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The accessibility of Poland's Space to the Trans-European Transport Network

Abstract
The aim of the article is to analyse the land transport accessibility of two trans-European corridors within the boundaries of Poland. The adjustment of the course of transport routes to the distribution of the population and the country's land development (including economic potential and logistic infrastructure) was outlined using measurements of cumulative accessibility. The results were presented in both cartographic form (isochrone approach) and tabular form (cumulative approach). Research was conducted adopting different forms of transport used for relocation (including foot traffic, car, rail and multimodal transport) and both the current and target layout of the transport network. This made it possible to determine the changes that will effectively run the process of investment in transport infrastructure on Polish territory. This allowed the identification of the areas of Poland which are particularly conveniently located in relation to domestic connections (in terms of the international network) and those for which the European transport network remains difficult to access.

Keywords
Trans-European Transport Network • transport corridor • accessibility • land development • Poland

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Introduction

The Trans-European Transport Network TEN-T is an instrument which facilitates co-ordination and ensures the cohesion and complementarity of infrastructure investment. In the aftermath of a review of guidelines for the TEN-T network accomplished in 2013, its new layout on the territory of EU members was established. This layout includes the core network forming the basis of development of the transport network which is to be the focus of EU activities, especially on cross border sections, missing links, multimodal connections and the most important bottlenecks, as well as the comprehensive network ensuring the accessibility and cohesion of all the Union's regions.

TEN-T issues are regulated by European Parliament and Council regulation no. 1315/2013 of 11 December 2013 on the EU guidelines concerning the development of the trans-European transport network. The Trans-European Transport Network (TEN-T) comprises: road, rail, air, sea and river routes representing the most important connections from the point of view of EU development, as well as point infrastructure elements in the form of seaports, airports, inland waterway ports and road and rail terminals. Among its integral elements are the smart transport systems whose implementation contributes to a surge in the network's capacity and traffic security and a decrease in the environmental pollution caused by transport. The aim of TEN-T network development is to ensure the territorial coherence of the EU and facilitate the free movement of goods and people.

The corridors of the core TEN-T network were established with the aim of ensuring the effective implementation of the network and accelerating work on infrastructure projects of the greatest European added value. The corridors should aid the coordination of different projects at the supranational level. They should also contribute to the development of core network infrastructure, solving the problem of bottlenecks, intensifying cross border connections and boosting the efficiency and sustainable character of the transport system. They should also contribute to the improved cohesion of EU regions through better territorial cooperation. In accordance with EU plans, the core network corridors will have been implemented by 2030. The issue of building TEN-T core network corridors was specified in two regulations of the European Parliament and the Council: no. 1316/2013 on establishing a new financial instrument called the Connecting Europe Facility (CEF), the exhibit of which specifies the route of these corridors and a list of projects to be financed initially from CEF; the regulation also specifies the functioning of the Connecting Europe Facility (CEF), which aims to finance investment in the TEN-T core network corridors; and no. 1315/2013 on the EU guidelines concerning the development of the TEN-T trans-European transport network, regulating organizational issues of the functioning of TEN-T trans-European transport.

The guidelines comprising the aims, priorities and general directions of activities in the field of trans-European networks were defined in Decision no. 1692/96 of the European Parliament and Council of 23 July 1996. The current assumptions concerning the TEN-T programme are included in the White Paper: Roadmap to a Single European Transport Area **–** Towards a competitive and resource efficient transport system. Its key goals include shifting 30% of road freight over 300 km to other modes (rail or waterborne

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Figure 1. The course of Trans-European corridors against the background of the transport network in Poland
Source: own study

transport) by 2030, and more than 50% of this transport mode by 2050; tripling the length of the existing high-speed rail network by 2030 and completing a European high-speed rail network by 2050; connecting all airports belonging to the core network to the rail network, preferably high-speed rail, and ensuring that all major seaports have good connections with freight rail transport and, if possible, the inland waterway system by 2050.

This article focuses on that part of the Trans-European Transport System with elements located within the boundaries of Poland (fig. 1). In addition, it refers only to land transport accomplished by means of 'land' transport modes, i.e. foot travel, car vehicles (road accessibility) and trains (rail accessibility). In turn, air, inland waterway and sea transport are not accounted for on purpose. The work concentrates on accessibility accomplished by means of 'land' transport modes.

The fundamental purpose of the Baltic-Adriatic transport corridor and the Baltic-North Sea Corridor, which are the subjects of this research, is to strengthen the strategic relationships between countries and regions on the north-south and east-west axes. The reinforcement of these connections is accomplished through improving their mutual transport accessibility, intensifying the movement of goods, people and information and promoting

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new transport directions. The importance of these transport axes where systematic and substantial trade exchange has been taking place for centuries seems to have been underestimated. The opportunity to increase the rank of the functioning connections arose along with the integration of Poland into the European Union structures.

