

## Comprehensive analysis of oversized cargo transportation market in Poland (2001-2022): Trends, regulations, and industry dynamics

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**Abstract:** The oversized cargo transportation market in Poland actively participates in developing the economy, providing services necessary for implementing large infrastructure and industrial projects on a national and European scale. Development and functioning of this sector in the EU and globally requires overcoming many organizational, technical and administrative barriers and difficulties, and the authors of several publications indicate how these services are developing. The current study contains a detailed analysis of data from 2001-2022. The paper characterizes the changes in particular years, indicating the main causes of the occurring processes, and defines the existing trends. It presents the legal framework that regulates the functioning of the domestic market. Moreover, it discusses the number of permits and the value of fees for issuing permits collected by the General Directorate for National Roads and Motorways (Generalna Dyrekcja Dróg Krajowych i Autostrad, GDDKiA) over two decades. The article also evaluates trends concerning the number of licenses with more than a 50% decrease compared to the maximum in 2008. It assesses the course of changes in values, which in 2021 reached their highest level during the period under assessment. Furthermore, it discusses the differences in the number of permits issued and applications submitted in 2014-2022. It describes the structure of the number of permits issued in categories IV-VII in 2014-2020 and categories III-V in 2021-2022. It characterizes the course of the largest operation in the history of Polish road haulage - the transport of an abnormally-sized TBM (Tunnel Boring Machine) - in terms of requirements and problems that occurred during the preparation and fulfilment of this order and were typical for the functioning of the sector. The evaluation provides the basis for summaries and



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conclusions on the development and condition of the oversized cargo transportation sector in the Polish road transport sector.

**Keywords:** oversized transport, number and value of permits for oversized transport, regulations, market analysis

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## 1. Introduction

Oversized cargo transportation is a comprehensive logistics, forwarding and transport service which usually requires lengthy and expensive preparations. In each case, it is necessary to conduct several organizational activities, including route planning, making cost estimations for the order, obtaining appropriate permits, and preparing a modern and specialized fleet that will enable safe loading, transport and unloading. It is also necessary to have professional staff who supervise the whole project, drive vehicles, pilot the convoy and provide technical service on the route during the fulfilment of the transport order (Pisz & Łapuńska, 2016; Ryczyński & Smal, 2017). Such a wide spectrum of market requirements determines at large or medium-sized business entities handle orders; alternatively, several companies cooperate to perform the service, offering transport, lifting and pilot activities.

The development of a universal classification of abnormal cargo presents a severe difficulty, resulting from the fact that such loads can be shipped using different modes of transport: by road, rail, sea, inland waterways or air. In each case, the limit values for its individual parameters change, ultimately determining how the order will be fulfilled, often in an intermodal system (Benedyk, Peeta, Zheng, Guo & Iyer, 2016; Zhang, Zhang, Zong & Zhang, 2013). Each mode of transport has a different nodal infrastructure, linear infrastructure and means of transporting cargo. Oversized cargo can be divided into subgroups considering the dominant parameter, i.e. external dimensions (length, width and height) and/or weight (Juściński, 2016).

The oversized cargo market has a heterogeneous generic and quantitative structure and a time distribution of demand over the year. The demand for each category depends directly on transnational processes, such as grants under EU programmes for agriculture or subsidies for infrastructure investments. It is also affected by changes to the law, which, like the amendment to the Renewable Energy Sources Act of 2016, minimized the demand for domestic transport of wind installations, which constituted a very dynamically developing segment of the market in Poland, analogous to the EU market (Autelitano, Garilli & Giuliani, 2017). A separate category is transport for military purposes, which has undergone dynamic development since the beginning of the war in Ukraine. The loads with the highest quantitative share include heavy construction machinery, large agricultural machinery and military vehicles (Ryczyński & Smal, 2017). A significant proportion is comprised of industrial equipment, i.e. transformers, generators, turbines, furnaces, boilers, elements of installations and pipelines and technological lines for the chemical, automotive, brewing, food, metallurgical industries, as well as cement plants and refineries (Chwalczuk, 2017; Paulauskas, Lukauskas, Plačiene, Maksimavičius & Jonkus, 2012). Occasionally, these are crane systems, steel structures, rail vehicles, components for the shipbuilding industry and forestry work machines. Sporadic orders also concern transporting large boats, yachts, planes or monuments. In Polish conditions, virtually any order for the transportation of oversized cargo must use road transport services and alternatively may involve a different mode of transport. The advantage of road transport is that it provides direct access to almost any place for loading and then unloading at the destination. These works cannot be carried out in any other way due to the limited access to railway sidings dedicated to serving particular business entities in Poland. To fully exploit the existing equipment capabilities in road transport, parallel efforts are needed to revise the linear and nodal infrastructure resilience standards. The problem particularly concerns bridge structures, whose load capacity cannot be a barrier that excludes particular road sections from routes of oversized cargo transport (Gnap, Jagelčák, Marienka, Frančák & Vojteková, 2022; Luo, Zhang, Huang & Yang, 2021; Petraška, Čižiūnienė, Jarašūnienė, Maruschak & Prentkovskis, 2017; Petraška, Čižiūnienė, Prentkovskis & Jarašūnienė, 2018; Petraška & Palšaitis, 2012).

