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Determinants of the Use of Logistic Labels by 3PL and 4PL Operators - Results of Studies in Poland

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Abstract:

Purpose: *The aim of this paper is to present the results of a study on determinants of logistics labels used by 3PL and 4PL operators in Poland. The study focused on examining the reliability of five research hypotheses on the impact of employment level and the role of logistics operators on the type and scope of logistics labels they use.*
Design/Methodology/Approach: *We used Bayesian ordinal regression to assess the reliability of the research hypotheses. We used data from a survey conducted on a population of 51 logistics operators operating in Poland.*
Findings: *The test results obtained indicate that the level of employment and the role of the logistics operator in the supply chain do not determine the type of logistics labels used - GS1 or own labels and do not determine the scope of logistics labels used - warehousing process or transport process.*
Practical Implications: *The research results have practical implications for companies cooperating with 3PL and 4PL logistics operators within supply chains. They indicate the determinants of the type and scope of logistics labels used by them, which ultimately translates into cooperation between partners in the supply chain. The research results may help to choose the logistics operator to operate the supply chain depending on the objectives of its individual links.*
Originality/Value: *The originality of the presented research results from the applied research method - Bayesian ordinal regression, rarely used in economic sciences to assess the reliability of research hypotheses concerning the determination of determinants of the studied phenomenon. The defined research hypotheses are an important contribution over the research on communication in supply chains.*

Keywords: *Logistics label, GS1, logistics service providers 3PL/4PL.*

JEL codes: *D30, L20.*

Paper Type: *Paper type.*

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1. Introduction

Supply chain integration, which requires both organizational and informational cooperation of business partners, aims at optimizing logistics processes by, among other things, eliminating paper circulation of documents and thus minimizing errors associated with it. The role of the logistics operator is not only to rationally organize the implementation of logistics processes, but also to integrate the information of the business partners it serves.

Logistics operators are usually classified into five groups (Werner-Lewandowska and Kosacka-Olejnik, 2020). For the purpose of this study, we characterized two of them, i.e., 3PL and 4PL, which is presented in Table 1.

Table 1. *Characteristics of 3PL and 4PL operators*

Operator type	Characteristics	Business example
Third Party Logistics (3PL)	These firms are the logistic service provider. As they provide the logistics services (shipper, warehouse operators etc.), they may be brokerage firms and organizer for supplying logistics services. 3PLs typically can provide transportation, warehousing, pool distribution, management consulting, logistics optimization, freight forwarding, transportation management, rate negotiations, cost evaluations and contract management services.	BCR is a 3PL service provider specializing in domestic and offshore warehousing, international freight forwarding and customs brokerage, but also provides e-fulfilment, specialized export services and other supply chain management services for your business
Fourth Party Logistics (4PL)	Fourth Party Logistics (4PL) is the integration of all companies involved along the supply chain. 4PL is the planning, steering and controlling of all logistic procedures (for example flow of information, material and capital) by one service provider with long term strategic objectives. Fourth party logistics (4PL) has evolved as a breakthrough supply chain solution comprehensively integrating the competencies of third party logistics (3PL) providers, leading edge consulting firms and technology providers.	BCR has performed 4PL functions such as consolidating a plethora of suppliers and carriers to provide a single-invoice solution that streamlines the supply chain process

Source: *Own creation based on: (Horzela et al., 2018; BCR, 2014).*

The effective functioning of supply chains requires information integration, which in the case of IT systems means that each piece of information should be entered into the enterprise's information system only once (STP principle - straight through processing). In such an approach, data acquisition costs are minimized, the consistency of collected and exchanged data can be better guaranteed and the risk of errors minimized. In addition, there should be no delay in the transmission of data within the supply chain (ZLE - zero latency enterprise), which means that the information entered into the system should be made available in real time to all users to whom it is in any way relevant (Speier, Mollenkopf, and Stank, 2008; Sassi, Arrivabene, and Romero, 2011).

Information integration is realized through communication channels and technologies supporting information flow between companies in the supply chain (Leuschner, Rogers, and Charvet, 2013). The most frequently formulated goal of supply chain management from a logistics perspective, among others, is to minimize the total cost of product and information flow while maintaining the level of quality of supply service required by customers - the so-called logistics of savings. The integration of chain participants is based on the use of modern information technology and widely understood partnership (Hadas *et al.,* 2015; Trojanowska, Varela, and Machado, 2017). Information technology capabilities and information sharing have a significant impact on logistics integration (Prajogo and Olhager, 2012; Horzela *et al.*, 2018).

