

Joanna Domagała

Warsaw University of Life Sciences – SGGW

Macro-logistics as tools for shaping today's economy

Makrologistyka narzędziem kształtowania współczesnej gospodarki

Abstract. The aim of the article is to determine the essence of micro- and macro-logistics and to present the elements of the macro-logistics system as factors in the development of the Polish economy. Secondary data was used to present the current state and perspectives for the development of four elements of the macro-logistics sub-system in Poland, i.e.: transport networks, systems of product distribution, infrastructure connected with the flow of information and systems for the management and treatment of waste. Also, the growing role of Polish logistics in Europe was noted.

Key words: micro-logistic, macro-logistic, economy, Poland

Synopsis. Celem artykułu jest określenie istoty mikro- i makrologistyki oraz przedstawienie elementów systemu makrologistyki jako czynników rozwoju polskiej gospodarki. Wykorzystując dane wtórne, zaprezentowano stan i perspektywy rozwoju czterech elementów podsystemu makrologistycznego w Polsce tj.: sieci transportowych, systemów dystrybucji produktów, infrastruktury związanej z przepływem informacji oraz systemów zagospodarowywania i utylizacji odpadów. Wskazano również rosnącą rolę polskiej logistyki w Europie.

Słowa kluczowe: mikrologistyka, makrologistyka, gospodarka, Polska

Introduction

In the era of globalisation, logistics is beginning to play not only a significant role in the functioning of individual enterprises but its importance on a macro-economic scale is increasing, too. Its effect on the entire economic system of a given country, continent or even world is being recognised. More and more often, the logistics sector, due to its growing significance, can be referred to as one of the sectors contributing to the generation of national income. Logistics makes up 13.8% of global GDP (the first decade of the 21st century – EUR 5.4 billion). Annual expenses on logistics in Europe and North America amount to about EUR 1 billion in each of these regions. In the European Union, logistics

accounts for 13% of the GDP (taking into account the entirety of logistical activities). At the same time, average logistics costs – including transport and storage – make up 10–15% of final costs of finished products. Considering the expected increase of the rate of growth of logistics on a macro-economic scale by about 50% until 2020, there is a clear upward trend¹.

According to Kempa [2010], macro-logistics is the entirety of the flow of tangible goods in an economy. Rydzkowski [1999] claims that macro-logistics includes global economic processes. In turn, Krzyżaniak perceives macro-logistics as the entirety of the flow of tangible goods in an economy, from their sources, through consecutive phases of processing, up to the ultimate links of final (consumption and investment) demand [Krzyżaniak 1997, p. 14]. On the other end, each economic entity creates an individual system of micro-logistics. The micro- and macro-economic approach to logistics differ in terms of the scale of analysed processes and flows. Both approaches condition each other and use a common philosophy of integration of physical flows and the accompanying information flows.

Aim and methods

The article aims to present the essence of micro- and macro-logistics, with special reference to the elements of the macro-logistics system as factors in the development of the Polish economy.

The article uses secondary data, such as Reports of Statistics Poland, EUROSTAT, World Bank, Reports of PKP Polskie Linie Kolejowe S.A., Reports of Polish Seaports, Reports of the Institute of Logistics and Warehousing in Poznań and the Civil Aviation Authority. The work makes use of the comparison method, deduction method, descriptive method as well as tabulation and graphic methods.

Links between micro- and macro-logistics, and the economy

Macro-logistics includes global economic processes studied on the level of e.g. country, industry, region, or international organisation. Therefore, within macro-logistics, we can differentiate [Matwiejczuk 2006, p. 24–25, Nowicka-Skowron 2000, p. 28–52]:

- meta-logistics – connected with the processes of enterprise cooperation;
- meso-logistics – occurs as a result of vertical integration of meta-logistical systems, includes trades and sections of the national economy;
- Euro-logistics – deals with logistical processes on the European level;
- global logistics – deals with logistical processes on the global level.

¹ The results were based on a model of econometric calculations taking into account 29 variables which included information concerning the geographic region, income level, country size, level of economy and transport (road, rail, and air transport of goods as well as the movement of containers in harbours). The results of the studies were quoted from: [Ojala et al. 2008].

The effect of the functioning of the macro-logistics system is the entire logistics infrastructure of a country, including e.g. transport routes, public means of transport, communication systems, the infrastructure of ports (land, sea, and airports), warehousing facilities, and customs warehouses, etc. (Table 1). An important area of macro-logistics is the making of economic laws and providing legal services to economic entities [Ficoń 2005]. Thus, macro-logistics systems include some components whose quantity and, most of all, quality has a significant effect on the efficiency and effectiveness of the functioning of enterprises. The importance of macro-logistics on today's market results not only from its specific role in the increase of the exchange of goods and globalisation of the economy but also from trends appearing in modern action strategies oriented at the management of entire supply chains and the growing role of time in today's management.

