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Innovation of Logistics Service Providers and its impact on logistics service efficiency of supply chains

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Abstract

Aim: This article presents the results of an empirical study relating to the impact of implemented innovations by 3PL operators and 4PL logistics integrators on the efficiency of supply chain logistics service.

Methodology: In the methodological layer, for the empirical research it was necessary to carry out a literature review, conducted using the procedure proposed by Tranfield, Denyer and Smart (2003). As shown in the review, the issue of innovation and innovativeness in supply chain logistics service provided by Logistics Service Providers has been addressed in the literature by many researchers, nevertheless often from different and even dissimilar perspectives. Hence, based on the literature review and the identified research gaps, an empirical study (quantitative survey, using Partial Least Squares (PLS) path modelling) carried out at a further stage with the main aim of identifying the impact of innovations implemented by Logistics Service Providers on the efficiency of supply chain logistics service. The survey was conducted among Logistics Service Providers (3PL, 4PL) operating in Poland.

Results: The research results showed, among other things, a strong impact of innovativeness of Logistics Service Providers on the efficiency of implemented logistics service of supply chains, which corresponds to the results of previous studies by other authors, including Grawe et al. (2015), and Bellingkrodt & Wallenburg (2013).

Implications and recommendations: The results of the research can be used to improve the activities of companies in the logistics services industry that wish to implement innovation and offer more advanced services.

Originality/value: The presented issues and conclusions from the conducted research can be treated as a voice in the discussion and an attempt to integrate previous literature studies, and therefore knowledge and research practice on the subject of innovations and innovative solutions implemented

by 3PL operators and 4PL logistics integrators and their impact on the efficiency of the realised logistics service of supply chains. The article also identifies limitations and directions for further research.

Keywords: innovations, Logistics Service Providers (3PL, 4PL), supply chains, efficiency

1. Introduction

The landscape of logistics services is undergoing significant transformation driven by a multitude of factors, including evolving customer requirements, competitive pressures, and the relentless pursuit of cost efficiencies. As Logistics Service Providers (LSPs) strive to meet these challenges, they increasingly turn to innovations in their service offers and operational processes. According to Flint et al. (2005, pp. 113-147), the understanding of innovation within the logistics sector is still relatively limited. They define logistics innovation as encompassing a broad spectrum of services − ranging from basic to comprehensive − recognised as new and beneficial by specific recipients, which may include business partners or internal stakeholders. This definition highlights that logistics innovation is not solely about groundbreaking advancements, as it can also involve incremental improvements to existing processes or the introduction of new services that enhance efficiency and/or value. Wallenburg and Lukassen (2011, pp. 438-454) echoed this sentiment, emphasising the need for more in-depth research into logistics innovation, particularly pertinent given that Wagner and Sutter (2012, pp. 94-98) identified the field as being in its nascent stages concerning recognition and scholarly attention. This research gap posed both a challenge and an opportunity to further explore how Logistics Service Providers can innovate to remain competitive and flexibly adapt to growing challenges and customer needs.

The evolution of LSPs has been significantly influenced by trends such as globalisation and outsourcing. Initially, logistics services were relatively straightforward, focusing primarily on transportation and warehousing. However, as the logistics services industry has matured, providers have begun to offer more intricate and integrated solutions, often classified as third-party logistics (3PL) and fourth-party logistics (4PL) services. As noted by Selviaridis and Spring (2007, pp. 125-150), as well as Wagner and Sutter (2012), 3PL providers deliver combined logistics services that meet a variety of customer needs, and coordination by external LSPs (4PL) to other service providers (Win, 2008; Zacharia et al., 2011; Wallenburg & Lukassen, 2011; Knemeyer & Murphy, 2004). Consequently, understanding the dynamics of logistics innovation is crucial for companies operating as LSPs that want to effectively deliver and implement these services.

This article presents selected results from a quantitative study covering innovations implemented by Logistics Service Providers (3PLs, 4PLs) and their impact on the efficiency of logistics service in supply chains. It is divided into several parts, the first of which presents the research methodology. The second part presents the results of the study, while the final one summarises the results and identifies research limitations and directions for future research.

2. Literature review

From a historical perspective, containerisation is recognised in the literature as an innovation aimed at increasing the efficiency of logistics operations. The advent of containerisation has facilitated a significant reduction in transport costs associated with the import and export of goods, which then opened up new markets for the sourcing and distribution of goods (Grawe, 2009, pp. 360-377).