The transport of oversized cargo is an elite segment of the transport services market in Poland and individual EU countries (Bădescu & Purcar, 2017). This is due to the high financial requirements of purchasing top-of-the-range tractor units, specialized low-loader trailers or ballast tractors and multi-axle trailers with high load capacity. In Poland, this type of service is provided by about two hundred

companies, and in this group, there are more than twenty entities that can be classified as important players internationally (Loos, 2017). Most industry entities are members of Ogólnopolskie Stowarzyszenie Pracodawców Transportu Nienormatywnego (the Polish Heavy Transport Association), which was established in 2008. As a non-governmental organization, the Association has assumed the role of an industry delegate and legal representative of business entities at the national level to change and/or reduce legislative and administrative barriers. Since 2014, the Polish Heavy Transport Association has been a member of the European Association of Abnormal Transport and Mobile Cranes (ESTA). Established in 1976, ESTA is the largest organization in the industry, bringing together representatives of companies offering oversized cargo and mobile crane transportation services from 18 European countries. The international activities aim to develop uniform requirements for obtaining permits for oversized transport operations (Bădescu & Purcar, 2017; Chwalczuk, 2017). In recognition of their high-quality services, many Polish companies have been nominated to the prestigious ESTA Awards of Excellence competition for the year's most spectacular oversized transport operation. In 2017, for the first time in history, a company from Poland was listed among the winners. The statuette in the category of transport over 120 tons was won by MTD Skuratowicz, which transported a 220-ton chemical reactor from Klaipėda in Lithuania to Grodno in Belarus. In 2023, MTD Skuratowicz repeated its success, winning the ESTA Awards of Excellence 2023 for transporting TBM machine components across Poland (Chwalczuk, 2017).

## **2. Literature review**

Oversized cargo transport, a quantitatively small segment of the road transport market, is a key element of large infrastructure projects in each case. Without such shipping operations, it is impossible to implement projects that are important for the development and modernization of many sectors of the economy and industry. These services are provided at the stage of facility construction, completion of technological lines, and subsequent renovations. Zsamboky (2018), using the example of oversized transport in the United States of America, argues that the transport of such cargo, although expensive and difficult to carry out, has several advantages. An important aspect in favour of such services is the ability to eliminate significant financial burdens for the manufacturer, supplier and customer. Cases of specific transport operations where the load was indivisible are presented in a number of studies. Autelitano, Garilli and Giuliani (2017) presented the transport of wind turbines in Europe. They reviewed the problems that occur during road transport of wind turbine components: nacelles, tower sections and rotor blades. Lamiroux, Laumond, Van Geem, Boutonnet and Raust (2005) analyzed the challenges of transporting six oversized components for constructing the Airbus A380. These transport operations are an example of an order fulfilled cyclically, an unprecedented event in this sector. Large-scale components manufactured in UK, Germany, Spain, and France factories must be transported to the assembly plant in Toulouse.

Mydlarz and Wieruszewski (2020) presented issues related to transporting large-size roundwood by road when there are frequent cases of too much pressure on the axles of the vehicle. Paulauskas, Lukauskas, Plačiene, Maksimavičius, and Jonkus (2012) stress the need to carry out extensive research at the national level that will enable the optimization of projects for the extension or modernization of the existing infrastructure, both roads and port terminals so that they are adapted to the fulfilment of such orders in a multimodal system. Benedyk, Peeta, Zheng, Guo and Iyer (2016) propose a model for strategic planning of investments involving intermodal facilities at regional and national levels. Luo, Zhang, Huang and Yang (2021) analyze the multimodal transport of oversized loads based on reconstruction measurements. The best routes mapped out in this way will support decision-making that guarantees the lowest level of risk. Bazaras, Batarlienė, Palšaitis and Petraška (2013) examined the optimization of the route choice for oversized cargo transport in terms of a number of criteria. Their evaluation system includes the type and quality of road surfaces, which determine the speed of the tractor-trailer combination, the curves and intersections, narrow sections on the route, low passes and the load-bearing capacity of bridges. Niculescu and Minea (2016) propose the implementation of National Single Window (NSW) telematic applications that will allow for integrated multimodal transport management based on SafeSeaNet, River Information Services and Intelligent Transport Systems for Road Transport. Kamiński (2020) and Javed, Zeadally and Hamida (2019) present the use of Cooperative Intelligent Transport Systems (C-ITS) as a solution to improve road transport safety and

efficiency. The priority for companies that offer abnormal transport services, which each use public road infrastructure between 22.00 and 6.00, is to maintain the highest level of safety (Zong, Yan, Chu & Yuan, 2009; Zong, Lu & Li, 2011). Hence, the proposal of systemic solutions that would offer support in emergencies.

Zong, Yan, Chu and Yuan (2009) discussed technologies essential for maintaining road transport safety of large and/or heavy loads. They presented several ways to optimize the transport process. Ryczyński and Smal (2017) also presented the problem of maintaining safety in oversized transport operations, with a particular emphasis on the selection of means of transport to move heavy military equipment. Brewer and Fitzpatrick (2017) analyzed the impact of oversized vehicles and truck convoys on the fluidity of traffic on national two-lane motorways. Hanssen and Jørgensen (2015) analyzed the factors that determined the financing plans for 83 different sections of the Norwegian national road network over a decade. Miltner (2018) presents the use of a C-ITS application in Germany - the HERCULES project (German: *Harmonisierte Entscheidungen zur Routensicherung mittels Cloudanwendungen für Unternehmen Effizienzsteigerung von Schwer- und Großraumtransportten*). It provides support for applicants and authorization organs when considering applications.

In general, transporting oversize cargo in market practice requires individual logistics preparation. This is the norm for both the European and global markets, although the scope of work in each country is governed by separate regulations (Chwalczuk, 2017; Corbally, Cahill & O'Connor, 2017; Gnap et al., 2022; Huang & Han, 2021; Radomir, 2017).

Bâdescu and Purcar (2017) analyzed the laws in different European countries and proposed a procedure that can be used to design universal legal requirements. Pisz and Łapuńka (2016) emphasize that oversized cargo transport operations are involved in each case-specific project for the transport, forwarding and logistics industry. In planning them, they propose a method that uses the theory of fuzzy sets when estimating the impact of a number of factors. Places on the route that are particularly difficult to navigate include sections in cities, and passages through roundabouts and bridges (Godavarthy, Russell & Landman, 2016; Huang & Han, 2021; Petru & Krivda, 2021; Wolnowska & Konicki, 2019).

