic processes depending on the level of the factor that affects the sustainable development of agricultural enterprises. The results of this analysis are shown in Table 1.

Table 1. Differences in costs of selected logistic processes depending on the level of the factor that affects the sustainable development of agricultural enterprises

Logistic process	Factor name and level	
A. Traveling between the farming center and the field (PLN / ha of land under crops)	Field arrangement pattern	
	advantageous	disadvantageous
	87.2	401.1
B. Traveling over the fields (when sowing, spraying, fertilizing and harvesting) (PLN / ha of land under crops)	Technological simplifications	
	none	some simplifications
	672.4	511.1
	Machinery performance	
	low	high
	785.5	675
C. Loading and unloading (plant and animal production) man-hour / ha of agricultural land PLN/ha of agricultural land	Mechanization level	
	low	high
	11.2	5.8
	201.6	197.2

Source: Wajszczuk (2008).

The conclusion from the analysis is that the cost index of two-way travel between the farming center and the fields was on average 4.6 times greater (varying in the range of 3.1 to 6.9) in enterprises with a disadvantageous field arrangement pattern than in enterprises with an advantageous one. Other factors that affected the differences in that index are the amount of technological operations involved in the production of certain crops, and the location of land under crops in relation to the farming center (which is the consequence of crop rotation). The amount of technological operations depends on the crop type and on the technology used; some of the enterprises covered by this study relied on a number of technological simplifications such as zero tillage or combined plant protection and fertilization operations.

The use of the abovementioned technological simplifications also considerably affects the number of travels across fields (which also depends on the efficiency of machinery used). As shown by research, optimizing these aspects undoubtedly contributes to reducing the number of travels (the difference in costs, for the same crops, was from 24% to as much as 46%), and significantly helps alleviating the adverse effects of the soil being compacted by machinery wheels. This is an important issue for plant production since the compaction of soil by the machinery's driving mechanisms leads to changing the physical and biochemical properties of soils, reducing plant yields and increasing the amount of energy consumed to cultivate compacted soils (Wielicki and Wajszczuk, 2000). The findings in this area are consistent with the pursuit of the first strategic goal of sustainable development of agricultural enterprises: agri-environmental sustainability.

Having in mind the implementation of the second strategic goal of sustainable development of agricultural enterprises—which is to improve the quality of human labor—it seems crucial to mechanize loading and unloading operations, including particularly arduous activities involved in animal production, such as feeding and removing manure. These are the most labor-intense logistics operations of agricultural enterprises, accounting for 70–75% of total expenditure related to transportation, as generally corroborated by research. The above is particularly true for businesses where the mechanization levels of these operations are low (Wajszczuk, 1998). On the other hand, enterprises with high mechanization levels of loading and unloading operations were observed to have reduced human labor inputs by ca. 50% while staying at a similar level of costs related to work performed by machinery used in these processes. This was the consequence of using modern yet costly technical solutions. Therefore, there was a reduction in costs of human labor, on the one hand, and an increase in machinery operating costs, on the other. Such a way of optimizing logistic processes (and, thus, the costs of logistics) is referred to in the literature as trade-off relationships (Milewska,

2005). Figure 1 below summarizes the role of logistics in the pursuit of strategic goals of sustainable development of agricultural enterprises based on the analysis carried out above.

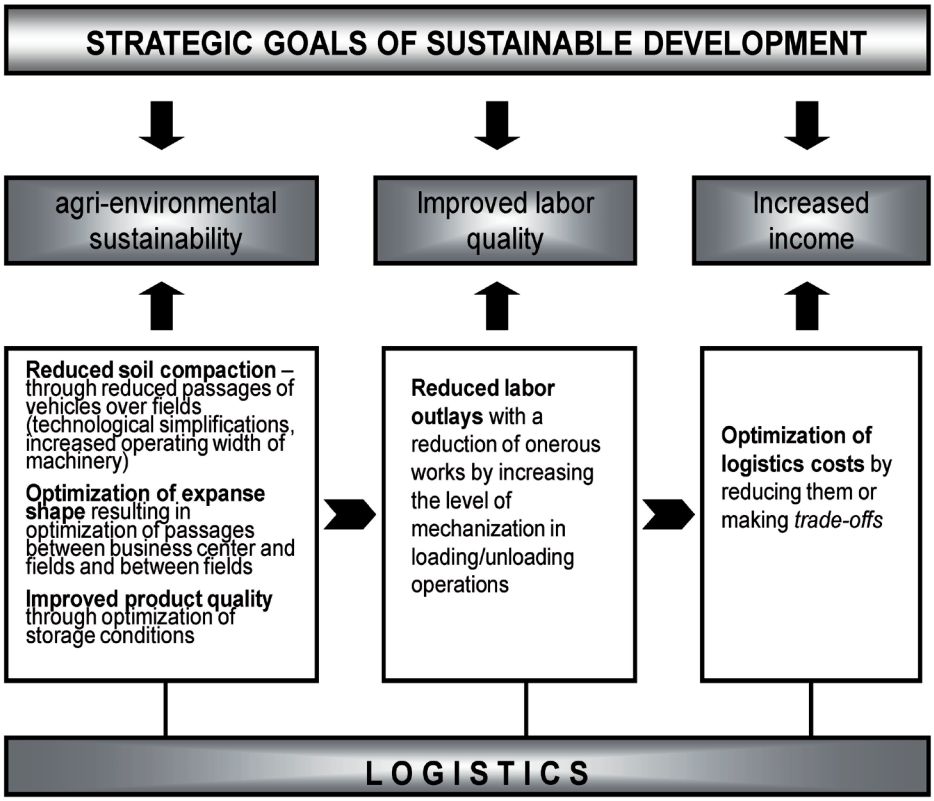

Fig. 1. Role of logistics in the pursuit of strategic goals of sustainable development of agricultural enterprises

Source: Wajszczuk (2008).

The role the concept of logistics social responsibility plays in managing sustainable food supply chains

As the work on the sustainable development concept progressed, new complementary concepts started to emerge, notably including Corporate Social Responsibility (CSR) (Ciliberti et al., 2008). As noted by Keijzers (2002), initially both concepts developed in parallel and have only recently become largely convergent. In the past, sustainable development was a topic focused solely on environmental

protection issues whereas CSR placed emphasis on social aspects such as human rights (Robinson, 2004). Today, many researchers consider sustainable development and CSR to be synonymous (Lehtonen, 2004).