In addition, innovative solutions such as cross-docking, electronic data interchange (EDI) and radio-frequency identification technology (RFID) should be pointed out. The pursuit of competitive advantage, increasing customer expectations, continuous process improvement (e.g. in inventory management) and the need to minimise costs stimulated the implementation of innovations by logistics operators (3PLs) and logistics integrators (4PLs) in the logistics services provided.

The provision of logistics services by specialised companies operating in new business models, such as operators (3PLs) and logistics integrators (4PLs), translates into added value for customers, along with

links in chains and supply networks. Issues related to innovation and innovation in logistics services, also referred to as 'innovation in logistics', 'logistics innovation', were addressed by many authors studying the issue from different perspectives. Van Klink and Visser defined innovation in logistics as the development and implementation of new elements in logistics management. These can take the form of the implementation of new processes, new logistics concepts, new supply chain solutions (system innovations) and the transition to new supply chains (market innovations) (Van Klink & Visser, 2004, pp. 340-346).

Wagner and Busse described innovation as subjective novelty resulting from a conscious management process aimed at economic exploitation (2008, p. 8). These definitions seem consistent in one aspect, as the authors pointed out, that in the context of logistics, innovations do not have to be new from a global or local market perspective. As long as they are new to a specific customer, they can be considered innovations (Lianguang et al., 2010, pp. 69-88). An important point of view was by A. Oke, who argued that innovation in logistics should include both improvements in service delivery and technological advances (cf. Wagner & Busse, 2008, pp. 13-29).

In their research findings, Grawe et al. (2015, pp. 88-101) stressed an extremely valuable benefit of cooperation between logistics service providers and their customers, namely the potential to co-create innovative business solutions, and the mutual exchange and sharing of knowledge between logistics service providers and their customers can stimulate the implementation of innovations. Their research showed that implemented logistics innovations have a positive impact on the efficiency of processes implemented by logistics service providers and the efficiency of this service expected by customers. In conclusion, it is worth signalling that despite differences in defining and interpreting the concepts of innovation or innovativeness of logistics service providers, many studies express the common view that innovation and innovativeness can provide companies with a competitive advantage and thus increase their market share (e.g. Fugate et al., 2010, pp. 43-62).

The interpretations and definitions published so far are complementary in the sense that they highlight the different forms that logistics innovation can take. Regarding the issue of efficiency of logistics operators, in the literature this is equated with the efficiency of logistics and the efficiency of supply chains (Mentzer, & Konrad, 1991, pp. 33-62). Defining the terms 'productivity efficiency', and 'logistics effectiveness' is interpreted differently by many researchers, e.g. for Mentzer and Konrad the former is understood as the ratio of resources used to the result obtained, while logistics effectiveness is the degree to which logistics objectives are achieved (1991, pp. 33-62, and Fugate et al., 2010, pp. 43-62). On the other hand, according to Langley and Holcomb, logistics efficiency is the ability to achieve predetermined goals, such as in meeting critical customer requirements (product guarantee, stock availability, lead time, convenience) (1992, pp. 1-27).

3. Methodology

In order to carry out the empirical study, in the methodological layer it was necessary to conduct a systematic literature review using the procedure proposed by Tranfield, Denyer and Smart (2003). The time range of the publication analysis adopted in the systematic literature review was 1990-2021 (Wasielewska-Marszałkowska, 2023). The conducted literature review made it possible to verify the existing state of knowledge, as well as to identify the research gap related to the insufficient description of the issues, especially fragmentary and inconsistent presentation of the framework of this area. During the literature review, a research tool (survey questionnaire) was developed, and the following research hypotheses were formulated:

H1: There is a positive and direct relationship between the innovativeness of Logistics Service Providers and their logistics efficiency.
H2: There is no significant difference between third-party and fourth party Logistics Service Providers when it comes to the relationship between innovativeness of logistics service and logistics efficiency.

In the empirical part, the research methodology adopted a quantitative study – a survey method, conducted by CATI, N=201, among transport, forwarding and logistics companies operating in Poland. The identification of logistics service providers operating in the 3PL and 4PL model was based on criteria adopted from the literature review. For the 3PL model, the following criteria were adopted in terms of the scope of services offered, and the range of activities (Leahy et al., 1995, pp. 5-13), i.e. distribution logistics, procurement logistics, contract logistics, transport by road, rail, sea/ocean, air, forwarding, customs services, cross docking, e-marketplace services, e-fulfilment, co-packing, picking and packing, as well as full-service logistics operator (3PL), one-stop shopping (integrated package of logistics services from one supplier), supply chain management, international and global reach.

