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## **Statistical Analysis of the Extent of the Use of Information Technology Systems for Logistics Management in an Enterprise**

The paper objective is to determine the extent of the use of information technology logistics management systems in enterprises across individual voivodships. Apart from the theoretical basis of information technology systems in use, the results of research carried out with statistical analysis methods have been presented. Also, branches and voivodships with the largest extent of the use of information technology systems for logistics processes have been determined.

Исследована степень использования информационной технологии в системах управления логистикой на предприятиях отдельных воеводств. В отличие от стандартных подходов в информационных технологиях представлены результаты исследований, проводимых методами статистического анализа. Определены области и воеводства, где в наибольшей степени используются системы информационных технологий для логистических процессов.

*Key words: information technology, logistics management, supply chain management, enterprise resource planning, customer relationship management, supplier relationship management.*

Globalization of markets, increase of the number of geographically scattered entities cooperating with one another, and thereby their bigger complexity, pose the need to develop appropriate technological solutions for information-decision processes. As the cooperating and competing entities saw the need for collaboration, new organization configurations started to emerge. They are different from traditional ones with seller-buyer relationships, which abounded in antagonisms and took advantage of the weaker. The supply chains exemplify such a configuration: «The supply chain structure was a two-echelon model: manufacturer (seller), and retailer (buyer)» [1]. Proper functioning of the supply chain is dependent on the cooperation between its participants. Accordingly, there comes the need for integration of the supply chain processes. Efficiency of the enterprises connected with the realization of the processes will mainly depend on communication accessibility and on the size and structure of human and capital resources [2]. One of the elements of communication infrastructure is information technology, which provides quick and smooth information flow in the supply chain. Ensuring efficient information flow is vital for taking decisions,

making the competitiveness strategies, and developing state economies. These are the areas where information technology is becoming a necessity [3]. The research shows that [4]:

1. The more sophisticated is the information technology used for processing orders, invoicing and settlement, exchanging information concerning delivery, managing the warehouses and stock, the better is the operational coordination between the suppliers.

2. The more sophisticated is the information technology used for the analyses of the trends of sales and customers needs, integration of planning and production functions, creating new market opportunities, the better is the strategic coordination between the suppliers.

The use of advanced information technologies in the supply chains is necessary to realize the processes which are becoming more and more complex as they involve many cooperating entities.

**Evolution of information technology systems facilitating the realization of logistics processes.** High complexity of organisations and the amount of information handled within and conveyed outside, demand a tighter cooperation between entities. It is information technology that enables this cooperation by improving effectiveness of the supply chains thanks to the centralization of information, providing shorter lead time and smaller batch size in the supply chains and reduction of the bullwhip effect, which causes poor supply chain performance. [1]. Considering the character of the processes in question, the systems facilitating them can be called information technology systems for logistics management. Since the early 1950's, the computer systems supporting logistics processes have undergone a characteristic evolution [5]. Initially, a Computer System was only used for stock management, and hence it was called inventory control (IC).

Over time, logistics processes became essential in entities management. Consequently, material requirements planning (MRP) systems appeared, supporting the processes of: demand-supply balancing, production and purchase planning, as well as planning and controlling stock. As MRP systems had acquired new functions, a new class of systems was introduced: MRP II (manufacturing resource planning), which supported: sale and production planning, demand management, material planning, production capacity and orders control, distribution resources planning. As a result of the evolution of MRP II systems, another class of systems appeared: enterprise resource planning (ERP), also known as money resource planning (MRP III). They enable full integration of all spheres of a company's activity, because they support the planning of company's resources, which are necessary for running all its business functions. The implementation of ERP systems brings the following benefits in the scale of a company [5]:

- supplying decision makers with information concerning the proper value-in-use, sharing information;
- integration of all geographically scattered organizational entities of an enterprise;
- integration of all spheres of enterprise's activity;
- processes orientation;
- ensuring real-time operation;
- increase of an enterprise's effectiveness and efficiency;
- matching implemented systems with an enterprise's needs in the scope of management;
- increase in the workers' assimilability and acceptability of information technology solutions.

Enabling entities cooperating with an enterprise to share the same information technology systems lead to the creation of Enterprise Resource and Relationship Processing (ERP II) systems. They allow for optimization of operational and financial processes between an enterprise and its partners as well as within an enterprise.