The aim of the article is to analyse land the transport accessibility of two trans-European corridors within the boundaries of Poland. The Baltic-Adriatic and Baltic-North Sea corridors comprise both roads and rail lines. In the case of rail, the only points that can be included in traffic are stops, stations and handling points of various kinds. Furthermore, the analysis of accessibility to the road network is single-point in nature as corridors function on the basis of the highest category roads (motorways and expressways), which are only connected with the road network surrounding them via nodes with slip-roads. This is why the analysis of accessibility to the trans-European network in this paper is based on the analysis of the accessibility of points. Cumulative accessibility is the main research method utilized in the later part of this study. This method made it possible to specify the level of adjustment of corridor routes and their point infrastructure elements to the elements of land development of Poland's space, including its settlement network, distribution of demographic potential and economic activity. Research was conducted for several variants of movement: foot travel, journeys on the road and rail network, and the multimodal network representing different configurations of the aforementioned transport modes, for both passenger and goods transport. The article presents the situation as of August 2016.

Source materials and research methods

At present, there is no universal and prevailing definition of transport accessibility and it is highly unlikely that such a definition will be elaborated in the future. Gould (1969) points out that accessibility is one of those commonly used terms that everyone uses, yet nobody can define or measure it once and for all. One of the definitions most frequently quoted in the literature on the subject is that proposed by Hansen (1959), according to which accessibility is described as the potential opportunities for interaction. In turn, Handy and Niemeier (1997) stress that interactions should be understood in a broader sense, both economic and social. Bruinsma and Rietveld (1998) point to yet another possible definition of accessibility, namely "the ease of spatial interactions", or more precisely, "the attractiveness of a node in a network taking into account the mass of other nodes and the costs to reach those nodes via the network". Ingram (1971) points to a similar definition, in the light of which accessibility is an inherent characteristic of a place operationalized in terms of overcoming some form of friction, for example, in the form of physical or temporal distance. Irrespective of the definition adopted, most authors point to the existence of certain components, segments or elements which are indispensable for the appropriate understanding of the problem and which comprise the integral ingredients of transport accessibility (Dalvi & Martin 1976). Two basic accessibility components which play a decisive role can also be distinguished in this work. These are the transport component represented by the road network, with all the rules for travelling around it, and the space use component showing how the researched space has been developed, including the part of it represented by an area of individual levels of accessibility to trans-European connections. Taking both components into account is one of the more important advantages of transport accessibility which, due to this property, provides feedback between transport policy and spatial development policy.

Among other sources, the authors used data from the Topographic Objects Database (BDOT) obtained from the Provincial Centre of Geodetic and Cartographic Documentation in Warsaw. This is an all-country system gathering topographic data and making them available which, apart from data, comprises an adequate financing system, organization, IT tools and legal acts. The normative Act which defines the standards of this database is the Regulation of the Minister of Internal Affairs and Administration of 17 November 2011 on databases of topographic objects, databases of geographical objects, and standard cartographic works.

In turn, information about the route and permitted maximum speed on individual sections of the road network was obtained from the resources of the General Directorate for National Roads and Motorways (GDDKiA), Province Roads Authorities as well as OpenStreetMap (OSM) databases. This is a community project which allows the use and editing of data under a Creative Commons licence (Haklay 2010).

Data on the rail network, including its course, maximum train speeds and the distribution of point elements (stations, stops, transhipment points) were made available by the PKP company Polskie Linie Kolejowe S.A. Data from the same institution was also used to analyse the distribution of points introducing load on the network – transhipment points. These are points where infrastructure exists to enable the loading and unloading of cargo to or from the railway wagons. These points are of particular importance when analysing the multimodal relationship. Stations and stops should be understood as points on the railway network where passengers may commence or continue their journey.

The author also included data on the distribution of all settlement units in Poland, together with their number of inhabitants. A central point was generated for every settlement unit and the number of the unit's inhabitants was given in accordance with the data of the Ministry of Internal Affairs and Administration, the Main Statistical Office and City and Municipality Offices.

The last element which was subject to analysis – totalling in individual isochrones of access – is the general number and distribution of economic entities in Poland, with a special focus on those which were classified in section H of the Polish Classification of Activities, which are connected with transport and warehouse management. The purpose of extending the analysis by companies connected with ensuring the movement of goods and people was to specify the sector's potential in the immediate supply base of transport corridors as units largely fuelled by movements provided in the corridors. Due to statistical confidentiality, the Central Statistical Office made the above data available with an accuracy to the basic territorial unit in Poland, which is the commune. A centroid was generated for each commune (total 2,478) and attributed with information on economic activities in its area. In the research procedure, these central points were totalled in individual isochrones.

The physical distance, however, plays a key role in the case of analysis of foot traffic. In Poland, it is customarily assumed that the zone of impact of public transport stops occupies an area with a radius ranging from 500 m to 1 km. This means that inhabitants may access the stop on foot within 6 to 12 minutes, assuming that their average speed is 5 km/h (Majewski & Beim 2008). Naturally, this model does not reflect the possibility of generating the demand for public transport services according to each stop, even if they were provided in all possible directions and with maximum frequency. This results from the fact that every inhabitant may have a distinct border distance which marks the point of resigning from using the stop (Gadziński 2010).

Generally, in the literature there are methodological problems connected with the border distance for different transport modes. In Great Britain, the equidistance of 640 metres is considered the maximum distance of access to the bus stop in a town, whereas for regional rail or underground stations this distance is 960

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metres (Majewski & Beim 2008). German urbanists, in turn, assume that the maximum distance for accessing a bus stop is 300 metres, a tram stop 400 metres, and a regional rail station 500 metres (Loose 2001). Consequently, this research adopted a few variants of border distance which the potential passenger must cover on foot to get to the stop. The distance was established using the Manhattan distance metric.

