Lean and agile supply chains of e-commerce: empirical research

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ABSTRACT
E-commerce is currently one of the main factors in economy development. An increasing number of customers order products via the Internet because of lower prices, convenience, a wider range of products, etc. They expect these products to arrive at their destination, preferably as soon as possible, with the possibility of various forms of payment, free returns. This requires efficient supply chains that simultaneously encompass two opposing concepts: leaness and agility. However, there is a research gap because no empirical studies have been carried out into how these concepts are used in supply chains of e-commerce at the same time. The goal of this paper is to identify the nature of supply chains in terms of their lean and agile approach in the context of the type of product being moved (which can be sold via e-commerce), logistical solutions and supply chain management, and trends that shape the image of supply chains. The basic source of empirical materials was the author's survey.

Introduction

E-commerce sales in the world in 2018 will grow by approx. 23.5% compared to 2017 and will amount to approx. $2.84 trillion (11.9% of total retail sales). By 2021, the global sale via the Internet is even expected to reach $4.9 trillion (eMarketer, 2018). The growth rate, the increasing share of e-commerce in total retail sales and the changing width and depth of the product range make it possible to conclude that most companies operating on the market and selling their products by traditional means have already established e-commerce channels, predict to create them or are on the list of potential (at the moment unaware of the opportunities offered by this type of market) e-commerce customers.

Incentives to shop online include: availability of products 24 h a day, more attractive prices than in traditional shops, ease of finding rare/specialised products, a wide range of available delivery/collection options, speed of order fulfilment. These are mostly logistic factors (Kawa, Pieranski, & Zdrenka, 2018). Logistics plays a key role in creating value for the end-customer. The creation of this value involves many different entities which are in the supplier – recipient relationship. Together, they form a network of companies,
which is referred to as the supply chain. Briefly speaking, supply chain spans all movement and storage of raw materials, work-in-process inventory and finished goods from point-of-origin to point-of-consumption (Srinivas, 2017). It encompasses the planning, implementing and controlling of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Moreover, supply chain management includes coordination and collaboration with different entities, which can be suppliers, intermediaries, logistics service providers and customers (CSCMP, 2018).

E-commerce has shifted the centre point of the logistics system from retailer to consumer, a new set of expectations emerges. As more shoppers buy online, the demand for a seamless shopping experience lands on retailers. They have to look for new possibilities to meet the customer expectations. Ensuring the expected level of customer service involves searching a balance between the benefit anticipated by the customer and the level of the costs necessary to provide it. It is related to two kinds of supply chain: lean and agile supply chain. The first one enables to offer goods at competitive prices, the second one is more freedom and flexibility to tailor the product to the current needs (Reis, Varela, Machado, & Trojanowska, 2016). Awareness of the extent to which the supply chain and the product being moved within it is agile and lean is likely to facilitate decision-making concerning the development of e-commerce and the choice of the tools to support its development.

Among the scientific papers combining the topics of e-commerce and supply chains, there are mainly studies that raise the subject of logistics customer service (Lin, Luo, Cai, Ma, & Rong, 2016), challenges of the logistics industry related to the dynamic growth of online sales (Joong-Kun Cho, Ozment, & Sink, 2008) and studies that deal with the behavioral and marketing issues connected to the creation of virtual sales channels (including cultural, economic and political conditions) (Lawrence & Tar, 2010). However, there are no articles in which the impact of supply chain types on the ability to create virtual sales channels with the support of smart solutions is considered.

Considering the growing importance of e-commerce and the fact that in the economic reality there are hybrids of different supply chains, it is appropriate to examine the nature of the chains and their links with e-commerce. On the basis of a literature review it can be concluded that in business practice, from the goods decoupling perspective, supply chains can be divided into lean and agile or ones binding both types at the same time. Going beyond the considerations at the level of the goods decoupling, in turn, it can be said that practically every supply chain has an element of agile or lean chains. This applies to supply chains that are considered exemplary in the industry, such as those of Unilever, Inditex, Cisco Systems, Colgate-Palmolive, Intel, Nike, Nestlé, PepsiCo, H&M, Starbucks, 3M, Schneider Electric, Novo Nordisk, HP Inc., L’Oréal, Diageo, Samsung Electronics (Gartner, 2018) and supply chains known only in local markets. Therefore, the further part of the study focuses on the above hybrid.

