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Accessing the EU: is the Polish transport sector a winner or loser?

Estimating the effect of the accession of Poland to the EU on its freight transport sector using the synthetic control approach

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Abstract

Poland accessed the EU in 2004. This accession was accompanied by enormous changes such as market liberalization, compliance with EU legislation, access to funds and access to the European Single Market. This paper examines the impact of EU accession on the Polish road, rail and air freight transport sectors using the synthetic control method. The synthetic control is based on 62 donor pool countries from 1970 to 2019. From the in-space placebo tests follow that none of the results are statistically significant. Hence, no conclusions can be drawn. Nevertheless, this paper provides a comprehensive literature review with several suggestions for follow-up research. Based on this paper, policymakers are cautioned against using literature without empirical evidence, as it may lead to overly optimistic policymaking. Empirical evidence would contribute to the debate on EU enlargement and improve the quality of policies. In conclusion, this paper is a call for further research.

Keywords: EU accession, Poland, transport, synthetic control, SCM, European Union

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Willianne Oudijk

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1. Introduction

In 2018, 23% of road freight transport in the European Union, hereinafter referred to as "EU", was carried out by Polish transport companies, which have the largest market share in the EU road freight sector (ITF, 2022; PWC, 2017). Moreover, in 2015 79% of the haulage work (road freight transport by a country other than the country of delivery or dispatch) was performed by Polish transport companies (Gis & Waśkiewicz, 2017). Nowadays the Polish economy is characterized by the significant contribution of the transport and logistics sector, 6% of its GDP is generated by this industry (PWC, 2017; Malkowska & Malkowski, 2021). Compared to 2000, the total transported weight per kilometer (ton-kilometers, hereinafter 'tkm') of the Polish road, rail and air transport sector has been tripled (207.298 tkm in 2000; 830.564 tkm in 2020) (OECD, 2022). According to Malkowska and Malkowski (2021), Poland's accession to the EU in 2004 could be one of the reasons.

The impact of joining the EU was not clear on beforehand. On the one hand, due to the accession Poland got access to the European Single Market. The geographical position of Poland as a block between Western and Eastern Europe as well as the ports in the north (Baltic Sea) and railways in the south could make Poland an key player in the European transport and logistics market (Połom & Goliszek, 2017). Moreover, the membership gave Poland access to large funds and resources to improve its infrastructure (Połom & Goliszek, 2017). On the other hand, the Polish transport market had a bad point of departure. Unfortunate infrastructure policies in the 1990s led to massive fragmentation of its infrastructure (Skowrońska, 2004). To become a member, Poland had to deregulate its markets, comply with EU legislation and compete with other low-cost carriers whereas the necessary infrastructure, investment climate and resilient business were lacking (Skowrońska, 2004). As follows from the literature presented in Chapter 3, the net impact of market liberalization is ambiguous. To examine the impact of the EU accession on the transport sector for Poland, this paper will answer the following research question: "What is the net effect of Poland's accession to the EU in 2004 on the amount of freight transported by Poland?".

The effect on the transport market is determined by the change in the amount of freight that is transported by the road, rail and air transport sector, because this measure is a universal measure used globally (it is measured by tonnage and kilometers) and is a good indicator for the size of the market (Profillidis, 2004; Lafontaine & Valeri, 2008;). Since Poland has its own currency (Złoty), every measure in money would be subject to changing exchange rates over time and therefore less appropriate.

This research question is both socially and economically relevant. Accessing the EU did not only change the economy and political institutions but changed the lives of the Polish citizens as well (Kolodziejczyk, 2016). The enormous expansion of the transport sector, at least with regard to the road freight sector, has among other things increased employment in Poland and improved the country's interconnectedness with other countries, leading to stronger international political and economic relations (Kolodziejczek, 2016). Economically, it is interesting to examine the net effect of EU accession on the Polish transport and logistics sector, as accession may enhance economic growth (Kolodziejczek, 2016). The debate on EU enlargement has been revived by Russia's invasion in Ukraine and the membership applications of Turkey and North Macedonia. These applications are treated with reservations by incumbent Member States, but also within the applicant countries the potential (economic) benefits associated with EU accession are discussed, including the academic literature on the transport sector (e.g. Francois, 2003; Jahanshahi, 1998; Kovacs and Spens, 2006; Lejour et al., 2009; Simola and Szekely, 2007). However, these studies are all ex-ante and limited to descriptive analyses.