Petru and Krivda (2017, 2019) point out that no provisions in the Czech Republic regulate the design of roads dedicated to the passage of oversized loads. Therefore, they present research and a database they created, which will be the basis for statistical analysis and regulations defining technical conditions for this type of transport. Corbally, Cahill and O'Connor (2017) confirmed that in Ireland when issuing permits for oversized vehicles, there is no formal procedure to analyze their impact on bridges along the route. They presented a study of the impact of convoys on bridges in the Irish Major Inter-Urban (MIU) motorway network. Marwan, Hainin, Warid, Idham and Naqibah (2019) focused on the problem of insufficient strength of bridges and roads, which, in the case of illegal or uncontrolled use by vehicle combinations with excessive axle loads, deteriorate rapidly. Problems of heavy vehicles on the roads are common in the EU and globally. Kokkalis and Panetsos (2015) discuss using the Egnatia motorway in Greece yearly to transport thousands of abnormal loads. Convoys reduce normal motorway capacity and destroy road surfaces and bridges. Wang and Zhao (2016) presented a similar problem concerning adjusting fees for permits issued for oversized vehicles. They used the mechanistic-empirical pavement design method and the Life-Cycle Cost Analysis (LCCA).

Gnap, Jagelčák, Marienka, Frančák and Vojteková (2022) focused their research on protecting bridge structures from damage. The authors proposed a method of global assessment of the impact of oversized road transport on bridges and presented the results of research in this field obtained in Slovakia in the years 2016-2020. Rymśa (2016) draws attention to the fact that since 2010, the basic standard in Europe for determining design loads for road bridges has been the European Standard – Eurocode 1. The technical conditions that were the basis for the development of this standard were created in the 1970s; hence, it is necessary to update them. Agbelie, Labi and Sinha (2017) attempted to estimate the total cost of bridge damage on motorways caused by the traffic of oversized vehicles. Godavarthy, Russell and Landman (2016) assessed the functioning of roundabouts, which are the most effective forms of traffic control and road safety. They suggested changes in the way roundabouts are designed that would not eliminate their advantages but at the same time would facilitate the movement of oversized vehicles, among others, by enabling them to drive straight through their central island. A similar problem occurring in the EU was presented by Petru, Dolezel and Krivda (2017). The research included an analysis of video surveillance of oversized convoys at roundabouts over several years. Meng,

Hu, Huang, Zhang and Jia (2015) presented the problem of negotiating turns at intersections by oversized transports in China and the impact of these manoeuvres on choosing the optimal route.

The solution to the problem of oversized cargo transportation is currently treated as a separate task performed by a specific economic entity (which provides the service alone or in cooperation with subcontractors), and the developed project directly reflects the individual know-how of the company fulfilling the order. Petraška, Čižiūnienė, Prentkovskis and Jarašūnienė (2018) emphasize that it is very difficult to classify the transport technologies of oversized cargo in the longer term, as equipment capabilities are changing dynamically. In the free market conditions, continuous expansion and replacement of the existing fleet, often dedicated to a specific type of cargo, is the business model transport companies adopt. Figlus and Kuczyński (2018) confirmed that choosing the right type of semitrailer and load-securing system affects the transport potential of the company. They presented the results of the analysis of damage in semitrailers carrying oversized loads and indicated the causes of destruction during their improper use. Koszałka and Zniszczyński (2016) presented the design of a multi-axle semitrailer for transporting large machines and simulation tests of its manoeuvrability in tight turns. In order to streamline the supply of oversize goods, Pashkevich, Shubenkova, Makarova and Sabirzyanov (2019) proposed solving two main problems: the choice of the optimal tractor-trailer combination and the choice of the best route using information and communication technologies. They demonstrated the concept of the Decision Support System (DSS), which enables the allocation of fleet units to the relevant transport orders. Ray (2007) presented the Department of Transportation's online decision support system for managing oversized vehicle traffic on Delaware highways in the United States.

Wolnowska and Konicki (2019) evaluated three variants of routes for the transport of oversized cargo through the city of Szczecin using the Analytical Hierarchical Process (AHP) method. De Luca (2014) presented research that aimed to answer the following question: Can society influence the process of strategic transport planning? He assessed the use of multi-criteria decision-making analysis based on the AHP method to support the participatory process of the public. Lasota, Jacyna, Wasiak and Zabielska (2022) in view of the need to develop increasingly new technological solutions for oversized transport, also proposed the use of multi-criteria analysis. They used the Electre I method to evaluate low-loader trailers and the AHP method to compare tractor units. Mishra, Khasnabis, and Swain (2013) discussed the problem of investing in new national transport infrastructure using the USA and Canada as examples. Pryn, Cornet and Salling (2015) described the application of sustainable development theory to assessing transport infrastructure in Denmark using a multiplicative AHP decision support model.

The collected technical parameters related to the infrastructure and the transport solutions used and experiences from fulfilling transport orders in market practice are not subject to collection, compilation and publication outside the entity that is the direct contractor. This problem should be treated as fundamental in trying to unify the used transport technologies and standardize logistics processes in planning routes across several countries. The stage of designing the route of transport, verification of restrictions resulting from the technical condition of the infrastructure, a project of the necessary modernizations, and completion of preparations by obtaining the appropriate permit are the issues described by Gnap et al. (2022) and Petraska et al. (2012, 2017, 2018).

Therefore, the current article presents an analysis of the domestic oversized transport market in terms of quantity and value in relation to economic processes to develop knowledge in this area. Knowledge of the market structure and its problems should be the basis for searching for and formulating solutions for managing this segment of transport services.

### **3. Structure of the oversized cargo transportation market**

The domestic market for oversized cargo transportation is regulated by a number of provisions, which are periodically updated. Legislation that describes the rules for the passage of oversized vehicles consists of four acts: the Traffic Law Act (1997), the Public Roads Act (1985), the Road Transport Act (2001) and the Administrative Procedure Code (1960). The implementing provisions are the Regulation of the Minister of the Interior and Administration on Road Traffic Control (2019) and the Regulation of the Minister of Transport, Construction and Maritime Economy on piloting abnormal vehicles (2012). The regulations of the Minister of Infrastructure are the following documents: on the technical

conditions of vehicles and the scope of their necessary equipment (2002), on permits for passage of oversize vehicles (2021) and the level of fees for issuing a permit for the passage of a non-standard vehicle (2021).