In the literature of the subject, research in the field of agile and lean supply chains, in which individual types of the chains are discussed separately, is predominant. However, the number of studies in which this subject is presented together is growing year by year. The issues of agile and lean chains are discussed from the perspectives of:

- their impact on the creation of sustainable supply chains (Ciccullo, Pero, Caridi, Gosling, & Purvis, 2018),
• improving the availability and efficiency of POC (point-of-care) diagnostic services (Kuupiel, Bawontuo, Mashamba, & Tivani, 2017),
• the performance of the supply chain and its individual links (Kashani & Baharmast, 2017),
• virtual supply chains (Kovács & Kot, 2017),
• the adjustment of the chain strategy to supply and demand (Madhani, 2017),
• implementation of chains that are both agile and lean at the same time (Haq & Boddu, 2017),
• creating a framework to support decision-making on the nature of the supply chain according to customer needs (Agarwal, Shankar, & Tiwari, 2006),
• the impact of digital technologies on value chains (Wyciślak, 2017),
• the consistency of operational strategies with supply chain strategies (Qi, Huo, Wang, Yeung, & Yan, 2017),
• the optimization of the network and security of stocks (Fichtinger, Chan, & Yates, 2017).

However, there are no studies showing the intensity of the occurrence of agile and lean supply chain features or studies combining the above types of chains with e-commerce issues.

The aim of the study is therefore to diagnose the nature of the supply chains of manufacturing enterprises that are or may be involved in the development of e-commerce. The second objective is to identify the relationship between the type of supply chains (analysed in the context of the type of the product being moved, logistics solutions and chain management and configuration) and the development of e-commerce and to indicate what kind of smart solutions can be used in this area. The third objective is to show how socio-economic trends affect e-commerce and the nature of supply chains. The first objective of the research will be achieved through quantitative research, while the realization of the second and third objective will be of a qualitative nature.

This paper is an extended version of other authors’ article (Kawa & Maryniak, 2018) which was presented at the ACIIDS 2018 conference. Its new contribution is the deeper literature review on lean and agile supply chains, and the presentation of socio-economic trends and the picture of e-commerce supply chain.

The structure of the paper is as follows. Section 2 describes the lean and agile supply chain. Section 3 presents the research methodology. Section 4 shows the research results. In Section 5 smart e-commerce solutions in lean and agile supply chains are given. Section 6 includes socio-economic trends and the picture of the e-commerce supply chain. Section 7 summarizes the article and points to future directions of the research.

**Lean and supply chain**

This paper concentrates on two seemingly very different types of chain – the first one is based on creating a cost advantage (lean supply chain) and the second one is based on the individualization of the product and logistics offer (agile supply chain). The decisions regarding how much focus there is on one or the other solution seem to have the greatest impact on the way the supply chain is managed, the form of the flowing products and the configuration of the distribution channels.

The leanness and agility of supply chains depend on their characteristics. Harrison and van Hoek (2002), for example, define the nature of chains (and their respective strategies)
using the criteria of market presence and those of competing in it. Naylor, Naim, and Berry (1999) assign an agile or lean character to chains depending on their resistance, ability to quickly reconfigure and the scheduling level. Christopher and Towill (2000) classify chains according to the nature of the product (its type, life cycle, diversity), the purchasing policy, the level of sales forecasting or the profit margin. Goldsby, Friffs, and Roath (2006) divide chains on the basis of the criterion of costs (of warehousing, stockholding, inbound and outbound transport, production and sourcing of raw materials). However, the most popular distinction between agile chains and lean chains is based on the already mentioned criterion of locating the decoupling point of goods (Chan & Kumar, 2009). It is the storage place for the major stocks in the supply chain. This point separates the part in which all activities are carried out according to the customer’s order from the part determined by the demand forecast. In the research, a mathematical approach is used to adopt legality in a supply chain, as well as case studies, bibliometric tests and other research methods. This is research, which focuses on the relations in supply chains as well in the products moving along them.