Table 1. Elements of macro-logistics systems

Tabela 1. Elementy systemu makrologistyki

Elements of macro-logistics systems	Specification
transport and freight networks	road network, rail network, auxiliary infrastructure, etc.
product distribution systems	logistics centres, container terminals, handling ports, etc.
infrastructure connected with the flow of information accompanying physical flows in supply chains	IT networks and databases concerning all areas connected with logistics in various sectors and trades
systems for the management and treatment of waste	installations for storage, recovery and neutralisation and/or incineration of waste; solutions allowing technological mergers of enterprises, etc.

Source: [Abt 1993, p. 192, Skowrońska 2013a, p. 10].

In turn, micro-logistics is most of all the logistics of a managing entity, i.e. the logistics of an enterprise. An enterprise – notwithstanding its scale – has similar goals in the market economy: generating income surpluses over costs, or making a profit while fully satisfying customer service standards. Micro-logistics can be divided into supply logistics, production logistics, sales logistics, and reverse logistics. The knowledge and development of micro-logistics is the basis for building global micro-logistics systems [Ficoń 2005].

There is a feedback loop between micro-logistics and macro-logistics systems. Full development of enterprise systems depends, most of all, on building macro-logistics systems, also including logistics chains, which are created as natural links between suppliers. Their form, however, is dependent on multiple conditions. They include legal and organisational circumstances and even cultural differences and differences in the development of various countries.

The growing role of macro-logistics results from the dependencies between logistics and the economy, such as [Skowrońska 2012, 2013b]:

- location of public logistics centres, affecting the level of availability of products made in distant parts of a country and the world;
- transport and warehousing infrastructure shaped by the state, affecting the behaviours of prospective industrial and commercial investors;

- basic economic importance of logistics for effective integration of peripheral areas and regions (logistics integrates enterprises located in the most distant parts of a country, continent, the world, resulting in the integration of markets, reducing the importance of geographic location, and, consequently, contributing to the support of the regional economic growth and competitiveness);
- acceleration of the harmonisation of organisational and legal procedures and standards thanks to the need of the functioning of enterprises creating the links of the supply chains based on identical technologies connected with the execution of logistics processes and document work-flow.

Current state and perspectives for the development of the elements of the macro-logistics system in Poland

Since 2007, the World Bank, in cooperation with scientists and logistics operators, has been publishing cyclical reports entitled “Connecting to Compete. Trade Logistics in the Global Economy”, concerning an analysis of logistics efficiency of over 160 countries using the Logistics Performance Index (LPI). In the 2018 ranking, the German logistics trade emerged the best, with a result at the level of 4.2 LPI score. Poland’s score of 3.54 (LPI score) gave it the 28th place out of the 167 qualified countries. In the first edition of the ranking in 2007, Poland came 40th (with 3.04 LPI score – Table 2). The LPI score is calculated as a weighted average of six key indicators:

- effectiveness of the process of border control, including customs control (Poland ranked 33rd);
- quality of infrastructure (e.g. of ports, railways, roads, IT technologies) (35th position);
- assessment of the organisation of international deliveries (12th position);
- competences and quality of logistics services (e.g. forwarders, customs agents) (29th position);
- possibility of identifying and tracing parcels (31st position);
- timeliness of the delivery of parcels concerning the scheduled delivery time (23rd position).

In turn, in the report published by the Fraunhofer Institute in 2017 entitled “Top 100 in transport and logistics services,” Poland came 7th among European countries in terms of the value of the market of logistics services (EUR 4.22 billion, which makes up about 4% of all European expenses). The evaluation of the market of logistics services in individual countries of the European Union is presented in Figure 1. The first three places are taken by Germany, the United Kingdom and France. The expenses on logistics services in the European Union are mainly made up of transport (45%), warehousing (33%), and reserves (15%), while administration costs make up 7% of expenses (Figure 2).