Over the years, the logistics too have gained a social focus in their environmentally-oriented measures. The common portion of these actions was defined as Logistics Social Responsibility (**LSR**) (Carter and Jennings, 2002).

Corporate Social Responsibility issues are of particular importance in food supply chains (FSCs). Food-related diseases (e.g. EHEC, BSE) and the increasing globalization of food production are the reasons why consumers become more and more aware of the importance of where their food comes from (Soysal et al., 2012). In these areas, consumer pressures resulted in greater interest in food production traceability and in the quality and freshness of food. Since logistics offers great opportunities in this respect and involves considerable costs (Wajszczuk, 2018b), it appears that logistic enterprises attempt to implement the LSR concept in their management practices to a broader extent. Because of new trends in supply chains (especially in FSCs), traditional FSC management strategies become inadequate, which requires the entrepreneurs to create new ones aligned with a new, rapidly developing concept: Sustainable Food Supply Chain Management (SFSCM) (Soysal et al., 2012), where LSR plays a key role.

Methodologies for measuring the sustainability level of logistics in agricultural enterprises: case studies

LSR is a relatively new concept, and its scope keeps evolving. It is being enhanced with new topics, e.g. ethical aspects, working conditions, philanthropic attitudes etc. (Carter and Jennings, 2004). Hence, a number of scientific centers make numerous attempts to develop comprehensive methods for assessing the state of implementation of that concept, both in enterprises and across supply chains. Previous attempts were of a more general nature and focused on assessing enterprises active in different industries (Murphy and Poist, 2002; Ciliberti et al., 2008). Hence, there is lack of industry-specific and enterprise-specific methods.

Having the above in mind, as the next goal in his research work, the author attempted to develop a series of methodologies for measuring and assessing the sustainability of logistics in food enterprises (in a processed-based approach) in the light of the LSR concept. The first attempts were presented in a paper titled ***Scorecard model for assessing process compliance with CSR and LSR*** (Wawrzynowicz et al., 2014). As mentioned earlier, CSR and LSR are complementary to one another, and therefore that paper attempted to develop a tool for a continuous

verification of all activity areas of an agricultural enterprise, with both concepts being taken into account. A pilot model was prepared based on research carried out with Farm Frites Poland Dwa, a company specializing in industrial cultivation of potatoes and seed potatoes, holder of a GlobalGAP (Global Good Agricultural Practices) certificate.

The development of a scorecard model for assessing CSR and LSR strategies required an analysis to be conducted of all processes implemented in the enterprise, including those related to cultivation, fertilization, plant protection, irrigation, harvesting, warehousing, transportation etc. A process mapping technique, which is one of the key tools of a process analysis, was used to identify specific processes covered by the study.

This resulted in developing a scorecard in the form of a matrix that allows to check and assess the fulfillment of a strategy with the use of identifiers for three main areas, i.e. economy, environment and society.

The matrix should be used for each mega-process (which results in a separate endpoint) because some of the sub-areas covered by the analysis can be related to more than just one product. In view of the above, three identifiers were used: F: fulfilled, U: unfulfilled, P: partly fulfilled, NA: not applicable.

The identifier-based analysis resulted in verifying whether specific sub-areas meet the defined CSR and LSR requirements of the strategy in place in the enterprise concerned. Also, the information collected this way enables defining further action for particular sub-areas covered by the strategy that takes account of the concepts contemplated above.

The research continued based on previous experience and having in mind the new trends in the concept of how to drive sustainable development of agricultural enterprises, so as to come up with a more precise tool used in measuring the sustainability of logistics in this type of businesses, with particular emphasis on LSR. This resulted in proposing a methodology underpinned by LSR which uses a process-based approach to measuring the sustainability of logistics in food enterprises (Wajszczuk, 2016a).

At the initial stage of LSR development, 47 different practices/sub-processes were defined for the purpose of analyzing (at an above-industry level) five main strategic processes which lay the foundations for that concept (Carter and Jennings, 2002), namely:

- Purchasing Social Responsibility (PSR),
- Sustainable Transportation (ST),
- Sustainable Packaging (SP),
- Sustainable Warehousing (SW),
- Reverse Logistics (RL).

A structural assumption was made that the methodology dedicated to agri-food businesses would comprise four stages. The first (basic) stage consists of identified sub-processes that form part of the five main strategic processes mentioned above. Hence, of the 47 sub-processes, the ones of relevance to the agribusiness sector were selected, and the resulting list was supplemented based on findings from the author's own research (Wajszczuk, 2013). The environmental (ENV), social (SOC) and economical (ECON) sustainability areas were identified for each sub-process. The second stage evaluates the implementation of different national and international standards applicable to social, environmental and qualitative aspects. The third stage of the methodology proposed examines the publication of non-financial reports. This means voluntary reports which describe the relationships between the enterprise and its stakeholders, and provide the interested parties with information on environmental, social and economic measures taken by the enterprise (Shepherd et al., 2001). In turn, the fourth stage evaluates whether the reports are available online, because practice shows that most of them are in-house documents not delivered to the public. In addition to the scope of assessment outlined above, the purpose of the three last stages is to verify the information obtained from a survey during the first (basic) stage.

For the proposed method of assessing the sustainability of logistics in agribusinesses, the analysis resulted in identifying a total of 73 sub-processes within the five main LSR processes. This includes 26 sub-processes verified when assessing the agribusinesses in terms of purchasing social responsibility (PSR); 20 sub-processes verified to determine the implementation level of sustainable transportation (ST); 8 sub-processes used in assessing compliance with sustainable packaging (SP); 7 sub-processes which enable determining the degree of sustainable warehousing (SW); and 12 sub-processes used in verifying the sustainability of reverse logistics (RL).

When verifying the sub-processes, account needs to be taken of the type of the enterprise considered, i.e. its location in the supply chain. Some sub-processes are characteristic of agricultural enterprises and will not be used in describing processing or trade companies (and vice versa). Having this in mind, one of four options is assigned to each sub-process in order to quantify the information retrieved from the survey:

- not applicable: no score, not subject to assessment,
- not implemented: a score of 0,
- partly implemented: a score of 1,
- fully implemented: a scored of 2.

Then, the scores are aggregated within specific main LSR processes and within sustainability areas (Table 2). With this score aggregation system, it is possible to

individually assess each main LSR process (5 indicators) and determine the sustainability implementation degree in the social, environmental and economical dimension of the LSR concept (3 indicators).