Research methodology

On the basis of the mentioned suggestions and the review of literature, activities characteristic for lean and flexible supply chains as well as their intensity in the Likert scale (from 1 to 5, where 1 meant ‘definitely yes’ and 5 – ‘definitely no’) were identified.

The subject of the research were big and medium-sized enterprises, classified, according to the data of the Polish Central Statistical Office, in Section C (manufacturing enterprises), excluding the enterprises which are not predestined for e-commerce. In Section C, 1087 medium and large entities were registered. At the first stage of the research, according to statistical procedures, 280 records were drawn. At the second stage, a non-probability sampling took place. The choice criterion was a declaration that the chains, in which the companies were functioning, to any extent were agile and lean. The respondents were decision-makers dealing with supply chain management. The research took place in 2017.

The basic source of empirical materials was the author’s survey. The studies were conducted via a direct visit of the interviewer in the enterprises. The used method involved structured interviews. Although the overall number of studied enterprises amounted to 115, materials from 71 enterprises were qualified for final analysis. The surveys which were only partially completed or in which there were inconsistencies with regard to the checklist questions were excluded from the studies.

The quality of the results were verified using validity and reliability measures (all convergent factor loadings and Cronbach’s alpha coefficients of constructs were higher than 0.60).

Nature of supply chains – research results

In order to identify the nature of supply chains in which the studied enterprise participate, average values of 30 test items concerning the aspects connected with product, logistics and supply chain management were calculated. Fifteen questions concerned lean supply chains, and the other 15 questions – agile supply chains. The graphs present the average values for all of the studied supply chains. Therefore, on the basis of the gathered material, one can expand the studies in the future and characterize particular supply chains with the use of the case study method.
Within the area of ‘product’, the representatives of the studied enterprises indicated that the most important thing for them is designing products taking into consideration the following issues: the increase in production efficiency, the decrease of products’ defectiveness and the creation of wide range of products in order to better match individual needs of the recipients (Figure 1).

The respondents concluded that, within logistics activities, they, above all, limit unnecessary activities during the movement of products in supply chains, optimize transportation routes (mainly from the point of view of the costs), smoothly adjust to the current transportation needs and reduce the costs of warehousing infrastructure service (Figure 2).

Within the process of supply chain management, the enterprises strive to eradicate problems ‘at root’. At the same time, they try to reconcile two seemingly contrary strategies. On the one hand, they organize the flows of goods in supply chains according to a previously specified schedule, and on the other hand, they try to quickly respond to current needs and ensure a high level of products’ availability. In addition, the studied

Figure 1. Lean and agile supply chain – nature of the product.

Figure 2. Lean and agile supply chain – logistics activities.
entities participate in relatively static supply chains since they conduct only small changes during the reconfiguration (Figure 3).

Taking into consideration average results for the studied aspects (Table 1): ‘products’, ‘logistics’ and ‘supply chain management’, one can conclude that within each of these aspects the enterprises in the first place adopt a policy of lean supply chains creation, and further on – agile supply chains. Lean activities in supply chains are rather important for the enterprises, while the agile ones are of moderate importance.

**Smart e-commerce solutions in lean and agile supply chains**

On the basis of the research carried out, it was found that companies do not generally have chains unambiguously profiled as lean or agile. The type of the product being moved, the way in which the supply chain is managed, as well as stock, transport and storage management policies are not subject to a single, clear strategy. It is also difficult to say that it is a mixed strategy. It rather seems that, with a few exceptions, managers do not appear to have a clear vision of the maximum allowable costs of agility.