A key change for the oversized cargo transportation market has been in force since 13 March 2021 and introduces:

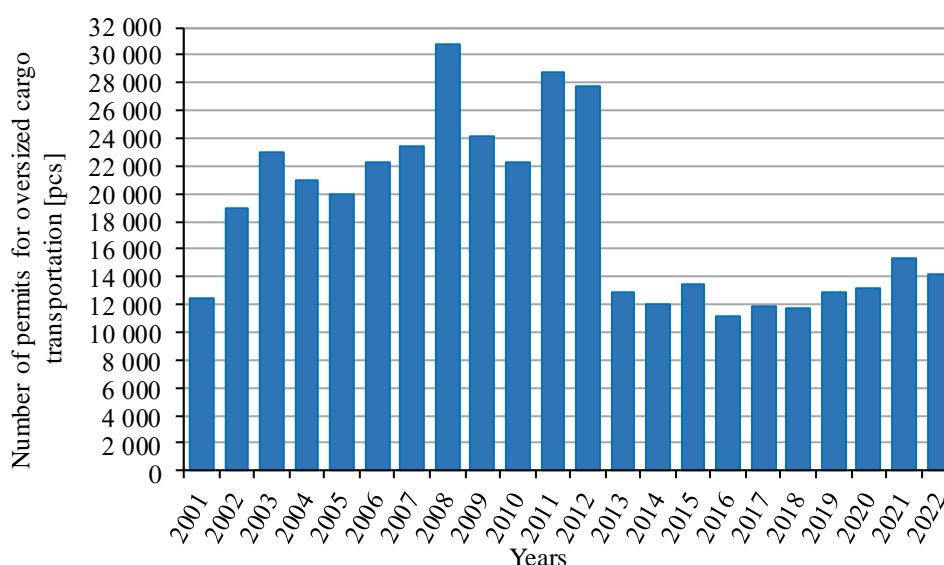
- a new division of categories of permits from I to V,
- templates of forms and the conditions for their submission and receipt by the applicant or proxy;
- new rules for the payment of fees and the procedure for their reimbursement,
- for category V, lists the specific requirements that must be met by the road to permit its use as a route for an oversized vehicle with a load.

In March 2021, the definition of an oversize vehicle was also revised by amending the provisions of the Traffic Law Act. All these changes were necessary for Polish law to adapt it to EU regulations.

### 3.1. Number of oversize transport permits

The number of oversize transport permits issued by Generalna Dyrekcja Dróg Krajowych i Autostrad (the General Directorate for National Roads and Motorways, GDDKiA) and by its subordinate branches in the years 2001-2022 is presented in Figure 1. In 2001, 12,468 permits were issued, in 2002 - 18,977, and in 2003 - 22,952 permits. The year-on-year comparison of the number of permits illustrates the growth dynamics at 52.2% and 21%, respectively. For the years 2004-2005, there was a decrease in the number of permits issued annually by 8.5% and 5%, respectively, while in the period 2006-2007 - another increase in relation to the previous year by 11.2% and 5.4%. Over the two studied decades, a record number of 30,721 permits were issued by GDDKiA and its subordinate branches in 2008, with a year-on-year increase in demand of 31.3%. The global economic crisis radically halted the implementation of large industrial investments, which generate high demand for oversized cargo transportation. This meant a 21.3% and 7.9% year-on-year decrease in permits in 2009-2010. The spectacular increase in demand in the next two years for transport of mainly heavy machinery and steel structures was caused by carrying out building projects related to the construction of sports stadiums for the UEFA EURO 2012 European Football Championship, as well as the construction of sections of motorways and major trunk roads dedicated to servicing this sporting event.

**Figure 1: Number of permits for oversized cargo transportation issued by the General Directorate for National Roads and Motorways and by its subordinate branches in the years 2001-2022**



Source: Author's study based on GDDKiA data

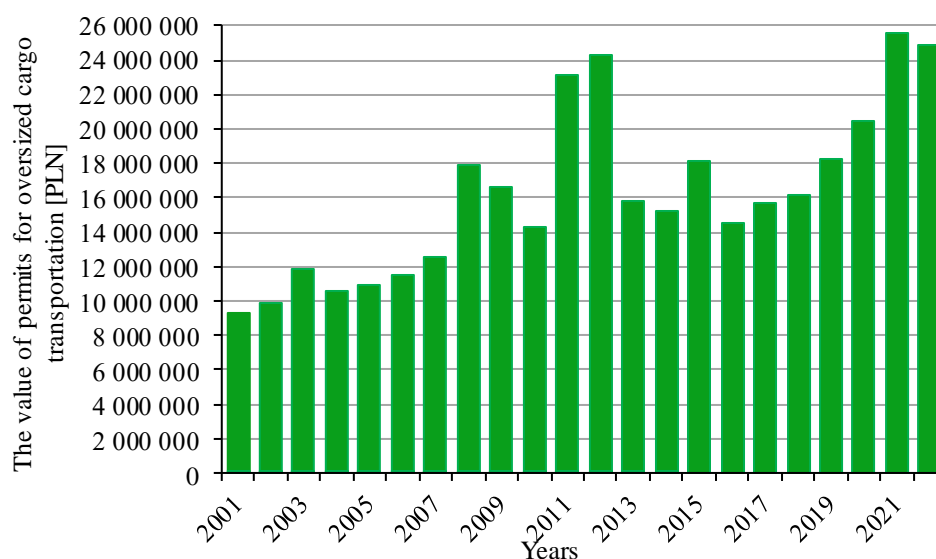
The favourable economic situation translated into issuing 28,795 permits in 2011 and 27,725 permits in 2012. Completing projects financed from European funds in the field of infrastructure and

supporting the purchase of large agricultural tractors and machinery, which also generated high demand for transport, caused a spectacular drop in demand for such services in the following years. There was a reduction in permits by as much as 53.3% in 2013 and a further decrease by 7.4% in 2014. In 2015, there was an increase of 12.6%, but a decrease of 17.7% in the following year. In 2016-2020, differences in the number of permits amounted only to a few percent. An increase of 16% in 2021 and a decrease of 7.8% in the following year lead to the conclusion that demand over the last decade was at a level that did not exceed 50% of the record demand in 2008. The COVID-19 pandemic was an obstacle to the functioning of the oversized cargo transportation market, but it did not drastically impact the number of permits issued. In connection with the state of epidemics in force from 20 March 2020 to 1 July 2023 in the territory of the Republic of Poland, a simplified system of issuing permits was introduced based on inter-ministerial arrangements to speed up their handling and issuing to transport companies.