To the best of my knowledge, this study is the first attempt to empirically assess the causal impact of accessing the EU on the size of the Polish transport sector. In order to assess the research question, the synthetic control method is applied using national annual data from 1970 to 2019. Thus, a macroeconomic perspective is used to address this question. The synthetic control method ('SCM'), introduced by Abadie and Gadeazabal (2003) and Abadie et al. (2010; 2015), builds upon the difference-in-difference method, although it recognizes that a single control group is not a reliable counterfactual for the treatment group (Abadie et al., 2010; Van Kippersluis, 2021). Therefore, the SCM creates a synthetic control group based on the weighted average of comparable units, called the 'donor pool', constructed from a set of observable macroeconomic characteristics, called 'predictor variables', from 1970 to 2019. Based on the donor pool, a synthetic control is constructed for each mode of transport. Data are derived from the OECD, ITF, UNECE, World Bank and the Penn World Table.

To test the validity of the estimates obtained by the SCM, several robustness analyses are carried out (Chapter 6). First, the treatment date is backdated to 2003 (for road freight transport) and 1997 (for rail and air freight transport) as an in-time placebo test to check for possible anticipation effects that could bias the estimates. Second, a leave-one-out placebo test is performed. This test checks whether the synthetic control depends too much on one of the donor countries while this country was exposed to an idiosyncratic shock, causing a biased synthetic control and thus biasing the results. Third, an in-space placebo test is performed to

check whether the EU accession (treatment) is the only driver of the results by assigning placebo treatments to the countries in the donor pool. Fourth, an additional analysis is performed using the synthetic control with LASSO ('SCUL'). This advanced synthetic control controls for the restriction on the weights when constructing the synthetic control, thereby relaxing the Convex Hull condition. By comparing the results of SCUL with the results of the main analysis it is checked whether there is a violation of the Convex Hull condition.

The findings presented in Chapter 5 show heterogeneous treatment effects for each transport mode. The treatment effects vary substantially between the pre-2007 and post-2007 periods. A positive net effect is found for road freight transport, while negative net effects are found for rail and air freight transport. All in all, the overall net effect seems to be positive for both the pre-2007 and the post-2007 period. Nevertheless, the robustness analyses show that the estimates are insignificant. Despite, the findings are in line with the findings in the literature as discussed in Chapter 3.

This paper contributes to the literature even though the results are not robust. First, this paper is innovative by applying the SCM to assess the development of transport markets (Jong et al., 2004). Second, the existing literature on the impact of EU accession on transport markets is very limited. Both the review of the existing literature and the attempt to estimate the net effect are novelties. The few (empirical) studies in the literature have an ex ante perspective or consider a very short time span. To the best of my knowledge, this paper is the first attempt to estimate the net effect based on a proper time path using an appropriate methodology. Finally, this paper can be seen as a steppingstone for further research on this topic.

This paper proceeds as follows. In Chapter 2 some background information is provided. In Chapter 3 an extensive overview of the literature on this topic is discussed. In Chapter 4 the data and methodology used to obtain the results of Chapter 5 are discussed. In Chapter 6 four types of tests are performed to test the robustness of the results. Chapter 7 contains a discussion, suggestions for follow-up research and policy implications. Chapter 8 concludes.

2. Background information

Accessing the EU is associated with a long process of (political) negotiations and diplomatic relations. Figure 1 shows the most important dates in this process for Poland. These dates are used for the analysis as well.

The formal request to become a member of the EU was made on 5 April 1994. In December 1994 the Member States of the EU adopted a pre-accession strategy for the countries that requested accession, which can be seen as a sign that the EU was willing to accept these countries as members. To become a member, Poland had to fulfill some political and economic requirements. The National Strategy for Integration (adopted in 1997) and the National Programme of Preparation for Membership in the European Union (adopted in 1998) were necessary to meet these requirements.