The following criteria were adopted for the 4PL integrator model regarding the scope of services offered, the range of activities (Cabdoi, 2004), namely service of e-markets, integrator of logistics processes along the supply chain, 4PL, integration and communication (e.g. integration of IT systems, provision of IT architecture), control (e.g. 3PL/service provider management, re-engineering, decision support systems), architecture/integration (e.g. supply chain visioning, integration of services, systems and information),international and global reach.

Therefore the quantitative survey conducted among the selected research sample (n=201), enabled to identify the target group of the study subjects within a total sample of 66 logistics service providers, among which 35 companies operating as 3PL logistics operators and 31 companies operating in the 4PL logistics integrator model. The research was conducted between February and June 2020. The questions were divided into several groups: general information about the company, the range of services offered, the types of innovations implemented (broken down into innovations based on the OSLO methodology/OSLO manual) and a statement adapted from the literature on innovation and efficiency in logistics services.

To verify the research hypotheses a two-stage modelling approach was used – first, the measurement model was analysed, followed by the structural model.

The next stage allowed the PLS-SEM[1] models to be included in a group of 3PL operators and 4PL logistic integrators to be analysed in an intergroup cross-section based on MGA algorithms (Multi-Group Analysis). The overall research model is presented in Figure 1.

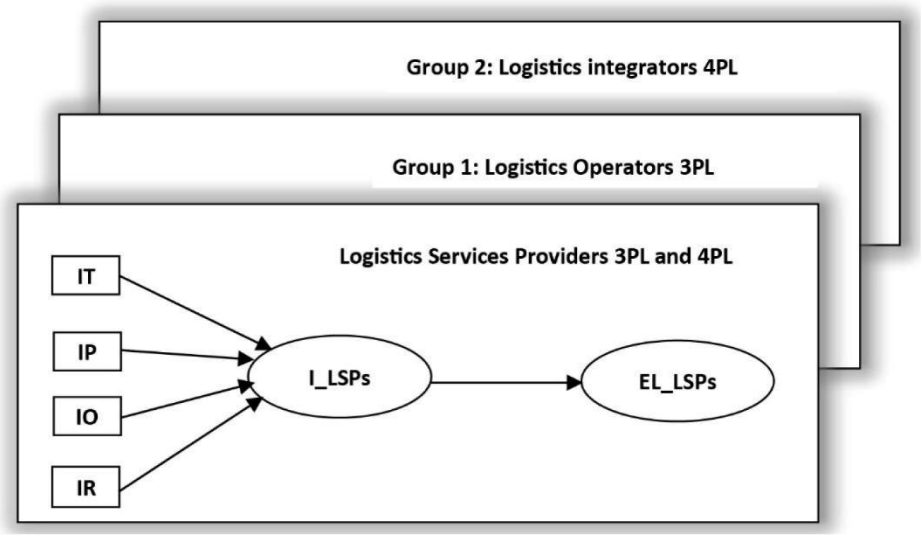


Fig. 1. General research model

Key: I_LSPs – innovation of Logistics Service Providers, IT – technological (process) innovation, IP – product innovation, IO – organisational innovation, IR – market (marketing) innovation, EL_LSPs – logistics efficiency of Logistics Service Providers.

Source: own elaboration based on survey results.

[1] Partial Least Squares (PLS) path modelling, also known as PLS structural equation modelling. (Hair et al., 2013, pp. 1-12).

The basis for the modelling analysis using PLS-SEM was provided by the results of the survey. The list of latent variables corresponded to the statements made in the survey questionnaire in relation to the innovation of Logistics Service Providers and the logistics efficiency of Logistics Service Providers (the list of statements is annexed to the article).

4. Empirical results from PLS-SEM modelling

In the analysis and interpretation of the PLS model results, a two-stage approach was adopted following Hulland (1999, pp. 195-204), comprising:

- stage one, focused on assessing the reliability and validity measurement of the model,
- stage two, focused on assessing the structural model, which enables the explanation of the relationships between the constructs under study.