By reason of the fact that the conditions of enterprise functioning change, which brings about changes of the requirements concerning business processes, information technology systems are integrated with systems tackling the cooperation of an enterprise with its marketing environment. The most important include:

- supply chain management (SCM) system;
- customer relationship management (CRM) systems;
- supplier relationship management (SRM) systems.

Above mentioned systems pave the way for tightening the cooperation with other entities from the marketing environment of an enterprise thanks to the exchange of information and joint planning of activities. CRM systems support sale, conducting marketing campaigns, and after-sale service. The customer support after sale is realized through the so called telephone service centre (call centre) which shortens the time of response to the customers' questions. That is why CRM systems endeavour to encode the intellectual capital. [6]. SRM systems allow for choosing right suppliers, working out supply strategy, and shortening supply cycles. SCM is a result of a steady convergence of the traditionally distinct areas of operations management, sourcing, and logistics into a single area. Information flows, physical flows and relationships link these areas together, and link these areas with upstream and downstream partners [7]. SCM „integrates suppliers, manufacturers, distributors, and customers through the use of information technology to meet customer expectations efficiently and effectively” [8]. Therefore, SCM system fulfils primarily the integration function un-

derstood as the integration of processes realized within an enterprise, the integration of geographically scattered organisational entities of an enterprise, and the integration of an enterprise with its business partners. SCM class systems, therefore, allow for modelling of the entire net of supplies as far as the processes of production and distribution are concerned.

Information technology facilitates the integration and coordination of business processes, especially with respect to control and connectivity [9]. Maintaining the continuity of information flow in all spheres of the enterprise activity or in the activity of a group of cooperating enterprises is the condition of efficient operation.

**Analysis of information technology support for logistics processes in Polish enterprises.** In Polish enterprises, most commonly used systems are: ERP, CRM, and SCM. They are usually used by medium and large enterprises whose number in Poland is gradually increasing. Table 1 presents the dynamics of the number of enterprises with respect to their size for the years 2006—2008.

In the year 2008, the number of enterprises (without section J) increased by 1.47%, and by 0.76% in comparison with the year 2006. The year 2007 saw a slight decrease in the number of enterprises in comparison with the year 2006, but it was due mainly to the decrease of the number of small enterprises. The number of small enterprises increased a little in the year 2008 in comparison with the previous year, in which, however, it decreased by 1.44% in comparison with the year 2006. Individual years saw a considerable increase in the number of medium and big enterprises. Small enterprises made a vast proportion of enterprises in the analyzed years: 67.4% — 2006, 78.7% — 2007, 77.8% — 2008.

The main characteristic of a developing information society is the fact that more and more companies are equipped with computers. Computerization is the foundation for the development of the economy based on knowledge and information exchange. However, what is most important for enterprises is the translation of the potential of information technologies into specific spheres of activity, in order to increase their effectiveness. Tables 2 — 5 present data concerning the

*Table 1. The dynamics of the number of enterprises with respect to their size for the years 2006—2008 (by quantity in January of analysed years) — absolute change*

Period	Total, % (without section J)	Small enterprises, % (10 — 49 employees)	Medium enterprises, % (50 — 249 employees)	Big enterprises, % (250 and more employees)
2007/2006	– 0.70	– 1.81	2.98	6.92
2008/2007	1.47	0.38	4.80	8.96
2008/2006	0.76	– 1.44	7.92	16.50

Source: own elaboration.

extent of the use of information technology in logistics management in enterprises for the years 2006—2008.

In 2006, big enterprises were best equipped with information technologies supporting logistics processes, small enterprises were much worse in this respect. The biggest proportion of enterprises possessing information technology system for tackling orders, automatically linked with the internal system for

**Table 2. Frequency coefficient of enterprises possessing information technology system for tackling orders in January 2006 by size of enterprises and sections (%)**

Specification	Enterprises, automatically linked with				
	the internal system for managing deliveries and stores	the systems for invoicing and payment realization	the systems for managing production, logistics and customer service	the systems external suppliers	the systems of external customers
Size of enterprises:					
small enterprises (10—49 employees)	10.3	13.8	5.5	3.2	1.7
medium enterprises (50—249 employees)	23.1	28.1	17.6	4.9	4.3
big enterprises (250 and more employees)	41.4	45.6	36.4	9.9	12.2
Section:					
<i>D</i> — industrial processing	13.1	17.0	10.7	1.7	2.6
<i>F</i> — construction	2.9	5.3	1.9	0.6	0.1
<i>G</i> — trade and repairs	21.5	24.4	9.9	7.6	3.6
H: groups 55.1 — 55.2 — hotels and other accommodation objects	8.7	19.0	4.2	0.4	0.4
<i>I</i> — transport, warehousing and communication	8.0	15.9	8.9	5.5	3.1
<i>K</i> : divisions: 70, 71, 74 — real estate and business activities	5.5	10.1	3.9	2.1	1.2
<i>K</i> : division 72 — information technology	18.1	24.0	15.4	4.4	4.7
<i>K</i> : division 73 — science	6.7	10.3	4.7	1.0	0.7
<i>O</i> : groups 92.1—92.2 — movie, video, radio, television	9.1	18.3	5.1	4.1	8.6