Table 2. Selected items from the report entitled “Connecting to Compete. Trade Logistics in the Global Economy”

Tabela 2. Wybrane pozycje z raportu “Connecting to Compete. Trade Logistics in the Global Economy”

Country	Ranking position and LPI value	Customs clearance and LPI Score	Infrastructure and LPI Score	Organisation of international deliveries and LPI Score	Quality of services and LPI Score	Monitoring of parcels and LPI Score	Timeliness of deliveries and LPI Score
Germany	1, LPI – 4.20	1, LPI – 4.09	1, LPI – 4.37	4, LPI – 3.86	1, LPI – 4.31	2, LPI – 4.24	3, LPI – 4.39
France	16, LPI – 3.84	19, LPI - 3.59	12, LPI – 4.0	17, LPI – 3.55	17, LPI – 3.84	12, LPI – 4.00	14, LPI – 4.15
Spain	17, LPI – 3.83	17, LPI – 3.62	19, LPI – 3.84	6, LPI – 3.83	18, LPI – 3.80	19, LPI – 3.83	20, LPI – 4.06
Poland	28, LPI – 3.54	33, LPI – 3.25	35, LPI – 3.21	12, LPI – 3.68	29, LPI – 3.58	31, LPI – 3.51	23, LPI – 3.95
Lithuania	54, LPI – 3.02	46, LPI – 2.85	66, LPI – 2.73	74, LPI – 2.79	54, LPI – 2.96	50, LPI – 3.12	43, LPI – 3.65

Source: [Kulikowska-Wielgus 2018].

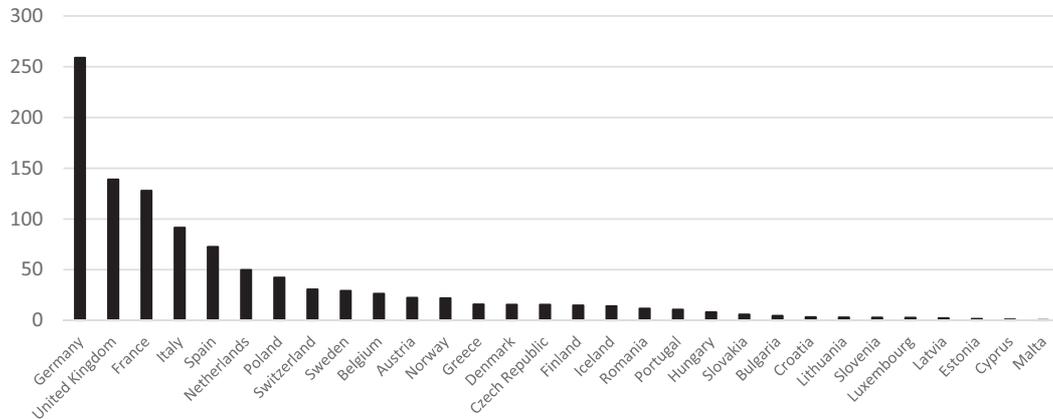


Figure 1. Logistics expenses in the European Union broken down by individual countries in 2016 [EUR billion]

Rysunek 1. Podział wydatków logistycznych w Unii Europejskiej między poszczególne kraje w 2016 roku [miliard EUR]

Source: [Fraunhofer Institute 2018].

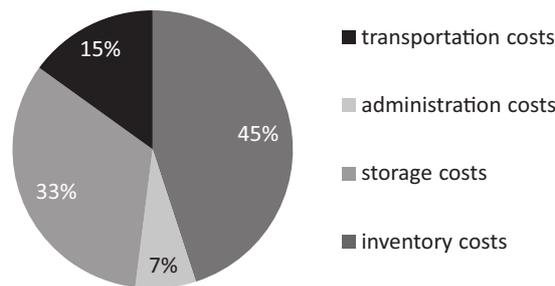


Figure 2. Expenses on logistics services in 30 European Union countries according to individual categories [%]

Rysunek 2. Wydatki na usługi logistyczne w 30 krajach Unii Europejskiej według poszczególnych kategorii [%]

Source: [Fraunhofer Institute 2018].

Taking into account the first element of macro-logistics – transport and shipping networks – it needs to be noted that recently the rate of modernisation of road infrastructure in Poland has weakened [Fechner and Szyszka 2018], resulting in a decrease in the increment of providing new and repaired national roads in relation to previous years. With increasing traffic of heavy goods vehicles, this has led to a deterioration of the technical condition of roads.

According to Statistics Poland, the total length of public roads in 2019 was 424,563.9 km, 72% of which were paved roads, and 28% were dirt roads. The total density of paved roads in 2019 was 135.9 km per 100 km². By comparing the number of kilometres of individual categories of roads, one can notice that almost 60% of them are municipal roads. They are the worst roads in terms of quality and have the least impor-

tance to the transport of people and goods. Another group are county roads, which make up slightly over 30% of all roads. This category is also used mainly for local purposes. The most important roads in the entire system are national and regional roads, which, unfortunately, constitute 4.6% and almost 7%, respectively, of all roads [Fechner and Szyszka 2018]. In the years 2000–2019, the length of motorways and express roads increased 7.5 times. However, it needs to be pointed out that the dynamics of the increment of the length of motorways and express roads in the years 2017–2019 is much lower than in the period 2010–2012 or 2012–2015 (Table 3). The presented statistic demonstrates the weakness of the Polish road infrastructure.