The first activity was to analyse the obtained results of the total loadings and cross loadings shaping the latent variables, which are the components of the output model. Note that the preliminary model (model 1) used a reflective approach, in which the latent variables for logistics efficiency of Logistics Service Providers (EL_LPSs) and for the sub-constructs in technological innovation (IT), process innovation (IP), organisational innovation (IO) and market innovation (IR) were determined from other observable variables.

When analysing the data obtained, the criteria indicated in the literature were taken into account, i.e. the significance level (p value), whose value should be less than/equal to an error of the first kind of $\alpha = 0.05$ ($p \leq 0.05$), as well as the values of the loads themselves, for which the recommended values should be equal to or greater than 0.5. Therefore, in view of the above requirements, it was necessary to remove eight variables. This action was taken in order to check what impact the removal of variables (for which these criteria are not met) would have on the reliability and relevance of the construct, while not lowering the AVE (Average Variance Extracted).

The analysis made it possible to carry out a further activity in which the eight variables were excluded, so that a reduced number of variables were used in the analysis, the calculations were repeated and the results verified. All the measures yielded values that met the required criteria, and therefore qualified for further measurement model evaluation activities.

The evaluation of the measurement model was based on a check of the reliability of the measure using Cronbach's α coefficients and composite reliability (CR). Note that with regard to the verification of reliability for both measures, an acceptable minimum value of 0.7 is indicated in the literature (Hair et al., 2013, pp. 1-12).

Relevance, on the other hand, was controlled by assessing convergent validity and discriminant validity. It should be stressed that convergent validity is usually assessed by the proportion of Average Variance Extracted (AVE), where, as indicated by Fornell and Larcker (1981, pp. 39-50), the value for each latent variable in the model should exceed 0.5. Differential validity was assessed by checking the Fornell and Larcker criterion (1981, pp. 39-50), indicating that the square root of the AVE value for a construct should be higher than the other correlations for that construct (Henseler et al., 2015, pp. 115-135). Detailed results of the reliability and convergent validity analysis of the measurement model are presented in Table 1.

Differential accuracy was assessed on the basis of the adopted Fornell-Larcker criterion. The results of the values for differential relevance were found to be satisfactory, moreover meeting the required levels, and are presented in Table 2.

Table 1. Results of measures of reliability and convergent validity of the measurement model (model 2) (n = 66)

Measures	I_LSPs*				EL_LSPs*
	IT*	IP*	IO*	IR*	
CR – *Composite reliability*	0.888	0.919	0.872	0.885	0.954
Cronbach α – *Cronbach alpha*	0.852	0.903	0.796	0.838	0.946
AVE – *Average Variance Extracted*	0.534	0.511	0.639	0.607	0.652

Key: *I_LSPs – innovation of Logistics Service Providers, *IT – technological (process) innovation, *IP – product innovation, *IO – organisational innovation, *IR – market (marketing) innovation, *EL_LPSs – logistics efficiency of Logistics Service Providers.

Source: own study using WarpPLS software version 6.0.

Table 2. Discriminant validity results for the measurement model (model 2) (n = 66)

Construct		EL_LSPs*	I_LSPs*			
			IR*	IO*	IT*	IP*
EL_LSPs*		0.807	0.606	0.028	0.506	0.191
I_LPSs*	IR*	0.606	0.779	0.122	0.714	0.532
	IO*	0.028	0.122	0.800	0.106	0.512
	IT*	0.506	0.714	0.106	0.731	0.478
	IP*	0.191	0.532	0.512	0.478	0.715

Key: *I_LSPs – innovation of Logistics Service Providers, *IT – technological (process) innovation, *IP – product innovation, *IO – organisational innovation, *IR – market (marketing) innovation, *EL_LPSs – logistics efficiency of Logistics Service Providers.

Source: own study using WarpPLS software version 6.0.