In December 1997 the start of the formal accession negotiations was approved. In 1998 the formal accession negotiations started. The aim of these negotiations is to investigate whether the requesting country is able to comply with the EU rules, to find out to what extent they already comply and to provide transitional measures for a transition period if necessary. These negotiations performed by the European Commission have to be approved by the European Council. The European Commission prepared a draft of the accession treaty, which had to be approved with an absolute majority vote in the European Parliament (occurred on 9 April 2003) and unanimously by the European Council (occurred on 14 April 2003). Thereafter, the treaty had to be ratified by all the incumbent Member States. The treaty entered into force on 1 May 2004. With this treaty not only Poland, but also Cyprus, the Czech Republic, Estonia, Latvia, Lithuania, Malta, Slovakia, Slovenia and Hungary have become a member of the EU.

Figure 1: Important dates in the process of accessing the EU for Poland

3. Literature Review

In this Chapter four relevant consequences on the transport sector are discussed in the light of relevant academic literature (Połom and Goliszek, 2017). First, I make some general remarks (par 3.1). Then I discuss the effects of the four consequences on the transport market: market liberalization (par 3.2); access to funds (par 3.3); the obligation to comply with EU legislation (par 3.4); and access to the European Single Market (par 3.5). Each paragraph starts with the effects on the road (see Appendix A.2 for literature overview), respectively the rail (Appendix A.3) and air freight sector (Appendix A.4).

3.1 General remarks

To the best of my knowledge, there has been no study that estimated the effects of accessing the EU on the Polish transport sector using an advanced methodology or an appropriate pre-intervention period. Nevertheless, some studies discuss the effects based on ex-post data of which an overview can be found in Appendix A. This paragraph discusses the main conclusions drawn from this review, differentiating between studies focusing on Poland and other countries.

Based on their studies, Gis & Waśkiewicz (2017), Malkowska & Malkowski (2021), and Połom & Goliszek (2017) find a net positive effect of EU accession on the Polish transport sector (in general). Additionally, Kuźnar (2008) concludes the specialization of the sector improved due to the accession. However, these studies only consider short time frames and do not use advanced methods that provide an appropiate counterfactual (Gis & Waśkiewicz, 2017; Kużnar, 2008; Połom & Goliszek, 2017). Hence, no effects are estimated.

Case studies on the potential effect of accessing the EU on the transport sector for other countries, such as Croatia, Turkey, Lithuania, Germany, Hungary, and Latvia, indicate that EU accession has minimal impact on the transport sector because of duration and intensity of the accession process (Francois, 2003; Jahanshahi, 1998; Kovacs and Spens, 2006; Lejour et al., 2009; Simola and Szekly, 2007). However, these studies are ex-ante and are limited to descriptive analyses. Again, no effects are estimated. Therefore, this study contributes to the existing literature by estimating the effect based on an appropriate pre-intervention period with an ex-post perspective using the synthetic control method.

3.2 Liberalization of the freight transport market

Accessing the EU forces a country to liberalize its markets. Several definitions of ‘liberalization’ are used in the literature. This study uses the broad definition referring both to

full removal and weakening of control by replacing regulations with a more flexible set (Taylor & Ciechański, 2018).

The Polish economy transformed from a centrally planned to a dynamic and global market economy which affected its transport sector (Spillan et al., 2004). Before the EU accession, the Polish transport sector consisted mainly of state-owned enterprises which focused on supply instead of demand and efficiency. In the 1990s a privatization process was initiated by the Polish government (Taylor & Chiechański, 2018). It was a slow process that failed several times due to unfortunate transport policies in the early 90s, lack of capital to invest in the sector, and lack of public support for the ownership transformation (Taylor & Chiechański, 2018). Therefore, the Polish transport sector had a poor point of departure when the accession process started in 1997. Hence, the effect of market liberalization on the freight transport sector is not clear. At best, liberalization lowers entry barriers, provides access to a wider (international) customer base, and increases efficiency through increased competition (Eisenkopf, 2006). On the downside, liberalization may result in destructive competition which in the worst-case causes market instability (Boylaud & Nicoletti, 2001; Eisenkopf, 2006; McKinnon, 1998). The following paragraphs discuss the sector-specific effects of market liberalization.