**Table 3. Enterprises using ERP, CRM systems and the systems for managing orders in January 2007 by size of enterprises and sections (%)**

Specification	ERP — computer system for planning enterprise's resources	CRM — software for customers		Systems automatically linked with					
		A	B	Total	the internal system for managing deliveries and stores	the system for invoicing and payment realization	the system for managing production, logistics and customer service	the systems used by external suppliers (from outside the company's capital group)	the systems used by external customers of an enterprise (from outside the company's capital group)
Size of enterprise employees:									
small (10 — 49)	8.7	18.4	10.2	33.8	13.4	21.4	7.5	4.0	2.1
medium (50 — 249 )	25.7	30.0	17.3	49.8	27.6	35.0	21.3	6.0	5.5
big (250 and more)	51.3	37.6	23.9	63.0	45.8	49.5	41.5	11.1	13.5
Section:									
<i>D</i> — industrial processing	13.4	18.6	10.5	38.0	15.7	25.0	13.3	2.4	3.1
<i>F</i> — construction	4.6	10.0	4.2	26.1	6.3	13.6	4.1	2.2	1.5
<i>G</i> — trade and repairs	17.2	25.1	16.9	44.7	26.6	31.5	12.3	8.8	4.0
<i>H</i> : groups 55.1 — 55.2 — hotels and other accommodation objects	10.1	27.0	18.3	48.9	14.6	31.5	7.4	1.6	1.6
<i>I</i> — transport, warehousing and communication	13.9	25.4	10.9	37.0	12.3	25.4	13.8	5.4	5.0
<i>K</i> : divisions 70, 71, 74 — real estate and business activities	9.4	24.3	8.1	24.7	7.1	13.9	5.6	2.4	1.6
72—information technology	24.5	57.0	33.6	56.7	28.6	35.0	26.7	11.4	5.7
73 — science	14.3	17.3	6.8	32.0	9.5	17.0	6.1	3.1	1.4
<i>O</i> : groups 92.1 — 92.2 — movie, video, radio, television	15.1	28.3	15.7	42.8	5.7	25.8	4.4	3.1	5.7

Source: own elaboration based on the data of Main Statistical Department in Poland

managing deliveries and stores, with the systems for invoicing and payment realization, the systems for managing production, logistics and customer service, external suppliers systems, and the systems of external customers was found among the following branches: section *G* — trade and repairs, section *K* (section 72) — information technology, section *D* — industrial processing. Mostly these branches used information technology systems facilitating logistics management. Branches with the smallest extent of information technology use are building and education.

Similar situation was observed in years 2007 (Table 3) and in 2008 (Tables 4 and 5). The marks at the Tables 3 and 4 are following: A — gathering and storing this information and making it accessible for other sections of an enterprise;

**Table 4. Enterprises using ERP and CRM systems in January 2008 by size of enterprises and sections (%)**

Specification	ERP — computer system for planning enterprise's resources	CRM — software for managing information concerning customers	
		A	B
Size of enterprise employees:			
small (10 — 49)	7.6	15.5	10.0
medium (50 — 249)	22.9	29.3	18.1
big (250 and more)	50.9	41.6	27.9
Section:			
<i>D</i> — industrial processing	12.8	16.2	9.4
<i>F</i> — construction	5.5	8.3	4.2
<i>G</i> — trade and repairs	15.1	24.9	19.1
<i>H</i> : groups 55.1—55.2 — hotels and other accommodation objects	7.8	20.4	15.1
<i>I</i> — transport, warehousing and communication	8.4	21.3	13.2
<i>K</i> : divisions 70, 71, 74 — real estate and business activities	9.2	20.2	8.7
72 — information technology	22.1	46.0	30.0
73 — science	9.7	21.0	8.0
<i>O</i> : groups 92.1 — 92.2 — movie, video, radio, television	16.0	39.9	25.8