The length of all motorways in the countries belonging to the European Union and the Schengen area in 2017 was over 82,000 km. The longest motorways are found in Spain (17,100 km), Germany (15,306 km) and France (11,612 km). In this respect, Poland comes 12th, after countries such as Italy, the United Kingdom, the Netherlands, Portugal, or Greece (Table 4).

In turn, by taking into account the rail infrastructure, it can be concluded that the length of railways in Poland has been gradually decreasing since 2009. In 2009, this value was 19,336 km; whereas in 2018, it dropped to 18,536 km (800 km less) – see Figure 3. In Poland, the basic rail network is managed by PKP Polskie Linie Kolejowe S.A. The rail network is divided into railway lines of national significance² (about 12,300 km) and local lines. Some railway lines which are important for international rail transport pass through Poland. These lines are covered by international railway lines agreements AGC³ and AGTC⁴ and visualised in TENT base network or the Regulations of the European Union setting forth transport corridors.

Table 3. Hard surface public roads in 2000–2019 [in km]
Tabela 3. Drogi publiczne o twardej nawierzchni w latach 2000–2019 [w km]

Description	2000	2002	2004	2006	2008	2010	2012	2015	2017	2019
Hard surface public road	249 828	250 291	252 273	255 543	261 233	273 760	280 719	287 649.9	288 000	303 956.9
of which:										
– motorways	358	405	552	663	765	857	1 365	1 559.2	1 637	1 675.8
– expressways	193	226	233	297	452	675	1 053	1 492.2	1 536	2 432

Source: [GUS 2002–2019].

² National lines are defined by the Regulation of the Council of Ministers of December 7th 2004 (Dz.U. 2004 nr. 273, poz. 2704) [in Polish] concerning the list of railway lines which, due to economic, social, defensive or ecological reasons, have a national importance.

³ AGC – Agreement on Main International Railway Lines.

⁴ AGTC – Agreement on Important International Combined Transport Lines and Related Installations.

Table 4. Motorway lengths in individual European Union countries in 2017 [in km]

Tabela 4. Długość autostrad w krajach Unii Europejskiej w 2017 roku [w km]

No.	Country	Motorway lengths	No.	Country	Motorway lengths
1	Spain	17 100	15	Croatia	1 313,8
2	Germany	15 306	16	Denmark	1 246
3	France	11 612	17	Hungary	1 155.2
4	Italy	6 943	18	Ireland	916
5	United Kingdom	3 649	19	Finland	900
6	Netherlands	3 070	20	Bulgaria	750
7	Portugal	2 948.8	21	Romania	746
8	Greece	2 133.2	22	Slovenia	617
9	Sweden	2 130	23	Norway	466.5
10	Austria	2 105	24	Slovakia	463.5
11	Belgium	1 763	25	Lithuania	324
12	Poland	1 639	26	Cyprus	257
13	Czech Republic	1 243	27	Luxembourg	167
14	Switzerland	1 447.4			

Source: [Rynek Infrastruktury 2018].

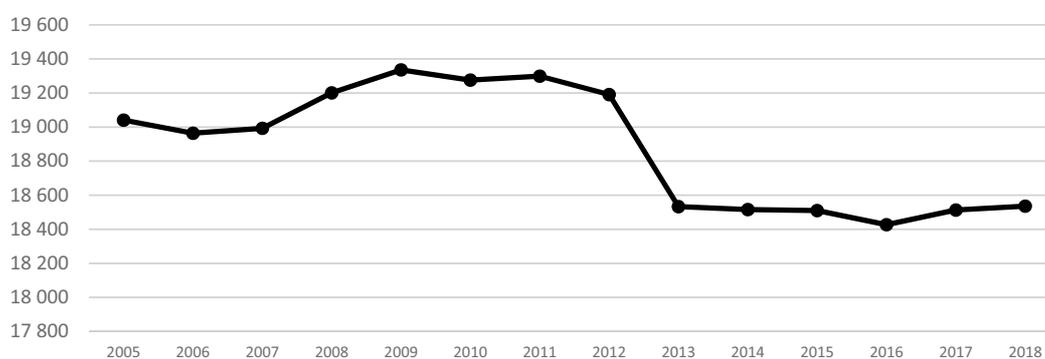


Figure 3. Długość linii kolejowych w latach 2005–2018 [in km]

Rysunek 3. Length of railway lines in 2005–2018 [w km]

Source: [PKP Polskie Linie Kolejowe S.A.].