The variant of research into travel time by individual car transport presented in this article assumes only one determinant conditioning the speed of vehicles, namely restrictions resulting from the Traffic Law Act (Act of 20 June 1997, Dz.U. 1997, no. 98, item 602, as amended). In this way, net travel times were determined taking into consideration neither breaks resulting from conditions on the road, nor breaks allowing the driver to rest or refuel. It was assumed that vehicles move at the maximum permissible speed on routes which allow the shortest possible travel time. Consequently, journeys on tolled fragments of motorways were also taken into consideration. Determinations of accessibility always sought the shortest route in the temporal sense, which did not always coincide with the shortest route in accordance with the real physical distance.

In the part of the analysis devoted to the rail network, research proceedings are conducted in accordance with the algorithm adopted for the road network. Only the travel times of individual line sections were established on the basis of the list of maximum speeds for passenger trains, being Appendix 2.1 to the rules of allocating train routes and using allocated train routes by licenced rail carriers as part of the 2014/2015 schedule, made available by the PKP company Polskie Linie Kolejowe S.A.

Transport accessibility may be researched in a number of ways. Some authors name as many ten or more methods (Bruinsma & Rietveld 1998). In most studies devoted to this problem, however, there is a certain consensus concerning the existence of a few major methods (Baradaran & Ramjerdi 2001; Geurs & van Wee 2004; Geurs & Ritsema van Eck 2001; Spiekermann & Neubauer 2002). It is worth pointing out, for instance, infrastructure-based accessibility, distance-based accessibility, cumulative accessibility, potential accessibility, and person-based accessibility (Rosik 2012).

This research uses one of the above approaches. The author introduced analysis based on measurements of cumulative accessibility. This method is also called isochronic accessibility, where accessibility is measured by assessing a set of destinations accessible in the given time with the given travel cost or effort. Accessibility measured by isochrones is sometimes alternatively referred to in the literature of the subject as daily accessibility. It is worth stressing that isochrones may also be used as an assessment tool of accessibility measured by distance, which is why, in some reviews of methods, accessibility measured by distance to a set of destinations is placed in the same category as accessibility measured by isochrones.

Even though time is a strict physical notion denoting an independent variable which can be quantified in the form of seconds, minutes, hours, days, and so on, the issue of temporal distance in studies into spatial accessibility is far from homogenous. In both scientific research and practical applications, there are many examples of the concretization of models describing temporal spatial accessibility. Polish literature comprises about a dozen comprehensive studies which summarize and systematize indicators, notably the works of Lijewski (1967), Domański (1963), Sobczyk (1985), Warakomska (1992), Ratajczak (1999), Taylor (1999), Rosik (2012) and Wiśniewski (2015).

Both in the case of travel and the speed of movement resulting from it, one fundamental differentiation should be taken into account, namely whether measurements refer only to the amount of time necessary to relocate, or the time needed for the whole journey. This is of considerable importance above all in the case of public transport in which the necessity to change and frequency of services play a vital role. In individual transport this factor is of lesser importance, although in this case the length of journey also does not depend solely on the time of drive, as in the case of longer journeys it is necessary to have a stopover in order to rest or have a meal, for example, but it is also important to take into consideration restrictions resulting from road conditions. This is a fairly complicated problem, which has been addressed by studies in the field of typical road traffic engineering (Gaca, Suchorzewski & Tracz 2008).

The literature on the subject includes several ways of dividing up space into areas demarcated by lines of identical temporal distance. It seems of key importance to consider here the methodology of delineating catchment areas based either on equidistance (Śleszyński 2004, 2007) and real isochrones of access to the given place (Śleszyński & Komornicki 2009) or the geometrical division of space, for instance, in the form of tessellation and Voronoi diagrams.

Overall, while measuring accessibility by means of isochrones, it is necessary to assume a certain maximum time and cost (journey budget). Subsequently, the number of destinations accessible in the time given or with the adopted cost is calculated (Spiekermann & Neubauer 2002). Other examples of research into daily accessibility include Schürmann, Spiekermann and Wegener (1997), Spiekermann and Wegener (1996) and Vickerman, Spiekermann and Wegener (1999).

The above source materials and methodological assumptions gave rise to the research procedure used in this study. The first step involved the construction of a transport network on the basis of which travel times were subsequently calculated. In this stage, every segment of the (pedestrian, road and rail) network was ascribed the maximum allowed speed, depending on the type of road it represents. This, in turn, allowed the estimation of the segment's travel time and finally the quickest routes were chosen between adopted points in accordance with Dijkstra's algorithm. All elements of the country's land development subject to analysis were then charted on the transport network. Central points were delineated for communes and settlement units so that they could later be calculated in accordance with the cumulative method. The subsequent stage of the research consisted of delineating the travel routes between the starting points and destinations selected for the analysis. Points on the transport network characterized by the same travel time were joined, forming relevant isolines. The author then calculated individual elements of development on areas limited by individual isochrones. This procedure was conducted for three temporal ranges: from 0 to 1 hour with 15-minute intervals. The analysis was limited to 30 minutes in the case of foot traffic only.