In such conditions, the creation of virtual sales channels entails a high risk. Introducing them on an ad hoc basis, without embedding them in the company’s strategy and without determining their importance for the value for the customers may cause more profits to be lost.

The following are examples of smart solutions that are used in the context of the product type, logistics solutions and e-commerce chain management and configuration.

**Product in e-commerce**

Authors suggest that the introduction of new products into the supply chain is ever more frequent (Maryniak, 2017; Simchi-Levi, Kyratzoglou, & Vassiliadi, 2013) and the products

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**Figure 3.** Lean and agile supply chain – supply chain management and its configuration.

**Table 1.** Agile and lean activities.

| Dimension               | Average values for lean activities | Average values for agile activities |
|-------------------------|-----------------------------------|------------------------------------|
| Product                 | 2.5                               | 3.3                                |
| Logistics               | 2.2                               | 2.5                                |
| Supply chain management | 2.5                               | 2.9                                |
themselves are less and less standard. As a result, it is becoming increasingly difficult to pursue a strategy of lean product economy and economies of scale. The development and introduction of online sales partly removes these barriers. Mass customization enables to generate product characteristics freely chosen by individual purchasers on a huge scale. The customer not only decides on the shape of this product, but also on the delivery method, type and frequency of the information received. The market of prosumers, who do not only engage in potential modifications of the final appearance of the product, but also design it almost from scratch, is also growing. The closer the decoupling point is to the lower part of the supply chain, the easier it is to adapt to individual customer requirements. It can therefore be assumed that the development of Internet distribution has an impact on the possibilities to create agile chains and at the same time facilitates the implementation of a strategy of saving at every stage of the product design. In the latter case, it is very important to pay attention to the quality of products, because in e-commerce customers return a large part of products (up to 70%), which generates additional transport costs and other operating costs. 

E-commerce is also connected with product digitization or addition of digital information to products. From the perspective of logistics, in which the physical flow of things must be present, complete digitization, where the product is transformed into an intangible form, e.g. music, film, book, is not of interest. E-tailers are interested in the addition of digital information to the product, which provides the customer with an added value, e.g. the ability to compare products in an application available on the vendor’s online platform, access to ratings and reviews of other users.

Logistics in e-commerce
Logistics in e-commerce is the main value creator for the customer. Without logistics, in particular without the delivery of goods to the customer, the online sales process would be very limited. It is also a source of costs that can reduce the value for the customer. For these reasons, within the framework of the logistic activity, the most organizational and technological solutions are introduced which improve the operational functioning of companies as well as their customer service.

In traditional trade, the retailer sells a product that the customer sees on the shelf at a certain moment, while in e-commerce the seller offers a kind of promise to fulfil the order. E-customers are not only interested in the product itself, but also in receiving up-to-date information about the shipment, in flexible and fast delivery and in simple and free returns of goods. If the product is not delivered to the customer in due time, is damaged or the driver’s service is not satisfying, then the customer may not re-purchase from the given e-tailer.

Besides door-to-door delivery, the customer can pick up the shipment at a PUDO (Pick Up, Drop Off) point, from a self-service terminal (e.g. parcel lockers) or at a bricks and mortar store. Returns of the purchased goods may be carried out in a similar way. In addition, payment for the purchases can be made during the fulfilment of the order, but also upon collection of the shipment from the courier (cash on delivery) or the self-service terminal (Kawa, 2017).

The important solution in e-commerce logistics affecting the agile supply chain is the Track & Trace (T&T) system which enables to monitor the vehicles in real time. It can
also get complete statistical information about the quality of the services provided. Thanks to this system, the customer has a possibility to dynamically change the time and place of delivery.