Information integration makes it possible to reduce the time required to generate data and information that are necessary for operational-level decision-making in logistics processes. The acquisition of real-time data increases the readiness of companies for possible changes in the plan for the implementation of logistics processes.

Synthesizing the above analyses, it should be stated that the task of the logistics operator in the supply chain is to bridge spatial and temporal gaps and other contradictions occurring between production and consumption (Horzela *et al.,* 2018). The use of a logistics operator should be considered in terms of economic efficiency, due to the continuous search for process and cost optimization.

The global supply chain relies on reliable communication, identification of transported cargo and coordination of logistics processes. In addition to electronic data exchange, i.e. the reduction of paper documents in favour of EDI messages, an important aspect connecting the information flow and the physical flow of goods is the use of a logistics label. The logistics label with its SSCC number enables the unique identification of the delivered goods with the information flow between business partners - e.g. with the delivery note (DESADV). Therefore, the ability to standardize logistics labels from different suppliers who are customers of logistics operators becomes a key optimization factor. One commonly used solution is the GS1 standards, which aim to improve the efficiency and transparency of supply chains. These solutions provide a standardized way to identify goods, cargo, assets, or locations, thereby allowing you to know exactly where a shipment is at any given time and share that information with other participants in the supply chain (Horzela *et al*., 2018).

Logistics Service Providers cooperate with different supply chain participants, thus they are exposed to the disturbances which appear in the economy (Werner-Lewandowska and Golińska-Dawson, 2021). In systematic literature review Chowdhury *et al.* (2021) have identified that the pandemic created ambiguous effect on supply chain.

The research was conducted in 2018 and 51 logistics operators doing their business in Poland participated. The selection of the population for identifying business needs and problems, based on companies operating in Poland, can be considered representative and allows deducing conclusions on an EU scale. Poland is an interesting market for a study in logistics sector.

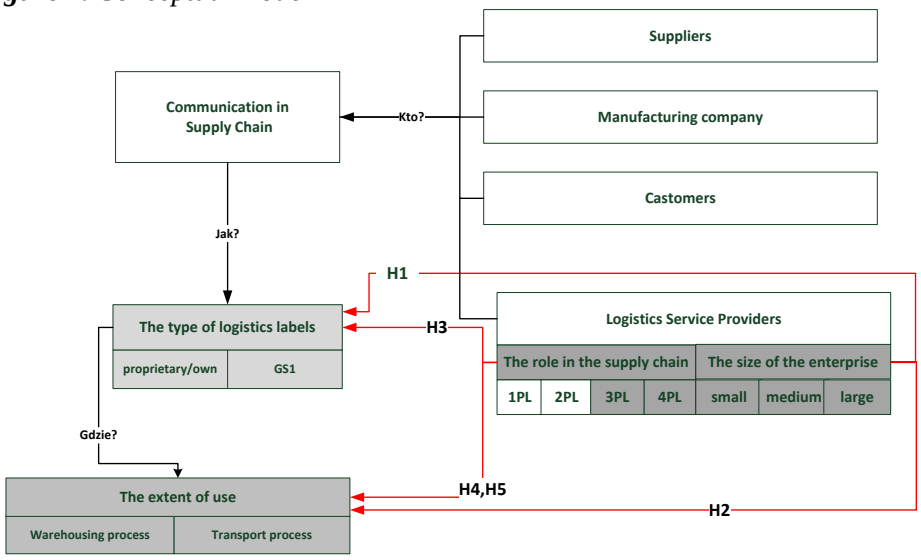
According to the data from the Eurostat, Polish logistics sector has got a very high share in tonne-kilometers terms in freight transport in European Union (16,4% of total EU) (EuroStat, 2019). Poland holds predominance in cabotage activity. In 2018 Polish haulers were the main third country haulers in country-to-country transport of goods in the EU (Werner-Lewandowska and Golińska-Dawson, 2021). According to Central Statistical Office data, in 2018 to the transport and ware-housing providers accounted for 12% of enterprises in Poland (Werner-Lewandowska and Golińska-Dawson, 2021). In addition, Logistics Service Providers generate the largest GDP impact among Polish service enterprises (Werner-Lewandowska and Golińska-Dawson, 2021).

2. Material and Methods

2.1 Scope of Research and Conceptual Model

The purpose of our research is to determine the determinants of the use of logistic labels by 3PL and 4PL operators in Poland. The conceptual model of the study is presented in Figure 1.