Commentary is necessary in relation to the stage of combining individual segments of the network, including the multimodal one. Individual segments were combined in these points where they might be connected in reality (junctions, nodes, slip roads, stops, stations, and so on). Since the author was not guided by the values indicated in railway schedules in relation to establishing travel time in the rail network, and they were calculated on the basis of maximum allowed speeds, the analysis also does not account for transfer time between transport modes. The role played by transfer time in the contemporary research into transport is invaluable, as reflected in numerous publications, such as Horowitz and Thompson (1994), Hoogendoorn-Lanser (2005), Van Hagen (2011), and Schakenbos et al. (2016). This is why it was assumed that changing transport mode does not entail time losses so as to avoid introducing yet another analytical thread into the research proceedings.

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Results

Car transport currently plays a dominant role in transport in the central part of Europe. Even more frequent usage of this means of transport will soon be encouraged by the forthcoming accomplishment of construction of the A1 motorway in Poland (Stępniak & Rosik 2013). Car transport, indispensable on short distances, will be gradually replaced, however, by rail transport on medium and long distances as the former is more energy intensive, more environment polluting and more often involved in accidents than any other means of transport. For distances in Europe it is rail transport that proves to be the most cost-effective transport mode, under the condition that the quality of the network allows it to be used in an uninterrupted way with reasonable speeds of 80-140 km/h and satisfactory technical condition is ensured. The existing rail network has a long way to go to achieve this. Waterways, in turn, are second to none as far as the transportation of heavy goods is concerned. Regrettably, they can be found only on small sections of the corridors in question, not forming a continuous water route, which is why they are of little use.

The main transport mode in cargo transport is rail, but air transport is preferred in the case perishable and special purpose goods and road transport is used for supplies to destinations. Supplies reach the cargo terminal of the closest destination where, either upon warehousing or directly, they are reloaded on lorries (or sometimes trains). The bulk reloading of goods of different origin will take place in warehousing terminals at the intersection points of corridor routes with other railway lines, especially from the Far East, as well as different category road routes. For the time being, air transport is the best form of passenger transport for distances from Scandinavia to the Mediterranean Sea and from the British Isles to the Baltic states. There is a general tendency to replace air transport with high speed rail over small and medium distances in the future. There has not been much progress in terms of the construction of the High-Speed Rail network in the area of East-Central Europe, including Poland. Chances are that Poland will be made to accomplish the long-prepared plans of the 'Y' line construction extended to the country's borders as a vital fragment of the Euro-Asian line, involving the construction of a High-Speed Rail line planned on the initiative of China from Beijing through Moscow and Minsk to the border of Poland and from Beijing through Kazakhstan, Iran and Turkey to Istanbul (Tsamboulas, Vrenken & Lekka 2007, Wilmsmeier, Monios & Lambert 2011). The 'Y' Line intersects with the Baltic-Adriatic Transport Corridor system in the Warsaw-Łódź node. This will require the efficient organization of both transfers in passenger traffic and handling stations for cargo from the east to the north and south of the corridor. Elements of the handling node already exist in the form of logistics centres in Warsaw, Łódź, Zduńska Wola and other places. The importance of the good organization of transfers in passenger traffic will continue to increase until the situation in countries east of Poland stabilizes and the high-speed rail line between Beijing and London/Rome is launched, as well as after launching the intercontinental Central Poland Airport between Warsaw and Łódź, the construction of which keeps being postponed into an undefined future, despite long-standing considerations. A train station must be built near the airport terminal on the intersection of the east-west high speed rail line (Y line) and the north-south line (the Baltic-Adriatic Corridor).

The construction of the Baltic-Adriatic transport corridor focuses mainly on economic, logistical and technical problems connected with facilitating rail and road connections for the purposes of freight transport.

In accordance with the presented research proceedings, the analysis included spatial accessibility of the Baltic-Adriatic Transport Corridor resulting from accomplishment of movements by means of different transport modes (fig. 2). A closer look at the differentiation of the spatial course of isochrones in Poland's space leads, naturally, to certain general conclusions concerning the present accessibility of the corridor. Nevertheless, it is only the superimposition of areas limited by individual isolines on the country's existing land development that brings some measurable results (tab. 1).

One of the purposes of the transport network is the integration of individual transport branches. Terminals of various kinds usually comprise elements connecting individual branches. In Poland, despite the relatively geographically adequate land structure of the transport network, the present system is characterized by relatively high general operation costs and low flexibility with respect to changes in demand (KPZK 2030 2012; National Strategy of Regional Development 2010-2020 2010). The majority of multimodal transport terminals in Poland are located on lines referred to in the European Agreement on Important International Combined Transport Lines and Related Installations. Terminals are located in the vicinity of cities including Gdańsk, Gdynia, Gliwice, Kraków, Łódź, Poznań, Pruszków, Sosnowiec, Szczecin, Świnoujście, Warsaw and Wrocław. The greatest concentration of terminals can be found in the region of Poznań and Katowice. The container terminals in Małaszewicze and the container handling point in Żurawica also play an important role in the eastern direction.