Table 2. Number of sub-processes in main LSR processes, total number of sub-processes per sustainability area, and maximum potential scores

Sustainability areas	Main LSR processes										Total in sustainability areas	
	PSR		ST		SP		SW		RL			
	a	b	a	b	a	b	a	b	a	b	a	b
Social	13	26	3	6	2	4	1	2	2	4	21	42
Environmental	8	16	12	24	7	14	6	12	12	24	45	90
Economic	16	32	12	24	1	2	2	4	3	6	34	68
Total	37	74	27	54	10	20	9	18	17	34	X	X

a: number of sub-processes confirming the implementation degree of a main process/sustainability area
b: maximum score for the implementation of a main process/sustainability area
Source: own study.

Data presented in Table 2 suggests that social sustainability is verified with 21 sub-processes, with PSR as the largest group. In turn, the environmental sustainability assessment is represented by the largest group comprising 45 sub-processes (including ST and RL and the largest sub-groups, each with 12 sub-processes). The economic dimension is represented in 34 sub-processes, with the largest group being composed of 16 PSR sub-processes. The fact that such a structure of sub-processes emerges out of the method proposed emphasizes the importance of the environmental dimension.

The sustainability of an area / main process in the light of LSR will be assessed with relative indicators expressed as a percentage. The following five-point scale was used:

- > 80%: the area / main LSR process is highly sustainable,
- 60% to 79%: the area / main LSR process is fairly sustainable,
- 40% to 59%: the area / main LSR process is moderately sustainable,
- 20% to 39%: the area / main LSR process is poorly sustainable,
- < 20%: absence of sustainability in the area / main LSR process.

In accordance with the assumptions, data retrieved from the survey in the first stage of the method proposed is verified with data coming from the three subsequent stages. In order to effectively implement LSR-compliant principles of sustainable logistics while remaining competitive in the food market, agribusinesses should launch and increasingly rely on procedures for deploying quality certification systems/standards that control the raw materials / products delivered

and the way they flow across the supply chains until reaching the end customer (Wajszczuk, 2016b). The list of standards covered by the second stage of this method is presented in Table 9.7, page 124 of the author's publication discussed in this Chapter (Wajszczuk, 2016a). Hence, the second stage will consider the implementation degree of relevant systems/standards. As some of the sub-processes presented in the first stage fall within the scope of certain standards, this is a verification stage.

In summary, the abovementioned publication proposes a comprehensive method for measuring and assessing logistics sustainability in agribusinesses. As a key component, it uses the proposed survey to verify the quantity, type and implementation of LSR-related sub-processes. If further aggregated, the data makes it possible to individually assess each main LSR process and determine the implementation degree of sustainable logistics in the social, environmental and economical dimension of the LSR concept.

As mentioned earlier, the first LSR-based methods for assessing the sustainability of logistic processes were of a more general nature. Therefore, in the literature on the subject, there is dearth of research findings on how much is logistics sustainability compliant with LSR at industry level or by enterprise type within an industry.

Having the above in mind, the author used his proprietary methodology—as adapted for the purposes of agricultural enterprises—to measure logistics sustainability with five main LSR-compliant areas/processes being taken into account. The study was focused on assessing the sustainability and implementation of processes in a purposefully selected large agricultural enterprise which had already attained much progress in implementing a sustainable development strategy (especially in terms of CSR) and in three small farms.

As mentioned earlier, Farm Frites Poland Dwa, the enterprise selected for this study, specializes in industrial cultivation of potatoes and seed potatoes. It holds a GlobalGAP (Global Good Agricultural Practices) product quality certificate, participates to the McDonald's Agriculture Assurance Program and operates ca. 3200 ha of arable land (AL) in the Pomorskie voivodeship. On the other hand, three family farms based in the Wielkopolskie voivodeship were selected for a comparative analysis. They focused on mixed (vegetable + animal) production and had 58 ha, 64 ha and 71 ha of arable land, respectively. Thus, the cognitive purpose of this pilot study was to test the methodology proposed and obtain first data on sustainability levels of logistics in large and small agricultural enterprises.

The analysis delivered some outputs on the main LSR processes and sustainability areas which, after being duly aggregated, resulted in a number of indicators. The indicators for main LSR processes were compared in accordance with the

grading scale adopted in this methodology, and provided grounds for concluding that FFPD demonstrates greater sustainability in its processes than family farms. Two processes in place at FFPD (ST and RL) proved to be highly sustainable (each at a level of 83%). Warehousing (SW) was fairly sustainable (at 69%) whereas medium levels of sustainability were recorded for PSR (51%) and SP (50%). Conversely, small/family farms were found to have poor levels of sustainability for the above processes and demonstrated unsustainable reverse logistics (RL) (with a rate of 17%). Transportation turned out to be their most sustainable process, reaching a medium level of 48%. In turn, the implementation of PSR, SP and SW was reported to be poorly sustainable.

The results of the analysis of logistics in the second (social, environmental and economic) dimension proved that LSR practices followed by FFPD generate a fair level of sustainability in the environmental and economic area while offering a medium level in the social area. In turn, sustainability levels recorded in family farms are much lower, with a medium rate of 42% in the social area and a poor score of 29% in the environmental dimension. Furthermore, logistic processes were found to be non-sustainable in the social area.

The case studies carried out with the large enterprise and the three small ones demonstrated that the degree of logistics sustainability grows faster in the former than in the latter. This is true for each main LSR process and for the social, environmental and economic dimensions.

As a continuation of research into this method for measuring and assessing logistics sustainability in agribusinesses, the verification was restricted to family farms engaged in mixed (plant and animal) production with different resources of agricultural land. Hence, the study focused on five family farms located in the Wielkopolskie voivodeship, with the following areas of arable land: (F1): 32 ha, (F2): 58 ha, (F3): 64 ha, (F4): 71 ha and (F5): 131 ha. All of them were engaged in mixed (plant and animal) production and differed in their field arrangement patterns (Wajszczuk, 2018a).

The results of assessing the degree of logistics sustainability and LSR compliance in selected family farms demonstrate quite a low level of sustainability and thus corroborate the findings from a pilot study carried out with that group of holdings (as described above). Another observation is that the scores vary between enterprises of different sizes. There is a positive correlation between the logistics sustainability level and the area of land, whether it comes to specific main LSR processes or the social, environmental and economic aspects. The results are presented in Tables 3 and 4.