In turn, the transport function of inland waterways in Poland is very limited. The requirements imposed on waterways of an international significance, i.e. class IV and higher were met in 2016 by only 5.9% of waterways, that is 214 km out of 3,654.6 km of inland waterways which are considered navigable [Fechner and Szyszka 2018, p. 78). This hasn't changed in Poland since 2007. The basic cause of this situation is the previously applied policy for the development of the transport infrastructure, which prioritised the investment needs of road and railway transport. The very low level of financing of inland waterways has led to their serious deterioration.

The second element of macro-logistics are distribution systems, including logistics centres, container terminals, handling ports, etc. The modern, commercial warehouse space in Poland in 2019 amounted to almost 17 million m². It is worth noting that over the period of 20 years, the supply of modern warehouse space increased over 16-fold (Figure 4). This rise in recent years has been caused by the increased activity of industrial developers on regional markets as well as the development of e-commerce, which has brought about several spectacularly big BTS-like investments (Amazon, Zalando). Most of the owners of modern warehouse space are industrial developers (76%), followed by private investors (about 11%) and investment funds (about 12%). The largest quantity of modern warehouse space is in the Masovian Voivodeship, because Warsaw and its surroundings, referred to by analysts as zones II and III, together constitute the largest internal consumption market in Poland, and this factor plays a key role in the demand for new warehouse space. Masovian Voivodeship is followed by Silesia, Greater Poland, Łódź, and Lower Silesia [Fechner and Szyszka 2018]. The determinants of the development of regional markets of warehouse space remain unchanged: quality, availability, and plans for the development of the infrastructure of road transport, the attractiveness of labour markets, and the size of internal consumption. These factors, however, have a varied effect on investors, decisions. With high gross demand for warehouse space, reaching up to 4 million m² in 2017, the vacancy rate dropped to an average level of 5.4%. According to data from the Institute of Logistics and Warehousing in Poznań, logistics operators (32%) and trading companies (28%) remain the main tenants of warehouses.

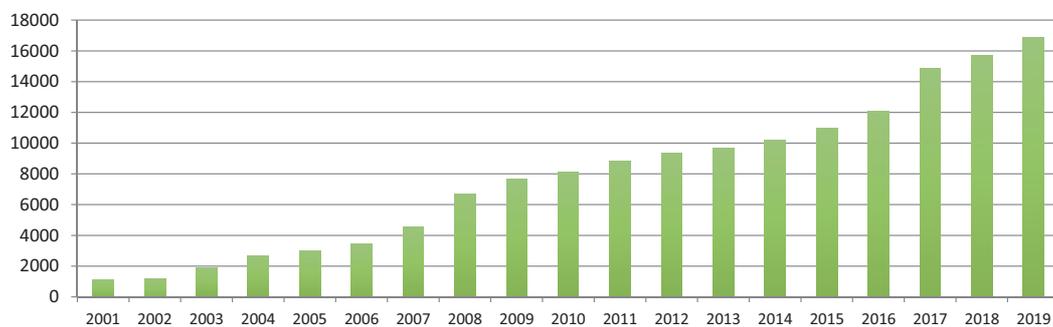


Figure 4. Modern warehouse space in Poland [in thousands m²]

Rysunek 4. Nowoczesna powierzchnia magazynowa w Polsce [w tysiącach m²]

Source: data from the Institute of Logistics and Warehousing in Poznań.

In 2017, Poland had 33 container terminals allowing inter-modal handling of transport units. Five of them handled freight in sea-railway and sea-road configurations (sea terminals), and the rest dealt with freight in railway-road configuration (land terminals) [Domagała 2019].

In Poland, one can distinguish three key seaports: Gdańsk, Gdynia, and Szczecin – Świnoujście group of ports. There are also other ports operating at the Polish coast, such as Elbląg, Police, Kołobrzeg, Darłowo, and some smaller ones, mainly fishing and tourist ports. The volume of goods handled in the Polish seaports exceeded 87 million t in 2017 (Table 5).

Table 5. Turnover in the biggest Polish seaports in years 2012–2018 [in thousands t]

Tabela 5. Obrót towarowy w największych polskich portach morskich w latach 2012–2018 [w tysiącach t].

Seaport	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gdynia	14 735	15 911	15 809	17 659	19 405	18 198	19 536	21 225	23 492
Szczecin – – Świnoujście	20 843	21 354	21 267	22 750	23 401	23 174	24 113	25 424	28 614
Gdańsk	27 182	25 306	26 897	30 259	32 278	35 914	37 289	40 614	49 032
Total	62 760	62 571	63 973	70 668	75 084	77 286	80 938	87 263	101 138

Source: [Actia Forum 2019, p. 2].