3.2.1 Road freight transport

The effects of liberalization on the road freight transport sector are extensively discussed in the literature (see Appendix A.2). Table 1 shows a short overview of these effects.

Table 1: Short overview of effects of liberalization on the road freight transport sector

Variable	**Effect**	**Variable**	**Effect**
Service quality (innovation and productivity)	+	Destructive competition	*
Business entry rate	+	Market instability	*
Competition	+	Establishment of subsidiaries in Poland	+

Prices	-	Outsourcing of Western Countries to Poland	+
Amount of transported freight	+		

*NOTE: In column (1) the name of the variable that changes due to the liberalization is provided, in column (2) the effect is denoted by + for an increase, - for a decrease and * for no effect, ± for no clear effect.*

The main positive effects are increased business entry rates, hence increased competition; decreased prices; and improved service quality, due to the stimulation of innovation and increased productivity (Belzer & Thörnquist, 2020; Boylaud & Nicoletti, 2001; Mačiulis, Vasiliauskas & Jakubauskas, 2009). Because of the liberalization, the initial focus of the state-owned companies on the transport of raw materials and primary goods shifted to highly processed goods and demand-driven flows, increasing the efficiency and performance of the road freight transport sector (Spillan et al., 2004). In conclusion, the liberalization would lead to specialized and sophisticated transport services and increase in growth rates. Moreover, Boylaud and Nicoletti (2001) and McKinnon (1998) find no evidence for negative effects, such as destructive competition, instability and/or a reduction in safety standards. Thus, the net effect of liberalization would be positive. Below, I discuss some of the side-effects.

Figure 14 (Appendix B) shows an enormous increase in the usage of road freight transport after 2004. The road freight transport sector can be divided into several sub-sectors: i) national transport (both place of delivery and dispatch is in Poland), ii) international transport (place of delivery or dispatch is in Poland) or iii) haulage (place of delivery and dispatch outside Poland). After accessing the EU, haulage transport increased significantly thereby dominating both national and international transport (Beltzer & Thörnquist, 2020; Boylaud and Nicoletti, 2001; Sternberg, Hofmann and Overstreet, 2020). It is unclear whether this increase is due to the liberalization, increased efficiency of Polish road carriers, or to the establishment of the European Single Market, removal of trade barriers and free movement of goods, services and people.

The market liberalization in conjunction with the European Single Market has unintentionally led to economic and social arbitrage between Western and Central and Eastern European countries (Belzer & Thörnquist, 2020; Hilal, 2008; Sitrand & Pastori, 2013). Transport companies from the Western part of Europe established networks of subsidiaries in Central and East Europe and started outsourcing to these countries because of the low labor

costs (Belzer & Thörnquist, 2020; Hilal, 2008; Lafontaine & Valeri, 2008; Sitrand & Pastori, 2013). This side-effect can explain the growth of the Polish road freight transport. Nevertheless, there is no evidence that new Member States such as Poland have been disproportionally favored by the liberalization, suggesting that the increase can be explained by Poland's large comparative advantage in transport services that could be exploited due to the accession (Hagemejer et al., 2014; Lafontaine & Valeri, 2008). So, I expect a tentative positive effect of liberalization on the road freight transport sector, hence the number of tkm transported.

3.2.2 Rail freight transport

The effects of liberalization of the railway freight transport market are extensively examined in case studies of Germany, the United States, the United Kingdom, and Sweden (Himola et al., 2007; Jahanshahi, 1998; Jensen & Stelling, 2007; Lalive & Schmutzler, 2008; Profillidis, 2004; Vassallo & Fagan, 2007). See Appendix A.2 for an overview of the full literature, and Table 2 for a summary of the effects.