Figure 1. *Conceptual model*



Source: *Own creation.*

In this study, we focused on examining the plausibility of 5 research hypotheses regarding the impact of staffing levels and the role of logistics operators on the type and extent of logistics labels they use:

H1: Employment level determines the type of logistics labels used (GS1 or proprietary).
H2: Employment level determines the extent to which GS1 standard logistics labels are used (warehousing process, transportation process).
H3: The role of the logistics operator determines the type of logistics labels used (GS1 or own).
H4: The role of the logistics operator determines the extent of use of GS1 state-of-the-art logistics labels (warehousing process, transportation process).
H5:The role of the logistics operator determines the extent to which proprietary logistics labels are used (warehousing process, transportation process).

2.2 Data for the Verification of Research Hypotheses

The verification of the research hypotheses was carried out for the population of N = 51 of Polish enterprises providing transport and storage services. The companies were selected according to the volume handled annually in Poland, based on the TOP list of logistics operators (GS1, 2018). The characteristics of the researched population of 51 logistics service providers, are presented in Table 2.

Table 2*. Basic information on the surveyed enterprises*

	Characteristics of researched population					
	Number of employees hired by the enterprise (E):				Cooperation with business partners:	
Responses (%)	E<10	10<E<50	50<E<250	E>250	·3PL	4PL
	3,92%	17,65%	21,57%	56,86%	64,71%	35,29%

Source: *Own study.*

The research was conducted in 2018 among leading logistics operators doing business in Poland. More than 77% of them are medium or large enterprises. More than 60% offer Third Party Logistics (3PL) services. According to the theory of estimation in operational research, the minimum research sample that guarantees the representativeness of the results is n=30. The confidence level should not be less than 85% and the maximum error greater than 18% (Balakrishnan and Basu, 1996). The analysis carried out by the author allows to state that assuming the maximum error of 15% and the confidence level of 95%, the research sample of 43 enterprises should be considered representative (Domanski and Kolinski, 2020). The obtained statistical sample of 51 logistics operators is not only representative but also allows deducing the obtained conclusions.

Data was analysed with R 4.0.2 statistical package. For each depend variable Bayesian regression with company size and operator role as predictors was conducted to determine whether credible differences between groups are present in the data. Company size was coded 0.5 for large companies and -0.5 for remaining companies, while for operator role the 3PL was coded as 0.5, and 4PL ad -0.5. with such coding the regression weights of each predictor represent estimated difference between groups. Binary dependent variables (yes-no questions) were analysed with logistic regression, and responses to questions on a 0-100% scale were analysed with linear regression.

In Bayesian statistics the inference is based on the posterior distributions of a parameter (e.g., regression weight). The posterior is usually summarized with a mean and 95% credible interval (95% CI). If the 95% CI excludes zero, the parameter value can be considered statistically credible. The models were fitted using brms package (Bürkner, 2017). The prior for regression weight on logit scale was set to normal (0, 1), assuring uniform coverage of the probabilities. For the linear models the prior was normal (0, 10). Four parallel chains with 2000 iterations (including 1000 for warmup) samples were used to approximate the posterior, and every second iteration was recorded to reduce autocorrelations in the chains. The sampling procedure was efficient, as evaluated with visual inspection of the posteriors, chains, autocorrelations plots and R-hats < 1.01.

3. Results

The reliability tests carried out allowed to conclude, with reference to the research hypotheses posed, that the level of employment does not determine the use of own logistic labels (H1). They are used by 100% of small or medium-sized companies and 90% of large companies, which is not enough to find reliable differences. No credible differences were observed for the proportion of usage of the GS1 between large (86%) and remaining companies (59%), $\beta_1 = 0.73$, 95% CI: [-0.45, 1.78].

Also, the role of the logistics operator does not determine the use of own logistics labels (H3). They are used by the same percentage (94%) of 3PL and 4PL operators. No credible differences were observed for the proportion of usage of the GS1 between companies with 3PL (63.6%) and 4PL (89%) operator roles, $\beta_2 = -0.84$, 95% CI: [-2.11, 0.36].

Regarding hypothesis H2 and H4, it is concluded that both the level of employment and the role of the logistics operator do not determine the degree of use of GS1 logistics labels. Table 3 presents results of Bayesian linear regressions conducted with questions form group 3 as dependent variables, and figure 2 presents average response as a function of company size and operator's role. No statistically credible differences were observed.