In turn, the effect of airports on the economy in Poland is smaller than in many other countries. Despite that, the network of airports each year contributes to the generation of 4% of the GDP, mainly thanks to its stimulating effect on other areas of the economy. Airports also create 440,000 jobs in the country. In a globalised economy, air transport is particularly significant in inter-continental freight. In Poland, apart from the Warsaw Chopin Airport, which handles about 72,000 t, only three other airports exceed the volume of 1,000 t of goods. They are Katowice (about 16,000 t), Gdańsk (about 4,000 t) and Wrocław (about 2,000 t) – see Table 6.

Table 6. The number of parcels handled in airports in the years 2015–2016 [kg]

Tabela 6. Liczba obsługiwanych przesyłek w portach lotniczych w latach 2015–2016 [kg]

Airport	2015	2016
Chopina in Warsaw	58 284 042	72 186 365
Katowice – Pyrzowice	14 523 862	15 586 274
Gdańsk	4 452 205	4 186 389
Rzeszów – Jasionka	3 863 349	731 770
Poznań Ławica	260 623	212 291
Wrocław – Starachowice	89 272	2 318 334
Szczecin – Goleniów	53 566	278 775
Bydgoszcz – Szwederowo	7 583	0
Port Lotniczy Lublin	14 968	1 007
Radom – Sadków	0	0
Warszawa – Modlin	0	0
Łódź – Lublinek	0	0
Kraków – Balice	0	3 487
Olsztyn – Mazury	0	0
Zielona Góra – Babimost	0	0

Source: [Urząd Lotnictwa Cywilnego].

The third element of macro-logistics is the infrastructure connected with the flow of information accompanying physical flows in supply chains. The dynamically growing needs concerning exchanging and processing bulk data (e.g. concerning the traffic, load, operations, container, shipping conditions — temperature, humidity) and its shar-

ing have led to development of digital cloud computing services. The needs for planning and monitoring transport have led to the development of multiple models of provision of digital services, e.g. SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service) or CaaS (Communication as a Service). The repeatability of demand for similar types of services (truck and trace, delivery notification, electronic data exchange, etc. – e.g. in seaports, logistics centres) in many transport companies has resulted in a dynamic development of platforms offering digital services in SOA (Service Oriented Architecture). Comprehensive digital service of the flow of goods and transport, handling operations or border checks takes into account the connection between digital services of administration systems and business in Poland and on a global scale. The digitisation of the settlement of digital services and transactions in transport chains (including the e-toll, fuel, handling of goods, secondment of drivers, etc.) is integrated with platforms for e-invoicing, e-payments and e-banking.

Over the past year, all European Union countries improved their digital performance. Finland, Sweden, Denmark and the Netherlands scored the highest ratings in DESI⁵ 2020 and are among the global leaders in digitalization. According to The Digital Agenda Scoreboard, Poland is among the six lowest-scored countries in the European Union in terms of digitization (Figure 5). Although Poland boasts a high level of penetration by mobile broadband services – making it stand out against other European Union countries – it still has a low level of penetration by broadband land-line Internet.

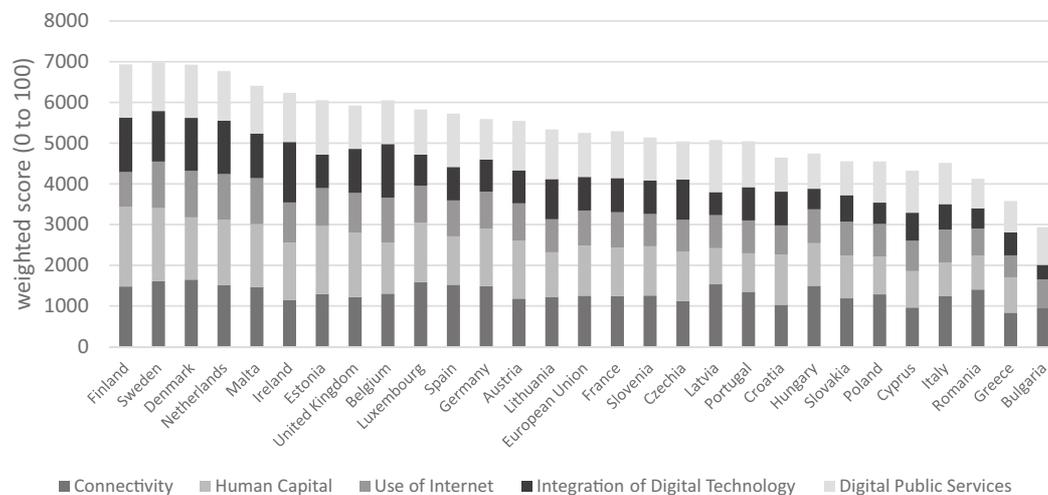


Figure 5. The Digital Economy and Society Index in European Union countries

Rysunek 5. Indeks digitalizacji gospodarki i społeczeństwa w krajach Unii Europejskiej

Source: [European Commission 2020].