Table 3. Logistics sustainability degree in specific areas

Sustainability areas	Total in sustainability areas									
	F 1		F 2		F 3		F 4		F 5	
	score	%	score	%	score	%	score	%	score	%
Social	5	12.5	6	15.0	6	15.0	7	17.5	8	20.0
Environmental	9	11.3	15	18.8	22	27.5	24	30.0	27	33.8
Economic	13	19.7	21	31.8	26	39.4	31	47.0	33	50.0

Source: own study.

According to the analysis of three specific sustainability areas, LSR practices implemented in the farms under consideration result in a poor degree (F3, F4 and F5) or total absence (F1 and F2) of sustainability in the environmental area, and in a total absence of sustainability in the social area. In turn, the highest sustainability levels for logistics were demonstrated in the economic area.

Table 4. Logistics sustainability degree in main LSR processes

Main LSR processes	Total in main LSR processes									
	F 1		F 2		F 3		F 4		F 5	
	score	%	score	%	score	%	score	%	score	%
PSR	10	13.9	15	20.8	15	20.8	19	26.4	21	29.2
ST	12	23.1	18	34.6	27	51.9	31	59.6	31	59.6
SP	3	18.8	3	18.8	3	18.8	3	18.8	6	37.5
SW	0	0.0	2	12.5	4	25.0	4	25.0	5	31.3
RL	2	6.7	4	13.3	5	16.7	5	16.7	5	16.7

Source: own study.

Meanwhile, as shown by a comparative analysis of indicators for main LSR processes, Sustainable Transportation is the most sustainable process in all farms under consideration. Conversely, no sustainability was reported in the area of Reverse Logistics.

The verification of the method for assessing the sustainability of logistic processes in terms of LSR can be summarized as follows: with the growing public pressure on improved safety of foodstuffs in the supply chain, agribusinesses who purchase primary products from small farms will require the latter to increasingly implement LSR principles for the sake of transparency. Based on that emerging trend, it may be concluded that even small enterprises, such as family farms, should intensify the implementation of LSR principles in their development strategies, thus becoming responsible suppliers of primary products for large processors.

Efficiency of transport processes vs. how to make them sustainable in agricultural enterprises

Over the last decade, in assessing the sustainability of logistics and – to be more precise – of transportation processes, more and more attention has been paid to how efficient these processes are from the perspective of CO2 emissions.

Indeed, one of the important problems of transportation processes is how they impact the environment. According to a World Economic Forum (2009) report, logistic processes (especially including transportation) account for ca. 2800 megatons of CO2 emissions per year, which is ca. 6% of total CO2 emissions from human activity around the globe. In turn, the results of a research based on lifecycle assessment, performed at the Carnegie Mellon University in the United States, suggest that transport processes account for 11% of 8.1 million tons of annual greenhouse gas emissions related to food consumption (Gant et al., 2015). Meanwhile, the World Bank estimates that logistical processes account for ca. 15% of total greenhouse gas emissions (Irigoyen, 2014), with 60% being generated by transportation processes.

The latter form an integral part of technological processes used in agricultural production and, due to production activities being distributed over space, cannot be eliminated. As mentioned earlier, many years of research show that they generate high outlays and costs while also having a significant environmental impact.

In the light of the above considerations, it becomes key for agricultural enterprises to seek the right relationship between necessary improvements in the efficiency of transportation processes and growing social demand for these processes to be environmentally friendly. The need to look for environmentally friendly solutions results from a number of reasons, including a shift in consumer attitudes. It follows from previous studies that many consumers prefer buying products from enterprises which take care of the environment and maintain good social relationships.

The vast majority of studies on transportation emissions focus on road transport. Meanwhile, there is lack of research into emissions from internal transportation, especially in agricultural enterprises which—as shown by a number of previous studies—are production and transportation businesses at the same time (Wolszczan, 1988; Krysztofiak, 2010; Wajszczuk, 2013).

Therefore, the author wanted his study to assess the efficiency of transportation processes used in plant production in terms of how they impact the environment. Primary data was retrieved from a survey with 16 selected family farms mostly engaged in plant production and located in Greater Poland (Wajszczuk, 2018c). The assessment was put in a context of how to make these processes sustainable in terms of their CO2 emissions.

The efficiency of transportation processes can be assessed from different angles. It is important for the indicators to reflect the particularities of the enterprise and of the processes it implements (Gębczyńska, 2012). Hence, in this case, efficiency was determined based on the ratio between the mass of items transported and the outlays and costs per hectare of crops concerned. Another determinant of efficiency of transportation processes is the quantitative and qualitative status of vehicles and the way they are used in the production processes (Tabor, 2008). Highly worn-out low-performance equipment with a low annual usage rate will not only generate high unit costs but also have an adverse environmental impact.

Therefore, to address that aspect, the sustainability of transportation processes was assessed by determining the CO_2 emissions index. The calculation was based on a formula compliant with REDcert, the systemic principles for the calculation of greenhouse gas emissions in accordance with Directive 2009/28/EC (2009). The following formula (1) was used to calculate CO_2 emissions generated by internal transportation during plant production activities:

$$GHG_{ep} = (NT \times W_{on} \times W_{weon} \times WE_{on}) / 1000 \quad (1)$$

where:
GHG_{ep} – total CO_2 emissions in kg per ton of products and materials transported per ha,
NT – outlays on transportation processes in kWh/ha,
W_{on} – diesel oil unit consumption ratio in kg/kWh [0.22 kg·kWh^{-1}],
W_{weon} – energy value index for diesel oil in MJ/kg [43.1 MJ·kg^{-1}],
WE_{on} – CO_2 emissions index for diesel oil in gCO2eq/MJ [87.64 gCO2eq·MJ^{-1}].

The comparative analysis resulted in determining plant-specific indexes of human labor and equipment inputs, energy inputs and costs of transportation processes. The efficiency of these processes and CO_2 emission indexes were calculated as the next step. This allowed to conclude that the group of root crops and maize grown for silage had the highest efficiency of transportation processes and the lowest unit CO_2 emission index. The average unit emission index was 6.22 kgCO_2·t^{-1} for sugar beet and slightly over 10 kgCO_2·t^{-1} for silage maize and potatoes. In turn, the highest unit CO_2 emission indexes in transportation processes were recorded for rapeseed (70.48 kgCO_2·t^{-1}) and green peas (42.60 kgCO_2·t^{-1}) which also demonstrated the lowest efficiency of transportation processes.