Automation is another area that companies are developing in order to reduce costs and speed up processes. In e-commerce, sorter and conveyor systems, mezzanines and other similar solutions are implemented to save storage space. More and more companies are investing in carry pick solutions, where the rack is transported by a robot to the picker, and pouch sorter solutions, in which orders are sorted at a high speed using special pouches, as well as picking robots, whose performance has not been fully satisfactory yet, but their use during peak times, holidays and at night gives companies a great competitive advantage. These solutions affect positively the lean supply chain.

Supply chain management in e-commerce

In most online shops, the buyer has a free choice in the methods of purchase, testing, reception and payment, thus (s)he decides to create the value of his or her product. This has a major impact on the supply chains that are being set up, which are more and more often configured for individual transactions. If this is combined with the fast-growing cross-border trade, where consumers around the world buy billions of products from different countries every day, a complex network of links is created. Each of customer can thus be the creator of logistic processes.

The importance of end-customers in e-commerce supply chain is growing. This can be seen from the trends in the logistics services industry. More and more solutions are emerging that allow to configure the supply chain. Apart from the place where they can pick their order up, the customers can also choose a convenient time to do so. In addition, it is possible to change deliveries dynamically using a smartphone.

At the same time, the concept of sharing economy is developing in supply chain which assumes the use of resources from outside the logistics services industry with the participation of modern technologies. For example, cars belonging to other companies or private persons are used to transport consignments. Similarly, free storage space is made available. This concept is based on the assumption that ‘access is better than ownership’. People possessing free resources, shoppers and online shops benefit from this. Customers can, then, simultaneously use and offer services to other market players. For the time being, these services are being developed mainly in larger cities where direct delivery is carried out without loading bays. Over time, more advanced solutions may emerge, resulting in even greater involvement of communities in logistics processes.

Socio-economic trends and the picture of e-commerce supply chain

Among the fundamental changes affecting the image of the e-chain and its character one can distinguish those which concern the society, technology and environmental well-being. Each of them influences the others. These include changes in terrorism, digital terrorism, pluralization, saturation of developed markets, resource shrinking, development of green technologies, innovation in materials engineering and many others.

In terms of technological developments, 3D printing is an example that could change e-commerce in the future, as it simplifies supply chains considerably. On the one hand,
implementation of this technology reduces the costs of transport and storage, and on the other hand, it results in an incredible increase in the agility of supply chains. The creation of intelligent factories, focused on serving the local community, makes the burden of e-commerce service costs shift to the last mile logistics. In future, products will increasingly be manufactured on demand, without the necessity to build up stocks or wait for them to be prepared and shipped from a supplier in another country. This will greatly simplify the operational processes and will not only reduce supply chain costs, but also affect the delivery time and product quality.

These technologies affect both manufacturing companies and service providers moving goods through the supply chain. Among other things, Mercedes Benz Trucks has launched a service of 3D printed spare parts. I turn, DHL, one of the leading e-commerce logistics service providers, is testing a variety of 3D printing equipment and printing techniques to identify applications with potential to redefine production strategies and supply chains (DHL, 2016). As a result of the use of the 3D technology, providers can be expected to capture part of the production processes from the production halls by moving them to zones in dedicated storage areas and to means of transport, as the products can be printed ‘on the road’ while being delivered to the customer.

In the area of social changes, one of the most important issues affecting e-commerce is the age structure of the community served and its pluralization. Demographic data clearly show that Europe and many other regions of the world are ageing. A generation of older people, whose purchasing habits have been developed by e-commerce, will ‘gain in strength’. At the same time, this generation is going to live longer and longer. The post-working community will require cheap products and services. Also, they will be people of the prosumer era who will not be satisfied with their mass segmentation. Therefore, e-commerce will have to create hybrid, economical and agile chains.

The reduction of the working age population is also a threat to the labour market of people employed in the individual links in the supply chain. In this context, trade-off decisions such as regionalization and flexibility versus costs will gain more importance. Simultaneously, these decisions will accelerate the process of automation and robotization.