It should also be added that the VIF (Variance Inflation Factor) values of the second-order construct I_LSPs showed satisfactory results, taking the recommended value of <3.3 (Kock 2015, pp. 1-10), respectively for the variables in the area of innovation of Logistics Service Providers, namely for the variables in the area of innovativeness of Logistics Service Providers, i.e. technological innovation (IT) with a value of 2.173, for product innovation (IP) with a value of 2.114, for organisational innovation (OI) with a value of 1.429, for market innovation (IR) with a value of 2.884, and for logistics performance of Logistics Service Providers (EL_LSPs) with a value of 1.701. It is worth mentioning that a reflexive approach was used in the analysis carried out. Concluding, the obtained data in the evaluation of the measurement model, it should be noted that both the values of Cronbach's α, CR total reliability, AVE for convergent accuracy, indicators of differential accuracy (the Fornell and Larcker criterion) and VIF parameters (Variance Inflation Factor) of the second-order construct correspond to the required criteria, therefore the model itself was considered reliable and accurate. In view of this, a further step was taken, i.e. the analysis of the structural model. Before assessing the structural model, the construct values were confirmed to be reliable, and in addition, the AVE and Cronbach's α values were also verified. As the data presented in Table 3 show, the results obtained fully fulfil the required value levels for the individual measures.

Table 3. Values of CR, AVE and Cronbach's α in the structural model (n=66)

Measures	I_LSPs*	EL_LSPs*
CR – *Composite reliability*	0.837	0.954
Cronbach α – *Cronbach alpha*	0.736	0.946
AVE – *Average Variance Extracted*	0.573	0.652

Key: *I_LSPs – Innovation of Logistics Service Providers, *EL_LSPs – Logistics efficiency of Logistics Service Providers.

Source: own study using WarpPLS software version 6.0.

The constructed structural model is presented in Figure 2. The convergence of the model was obtained in eight iterations. The construct innovation of logistics service providers (I_LSPs) comprised four latent variables: IT − technological (process) innovation, IP − product innovation, IO − organisational innovation, IR − market (marketing) innovation. The construct logistic efficiency of Logistics Service Providers (EL_LSPs) included 11 observable variables.

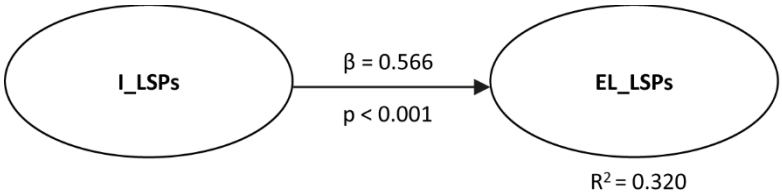


Fig. 2. Structural model

Key: I_LSPs − innovativeness of Logistics Service Providers, EL_ LSPs − Logistics efficiency of Logistics Service Providers.

Source: own study using WarpPLS software version 6.0.

The relationship between the studied constructs in relation to the verification of hypothesis H1 in the structural model was verified by evaluating the obtained parameter values, such as: f2 (effect size), (β) (path coefficient), as well as the significance level value (p value). The results of this analysis are presented in Table 4.

Table 4. Results of the examined relationship between constructs in the structural model − verification of hypothesis H1

Path	*Path coefficient* (β)	*p value*	*Effect size* (f^2)
I_LSPs→EL_LSPs	0.566	<0 .001	0.320
Hypothesis to be verified		H_1	
Result		Hypothesis positively verified	

Source: own study.

Analysing the data included in the above table in relation to the mentioned parameters, it should be noted that they assumed appropriate and recommended values. Furthermore, when analysing the obtained value of 0.320 for the R2 coefficient, it is worth stressing that the recommended R2 values by Hair et al. (2013) are between 0 and 1, with the researchers clearly indicating that higher levels imply a higher level of predictive accuracy. Furthermore, they emphasise that it is difficult to give practical rules for acceptable R2 values, as this depends on the complexity of the model and the research discipline. It was also pointed out that R2 values of 0.75, 0.50 or 0.25 for latent variables can generally be described as significant, moderate or weak (Hair et al., 2016, p. 198). In contrast, Sanchez considered an R2 value of > 0.60 as high, the range from 0.30 to 0.60 as moderate, and defined a value below 0.30 as low (Sanchez, 2013, p. 68).

It should also be noted that the Q^2 coefficient (Q-squared coefficients), also known as the Stone-Geisser coefficient, for assessing predictive validity (or significance), took on a value of 0.347, which should be considered a satisfactory result. The literature indicates that an acceptable value for predictive validity (Q^2 coefficient) should be greater than 0 (Kock, 2018, p. 79). The Q-squared coefficient is sometimes referred to as the resampling equivalent of the R2 coefficient (R-squared coefficient) (Kock, 2018).