In the context of the goal of this study, the conclusion was made that an increase in efficiency of internal transportation processes of agricultural enterprises goes hand in hand with a reduction in unit CO_2 emissions.

Today, it is of utmost priority to seek the appropriate relationship between the efficiency and environmental impact (viewed from the perspective of CO_2 emissions) of transportation processes. Also, this study is consistent with the European Commission's 2050 roadmap for a low-carbon economy (2014) which states that CO_2 emissions of the transportation sector need to be reduced by ca. 60% against the 1990 baseline by 2050. Greenhouse gas emissions from road transport increased by 29% between 1990 and 2007. That negative trend subsequently came to a stop; due to high prices of oil, greater efficiency of passenger car engines and slower growth in mobility, the period 2007–2011 witnessed a decline in greenhouse gas emissions by 6%.

The research on these topics and the findings derived from it should be viewed as a basis for broader study projects carried out not only in family farms but also in large agricultural enterprises, all the more since they deploy transportation processes on a larger scale.

Role and importance of logistics in food supply chains: particularities, challenges, definition of agri-food logistics

Based on the findings from the author's own research and on a study of the relevant literature, this part of the present Chapter structures the knowledge on the particularities of food supply chains (FSCs) in the context of logistics, with particular focus on agricultural enterprises. It presents the role and importance of logistics in FSCs. Also, having in mind the growing environmental, social and ethical requirements for food supply chains, it formulates the challenges faced by logistics and outlines its further development paths in the agri-food sector. The summary attempts to answer the following question: *in the light of the above considerations, what is the adequate definition of logistics for the agri-food sector*?

The many years of research carried out both by the author himself and by different scientific centers were used to detail the list of characteristics of agricultural production which determine the logistics of agricultural enterprises. These include (Kapusta, 2008; Klepacki, 2011; Wajszczuk, 1998a; 1998b; 1998c):

- *the spatial nature of agricultural production* (considerable costs of internal transportation resulting from traveling multiple times per season to each field which can be located a couple or ten to twenty kilometers away from the farming center),
- *dependency on climate conditions and seasons* (seasonality often results in the need to quickly generate large amounts of stocks which occupy much storage space),

- *timeliness of economic processes* (untimely harvesting can entail considerable, if not total, crop losses; disruptions in the transportation of certain products, e.g. milk, can result in it losing its properties and, thus, its commercial value),
- *continuity of the production process with intermittent labor processes* (this results from the seasonality effect and means uneven demand for productive inputs),
- *diversity of cargo* (e.g. cereal gains, beet roots, potato tubers, dried or succulent roughage, milk, livestock; this results in the need to own a diversified vehicle fleet) (Čepinskis and Masteika, 2010); animal transport is subject to particular restrictions, as laid down in applicable regulations of the European Union[2],
- *extremely large total cargo mass* (including both the number of tons transported and the number of travels); this is illustrated by the results of previous research which suggest that depending on the production line and intensity level, a total of 20 to 80 tons of cargo per hectare of agricultural land is transported every year,
- *agricultural goods being transported in one direction* (good management practices make it possible to alleviate that inconvenience in external transportation: transporting the product for sale and returning to the base with productive inputs purchased; however, this is impossible in internal transportation between the base and the field); empty runs are characteristic of agricultural enterprises, and result in extremely low vehicle usage ratios (varying in the range of 10% to 95%) (Gebresenbet and Bosona, 2012),
- *short distance traveling on poor quality roads* (poor quality of roads has a detrimental effect on the quality of agricultural produce, especially such as succulent roughage: forage, fruit, certain vegetables etc.),
- *many agricultural products being largely unfit for transportation and storage* due to short life and vulnerability to damage (this is combined with the presence of risk of losses during transportation over excessive distances or during prolonged storage; particularly vulnerable items include plant products such as forage, fruit, vegetables and animal products such as milk and meat); moreover, if improper transportation, warehousing and processing technologies are taken into account, harvest and post-harvest losses

[3] The first European Union's Directive on the protection of animals during transport was adopted in 1977. The new provisions have been applicable since 1991 and 1995. Accordingly, a transporter of live animals must meet the following conditions prior to departure: be authorized to transport animals; entrust the transport of live animals to competent staff who demonstrate adequate skills and knowledge; plan the journey; ensure the use of adequate vehicles; ensure that water, feed and rest are provided as and when needed; the animals must be fit for transport.

reach 60–70% in developing countries vs. only 1–2% in the U.S. (Gebresenbet and Bosona, 2012; Tan, 2012).

Therefore, already in 1913, Albrecht Thaer had a good reason to believe that *whether they want it or not, farms are transport undertakings* (Wolszczan, 1988), now a well-known saying.

In view of the progressing globalization and the particularities of agricultural production presented above, it can be concluded that these characteristics are not only determinant for logistics in agricultural enterprises but also affect the functioning of whole FSCs by amplifying and generating new determinants. For instance, they hamper FSC traceability, an extremely important aspect which makes it possible to quickly locate the source of a threat and remove defective products from the market. Based on a literature study, the following problems (which at the same time pose a number of challenges to logistics) were identified in this area:

- *how to ensure consistent product quality across many small farms* (a problem which results from the variability of weather and biological factors which affect organoleptic properties such as taste, smell, texture etc.),
- *different sources of supply for particular batches of raw materials* (a factor which is related to the one listed above but is amplified by the internationalization of supply chains resulting from the quest for new, affordable sources of raw materials),
- many supplies of diversified raw materials contribute to the *problem of contamination* (infection) and to difficulties in ensuring a consistent recipe for further processing in the supply chain,
- continuous production is the prevailing production type in AFSC (production of milk, sugar, flour etc.: it is difficult to ensure the traceability of raw material sources); it is the contrary for other sectors where discrete production prevails (assembly of vehicles, washing machines etc.: it is easy to ensure the traceability of particular parts and components),
- *presence of a number of independent intermediaries across the supply chain* (from farm to fork): this contributes to numerous disruptions in the information flow and, as a consequence, to making excessive stocks upstream in the supply chain (the bullwhip effect[4]); also, the large number of players in