Undoubtedly, the highest accessibility levels can be found in the point network of railway lines forming part of the Baltic-Adriatic Transport Corridor. If it is assumed that potential passengers would decide to walk or go by car to train stations and stops, devoting less than 60 minutes to this stage of their journey, then the railway connections between the Scandinavian countries and the Mediterranean Sea are within reach of over 70% of Poland's population. It is worth drawing attention to the changes in accessibility which accompany extending the network of nodal elements of the corridor's road network from the current state to the target one. The investment effort that must be made to develop the network will bring about (assuming that other factors remain unchanged) relatively minor changes in accessibility, both in the spatial and the cumulative dimension, in relation to settlement units or population size.

The corridor also comprises the course of High Speed Rail line 'Y' from Poznań through Kalisz and Łódź to Warsaw, which is still in the preparatory phase. Planning this undertaking as part of the new financial perspective will increase the capacity in the route of line no. 3 (E20) and along the Warsaw diagonal line. This is very important from the point of view of handling agglomeration traffic, which collides functionally in some sections with long distance traffic (Rosik et al. 2016).

A complementary route in the rail infrastructure is the west-southern arm of the planned route of the High-Speed Rail (line 'Y') from Poznań to Wrocław, ensuring effective connection with the capital of Lower Silesia with Warsaw. This is a key element from the point of view of cost-effectiveness of the High-Speed Rail investment as a whole, since there is no convenient rail corridor which would connect these two dynamically developing metropolitan areas. The Poznań–Kalisz–Warsaw section itself, entered into the TEN-T network, would not be economically effective in relation to the parallel line no. 3 (E20) without the southern branch (Market analysis... 2012).

This infrastructure investment should be seen as one of the biggest 'jumps' towards a higher level of spatial accessibility of the TEN-T. This is confirmed by the results of the cumulative availability included in table 1. Looking at the current layout of the railway network in Poland, it is clear that it stems from the needs of the distribution of coal from Silesia. Once coal is no longer being transported, the true potential of the railway network will be

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'unleashed'. The combination of this potential new investment in a high-speed rail network can bring synergistic efficiency at the level of spatial accessibility.

The spatial accessibility of the North Sea–Baltic Sea Corridor resulting from handling traffic flow by means of different transport modes was analysed in accordance with the adopted scientific proceedings (fig. 2). The spatial differentiation of the course of isochrones in Poland leads to the conclusion that the multimodal east-west network brings the highest territorially temporal accessibility levels. Nevertheless, it was only the superimposition of areas limited by individual isolines on the existing land development that brings measurable effects and allows objective conclusions to be drawn (tab. 1).

Much of the road network of TEN-T corridors in Poland is already complete (fig. 2). The state of the railway infrastructure, however, remains a problem. Studies devoted to TEN-T corridors within Poland point to an array of activities to be undertaken in order to eliminate speed limits, increase the length of goods trains and improve the standards of axle load, pointing to an array of line sections which need investment. Larger investment is required in the case of the North Sea–Baltic Sea Corridor. A study devoted to this corridor reveals a problematic lack of decision concerning the construction of a high-speed rail line between Warsaw, Łódź and Poznań as a factor preventing the usage of the cargo transport potential of line no. 3 between Poznań and Warsaw to the full. Without a high-speed rail line being built, this cannot become a line dedicated to cargo connections.

Research into the accessibility of Poland's space to the Trans-European Transport Network is not just the ordinary sum of partial results obtained previously. The concurrence of the highest parameter transport infrastructure connecting Europe from east to west and north to south provides results which are synergic in nature. This concerns, naturally, those parts of Poland where the two corridors intersect. The metropolitan areas of Warsaw, Łódź and Poznań are in the most privileged position in this respect (Igliński 2014). The strip between Łódź and Warsaw is a particularly attractive area for potential investors conducting economic activity for which access to the national and international market is of key importance. The corridors shaped by the European transport policy brought about, at the same time, a considerable area of transport exclusion. The south-eastern part of Poland (and especially the Podkarpackie region) remain outside the reach of the one-hour isochrone of relocation by any transport mode (fig. 2).

The course of the trans-European corridors in relation to the distribution of population and the land development of Poland entails the exclusion from pan-European transportation of about one quarter of the population and a similar share of economic entities. They remain at a travel distance of over one hour from the nearest nodal point where it is possible to join trans-European transportation (tab. 1). At the same time, it must be stressed that those in the immediate vicinity of the corridors located at a distance not exceeding 15 minutes' travel are clearly in the majority in these groups.

Conclusions

Due to the history of the transport links in question (for example, the trade routes of the Celts, Goths, Gepids, Normans; the amber route), the functioning of transport corridors in their present shape seems natural and represents a confirmation in the official EU policy of structures which have functioned in an unchanged form practically since the beginning of settlement in the area. It is necessary, however, to determine whether they also fit in with the present land development of Poland's space and well-conceived management of corridor development so as to use their historical potential in the best possible way. The condition of the corridors also affects the economic situation of the areas through which their networks run.