Equally important and requiring assessment is the effect size (f2) parameter (effect size), which examines the strength of the relationship between the independent and dependent variable. Cohen indicated values for f2, i.e. effect size, at 0.02 and 0.15 and 0.35, which should be interpreted as weak (small), medium and large effects respectively (Cohen, 1988, p. 477 and next). As presented in the

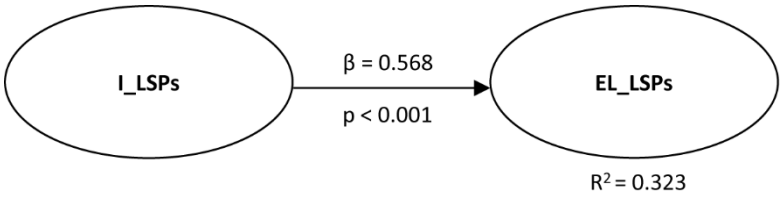
summary table (Table 6), the f2 value in the model in question was recorded at a satisfactorily high level of 0.320.

With regard to the overall fit index (also referred to as a measure of the explanatory power of the model) (GoF), as suggested by Wetzels et al (2009, pp. 177-196), if the value is equal to or greater than 0.1, it is referred to as small, while if the value is equal to or greater than 0.25, it is interpreted as medium, and if it is equal to or greater than 0.36 it is a large fit index. For the structural model developed in the paper, as shown in the results for the GoF indicator, a value of 0.443 was obtained, which should be interpreted as the desired fit value.

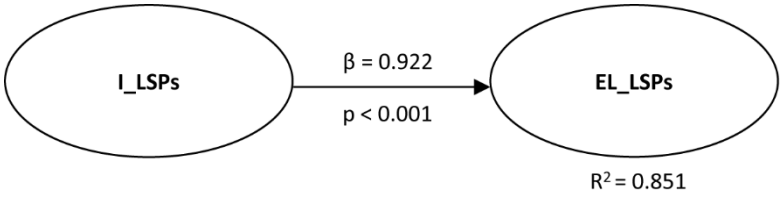
Note that the significance level (p value) in the structural model in question showed a value < 0.001, moreover the results obtained for (β) (path coefficient) assumed a value of 0.566, thus β as the path coefficient value showed the expected value in the estimated model (Kock, 2016, pp. 1-6). The level referred to as Critical T ratios, i.e. critical T coefficients, calculated based on the software adopted by the researcher based on the chosen confidence level, were also verified. The T ratio and confidence interval can be used to verify the hypothesis(s), either instead of the p-value or in combination with these values. The critical T ratios for the developed structural model were at the level of 1.960, which should be interpreted as a significant and recommended result (Kock, 2016).

Summarising the results, it should be concluded that there were no grounds to reject hypothesis H1, according to which there is a positive and direct relationship between the innovativeness of logistics service providers and their logistical efficiency. Hence, as a result, hypothesis H1 was positively verified.

The next step taken to verify hypothesis H2, which assumes that there is no significant difference between 3PL logistics providers and 4PL logistics integrators in terms of the relationship between their innovativeness and logistics agility in supply chain services, was to perform a PLS-SEM analysis of the intergroup cross-sections using MGA (Multi-Group Analysis) algorithms for this purpose. The first activity was to analyse the data and evaluate the results of the model for the 3PL logistics operator group and the model for the 4PL logistics integrator group, respectively (see Figure 3).



a) 3PL logistics operator group model (n = 35)



b) 4PL logistics integrator group model (n = 31)

Fig. 3. PLS-SEM models for different groups of Logistics Service Providers

Key: I_LSPs − innovation of Logistics Service Providers, EL_LSPs − logistics efficiency of Logistics Service Providers.

Source: own study using WarpPLS software version 6.0.

Interpreting the data in the figure above, note the differences in the values for the parameter involving the coefficient (β) (path coefficient), which for the model of 3PL logistics operators indicated a value of 0.568, while for 4PL logistics integrators − 0.922. This result should be read as clearly prevailing for the developed form in which 4PL integrators operate. However, with regard to the results involving

the significance level parameter (p value), it should be emphasised that for both the analysed model for the 3PL group and the model for the 4PL group, the values indicated the recommended significance level, indicating a value of $p < 0.001$.

The next step was to analyse the differences between groups. An intergroup comparison was made between the two study groups, which were 3PL logistics operators and 4PL logistics integrators, which allowed the second research hypothesis to be verified. According to Kock, the MGA (Multi-Group Analysis) should be based on a comparison of path coefficient values (β), for which, as the author pointed out, there are no significant differences at p values higher than 0.10 (Kock, 2014, pp. 1-13). The results of the analysis are presented in Table 5.