### 3.2. The value of oversized cargo transportation permits

The amount of fees for permits for oversized cargo transportation issued by GDDKiA and its subordinate branches in the years 2001-2022 is presented in Figure 2. In 2001, permits worth PLN 9,291,985 were issued, and in the next two years, their value increased by 6.93% and 19.3%, respectively, year-on-year. After a one-year decrease of 10.71% in 2004, over the next four years, the value of issued permits increased by 3.64%, 4.93%, 8.6% and as much as 43.33%, respectively, thanks to which it reached PLN 17,917,090 in 2008, which was a record year in terms of the number of permits issued by GDDKiA.

**Figure 2: The value of permits for oversized cargo transportation issued by the General Directorate for National Roads and Motorways and by its subordinate branches in the years 2001-2022**



Source: Author's study based on GDDKiA data

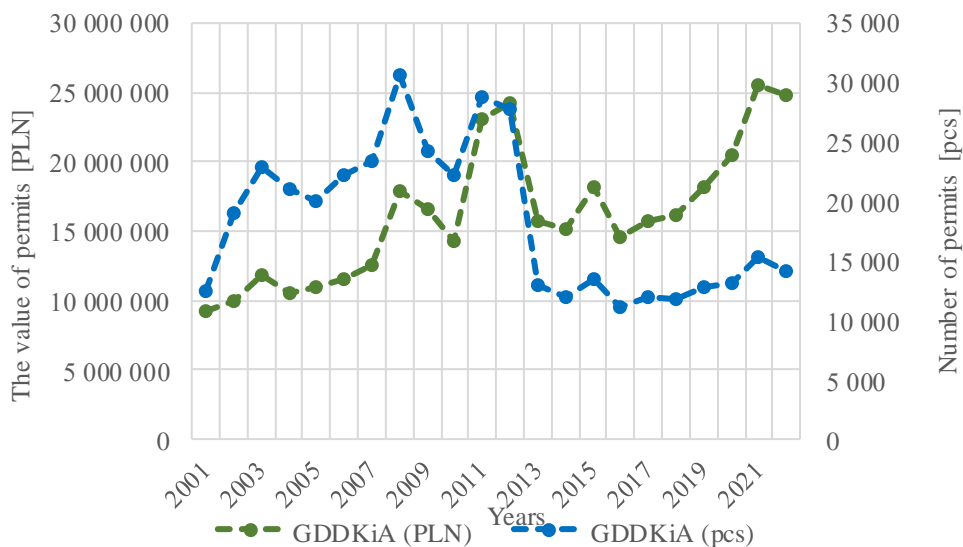
The decrease in the number of permits issued caused by the global economic crisis resulted in a year-on-year reduction of 7.4% and 13.71%, respectively. In the years 2011-2012, there was a high increase in the value of permits issued for oversized cargo transportation, to a record level in the first decade analyzed, i.e. PLN 23,097,761 and PLN 24,312,731 respectively. An important issue that had a key impact on the structure of the permit fee market was the amendment to the Act which from 19 October 2012 introduced new categories of permits from I to VII for the passage of oversized vehicles. It changed the method of calculating and the fees for obtaining permits in particular categories I-VI for 1, 6, 12 or 24 months and in category VII for single (14 days) or multiple (30 days) journeys. The economic downturn caused a reduction of 35.07% and 3.75% between 2013 and 2014. After a one-year increase of 19.77%, there was another reduction of 20.04%; hence, 2016 set the minimum value of permits for

the second decade. The next four years were characterized by a gradual increase in the value of fees for issuing permits by 7.91%, 3.17%, 12.54% and 12.15%, respectively. The high fee increases by 25.31% in 2021 translated to a total of PLN 25,619,900 paid, a record sum during the two analyzed decades. In 2022, there was only a reduction of 3.04%, i.e., companies paid PLN 24,841,610 in fees.

### 3.3. Analysis of market changes

The comparison of changes in the number and value of permits for oversized cargo transportation issued by the General Directorate for National Roads and Motorways and by its subordinate branches in the years 2001-2022 makes it possible to formulate general conclusions characterizing this part of the transport market (Fig. 3). In the subsequent years of the first decade, during which there was a very dynamic increase in the number of permits in most annual periods, and a record was broken for the number of permits issued, their value had a significantly lower upward trend. For 2008-2012, the quantity and value structure should be considered analogous regarding the level of successive increases and reductions. In the years 2013-2016, despite an analogous downward trend, the quantitative reduction was higher. For the subsequent period of 2017-2022, the trend was reversed, which was identified after the analysis of data from the first decade. In the following years, during which there was a very dynamic increase in the value of fees for permits in all annual periods, their number showed a shallow upward trend. In addition, 2021-2022 saw a record level of fees paid by transport companies for issuing permits for oversized cargo transportation.