It seems particularly interesting to observe the connection between accessibility resulting from the functioning of a monotransport network and that resulting from travelling by different transport modes. It is worth stressing here the relationship between the share of Poland's population living in the areas of isochrones between 0-15 and 15-60 minutes. It might seem that the possibility of relocating on foot, by car or train will bring the highest spatial accessibility of the corridor. The supremacy of the multimodal network can be seen, nevertheless, in the high accessibility of Poland's population in the isochrone of the shortest time of access to the railway network. This does not translate into a large number of settlement units, which leads to the conclusion that the multimodal network (especially its rail segments) ensures the most effective connection of the country's most densely populated settlement units (Fozza & Recagno 2012). This does not entail, however, an increase in the surface of high accessibility areas, which results directly from the nature of the Polish rail network. In some sections it proves competitive in relation to the road network in terms of travel speed, yet due to its low density it cannot compete with respect to the extent of penetration of the country's surface area.

It is the point network of rail connections that is characterized by the highest accessibility levels for east-west connections, as is the case with the Baltic–Adriatic Corridor. Due to the considerable disproportions between the one-unit east-west corridor and the two-unit north-south corridor, comparing the absolute values of their accessibility seems to be a foregone conclusion. A comparative analysis may be based on the juxtaposition of results obtained for corridors for individual transport networks. Considering the importance of the North Sea–Baltic Sea Corridor in international freight flow, very beneficial accessibility levels of handling points can be seen on the rail lines forming it. Assuming that potential suppliers would decide on delivering freight by car transport to rail loading points in a time not exceeding 60 minutes, the rail connection of countries on the east-west axis is accessible to over 37% of economic entities. The same regularity also concerns companies connected exclusively with the logistics branch. It is also worth paying attention to the changes in accessibility that accompany the extension of the node network of the corridor road network elements from the present state to the target one. Profit, understood as an increase in accessibility for the population brought about by the investment effort necessary to develop the network, will amount to (assuming that other factors remain unchanged) about two percent.

The success of the Baltic-Adriatic Transport Corridor depends both on infrastructure and economic factors. If the former result from linear and single-point investments in the corridor zone, then the latter depend on the economic processes generated by infrastructure: mainly movements of goods and people, as well as the creation of added value. Infrastructure is a necessary, if insufficient, condition to generate movements. Opportunities for successful development may be taken advantage of in a situation when the transport corridor is no longer treated as an infrastructure bundle ensuring transport functions alone. It should be treated as a development zone axis or, in other words, an area of dynamic growth whose functioning and perspectives depend, among other things, on the effectiveness and quality of infrastructure and transport services. In this way, both the infrastructure and economic movements generate each other and function in mutual dependence (Allen at al. 2012).

The concepts elaborated by the European Commission and individual countries are to ensure the cohesion of the route of Transport Corridors and fit them adequately into the locally planned investments in infrastructure. Analysing the participation

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Table 1. Spatial development of Poland in terms of one-hour theoretical access time to the Trans-European Transport Corridors

connection	travel time [minutes]	0-15	15-30	30-45	45-60	sum
by road network to existing road nodes	surface area [km²]	16,682.2	43,463.2	47,544.4	49,853.0	157,542.8
	share [%]	5.3	13.9	15.2	15.9	50.4
	settlement units	3,445	8,504	9,029	8,776	29,754
	share [%]	6.5	16.1	17.1	16.7	56.5
	population	11,037,843	5,204,760	5,456,878	4,034,151	25,733,632
	share [%]	29.3	13.8	14.5	10.7	68.4
	economic entities	1,525,768	543,737	600,617	386,926	3,057,048
	share [%]	36.5	13.0	14.4	9.3	73.1
	economic entities connected with transport and warehouse management	90,184	34,000	36,617	23,380	184,181
	share [%]	35.1	13.3	14.3	9.1	71.8
by road network to target road nodes	surface area [km²]	21,367.3	50,628.5	52,473.4	51,073.6	175,542.8
	share [%]	6.8	16.2	16.8	16.3	56.1
	settlement units	4,450	9,885	9,881	8,714	32,930
	share [%]	8.4	18.8	18.7	16.5	62.5
	population	12,687,920	5,478,831	5,027,580	3,544,630	26,738,961
	share [%]	33.7	14.6	13.4	9.4	71.1
	economic entities	1,684,369	568,191	547,806	336,562	3,136,928
	share [%]	40.3	13.6	13.1	8.0	75.0
	economic entities connected with transport and warehouse management	99,323	36,154	33,578	20,194	189,249
	share [%]	38.7	14.1	13.1	7.9	73.8
by road network to handling points	surface area [km²]	22,274.5	56,498.8	62,033.1	55,480.7	196,287.1
	share [%]	7.1	18.1	19.8	17.7	62.8
	settlement units	5,065	11,236	11,318	9,029	36,648
	share [%]	9.6	21.3	21.5	17.1	69.5
	economic entities	1,539,466	658,933	769,517	332,376	3,300,292
	share [%]	36.8	15.8	18.4	7.9	78.9
	economic entities connected with transport and warehouse management	91,395	41,860	47,768	20,744	201,767
	share [%]	35.6	16.3	18.6	8.1	78.6
by road network and on foot to train stations and stops	surface area [km²]	8,372.1	32,574.7	49,519.7	60,560.9	151,027.4
	share [%]	2.7	10.4	15.8	19.4	48.3
	settlement units	1,932	6,602	9,945	11,049	29,528
	share [%]	3.7	12.5	18.9	21.0	56.0
	population	7,519,697	6,278,185	5,837,514	5,473,935	25,109,331
	share [%]	20.0	16.7	15.5	14.5	66.7
	economic entities	1,019,528	743,169	530,009	619,395	2,912,101
	share [%]	24.4	17.8	12.7	14.8	69.6
	economic entities connected with transport and warehouse management	59,212	45,606	33,730	38,099	176,647
	share [%]	23.1	17.8	13.1	14.8	68.8