⁵ The Digital Economy and Society Index (DESI) is a composite index that summaries relevant indicators on Europe’s digital performance and tracks the evolution of European Union member states, across five main dimensions: connectivity, human capital, use of Internet, integration of digital technology, digital public services.

The fourth element of the macro-logistics system are systems for the management and treatment of waste. Waste management in Poland is based on the European hierarchy of waste management, in which the most desirable scenarios include preventing the production of waste and preparing waste for re-use, followed by recycling (including composting) and other methods of recovery (e.g. incineration with energy recovery) [Baran and Karlewska 2016, Kwaśniewski et al. 2018]. The last element in the hierarchy is the disposal (neutralisation) through storage of waste which cannot be recovered and neutralised in a manner that is safe for human life and the environment [Klojzy-Karczmarczyk and Staszczak 2013]. Although this option is the most harmful for the environment and human health, it is also one of the least expensive methods of waste management [Toruński 2010]. Since July 1st 2013, tasks in the scope of the management of municipal waste are the responsibility of municipalities as the managers of waste produced within their areas [Primus and Rosik-Dulewska 2018]. The main obligation of municipalities in the scope of its tasks concerning the management of municipal waste is to provide conditions for the functioning of a system of separate collection and pick up of municipal waste from residents. Municipalities are also obligated to build, maintain and operate regional facilities intended for the processing of communal waste (Regional Municipal Waste Treatment Facilities).

Conclusions

Due to the growing role of logistics on the macro-economic scale, the logistics sector has started to play a decisive role in providing: efficacy, efficiency and effectiveness of national economies, and, consequently, of the global economy. Macro-logistics itself is becoming a *sine qua non*-condition for the development of domestic and international trade. Macro-logistics is also becoming a factor facilitating convergence, i.e. imitation or catching up with highly developed countries. Through its integrating, coordinating and synergic properties, which facilitate the management of the complexity of configurations caused by globalisation, macro-logistics is becoming a tool for achieving not only a competitive advantage but also supporting the increase of prosperity, understood as an improvement of all conditions which affect enterprises.

The position of Polish logistics in Europe is perceived mainly through the aspect of international transport, in which Poland has been a decisive leader for many years now, accounting for 25% of the total tonnage of shipped goods. Besides, Poland continues strengthening its position, as – despite protectionist moves of other countries – it is developing faster than the European Union average. Poland remains attractive for foreign investors in the logistics sector mainly due to the low costs of operating a business, attractive location, and qualified workers. To sum up, it can be argued that Polish logistics is on a path towards accelerated growth. The determinants are consumption and exports on one part, and e-commerce and digitisation on the other part. The projected economic growth of Poland, constantly modernised road, logistics, and digital infrastructures, as well as the growing e-commerce market support strong prospects for the development of logistics.