Table 3. *Results of Bayesian linear regressions with dependent variables*

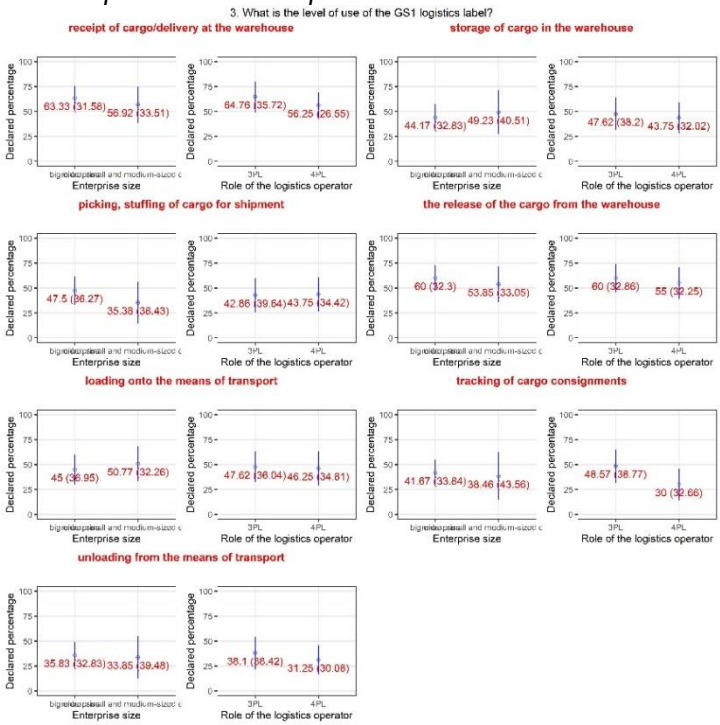
	Me	SE	LI	UI
	Warehousing process - stages:			
	Receipt of cargo/delivery at the warehouse			
Company size	3.54	7.62	-11.51	18.77
Role of the logistics operator	4.53	7.54	-9.89	18.84
	Storage of cargo in the warehouse			
Company size	-1.81	8.21	-17.98	14.17
Role of the logistics operator	1.46	7.68	-13.13	16.68
	Picking, stuffing of cargo for shipment			
Company size	4.4	8.11	-12.07	19.86
Role of the logistics operator	0.22	7.97	-15.19	15.4
	Release of the cargo from the warehouse			
Company size	3.18	7.39	-11.32	18.33
Role of the logistics operator	2.8	7.26	-11.29	17.64
	Transportation process - stages:			
	Loading onto the means of transport			
Company size	-2.4	8.01	-17.31	13.64
Role of the logistics operator	0.23	7.89	-14.49	15.26
	Tracking of cargo consignments			
Company size	2.08	7.97	-13.68	17.04
Role of the logistics operator	7.67	8.02	-8.54	22.53
	Unloading from the means of transport			
Company size	1.11	7.87	-14.88	16.37
Role of the logistics operator	3.23	7.9	-12.48	18.4

Note: *Me, SE, and LI and UI are median, standard deviation, and lower and upper bounds of 95% credible interval, of the posterior distribution of a regression weight*
Source: *Own study.*

Regarding hypothesis H5, it should be stated that the role of the logistics operator does not determine the degree of use of own logistics labels.

Table 4 presents results of Bayesian linear regressions conducted with questions form group 4 as dependent variables, and Figure 3 presents average response as a function of company size and operator's role. No statistically credible differences were observed.

Figure 2. *Mean (standard deviation) responses (red numbers) as a function of company size and operator's role. Blue point is the mean, and the vertical line shows 95% confidence interval of the mean*