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Continued Table 1. Spatial development of Poland in terms of one-hour theoretical access time to the Trans-European Transport Corridors

connection	travel time [minutes]	0-15	15-30	30-45	45-60	sum
by multimodal network to all corridor nodes	surface area [km²]	22,005.2	53,254.4	61,018.4	58,386.8	194,664.8
	share [%]	7.0	17.0	19.5	18.7	62.3
	settlement units	4,880	10,526	11,261	9,661	36,328
	share [%]	9.3	20.0	21.4	18.3	68.9
	population	12,871,927	5,975,780	6,037,113	3,971,834	28,856,654
	share [%]	34.2	15.9	16.0	10.6	76.7
	economic entities	1,722,784	592,245	706,210	317,596	3,338,835
	share [%]	41.2	14.2	16.9	7.6	79.8
	economic entities connected with transport and warehouse management	103,537	37,199	43,616	18,586	202,938
	share [%]	40.4	14.5	17.0	7.2	79.1

Source: own study

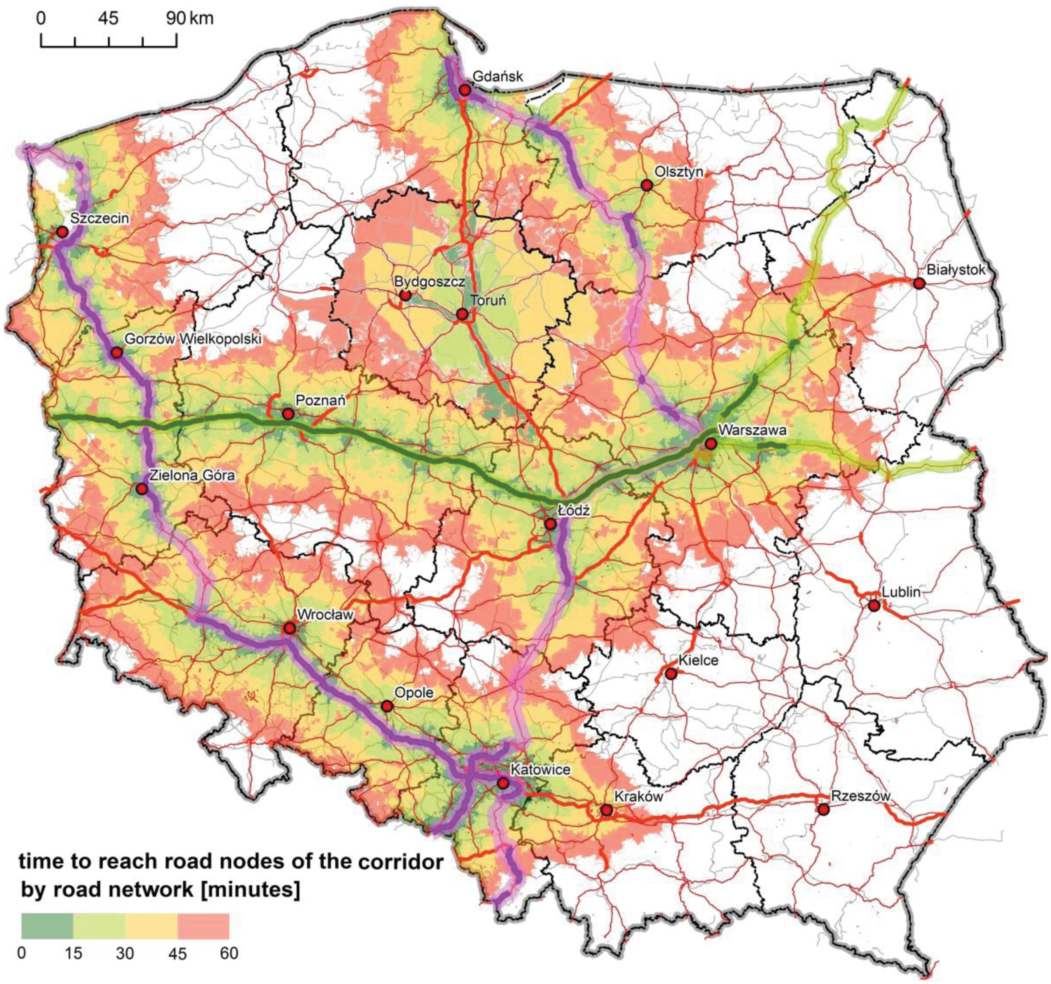

Figure 2. Spatial differentiation of the time transport accessibility of Trans-European Transport Corridors within the boundaries of Poland
Source: own study