**Figure 3: Comparison of changes in the number and value of oversized cargo transportation permits issued by the General Directorate for National Roads and Motorways and by its subordinate branches in the years 2001-2022**



Source: Author's study based on GDDKiA data

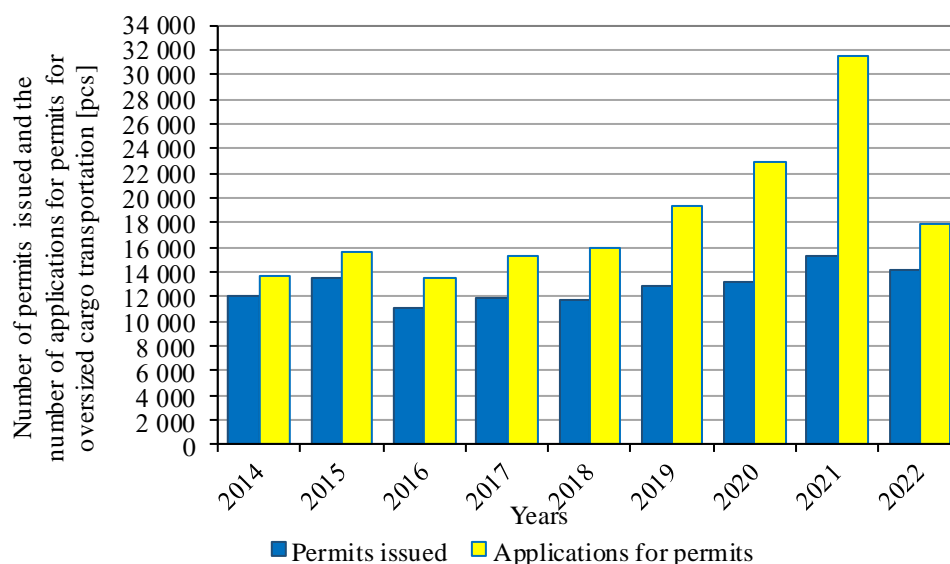
### 3.4. Analysis of the number of applications and permits issued

The number of permits issued by the General Directorate for National Roads and Motorways and by its subordinate branches and the number of applications for permits for oversized cargo transportation in the years 2014-2022 are presented in Figure 4. It should be emphasized that the surplus of documents submitted by transport companies over the number of permits issued is characteristic of all the years the surveys cover. The surplus of applications submitted for evaluation amounted to a dozen or so percent in 2014 (14.82%) and 2015 (15.49%). The next three years represent a gradual increase in applications: by 21.93% in 2016, 28.48% in 2017 and 35.11% in 2018. The upward trend increased, which meant that GDDKiA received a higher number of applications in 2019 (by 51.3%), 2020 (by 73.93%), and 2021 (by 105.94%).



The situation in 2021, when the number of applications submitted was more than twice the number of permits issued, resulted in actions at the legislative level aimed at radically reducing the amount of documents that reached the Directorate. The problem of a very high increase in permit applications was destructive for the GDDKiA structures that handle this part of the market because documents were directed to the same number of officials. The increase in the number of applications needed not be due to a real increase in the demand for moving oversized loads. In the situation of very large organizational difficulties in the transport market, resulting, among others, from the COVID-19 pandemic, transport companies adopted a strategy of duplicating applications. The financial burden was aimed at reducing the number of applications submitted to the directorate for the same planned transport order. For the same vehicles that were to be used to carry out oversized transport, the companies created different configurations of (alternatives for) the proposed routes of the convoy. Such actions should be treated as one of the methods of time optimization in obtaining and then fulfilling the order; on the other hand, it was also an action aimed at cost optimization (Meng et al., 2015; Pashkevich et al., 2019; Petraška et al., 2017; Pisz & Łapuńska, 2016). However, by the procedure, each such request initiated new, separate administrative proceedings and required appropriate consideration. For the entity, this method reduced the risk of refusal and minimized the waiting time to a single time frame, but for the office, it meant it had to carry out activities that were completely unnecessary in terms of its subsequent market efficiency. In connection with the above, an amendment to the Traffic Law Act was adopted, which entered into force on 1.01.2022 (Road Traffic Law, 1997). For category V permits, which accounted for 2/3 of the total permits, section 3 of Article 64d was reworded. According to this amendment, the applicant was required to simultaneously attach proof of payment of the fee for issuing the permit. At the same time, it was confirmed that in the event of cancellation of the application, the decision to discontinue the proceedings, and in any other case where the entity does not receive the relevant permit, the fees paid will be refunded. In such a case, the entity is required to submit a separate application for a refund of the fee to the company account.

**Figure 4: Number of permits issued by the General Directorate for National Roads and Motorways and by its subordinate branches and the number of applications for permits for oversized cargo transportation in the years 2014-2022**



Source: Author's study based on GDDKiA data

Following the applicable regulations, in the case of a Category V permit, GDDKiA assesses the application and issues a decision within 14 working days from the date of submission of the documents or within 30 days when there is a need to approve the nature of works aimed at adapting individual elements of road infrastructure along the route of the cargo. This time is significantly longer than Category III and IV permits, issued within 3 working days from submitting a correctly completed application. Any application submitted in category V for the route and the laden vehicle parameters requires several consultations. Before issuing the permit, GDDKiA is required to obtain consent from all

operators of individual road sections on which the convoy is planned to travel. It is important to divide the competencies assigned to the operators of the voivodeship, district (powiat) and municipal roads, concessionaires of motorway sections and city presidents within the boundaries of cities with district (powiat) rights. Several parameters and unknowns subject to assessment mean that application does not automatically equal consent and issuing the permit, and the amount of potential impediments, irregularities, expert opinions and necessary corrections are generally high. The applicant must also take into account the possibility of absolute refusal in the event of a critical non-conformity that could potentially pose a threat to other users, nodal infrastructure, linear infrastructure and/or engineering facilities along the route (bridges, viaducts, culverts, etc.) (Gnap et al., 2022; Paulauskas et al., 2012; Petraška et al. 2018; Petraška & Palšaitis, 2012; Petru & Krivda, 2021). The amendment to the Act had a positive effect, as in 2022, there was a very high reduction in the number of submitted applications, which exceeded the number of issued permits by only 26.77%. A fourfold reduction in the number of redundant applications meant that, in 2012, as many as 13,622 administrative procedures were initiated that in previous years had concerned the same orders.