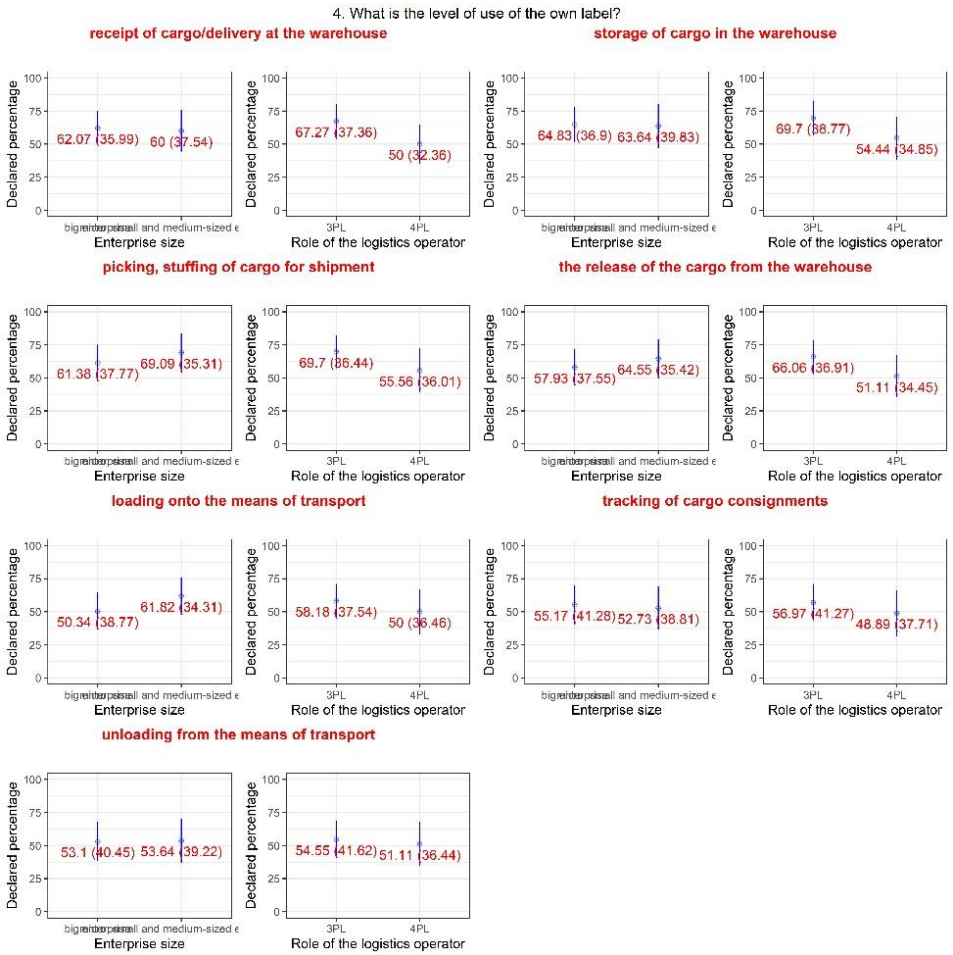
Source: *Own creation.*

Table 4. *Results of Bayesian linear regressions with dependent variables*

	Me	SE	LI	UI
		Warehousing process - stages:		
		Receipt of cargo/delivery at the warehouse		
Role of the logistics operator	8.34	7.49	-6.58	22.92
		Storage of cargo in the warehouse		
Role of the logistics operator	7.12	7.64	-7.93	22.08
		Picking, stuffing of cargo for shipment		
Role of the logistics operator	6.25	7.28	-8.22	20.23
		Release of the cargo from the warehouse		
Role of the logistics operator	6.25	7.28	-8.22	20.23
		Transportation process - stages:		
		Loading onto the means of transport		
Role of the logistics operator	2.89	7.41	-11.45	17.59
		Tracking of cargo consignments		
Role of the logistics operator	3.51	7.69	-11.23	18.2
		Unloading from the means of transport		
Role of the logistics operator	1.51	7.49	-13.14	16.21

Note: *Me, SE, and LI and UI are median, standard deviation, and lower and upper bounds of 95% credible interval, of the posterior distribution of a regression weight*
Source: *Own study.*

Figure 3. *Mean (standard deviation) responses (red numbers) as a function of company size and operator's role. Blue point is the mean, and the vertical line shows 95% confidence interval of the mean*



Source: *Own study.*

4. Conclusions

The logistics label is a solution for combining the integration of information flow between the IT systems of business partners and the physical flow of cargo. 3PL and 4PL logistics operators are forced to digitize their logistics processes, but the role of the logistics label, which confirms the physical activities of cargo transportation or handling in the warehouse, continues to grow.

Conducted research clearly indicates that the information integration of logistics operators with partners in the supply chain, using the logistics label, requires standardization. Currently, more than 90% of operators still use non-standard labels (their own, or dedicated by customers), which not only hinders integration processes in supply chains, but above all increases the risk of errors, which have a direct impact on operational efficiency and the generation of excessive costs.

Optimization efforts are hampered due to the low scalability of the effects - the lack of standardization prevents the introduction of universal solutions for many business partners. The primary barriers to the use of GS1 standard labels are the inadequacy of contractor IT systems in terms of available functionality, customer resistance to implementation, and lack of belief in the benefits of logistics label standardization. This reluctance of business practices to standardize labels has an indirect impact on the digitalization of logistics processes carried out by 3PL and 4PL operators, due to inhibiting the implementation of solutions based on the paperless concept and electronic data interchange (EDI). The direction of further research in this area should be to identify the potential benefits of implementing standardized logistics labels.

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