[4] The bullwhip effect (also known as the whiplash effect or the whipsaw effect) means that changes in demand get amplified along the supply chain. Relatively small variations in demand from final customers grow as the information on the demand is transferred upstream to the producer and then to the suppliers. The effect of demand amplification was identified and described for the first time in 1958 by Jay Forrester. He believed that the main reason behind it was the behavior of managers who made rational decisions, i.e. overestimated the increase or decline in customer demand and assumed that these variations would continue. Also, he pointed out to other sources of that effect: the existence of a time gap between the submission and the fulfillment of an order and material flows; and the impact of promotional campaigns on demand fluctuations.

the supply chain encourages the establishment of many formal and informal relationships which obstruct the desired development of partnership and trust across the chain,
- the above problem leads to the emergence of long marketing channels and results in unequal power relations in the supply chain; this leads to the establishment of business models which cannot be sustainable for small and medium enterprises; the final price of food can reach almost 250–350% of farmgate prices, especially in developing countries (Verma, 2013),
- *poor infrastructure and limited access to inputs (technologies, funds, innovations) required* to attain high levels of efficiency; this is believed to be the biggest challenge for suppliers from developing countries (OECD/WTO, 2013) while also being a standard (e.g. ISO 22000[5] or FSSC 22000[6]) required by global markets[7],
- there are major difficulties in determining *the systems and mechanisms which coordinate horizontal cooperation between farms*, mostly due to lack of confidence and financial support, especially in developing countries (e.g. absence of proven business models, lack of state-of-the-art warehousing infrastructure, lack of ICT solutions, trainings etc.).

The solution that could be efficient in alleviating, if not eradicating, the above problems is to quickly implement short food supply chains, a model which became extremely popular during the COVID-19 pandemic that disrupted the global supply chains.

Short supply chains bring advantages to both producers and consumers as well as to the environment. Consumers increasingly often demand products of proven origin, sourced from local suppliers, processors and farmers. The farmers too are interested in shortening the supply chain of farm products by avoiding intermediaries. This way of selling has a number of consequences, including lower product prices for final buyers. Consumer expectations trigger the establishment of different kinds of local food networks, including farmer marketplaces, direct sales by producers, or sale and delivery to the customer.

[5] ISO 22000: the definition of food quality and safety standards.
[6] FSSC 22000: a standard developed by the Confederation of the Food and Drink Industries of Europe and notable food producers as an enhancement to ISO 22000.
[7] Food CERT, 2015. ISO 22000, FSSC 22000, http://www.foodcert.pl/iso22000?gclid=CKHgi8nOxcMCFQ6WtAodnl4AlA , accessed on January 22, 2015.

Summary and conclusions

In summarizing the above considerations which take the particularities of FSCs/ agricultural enterprises into account, the analysis should be geared to the definition of logistics. The term itself[8] was defined in 1998 by the Council of Supply Chain Management Professionals. However, since that time, the differences between economic sectors and the progress in industry-specific logistic technologies have resulted in the emergence of multiple definitions of logistics which are adequate for specific sectors. Based on a review of definitions provided in selected publications and on the author's own research (Ahumada and Villalobos, 2011; Angeles Sanfiel-Fumero et al., 2012; Chen et al., 2012; Gebresenbet and Bosona, 2012; Hsiao et al., 2010; Kukovič et al., 2014; Liping, 2012; Kramar et al., 2013; Vaněček and Kaláb, 2003; Wajszczuk, 2012), the term *agri-food logistics* (as defined below) was proposed to be used in the context of the agri-food sector:

Agri-food logistics *is an important part of the economy and an integrated system comprising the processes of planning, implementing and controlling the flow of materials, raw materials and agri-food products and the accompanying information, from their manufacturing locations to the final buyer, through warehousing, processing and trading links, designed to secure the smooth supply of safe foods and products used for other purposes*[9] *to the customer at minimum cost and in an environmentally friendly manner.*

In the light of the above, the classical approach to logistics expressed by the "7R" formula (Coyle et al., 2002: Right product; Right quantity; Right condition; Right place; Right time; Right customer; Right price) fails to exhaust the scope of and requirements for logistics in food supply chains, and should be supplemented with another "R" which stands for the ***Right environmental responsibility***. Hence, the modified "**8R**" principle defines eight procedural requirements for the process of material, raw material, animal and agri-food product flows, and the adequate way of performing the basic logistic tasks in FSCs / agricultural enterprises.

The presentation of different aspects of making logistics sustainable in the agri-food sector gives grounds for the following conclusions:

1. The study of the relevant literature and the author's own research identified some particularities of FSCs which need to be taken into consideration when designing dedicated systems.

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[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.*

[9] E.g. biomass production for energy generation (biofuels).

2. There is seemingly increased pressure on optimizing logistics in three dimensions (costs, time and environment), which is consistent with the implementation of sustainable development strategies.
3. Considering the growing consumer expectations for the quality and safety of food and animal welfare, as well as the growing social expectations and legal requirements for environmental protections, the LSR concept is likely to further develop, especially in food supply chains.
4. Also, there will be greater concentration of farms, processing plants and warehouses so as to decrease their number while increasing their size.
5. This will drive greater integration inside the chain and will contribute to building relationships between all links.
6. In order for FSCs to be able to compete efficiently, it will be necessary to implement systems to certify the quality and delivery method of raw materials and products.
7. The main problems facing FSCs, as identified in this study, are in particular related to long global models which at the same time represent a challenge to logistics.
8. Over the last decade, food economics has witnessed the rapid implementation of short supply chains, a model which became extremely popular during the COVID-19 pandemic that disrupted the global supply chains.
9. A definition of agri-food logistics was proposed which takes account of LSR guidelines.
10. It is proposed that the classical approach to logistics be extended with the right responsibility for environmental protection (7R → 8R).

References

Ahumada, O., Villalobos, J.R. (2011). Operational model for planning the harvest and distribution of perishable agricultural products. Int. J. Prod. Econ., 133(2), 677–687.

Angeles Sanfiel-Fumero, M., Ramos-Dominguez, Á.M., Oreja-Rodríguez, J.R. (2012). The configuration of power in vertical relationships in the food supply chain in the Canary Islands: An approach to the implementation of food traceability. Brit. Food J., 114(8), 1128–1156.

Blaik, P. (2001). Logistyka (Logistics). Warsaw: PWE.

Baum, R., Śleszyński, J.(2008). Teoretyczne aspekty trwałego i zrównoważonego rozwoju gospodarstw rolnych (Theoretical aspects of durable and sustainable development of farms). Ekonomia i Środowisko, No. 1(33), 8–24.