The future image of supply chains is also undoubtedly influenced by the diversity of societies in terms of origin and nationality resulting from natural migration caused by greater freedom of movement of persons, as well as from migration resulting from military operations. This trend is reflected both in the need for even greater product differentiation and both in logistics and industry in many countries. Examples include multilingual Pick-by-Voice systems in Russia or Polish messages displayed at assembly lines in Germany. It can be assumed that cultural diversity will make it more difficult to achieve economies of scale in e-chains and will influence the duplication of goods in similar but different versions. The e-supply chain will therefore need to contain agile and lean ideas.

Every year there is also a growing trend towards the creation of green supply chains. It should be noted, however, that pro-environmental cooperation between actors in the supply chain is much more difficult in the case of chains that are more agile than lean. For e-commerce, where processes are generally extremely dynamic, it is even more difficult to develop green solutions. Therefore, in practice it is important for enterprises to develop green behaviour at the level of individual links. In the event of reconfiguration of supply chains resulting from lean or agile strategies, each actor in the supply chain
should have a green profile. This applies both to e-commerce operators and both to manufacturing and trading companies involved.

There are many ideas that have a direct impact on the creation of green chains. This is reflected, inter alia, in formalized environmental systems (for example, the eco-Management and audit system – EMAS, Cleaner Production), standardized systems (for example, ISO 14001), and EU and sectoral directives (for example, RoHS, WEEE, EuP, REACH).

One of the many ways to improve eco-efficiency is to use indicators to measure it in practice. Among the basic indicators the following can be distinguished: individual indicators, key performance indicators (KPIs), composite indices, material flow analysis (MFA), environmental accounting, eco-efficiency indicators, lifecycle assessment (LCA) indicators, social responsible investment indices (SRI) (OECD, 2009). These indicators have mainly been designed to improve the environmental performance of the products moved or the processes at the operational level in this area. Although these indicators vary in structure and use, each of them can help to create environmental balance in the e-commerce supply chain. Their use in different combinations facilitates management in this field. ‘For example, it might be useful to combine material flow analysis, LCA indicators and environmental accounting’ (OECD, 2009, p. 22).

Conclusion

The approach to logistics has considerably changed as a result of the emergence of Internet technologies in business. This is not only about the digitalization of some products (e.g. music, films, books), where logistics is not needed, but also about the very dynamic development of e-commerce of other goods. On the one hand, the Internet has eliminated intermediary links in the supply chain and, on the other hand, new sales and distribution channels have been created. The central focus of interest has been moved to the final customer placing the order at any location and time. The route to the store has been replaced with home delivery. After online sales appeared, the customer has become an integral part of the logistics process and, often for the first time, has dealt with logistics services.

Thanks to our research we can conclude that despite these trends of creating agile chains in the market, traditionally structured chains, in which the main determinants of strategy are production costs and productivity, function to a large extent, and therefore e-commerce solutions should first of all take into account the cost-efficiency needs. However, it should be added that at the level of individual companies, it can be seen that the chains in which they operate are a kind of hybrids and rarely aspire to be only lean or agile.

As noted in this paper, in e-commerce the customer influences the supply chain configuration (using a lean and agile approach at the same time), in particular in the field of the delivery of the purchased products. The smart solutions that are used in the context of the product type, logistics solutions and e-commerce chain management and configuration are very important. Moreover, it can be said that the basic social, technological and environmental trends stimulate the creation of both agile and lean chains.

The research just like other research is limited. The companies came from a well-developed economic region. The results may have been different, if it took place in poorer
regions. What is more, it is worth expanding the future research to include also the
moderators, such as company size or production profile.

A potential aim of further research may be to present the perception of this impact from
the perspective of the customers themselves. As a result of these studies, it will be possible
to develop a model for configuring the e-commerce supply chain, which is lean or agile
depending on the market conditions, customers preferences and smart solutions. The
results may be an inspiration to design modern technologies, which will improve mana-
ging of hybrid chains.

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