Source: own elaboration based on the data of GUS

**Table 5. Enterprises keeping electronic information exchange concerning the management of the supply chain in January 2008 by size of enterprises and sections (%)**

Specification	Enterprises keeping electronic exchange concerning the management of the supply chain												
	With the suppliers					With the receivers					Via the Internet	Electronic information exchange (XLM, EDIFACT, etc.)	
	Connected with					Connected with							
	Total	Demand prognostics	Stock on hand information	Production plans	Connected with the progress of deliveries realization	Total	Demand prognostics	Stock on hand information	Production plans	Connected with the progress of deliveries realization			
Size of enterprises:													
small (10 — 49 employees)	7.2	3.9	6.0	4.1	7.4	4.7	3.1	3.6	3.0	5.6	8.6	3.6	
medium (50 — 249 employees)	13.0	7.5	11.2	8.0	12.9	10.2	6.0	8.2	7.3	10.9	13.1	7.9	
big (250 and more employees)	17.4	10.7	14.7	11.5	16.1	15.2	9.8	12.2	10.9	16.2	18.1	16.3	
Sections:													
<i>D</i> — industrial processing	7.5	4.3	5.7	5.8	7.8	5.0	5.7	6.0	8.1	8.5	4.3	5.0	
<i>F</i> — construction	3.1	0.8	2.7	1.5	3.0	1.1	1.3	1.3	2.3	5.1	0.8	1.1	
<i>G</i> — trade and repairs	14.4	8.0	13.2	6.9	13.4	6.8	4.2	6.0	3.4	7.8	13.7	7.7	
<i>H</i> : groups 55.1 — 55.2 — hotels and other accommodation objects	7.6	6.8	2.9	1.6	7.3	5.5	3.8	1.5	5.9	10.5	3.4	5.5	
<i>I</i> — transport, ware housing and communication	8.2	4.6	6.0	4.9	11.3	5.0	4.5	4.7	11.6	13.8	7.0	5.0	
<i>K</i> : divisions 70, 71, 74 — real estate and business activities	3.2	1.7	2.4	2.2	3.5	1.6	1.7	2.2	3.5	4.5	2.2	1.6	
72 — information technology	10.8	4.4	9.4	5.1	12.7	3.4	3.1	4.9	9.2	20.5	7.6	3.4	
73 — science	5.3	1.7	4.7	2.3	5.7	2.3	3.0	4.0	6.0	12.3	5.0	2.3	
<i>O</i> : groups 92.1 — 92.2 — movie, video, radio, television	11.7	4.9	9.2	6.7	8.6	9.2	8.6	6.1	11.0	11.0	2.5	9.2	



B — analysis of this information for marketing goals (price calculation, promotion management, defining campaigns and distribution canals etc.). These are big enterprises that extensively use ERP, CRM and systems for handling orders. In terms of branches it is section *G* — trade and repairs, *K* (section 72) — information technology, *D* — industrial processing, and additionally, *I* — transport, warehousing and communication. In 2008 there was also a considerable proportion of enterprises from section *O* (groups 92.1 — 92.2) — movie, video, radio, television, which used ERP, CRM, and information technology systems for tackling orders. These trends are the same for enterprises dealing with the electronic exchange of information concerning the supply chain management.

**Comparison of voivodships with respect to the extent of information technology use.** Voivodship is one of the Polish administrative units. Individual voivodships differ with respect to the extent to which enterprises use information technology. The extent will translate directly into capacity for the implementation of information technology logistics management systems, which help to reduce costs and increase income, and thereby contribute to the development of entire regions. Therefore, it is important to evaluate the extent of information technology logistics management systems use for individual voivodships. This task can be performed with the method of multi-dimensional comparative analysis.

The extent of information technology logistics management systems use for individual voivodships has been described with many variables. The isolated variables are connected with two periods: January 2007, and January 2008. Unfortunately, the data sets for the periods differ, as the values of some variables are not accessible. Data set determining the extent of information technology logistics management systems use includes:

1. The number of enterprises using ERP — computer system for planning enterprise's resources.
2. The number of enterprises using CRM — software for managing information concerning customers, which allows for gathering and storing this information and making it accessible for other sections of an enterprise.
3. The number of enterprises using CRM — software for managing information concerning customers, which allows for analysis of this information for marketing goals.
4. The number of enterprises using the system for managing orders automatically linked with the internal system for managing deliveries and stores.
5. The number of enterprises using the system for managing orders automatically linked with the system for invoicing and payment realization.
6. The number of enterprises using the system for managing orders automatically linked with the system for managing production, logistics and customer service.