Carter, C.R., Jennings, M.M. (2002). Logistics social responsibility: An integrative framework. J. Bus. Logist., vol. 23, No. 1, 145–180. DOI:10.1002/j.2158-1592.2002.tb00020.x.

Carter, C.R., Jennings, M.M. (2004). The role of purchasing in corporate social responsibility: A structural equation analysis. J. Bus. Logist., 25, 1, 145–186. https://doi.org/10.1002/j.2158-1592.2004.tb00173.x.

Čepinskis, J., Masteika, I. (2010). Role of logistics in the development of Lithuanian meat sector. Econ. Rural Dev., Vol.6, No. 1, 23–29.
Chen, Y., Li, D., Li, L., Zheng, Y. (2012). A Bayesian Based Search and Classification System for Product Information of Agricultural Logistics Information Technology. Computer and Computing Technologies in Agriculture V. IFIP Advances in Information and Communication Technology, 437–444.
Christopher, M. (2000). Logistyka i zarządzanie łańcuchem dostaw (Logistics and supply chain management). Warsaw: Polskie Centrum Doradztwa Logistycznego.
Ciliberti, F., Pontrandolfo, P., Scozzi, B. (2008). Logistics social responsibility: Standard adoption and practices in Italian companies. Int. J. Prod. Econ., No. 113, 88–106. https://doi.org/10.1016/j.ijpe.2007.02.049.
Coyle, J.J., Bardi, E.J., Langrey Jr., J.C. (2002). Zarządzanie Logistyczne (Logistic management). Warsaw: Polskie Wydawnictwo Ekonomiczne.
Directive 2009/28/EC of the European Parliament and of the Council of April 23, 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, accessed on 19.03.2018.
European Commission (2014). Communication from the Commission to the Council and the European Parliament, Strategy for reducing Heavy-Duty Vehicles' fuel consumption and CO_2 emissions, Brussels, May 21, 2014, COM(2014) 285 final.
Gebresenbet, G., Bosona, T. (2012). Logistics and supply chains in agriculture and food. In: A. Groznik, & Y. Xiong (Eds.), Pathways to Supply Chain Excellence. IntechOpen. https://doi.org/10.5772/25907.
Gębczyńska, A. (2012). Pomiar efektywności procesów logistycznych (Measuring the efficiency of logistic processes). Scientific Journals of WSB University in Wrocław, No. 32, 211–220.
Hsiao, H.I., van der Vorst, J.G.A.J., Kemp, R.G.M., (Onno) Omta, S.W.F. (2010). Developing a Decision-making framework for levels of logistics outsourcing in food supply chain networks. Int. J. Phys. Distrib. Log. Manag., 40(5), 395–414.
Irigoyen, J.L. (2014). To feed the future, let's make logistics and transport sustainable, http://blogs.worldbank.org/transport/feed-future-let-s-make-logistics-and-transport-sustainable, accessed on 19.02.2018.
Kapusta, F. (2008). Agrobiznes (Agribusiness). Warsaw: Centrum Doradztwa i Informacji Difin Sp. z o.o.
Keijzers, G. (2002), The transition to the sustainable enterprise. J. Clean. Prod., vol.10, No. 4, 349–359. https://doi.org/10.1016/S0959-6526(01)00051-8.
Klepacki, B. (2011). Agrologistyka – nowe wyzwanie dla nauki i praktyki (Agri-food logistics: a new challenge for science and practice). Logistics 3, 12–13.
Kramar, U., Topolšek, D., Lipičnik, M. (2013). How to define logistics in agriculture? http://www.kgau.ru/new/all/konferenc/konferenc/2013/e8.pdf, accessed on 22.01.2015.
Krysztofiak, A. (2010). Elementy teorii transportu rolniczego (Elements of the agricultural transport theory). Poznań: Wydawnictwo Uniwersytetu Przyrodniczego.
Kukovič, D., Topolšek, D., Rosi, B., Jereb, B. (2014). A comparative literature analysis of definitions for logistics: between general definition and definitions of subcategories. Bus. Logist. Modern Manag., 14, 111–122.
Lehtonen, M. (2004). The environmental–social interface of sustainable development: Capabilities, social capital, institutions. Ecol. Econ., 49(2), 199–214. https://doi.org/10.1016/j.ecolecon.2004.03.019
Liping, W. (2012). Study on Agricultural Products Logistics Mode in Henan Province of China. In Y. Wu (ed.), Software Engineering and Knowledge Engineering: Theory and Practice (p. 635–640). China: Central China Normal University.