References

- Abt S., 1993: Logistyka – wyróżnikiem nowej generacji gospodarowania [Logistics – a distinguishing feature of the new generation of management], *Problemy Magazynowania i Transportu* 4, 172–192 [in Polish].
- Actia Forum, 2019: Port Monitor. Polish ports in 2018, Gdynia.
- Baran J., Karlewska M., 2016: Teoretyczne aspekty logistycznego systemu gospodarki odpadami [Theoretical aspects of Logistics waste management system], *Zeszyty Naukowe Ekonomika i Organizacja Logistyki* 1(3), 5–17 [in Polish].
- Domagała J., 2019: Efficiency of Polish seaports against the background of the largest ports in Europe, *Zeszyty Naukowe Ekonomika i Organizacja Logistyki* 4(3), 77–85.
- European Commission, 2020: The Digital Economy and Society Index (DESI), [electronic source] <https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi> [access: 16.11.2020].
- Fechner I., Szyszka G., 2018: Logistyka w Polsce. Raport 2017 [Logistics in Poland. Report 2017], Biblioteka Logistyka, Poznań [in Polish].
- Ficoń K., 2005: Zarys mikrologistyki [Micrologistics], BEL Studio Sp. z o.o., Warszawa, Gdynia [in Polish].
- Fraunhofer Institute 2018: TOP 100 in European Transport and Logistics Services 2017/2018.
- GUS, 2002–2018: Transport – wyniki działalności. Informacje i opracowania statystyczne [Transport – activity results. Statistical Information and Elaborations], Warszawa [in Polish].
- Kempa S., 2010: Logistyka – narzędzie kształtowania procesów gospodarczych [Logistics – a tool for shaping economic processes], Artykuł w ramach projektu szkoleniowego współfinansowanego z Europejskiego Funduszu Społecznego, Projekt realizowany pod nadzorem Polskiej Agencji Rozwoju Przedsiębiorczości, [electronic source] <http://www.kdkinfo.com.pl> [access: 02.07.2010] [in Polish].
- Kłojzy-Karczmarczyk B., Staszczak J., 2013: Ograniczenie składowania w wyniku segregacji i selektywnego wybierania frakcji suchej odpadów komunalnych [Reduction of waste at landfills as a result of segregation and selective collection of municipal dry waste fraction], *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi PAN* 84, 75–87 [in Polish].
- Krzyżaniak S., 1997: Logistyka w gospodarce narodowej [Logistics in the national economy], *Logistyka* 4, 11–16 [in Polish].
- Kulikowska-Wielgus A., 2018: Polska logistyka coraz wyżej w rankingu Banku Światowego [Polish logistics increasingly higher and higher by the World Bank], *trans.info*, [electronic source] <https://trans.info/pl/polska-logistyka-coraz-wyzej-w-rankingu-banku-swiatowego-104083> [access: 15.11.2020] [in Polish].
- Kwaśniewski K., Grzesiak P., Kapłań R., 2018: Ocena efektywności ekonomicznej procesu zgazowania odpadów komunalnych i przemysłowych [The economic assessment of the municipal and industrial waste gasification process], *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią PAN* 107, 5–18 [in Polish].
- Matwiejczuk R., 2006: Zarządzanie marketingowo-logistyczne [Marketing and logistics management], C.H. Beck, Warszawa [in Polish].
- Nowicka-Skwron M., 2000: Efektywność systemów logistycznych [The effectiveness of logistics systems], PWE, Warszawa [in Polish].
- Ojala L., Andersson D., Naula T., 2008: Logistics Value Chain, Memedovic Global Production Networks, UNIDO.

- PKP Polskie Linie Kolejowe S.A., Raport roczny, [electronic source] <https://www.plk-sa.pl/biuro-prasowe/raport-roczny/> [access: 29.09.2020] [in Polish].
- Primus A., Rosik-Dulewska C., 2018: Potencjał paliwowy frakcji nadsitowej odpadów komunalnych i jego rola w krajowym modelu gospodarki odpadami [Fuel potential of the oversieve fraction of municipal waste and its role in the national waste management model], *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi PAN* 105, 121–134 [in Polish].
- Rydzkowski W., 1999: Aktualne tendencje w logistyce europejskiej [Current trends in European logistics], *Logistyka* 1, 6–8 [in Polish].
- Rynek Infrastruktury, 2018: Polska 12 w Europie pod względem długości autostrada [Poland 12 in Europe in terms of the length of highways], [electronic source] <https://www.rynekinfrastruktury.pl/wiadomosci/drogi/polska-12-w-europie-pod-wzgle-dem-dlugosci-autostrad-63987.html> [access: 20.11.2020].
- Skowrońska A., 2012: Makrologistyka a heterodoksyjne teorie i koncepcje ekonomiczne [Macrologistics and heterodox theories and concepts in economics], *OPTIMUM Studia Ekonomiczne* 1(55), 3–28 [in Polish].
- Skowrońska A., 2013a: Makrologistyka jako czynnik rozwoju gospodarki światowej w warunkach kryzysu ekonomicznego [Macrologistics as a factor in the development of world economy in economic crisis], *Gospodarka Materialowa & Logistyka* 9(1225), 10–20 [in Polish].
- Skowrońska A., 2013b: Od systemu transportowego do systemu makrologistycznego, czyli odpowiedź na nowe uwarunkowania i perspektywy rozwoju [From the transport system to the macrologistic system or an answer to new conditions and perspectives of development], *Studia Ekonomiczne* 143, 349–362 [in Polish].
- Toruński J., 2010: Zarządzanie gospodarką odpadami komunalnymi w Polsce [Waste disposal council management in Poland], *Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach. Seria: Administracja i Zarządzanie* (14)87, 31–47 [in Polish].
- Urząd Lotnictwa Cywilnego, [electronic source] <https://www.ulc.gov.pl/pl/statystyki-analazy/statystyki-i-analazy-rynku-transportu-lotniczego/3724-statystyki-wg-portow-lotniczych> [access: 29.09.2020] [in Polish].

Correspondence address:

Joanna Domagała, PhD, habil.
(<https://orcid.org/0000-0001-9801-4344>)
Warsaw University of Life Sciences – SGGW
Institute of Economics and Finance
Department of Logistics
166 Nowoursynowska St., 02-787 Warsaw, Poland
e-mail: joanna_domagala@sggw.edu.pl