Table 5. Results of the comparison between 3PL and 4PL groups − verification of hypothesis H2

Path	3PL* (n = 35)		4PL* (n = 31)		3PL vs. 4PL	
	Path coefficient (β)	*p value*	*Path coefficient* (β)	*p value*	*Absolute path coefficient differences* (β)	*p value*
I_LSPs→EL_LSPs	0.568	< 0.001	0.922	< 0.001	0.354	0.021
Hypothesis to be verified					H_2	
Result					Hypothesis is not confirmed	

Source: own study.

In interpreting the results of the data analysis, it should be noted that the absolute differences for path coefficients (β) were recorded at 0.354. Furthermore, the intergroup p-value adopted a level of 0.021, thus clearly indicating the presence of significant differences for the individual groups. Therefore, the results obtained allow to conclude that there were grounds for rejecting hypothesis H2, according to which there is no significant difference between 3PL logistics operators and 4PL logistics integrators in terms of the relationship between their innovation and logistics efficiency in supply chain services.

In conclusion, it is worth pointing out the results of the PLS-SEM structural equation modelling analysis. The key conclusion confirming the verified hypothesis H1, that there is a positive and direct relationship between the innovativeness of logistics service providers and their logistics agility. Furthermore, the innovativeness of both 3PL operators and 4PL integrators has a significant impact on their logistics agility. This corresponds with the results of earlier studies (cf. Grawe et al., 2015, pp. 88-101), Özoğlu & Büyükkeklik (2017, pp. 55-67), and Qian et al. (2019)). Another equally important conclusion, at the same time answering the following research question: Which forms (models) of logistics service influence the logistics efficiency of supply chains?, indicates that the impact of innovation on logistics efficiency is much stronger for the group of 4PL integrators than for 3PL operators, which was verified in relation to the second research hypothesis. In the author's opinion, the results and conclusions obtained from the study may constitute a significant contribution to the researched issue, while at the same time this area requires further research.

5. Discussion and conclusion

The analysis of the literature, as signalled earlier, showed a deficit of research relating to the research issue addressed in the paper. Hence, based on a systematic literature review and an empirical study, the identified research gaps were filled, contributing to the existing body of research.

The author established a strong influence of the innovativeness of logistics service providers on the efficiency of the realised logistics service of supply chains, which corresponds to the results of previous studies by other authors, e.g. Grawe et al. (2015) or Bellingkrodt & Wallenburg (2013, pp. 209-221). Key in this respect was the finding that the impact of innovation on logistics efficiency is much stronger for 4PL integrators than for 3PL operators.

The results obtained and conclusions drawn from the study have an impact on business practice, confirming that logistics service providers should demonstrate a high level of awareness that today's customers are increasingly demanding. In addition, logistics service providers should be aware that customers expect not only adequate logistics services, but also that logistics companies will follow current trends in digitalisation, process automation and technology implementation. Equally important are the requirements of LSP customers in terms of their pro-environmental activities (not only related to compliance with applicable legal regulations) in the logistics services they provide, but also the scale of the services provided.

The research results can also serve as a contribution to improving activities in the field of creating and implementing innovations and innovative solutions in the logistics services industry, aiming to reach a higher level of functioning and thus provide and offer services on an international or even global scale. It can be assumed that this will be of particular importance in building and maintaining their competitive advantage.

According to the survey, the highest innovation as well as competitiveness, characterise logistics service providers operating under the most advanced business models in the industry. Operators operating under less advanced models need to take this fact into account in their strategies when looking for market niches or pursuing 3PL and 4PL models.

In conclusion, one should also highlight the identified limitations of the empirical research conducted and directions for further exploration. The main limitation is that the research sample covered logistics service providers operating in only one country, Poland.

Another limitation was the size of the survey population – 66 logistics service providers identified in the quantitative study (35 3PL operators and 31 4PL logistics integrators) – it can be assumed that this size will undergo dynamic changes, resulting not only from mergers and acquisitions, but also from the development of companies towards more advanced models of logistics service providers. Hence, it is recommended that the survey be repeated or even extended in new contexts, allowing for more generalised conclusions.