Michna, W. (2000) Jakość surowców rolnych i żywności jako ważny składnik oceny zrównoważonego rozwoju rolnictwa (Quality of agricultural raw materials and food as a major factor in assessing sustainable agricultural development). Puławy Diary, Institute of Soil Science and Plant Cultivation, Puławy, 120/II, 317–323.
Milewska, B. (2005). Możliwości zastąpienia relacji trade-off relacją trade-up w logistyce i produkcji (cz.1) [Ability to move from trade-off relationships to trade-up relationships in logistics and production (Part 1)]. Logistyka (Logistics), 5, 17–18.
Murphy, P.R., Poist, R.F. (2002). Socially responsible logistics: An exploratory study. Transport. J., 41, 4, 23–35.
OECD/WTO (2013). Aid for Trade and Value Chains in Agrifood. http://www.wto.org/english/tratop_e/devel_e/a4t_e/global_review13prog_e/agrifood_47.pdf , accessed on 22.01.2015.
Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. Ecol. Econ., 48(4), 369–384.
Runowski, H. (2000). Zrównoważony rozwój gospodarstw i przedsiębiorstw rolniczych (Sustainable development of farms and agricultural enterprises). Rocz. Nauk. SERiA, II, 1, 94-102 (SERiA Scientific Yearbooks, II (1), 94–102.
Runowski, H. (2004). Gospodarstwo ekologiczne w zrównoważonym rozwoju rolnictwa i obszarów wiejskich (Organic farms in a sustainable agricultural and rural development). Wieś i Rolnictwo, 3(124), 24–37.
Ryszkowski, L. (1998). Zasady ochrony środowiska rolniczego (Principles of agricultural environment protection). Przegląd Komunalny, Special Appendix, 7, 20–22.
Shepherd, K., Abkowitz, M., Cohen, M.A. (2001). Online corporate environmental reporting: Improvements and innovation to enhance stakeholder value. Corporate Environmental Strategy, 8(4).
Skowrońska, A. (2006). Logistyka jako narzędzie równoważenia rozwoju (Logistics as a tool in making development sustainable). Prace Naukowe Akademii Ekonomicznej we Wrocławiu, nr 1190, 483–494. http://www.kee.ae.wroc.pl.
Soysal, M., Bloemhof, J., van der Vorst J.G.A.J. (2012). A Review of Quantitative Models for Sustainable Food Logistics Mangement: Challenges and Issues. In: J. Deiters J.,Rickert U., Schiefer G. (ed.), Proceedings in System Dynamics and Innovation in Food Networks. University of Bonn, Germany, Innsbruck, Igls, Austria.
Tabor, S. (2008). Postęp techniczny a efektywność substytucji pracy żywej pracą uprzedmiotowioną w rolnictwie (Technical progress vs. the efficiency of substituting human and animal labor inputs with automated work in the agricultural sector). Agricul. Eng., 10(108).
Tan, D. (2012). Developing Agricultural Products Logistics in China from the Perspective of Green Supply Chain. Int. J. Bus. Manag., 7(21), 106–112.
Vaněček, D., Kaláb, D. (2003). Logistics in agricultural production. Agric. Econ. – Czech, 49(9), 439–443.
Verma, I. (2013). Agri-logistics in India: Challenges and Emerging Solutions. http://yourstory.com/2013/05/agri-logistics-in-india-challenges-and-emerging-solutions/, accessed on 22.01.2015.
Wajszczuk, K. (1998a). Wielkość i struktura nakładów pracy i siły pociągowej w transporcie rolniczym w gospodarstwach indywidualnych (The amount and structure of labor and tractive power in agricultural transportation in individual farms). Roczniki Akademii Rolniczej w Poznaniu, 303, 91–99.
Wajszczuk, K. (1998b). Analiza struktury masy przewozowej w transporcie wewnętrznym w gospodarstwach rolnych (Analyzing the structure of cargo in internal farm transportation). Roczniki Akademii Rolniczej w Poznaniu, 303, 79–90.
Wajszczuk, K. (1998c). Analiza struktury masy przewozowej w transporcie wewnętrznym w gospodarstwach rolnych (Analyzing the structure of cargo in external farm transportation). Roczniki Akademii Rolniczej w Poznaniu, 303, 111–122.

Wajszczuk, K. (2008): The role of logistics in sustainable development of agricultural enterprises. J. Agribus. Rural Dev., 1 (7), 141–148.
Wajszczuk, K. (2012). Agrologistyka coraz bardziej popularna (Agri-food logistics becoming increasingly popular). An interview published in Logistyka (Logistics), 4, 32–33.
Wajszczuk, K. (2013). Model rachunku kosztów logistyki dla przedsiębiorstw rolniczych (A model for calculating logistic costs in agricultural enterprises). Poznań: Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu.
Wajszczuk, K. (2016a). Metodyka pomiaru zrównoważenia logistyki dla przedsiębiorstw sektora gospodarki żywnościowej na bazie koncepcji LSR — ujęcie procesowe (Measurement methodology for logistics sustainability in food enterprises based on the LSR concept: a process-based approach). In: E. Mazur-Wierzbicka (ed.), Procesy organizacji – wybrane aspekty (Organizational processes: selected aspects) (p. 111–127). Zarządzanie procesami w teorii i praktyce (Theory and practice of process management), a series by the University of Szczecin, Faculty of Management and Economic Sciences, 6.
Wajszczuk, K. (2016b). The Role and Importance of Logistics in Agri-Food Supply Chains: An Overview of Empirical Findings. Logistics and Transport., 2(30), 47–55.
Wajszczuk, K. (2017). *Strategie logistyki dla przedsiębiorstw rolniczych na bazie koncepcji LSR – case study* (LSR-based logistics strategies for agricultural enterprises: a case study). Studies and Papers of the Faculty of Management and Economic Sciences, University of Szczecin, No. 48/2: 351–62. http://dx.doi.org/10.18276/sip.2017.48/2-30.
Wajszczuk, K. (2018a): *Assessment of logistics sustainability in family farms based on the LSR concept.* Journal of Agribusiness and Rural Development, 3(49), 343–348. http://dx.doi.org/10.17306/J.JARD.2018.00392.
Wajszczuk, K. (2018b). Verification of an innovative logistics-based costing model for agricultural enterprises in a process approach. International Institute of Social and Economic Sciences**.** Proceedings of Economics & Finance Conference**,** Rome: 537–551, indexed in Web of Science™ Core Collection *Conference Proceedings Citation Index.* http://dx.doi.org/10.20472/EFC.2018.010.038
Wajszczuk, K. (2018c). Efektywność procesów transportowych a problem ich zrównoważenia w przedsiębiorstwach rolniczych (Efficiency of transport processes vs. how to make them sustainable in agricultural enterprises). In: M. Kunasz (ed.), Orientacja procesowa w zastosowaniach (Process-oriented approach: use cases) (p. 105–116), Zarządzanie procesami w teorii i praktyce (Theory and practice of process management), a series by the University of Szczecin, Faculty of Management and Economic Sciences, 10.
Wawrzynowicz, J., Baum, R., Wajszczuk, K., Sajna, P. (2014). Model karty oceny procesów zgodnie ze strategią CSR i LSR (Scorecard model for assessing process compliance with CSR and LSR). Logistyka (Logistics), No. 6, 13895–13900.
Wielicki, W., Wajszczuk, K. (2000). The soil compaction influence on energetic efficiency of sugar beets production. The 69th EAAE, Sustainable Energy. Wageningen: The Netherlands Wageningen University, 464–474.
Wolszczan, J. (1988). Transportochłonność rolnictwa (Transport intensity of agriculture). Zesz. Probl. Post. Nauk Rol., 348, 35–41.
World Economic Forum (2009). Supply Chain Decarbonization: The role of Logistics and transport in reducing supply chain carbon emissions. Geneva: World Economic Forum, http://www3.weforum.org/docs/WEF_LT_SupplyChainDecarbonization_Report _2009.pdf, accessed on 3.02.2018.
Woś, A., Zegar, J.S. (2002). Rolnictwo społecznie zrównoważone (A socially sustainable agriculture). Warsaw: Institute of Agricultural and Food Economic.
Ziętara, W. (2000). Zrównoważony rozwój obszarów wiejskich (Sustainable rural development). SERiA Scientific Yearbooks, vol. II, 1, 5–7.