7. The number of enterprises using the system for managing orders automatically linked with the systems used by external suppliers of an enterprise (from outside the company's capital group).

8. The number of enterprises using the system for managing orders automatically linked with the systems used by external customers of an enterprise (from outside the company's capital group).

An analysis for January 2008 has been carried out on a set including the following variables:

1. The number of enterprises using ERP — computer system for planning enterprise's resources.

2. The number of enterprises using CRM — software for managing information concerning customers, which allows for gathering and storing this information and making it accessible for other sections of an enterprise.

3. The number of enterprises using CRM — software for managing information concerning customers, which allows for analysis of this information for marketing goals.

4. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the suppliers, connected with stock on hand information.

5. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the suppliers, connected with production plans.

6. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the suppliers, connected with demand prognostics.

7. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the suppliers management of the supply chain with the suppliers, connected with the progress of deliveries realization.

8. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the receivers, connected with stock on hand information.

9. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the receivers, connected with production plans.

10. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the receivers, connected with demand prognostics.

11. The number of enterprises keeping electronic information exchange concerning the management of the supply chain with the receivers management

Table 6. Ordering of voivodships by measure of development

January 2007		January 2008	
Ordering of voivodships	Measure of development	Ordering of voivodships	Measure of development
Mazowieckie	0.279	Mazowieckie	0.210
Podkarpackie	0.939	Kujawsko-pomorskie	1.008
Kujawsko-pomorskie	0.969	Malopolskie	1.181
Dolnoslaskie	0.998	Lubuskie	1.231
Pomorskie	1.145	Podkarpackie	1.473
Slaskie	1.150	Dolnoslaskie	1.522
Opolskie	1.263	Pomorskie	1.664
Lubuskie	1.345	Swietokrzyskie	1.672
Wielkopolskie	1.430	Slaskie	1.998
Podlaskie	1.611	Wielkopolskie	2.017
Lodzkie	1.617	Lodzkie	2.025
Zachodniopomorskie	1.830	Opolskie	2.444
Malopolskie	1.838	Podlaskie	2.528
Lubelskie	2.315	Zachodniopomorskie	2.606
Swietokrzyskie	2.377	Warminsko-mazurskie	3.224
Warminsko-mazurskie	2.464	Lubelskie	3.280

Source: own elaboration

of the supply chain with the suppliers, connected with the progress of deliveries realization.

12. The number of enterprises keeping electronic information exchange via the Internet.

13. The number of enterprises keeping automatic electronic information exchange (XLM, EDIFACT, etc.)

All variables are stimulants. Data has been recalculated and converted for a single inhabitant of a section in order to improve their comparability. Moreover they were normalized, thanks what values of all variables are nominal and included in the interval [0; 1]. The variables were normalized by the formula:

$$z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{O_j}, \quad i=1, 2, \dots, n; \quad j=1, 2, \dots, m,$$

where  $z_{ij}$  — value of object  $i$  of variable  $X_j$  after normalization;  $\min_i x_{ij}$  — minimal value of variable  $X_j$  (for  $i=1, 2, \dots, n$ );  $O_j$  — difference between maximal and minimal value of variable  $X_j$ .

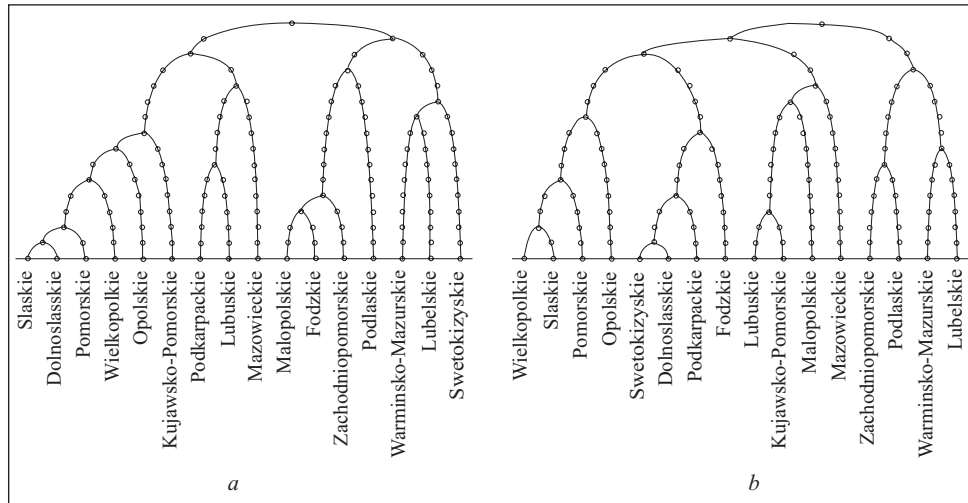
Table 6 presents the ranking of voivodships according to their similarity to the standard in the analyzed periods.