In order to properly assess the structure of the oversized cargo transportation market, it is necessary to analyze it in terms of the demand for permits in particular categories. The quantity structure of permits issued for oversized cargo transportation in categories IV-VII in the years 2014-2020 and categories III-V in the years 2021-2022 by the General Directorate for National Roads and Motorways and by its subordinate branches is presented in Table 1.

**Table 1: Quantity structure of permits issued for oversized cargo transportation in categories IV-VII in the years 2014-2020 and categories III-V in the years 2021-2022 by the General Directorate for National Roads and Motorways**

Year issued	Category IV [pcs]	Category V [pcs]	Category VI [pcs]	Category VII [pcs]	Total number of permits issued [pcs]
<b>2014</b>	414	2 420	983	8 169	11 986
<b>2015</b>	427	2 593	1 137	9 341	13 498
<b>2016</b>	409	2 469	1 317	6 913	11 108
<b>2017</b>	401	2 727	1 464	7 312	11 904
<b>2018</b>	364	2 663	1 646	7 080	11 753
<b>2019</b>	369	2 644	1 799	8 040	12 852
<b>2020</b>	321	2 558	1 923	8 390	13 192
<b>2021</b> (until 12/03)	64	629	481	2 702	
<b>Change in the classification of permits</b>		<b>Category III [pcs]</b>	<b>Category IV [pcs]</b>	<b>Category V [pcs]</b>	15 305
<b>2021</b> (from 13/03)		445	3 472	7 512	
<b>2022</b>		589	4 492	9 037	14 118

Source: Author's study based on GDDKiA data

The lowest number of permits was issued each year between 2014 and 2020 for category IV. Their proportion was the highest in 2016 (3.68%) and the lowest in 2020 (2.43%). In 2021, when the categories changed, the sum of permits for the old category IV and the new category III amounted to 3.33%, and in 2022, the new category III represented 4.17% of the total number of permits issued. For category V, the percentage of permits issued had an intermediate and balanced level in 2014-2020. The maximum share was recorded in 2017 (22.91%) and the minimum in 2015 (19.21%). In 2021, the total number of permits for the old category V and VI and the new category IV amounted to 29.33%; in 2022, the new category IV represented 31.82% of all permits. For category VI, the percentage of permits issued in 2014-2020 showed an increasing trend. The minimum share was recorded in 2014 (8.20%), and the maximum was in 2020 (14.58%). In 2021, when the regulations were changed, category VI was abolished. For Category VII, the percentage of permits issued was high in 2014-2020. The maximum share was recorded in 2015 (69.20%) and the minimum in 2018 (60.24%). In 2021, the total of permits for the old category VII and the new category V was 66.73%, and in 2022, the new category V represented 64.01% of all the permits issued that year.

#### 4. The largest abnormal transport operation in 2022

The largest oversized cargo transport operation in the history of Polish road haulage was carried out in 2022. The order included road transport of the TBM (Tunnel Boring Machine), which was to be used for drilling the tunnel on the S19 Rzeszów Południe - Babica expressway section. The largest elements of the TBM machine were transported by sea from the Spanish port of Santander to Szczecin. The smallest elements were directly delivered by road from Spain to Babica and some delivered by ship to Szczecin. The largest components were reloaded to barges and pontoons and floated to Opole down the Oder. The further stage of transport had to be carried out also by road. The fulfilment of the order was preceded by several months of preparations, during which it was necessary to find solutions to several problems characteristic of oversized transports in all European countries (Corbally et al., 2017; Gnap et al., 2022; Juściński, 2016; Palšaitis & Petraška, 2012; Paulauskas et al., 2012; Petru & Krivda, 2021).

In the case of the TBM machine, it was particularly difficult to plan the route necessary to obtain a Category V permit due to the extreme weight and size of the loads. The basic condition for ensuring safety during transport was a detailed check of the technical condition of individual sections on the planned route.

The road and each road engineering structure were assessed as follows:

- bridges in terms of load capacity,
- the height of the viaducts,
- the size and spatial configuration of roundabouts and intersections,
- the placement of the technical infrastructure near the road right-of-way in terms of potential restrictions or obstacles, which would require additional work on removing and subsequently placing them back (road signs, roadway lights, gantries, etc.);
- analysis of current conditions and their potential change in road works or other impediments affecting the capacity of the road right-of-way.

Determination of the route required performing a detailed expert study of road sections and all 396 bridge structures that were located on it to determine whether they met the required strength conditions (Agbelie et al., 2017; Gnap et al., 2022). Although the distance between the port in Opole and Babica for the route on the A4 motorway is 369 km, GDDKiA issued a permit for the route with a length of 760 km. In the case of oversized transports, the optimization of the length of the road is not considered a key condition. The route choice that was more than twice as long resulted from the critical assessment of the technical parameters of the bridge structures on the Katowice-Kraków section. They made it impossible to transport the TBM machine by the shortest route, i.e. the A4 motorway to Rzeszów. The first private highway in Poland, A4 between Katowice and Kraków, was built on a road constructed in the 1970s and 1980s; hence, its technical parameters do not correspond to the standards of the motorways built nowadays. The order was planned to be fulfilled using fourteen tractor-trailer combinations divided into three convoys. The main contractor was MTD Skuratowicz, and the subcontractor was DB-PRO. The first convoy with the largest element, the TBM cutter head, departed on 11 November 2022 from the Famet River harbour in Opole and reached its destination on 29 November 2022. It consisted of two MAN TGX41.680 ballast tractors, a V8 engine with a maximum power of 500 kW (680 HP), and an 8×4 drive. With one at the front as a towing vehicle and the other at the rear as a pushing vehicle (in a so-called push-pull combination), they formed a tractor-trailer combination with a length of 74 meters and an unladen weight of over 260 tons. The 34-axle transport semitrailer was constructed by combining two Goldhofer THP-ET modules, each with 17 axles and a turntable for heavy loads. For the protection of bridge structures, an innovative solution was used to connect turntables with the so-called fly-over-bridge through adapters, which had been specially designed by the German company Greiner for transporting the TBM machine. Using the bridge as a supporting element of the semitrailer made it possible to obtain an even weight distribution on the axles of the modules. The first convoy carrying a shield, 9 m wide and weighing about 220 tons, had a total weight of 488 tons (GDDKiA, 2022).