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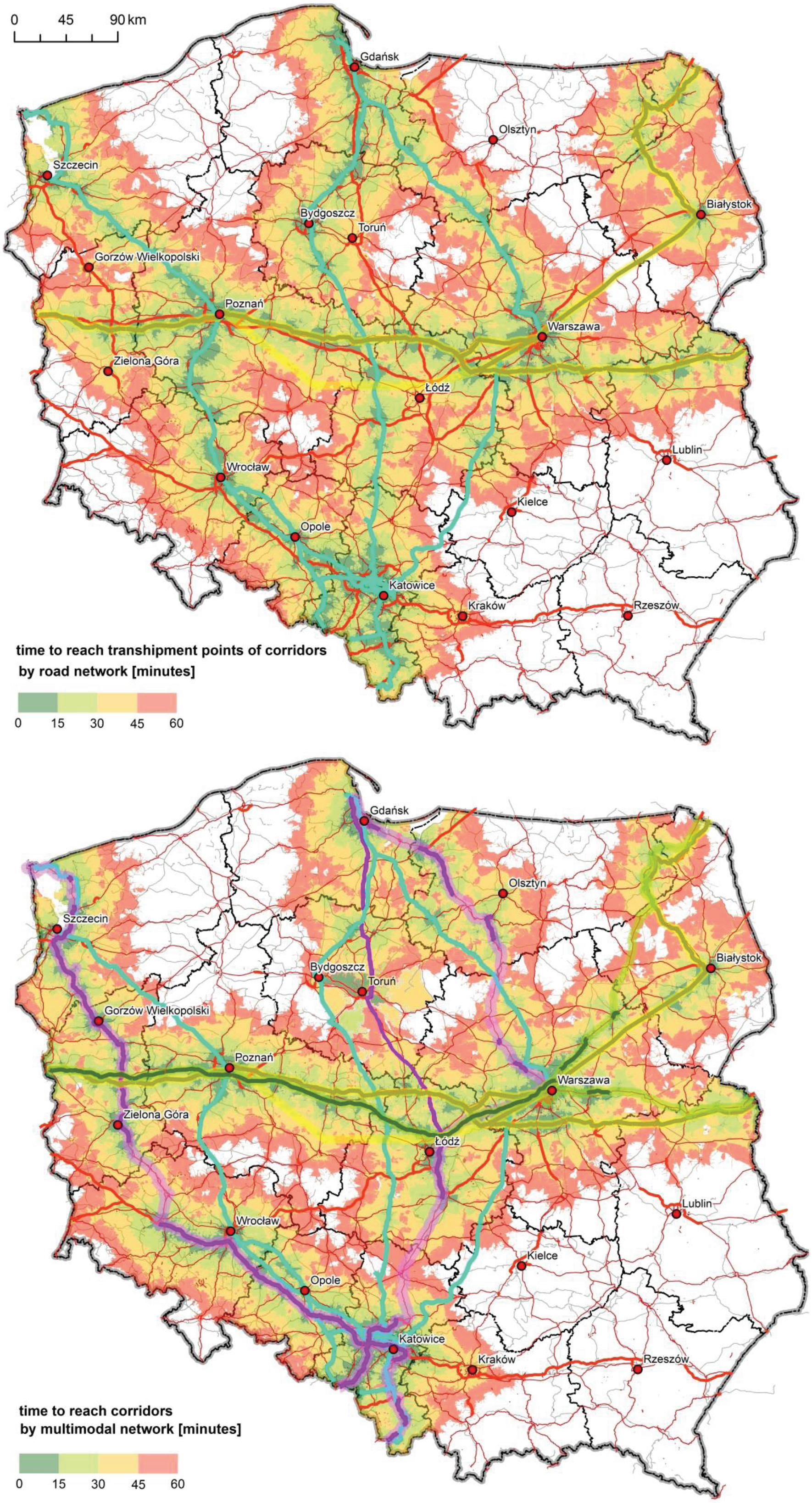

Continued Figure 2. Spatial differentiation of the time transport accessibility of Trans-European Transport Corridors within the boundaries of Poland
Source: own study

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of Poland in economic exchange, it can be observed that the main movement of goods is realized latitudinally. Poland's biggest economic partner is Germany. The construction of the A2 and A4 motorways and the S8 expressway appreciably changes the connections of Poland's main industrial centres and the west of Europe. Modern infrastructure has allowed cargo transport to speed up. Currently it is possible to relocate goods from Warsaw to Berlin in a time of under 9 hours with just a one-person crew. The situation looks slightly different in the case of the movement of imported goods. Ports in both Germany and the Netherlands are important places of sea container transhipment for Poland, which may also considerably affect the occurrence of a stream of cargo moving from south to north or vice versa (Grzelakowski 2013, 2014).

If investments complementing the missing links in the route of the corridors in Poland are constantly implemented (despite varying effectiveness), then the country's demographic and economic potential deprived of such direct accessibility should become the subject of active policy in the fields of transport planning and spatial development. Changes to the course of trans-European structures involve a process which must be supported by supraregional arguments. In turn, areas remaining outside its strong influence should be 'drawn' to the TEN-T network by investments connected with the local and regional transport network. This is why Poland's spatial accessibility to trans-European networks will remain an open issue as long as measures are taken to increase the parameters of regional transport infrastructure and improve the traffic control system. Spatial policy will also prevent development from spreading uncontrollably and, at the same time, preventing dispersion of both the population and economic activity.

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