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Annex

Table A1. List and codification of variables for the estimation of PLS-SEM models

Group of latent variables (construct)	Latent variables (sub-construct)	Code of the observable variable	Statement wording	Measurement scale adopted in the survey questionnaire
Logistics efficiency of Logistics Service Providers (EL_LSPSs)	-	EL_LSPS1	We deliver 100% of customer orders on time.	7-point Likert scale; from 'completely disagree' (1) to 'completely agree' (7)
		EL_LSPS2	We offer competitive prices to our customers (including a competitive rate for cargo delivery).	
		EL_LSPS3	We deliver high quality services.	
		EL_LSPS4	We reduce our customers' logistics costs.	
		EL_LSPS5	We meet declared (promised) delivery dates.	
		EL_LSPS6	We guarantee an above-average (in relation to the industry average) level of safety of transported loads.	
		EL_LSPS7	We flexibly adapt our service offerings to our customers' requirements and needs.	
		EL_LSPS8	Orders are delivered accurately, without errors or mistakes.	
		EL_LSPS9	Our cooperation with customers is characterised by a high level of mutual trust and loyalty.	
		EL_LSPS10	The high quality of service translates into an increase in our customers' bottom line.	
		EL_LSPS11	Our wide range of services translates into increased financial performance for our customers.	
Innovation Logistics Service Providers (I_LSPSs)	Technological (process) innovation (IT)	IT1	We use IT support systems in the services we provide to clients.	
		IT2	Our company uses GPS-based solutions in the services provided.	
		IT3	Our company uses barcode-based solutions in the services offered.	
		IT4	Our company applies solutions based on RFID.	
		IT5	We use ERP system solutions in 100% of the customer services provided.	
		IT6	We use a CRM system for our customer services.	
		IT7	The technologies and IT tools used in our company enable us to process, retrieve and securely transmit any information for our customers.	
		IT8	We use TMS tools in our customer logistics service.	
	Product innovation (IP)	IP1	Our company offers a wide range of logistics services to our customers (e.g. packaging services, supply chain management, co-production services).	
		IP2	Our enterprise offers inventory financing services.	
		IP3	Our enterprise offers only one type of service to our clients (e.g. only transport services).*.	
		IP4	We offer our clients consolidation warehouse services.	
		IP5	We offer distribution management services to our customers.	
		IP6	We offer labelling services to our customers.	
		IP7	We offer real-time tracking services to our customers.	
		IP8	We offer product testing and repair services to our customers.	
		IP9	We offer our customers customs services (customs handling).	
		IP10	We offer our customers delivery planning and cost optimisation services.	
		IP11	We offer our customers 3PL supplier qualification and assessment services.	
		IP12	We offer our customers contract negotiation services with logistics service providers.	
		IP13	We offer our clients services for managing the flow of all materials and products within a supply chain or network.	
	Organisational Innovation (OI)	IO1	We do not provide any logistics services based on our own material resources (e.g. means of transport, warehouses).	
		IO2	We carry out logistics services for customers based 100% on our own material resources (e.g. means of transport, warehouses).	
		IO3	We introduce new methods of organisational management (e.g. code of ethics, Kaizen/Lean Management principles, ISO standards).	
		IO4	We provide our services on a national basis.	
		IO5	We provide services to our clients internationally (many countries).	
		IO6	We provide services to our customers on a global basis (multiple continents).	
		IO7	The number of branches (subsidiaries) of our company ensures 100% implementation of the services offered.*.	
		IO8	We offer value-added services (so-called VAS, e.g. labelling, packaging, picking, creation of promotional kits) as part of our customer service package.	
	Market (marketing) innovation (IR)	IR1	We make information available to customers (information sharing) (e.g. to integrate and coordinate processes).	
		IR2	Corporate Social Responsibility is an indispensable element in the implementation of logistics services for our company's customers.	
		IR3	Our company implements environmentally friendly logistics solutions for customers (e.g. reduction of CO2 emissions) in its services through sustainability measures.	
		IR4	We implement significant improvements in distribution services (e.g. dedicated distribution channels, distribution optimisation tools).	
		IR5	We use Internet marketing, online marketing tools, social media.	
		IR6	We sell services using transport and logistics exchanges (marketing targets).	

Key: *Statements with an asterisk are reversed statements (with a negative orientation) for which respondents' results were recoded to standardise the orientation for all items on the survey instrument. Underlined statements were those removed in the analysis of the measurement model in order to improve the reliability of the measurement.

Source: own study based on the survey.