Irrespective of the set of data and period analyzed, Mazowieckie voivodship is characterized by the greatest extent of the use of information technology systems for logistics management. The fact that this voivodship is the most similar to the standard means that it is a standard for the other voivodships. Warmicko-Mazurskie and Lubelskie voivodships bear the least similarity to the standard (the former in January 2007, the latter in January 2008), which proves their backwardness with respect to the use of the information technology systems for logistics management, in comparison to other voivodships. No matter which period taken into consideration, these two voivodships rank last. The best voivodships for both analyzed periods are: Mazowieckie, Kujawsko-Pomorskie, Podkarpackie and Dolnoslaskie. However, Podkarpackie voivodship fell from position 2 to 5 in January 2008, Dolnoslaskie voivodship from 4 to 6, and Kujawsko-Pomorskie voivodship moved up from the position 3 in January 2007 to the position 2 in January 2008. Switokrzyskie voivodship moved up to the position 8 in January 2008 from the penultimate position in the ranking in January 2007. Similarly, Maiopolskie voivodship moved up from the position 13 to the position 2 in the second period.

The analysis results are undoubtedly influenced by the inventory of characteristics which describe the extent of the use of information technology systems for logistics management. However, the analysis displays certain tendencies concerning the informatization of logistics activities in voivodships. The voivodships have been grouped on the basis of distance matrix, which allowed for determining the groups of most similar voivodships. Figure is a graphic representation (the so called dendrogram) of similarities and differences between the voivodships.

Considering the set of all variables for each of the analyzed periods, the first group of voivodships has been determined. It includes Slaskie and Dolnoslaskie voivodships for the year 2007, and Switokrzyskie and Dolnoslaskie voivodships for the year 2008. The distances between these voivodships are the smallest, which indicates the biggest similarity with respect to the analyzed characteristic between them. Mazowieckie voivodship appears in the group: Podkarpackie and Lubuskie voivodships for 2007 and Kujawsko-Pomorskie and Lubuskie for 2008.

**Conclusions.** Information Technologies contribute to the civilization progress and development of information society. Their implementation has become crucial for contemporary enterprises, which in order to meet the market's requirements, have to cooperate with other entities. One of the elements of this cooperation is sharing information proper for deciders and using it for developing



Dendrogram for voivodships: *a* — all variables for January 2007; *b* — all variables for January 2008  
 Source: Own elaboration

plans for the management of enterprise’s resources. Implementing information technology systems for logistics management contributes to efficient management through providing effective assistance to the deciders as far as the logistics processes are concerned.

Poland does not belong among the countries with a high extent of available information systems use. Companies, however, eagerly use information systems for logistics management, especially ERP, and CRM and SCM, which cooperate with ERP.

A proportion of enterprises using information technology systems for processing orders increased from 24.87% in 2006 to 37.68% in 2007. In 2008, 14.09% of enterprises were using systems for managing supply chains. Similar are proportions of enterprises using ERP (13.27% — 2007, and 12.06% — 2008) and CRM — both for gathering, storing customer information and sharing it with other parts of the enterprise (21.1% — 2007, and 12.0% — 2008), and analyzing customer information for marketing goals (11.9% — 2007, and 12.2% — 2008).

The voivodships are differentiated according to their extent of logistics management systems use. Mazowieckie voivodship is the best in this respect which can be connected with the centralization of capital and nerve centres operating in supply chains in this area. However, dynamic environment calls for constant innovation in enterprises, and accordingly in used information systems too. A statistical analysis of the extent of the use of information technology management systems allows not only for the evaluation of the development of individual

voivodships, and determination of their similarities, but also for setting a standard for other entities.

Досліджено ступінь використання інформаційної технології в системах управління логістикою на підприємствах окремих воєводств. На відміну від стандартних підходів у інформаційних технологіях наведено результати досліджень, виконаних методами статистичного аналізу. Визначено області та воєводства, де найбільше задіяно системи інформаційних технологій у процесах логістики.

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