Table 2: Short overview of effects of liberalization on the rail freight transport sector

Variable	**Effect**	**Variable**	**Effect**
Competition	±	Costs	+ (short-to-mid run), - (long run)
Efficiency	+	Share of rail freight transport in total freight transport	+
Prices	-	Performance	± (short-to-mid run), + (long run)

*NOTE: In column (1) the name of the variable that changes due to the liberalization is provided, in column (2) the effect is denoted by + for an increase, - for a decrease and * for no effect, ± for no clear effect.*

The literature review by Profillidis (2004) illustrates that the size of the effects mentioned in Table 2 varies significantly across countries. Similar positive effects as in the road transport sector are found, such as an increase in efficiency and decrease in prices (Eisenkopf, 2006; Mäkitalo, 2011; Laisi, 2011). Contrarily, intermodal (between different transport modes) and intramodal (within the railway sector) competition play a major role in the success of liberalization (Eisenkopf, 2006). In particular, the threat large former state-owned firms push out smaller private rail operators due to their dominant market share, maintaining their

competitive position, might result in destructive competition, decreasing both the intermodal and intramodal competition and hence efficiency (Eisenkopf, 2006; Laisi, 2011). Especially since the intermodal competitiveness of the rail freight transport sector has weakened due to globalization (Simola & Szekely, 2007). Nevertheless, Esposito, Cicatello, and Ercolano (2020) found a negative correlation between the degree of regulation and the share of rail freight transport in total freight transport, i.e. the less regulation, the higher the share of rail freight transport.

This is in line with the work of Hilmola e.a. (2007) and Jensen and Stelling (2007), who found that liberalization leads to higher costs and lower performance in the short-to-mid-run but to lower costs and higher performance in the long-run (Hilmola et al., 2007; Jensen & Stelling, 2007). This result can be explained by the Polish pre-accession rail freight transport market. Each region in Poland had its own, different railway system (Połom & Goliszek, 2017). The railway lines were managed by the state-owned company (*Polskie Koleje Państwowe*) and there were a few operators (Połom & Goliszek, 2017). Liberalization required investments were needed to create a unified system, and companies had to adjust their business operations.

In conclusion, most of these studies use a descriptive analysis to find moderate to substantial positive effects of liberalization on the performance of the sector in terms of transported freight and efficiency and cost reduction ((Hilmola et al, 2007; Jahanshahi, 1998; Jensen & Stelling, 2007; Profilidis, 2004). However, these studies have some shortcomings: they lack good baseline scenarios; they do not include estimates of the effects; and the interventions studied are not comparable to accessing the EU to any extent (Hilmola et al., 2007). This study tries to fill this gap.

3.2.3 Air freight transport

Appendix A.4 provides an overview of the literature regarding the effects of the liberalization on the air freight transport sector, Table 3 provides a summary.

Table 3: Short overview of effects of liberalization on the rail freight transport sector

Variable	**Effect**	**Variable**	**Effect**
Competition	+	Traffic (number of departures)	+
Cost of aviation	-	Destructive competition	*

Airport accessibility	+	General economy	+
Quality of services	+	Number of low-cost carriers	+

*NOTE: In column (1) the name of the variable that changes due to the liberalization is provided, in column (2) the effect is denoted by + for an increase, - for a decrease and * for no effect, ± for no clear effect.*

First, liberalization had some positive effects. It led to the establishment of new (low-cost) carriers in the market, which increased the competition and ultimately reduced the costs of aviation, and improved air transport accessibility due to increased connectivity in the intermodal transport network (Fu et al., 2010; Neiberger, 2008; Reynolds-Feighan, 1991; Wąsowska, 2017). Moreover, the financial and technical efficiency, hence the quality of the aviation services, increased (Augustyiak et al., 2015; Wąsowska, 2017).

However, compared to the EU, the Polish air freight transport sector represents only a small part of the total Polish transport sector. This can amongst others be explained by cheaper transport modes (road and rail), lack of developed infrastructure, lack of far-reaching planning, bureaucracy, and high prices for renting warehouses and office buildings (Barczak, 2019; Wąsowska, 2017). Moreover, the Polish national carrier has no freighters, so cargo must be transported on passenger planes.