The second convoy with the heaviest element, i.e. the TBM drive motor, departed from Opole on 2 December 2022, and arrived at its destination on 20 December 2022. It transported the main drive motor, which had a width of almost 9 m and a weight of 240 tons; the whole tractor-trailer combination weighed 500 tons. The remaining components of the TBM machine were delivered to Babica by the third

convoy on 30 January 2023 and were transported on combinations formed from a single tractor unit and platform, with a total length of 25 to 35 m. The loads were 6 to 8 m wide, and the weight of the tractor-trailer combination with the transported load was between 115 and 240 tons. The convoys travelled from 10.00 p.m. to 6.00 a.m. at speeds of up to 10 km/h across bridges and within 20-30 km/h on the remaining road sections. The convoy that carried the largest elements consisted of 5 ballast tractors and occupied almost 4.5 km of road right-of-way. Hence, it was also necessary to precisely plan where the vehicle column would stop for each daily rest period. Sixteen pilots supervised the convoy. The convoys were allowed to use protective elements such as crash attenuators behind the vehicle column and signalling devices in the form of variable message signs. In addition, police escorts were provided to ensure the safety of other road users. As the convoy occupied an entire road lane, the police excluded it from use, redirected traffic to a parallel lane or directed vehicles to local roads, creating detours. Meeting the formal requirements for obtaining a Category V permit made it necessary to obtain two further documents for each transport. This was determined by the planned journey time, which was estimated to be three weeks. The Traffic Law Act allows issuing a single permit for not more than 14 days (GDDKiA, 2022).

## 5. Conclusions

Road transport of oversized cargo in Poland is an elite part of the market. The fact that only a small selection of companies provide such services results from the high financial barrier related to the purchase and cyclical exchange of transport units consisting of top-class tractor units and/or ballast tractors as well as specialized semitrailers and/or multi-axle trailers. Large labour inputs required to prepare the transport, obtain appropriate paid permits and then perform the difficult service generate high costs, which must be considered in calculating fees for fulfilling the order. It should be emphasized that the largest domestic companies currently have equipment, professional knowledge, and experience comparable to those of the leading European companies. This is confirmed by the subsequent prizes won by Polish companies in the ESTA Awards of Excellence competition for Europe's most spectacular transport operation.

The domestic oversized cargo transportation sector operates under strong customer competition and, thus, has difficulties acquiring orders. For years, companies have suffered from rising operating costs, increased employment costs and strict penalties for violating current regulations. The potential capabilities of domestic companies that offer oversized transport services were correlated with the variable demand generated by the market. Quantitative analysis of completed orders based on permits issued by GDDKiA and its subordinate branches showed significant market size changes over the last two decades. In recent years, orders have decreased by more than 50% compared to the maximum level reached in 2008. At the same time, the value of fees for permits increased and, in 2021, reached the highest level in the period under assessment. Due to the COVID-19 pandemic, the phenomenon of duplication of applications occurred on the market. The tendency, detrimental to GDDKiA's work, was interrupted by legislative changes when, in 2021, the number of applications submitted was more than twice as high as the number of permits issued. Market regulation is also supported by changes introduced after a decade in the number of categories of permits issued from seven to five and other regulations that have adapted the domestic market to EU regulations.

The existing network of national and provincial road links in Poland is not adapted to transporting oversized cargo, and the technical parameters of engineering structures built in recent decades (bridges, viaducts) constitute a significant or even critical limitation that makes it impossible to perform transport operations of this type. The problems existing in this area are typical and comparable generically and structurally to those discussed in the literature for particular countries in Europe, Asia or America. Due to high costs and limitations, changes in the infrastructure used are complex, even impossible, to implement. Therefore, motorways and trunk roads built in the last decade according to new standards constitute a positive change for the sector. However, bridge structures still do not have data on permissible load capacity, hence the requirement to conduct an expert evaluation for each transport. Limitations in many cases result in the need to cover a much longer route than the optimal one, and the transport of the TBM machine is a classic example. Nodal infrastructure facilities, in many cases, do not provide the necessary space for manoeuvres for vehicles with oversized loads. The transport of the TBM machine required the execution of tasks typical for this type of order, which

extends the journey time and generates costs due to labour input. Numerous adaptation works of varying difficulty were necessary at roundabouts and intersections, which were restored to their original condition. A positive change that allows for efficient passage of the convoy is new intersections with circular traffic. There are no concrete structures or embankments on them no high curbs; it is easy to disassemble and install road signs, and more frequently, they offer a solution in the form of an alternative route through the centre of the roundabout.

Systemic problems in the domestic market, which should be solved following the example of other countries, include:

- the lack of an electronic database of current parameters of roads, bridges and viaducts, which prolongs the procedure of route planning and obtaining permits;
- the lack of a nationwide system for registering oversized cargo transport (an online platform), where companies would be able to post information about when and where they will travel, which is crucial for transparency and road safety;
- strict limitation of the travel time of oversized tractor-trailer combinations only to the night time from 10.00 p.m. to 6.00 a.m.;
- changing the current procedure that requires submitting applications on paper forms, which have limited functionality and need to be filled in and signed each time, which is an example of time-consuming bureaucratic activities;
- the introduction of amendments to the Administrative Procedure Code allows an electronic method of submitting applications and issuing permits, which would benefit transport companies and authorities issuing permits.

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## Conflicts of interest

The authors declare no conflict of interest.

## Data availability

Some or all data and models that support the findings of this study are available from the corresponding author upon reasonable request.

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