Liberalization of the air freight market has also a positive effect on the general economy by providing employment opportunities, stimulating trade, and improving the quality of transportation and logistics services (Fu et al., 2010). However, Graham (1998) noted that the impact of liberalization is restricted by factors such as geography of population, production, urbanization, and wealth. This explains why Warsaw airport benefited the most from the accession (Barczak, 2019). Because of the macroeconomic changes, Barczak (2019) and Wąsowska (2017) expect more growth of airports in the long run.

Hagemejer et al. (2014) estimated that in the most optimistic scenario of full liberalization of services the output of the Polish air transport sector would increase by 5.6%. However, based on their spatiotemporal analysis Sadowski et al. (2020) conclude that the air freight transport sector in Poland grew with a slower pace than the road, rail and sea freight transport sectors between 2010-2018. Thus, the literature does not provide a clear answer on the impact of liberalization on the air freight transport sector, hence the number of tkm transported. This study tries to provide this answer.

3.3 Complying with EU legislation

Accession to the EU also changed the institutional framework in which the transport sector operates, which is one of the essential factors for understanding changes in the market (Naletina et al., 2020). For example, Lejour, Mervar and Verweij (2009) estimated that Croatian transport services would increase by 11% due to Croatia's better position on the Corruption Perceptions Index as a result of stricter legislations associated with accessing the EU. Spillan et al. (2004) also expected that the adoption of EU policies would enhance the development of small- and medium sized companies.

Compliance with EU legislation leads amongst others to standardization of the market, such as container sizes, driving hours, working conditions etc., which could improve the performance of the sector (Button, 2005; Gharehgozli et al., 2019). Conversely, EU laws are generally stricter than former Polish laws (Skowrońska, 2004). Some companies faced difficulties in understanding the laws, making investments to comply with them and changing their business model (Borkowski and Bąk, 2018). Additionally, Poland's institutional infrastructure also had problems with adoption, which led to inconsistencies in transport policies, a mismatch between infrastructure development and the geography of economic activity, the ill-functioning of large state-owned carriers, and obstacles to improving road safety (Komornicki, 2005). Below I discuss the expected effects for each transport mode.

3.3.1 Road freight transport

Based on their qualitative research on the EU's proposed Mobility package, Borkowski and Bąk (2018) conclude that an increase in regulations in the road freight transport market negatively affects the business success of small transport companies and companies from the EU's periphery region, such as Poland. Regulations on working conditions and restrictions on cabotage, increase transport costs which ultimately lead to lower revenues in the sector due to a decrease in transport operations as a result of unprofitable price competition (Borkowski & Bąk, 2018). Nevertheless, Polish road carriers were able to comply with most of the EU regulations during the transition period, and continued operating cost-competitively (Platje, 2006). At the same time, EU regulations and laws on working hours and rest periods are relatively often violated by Polish drivers and/or carriers (Solakivi and Ojala, 2010; Smedt and Wispelaere, 2020). Therefore, the effect is ambiguous. The fewer transport operations, the lower the number of tkm transported. However, if laws are violated and companies still operate cost-effectively, it is unlikely there is an effect on the number of tkm transported.

3.3.2 Rail freight transport

Seventeen percent of the difference in rail freight transport use between the USA and Europe can be explained by differences in transport policies (Vasallo & Fagan, 2007). Standardization of e.g. safety standards, working conditions and power supply systems is a necessary condition for international rail freight transport or a market with (perfect) competition, as emphasized by Raith (2003) and Božičik (2006). However, much of the EU legislation on rail freight transport is in the form of directives that must be transposed into national law to be binding (Kircher, 2006). This allows countries to implement these directives in different ways and at different times, creating heterogeneity, neglecting possible side effects and removing both soft and hard entry barriers (Jarzembowski, 2006; Kircher, 2006). Member States have an incentive to implement these directives slowly to preserve their monopoly position or competitive advantages due to more lenient legislation (European Commission, 2006; Jarzembowski, 2006). Nevertheless, as Poland approached its accession date, it accelerated the process of adopting the regulations, which resulted in fierce competition in the market (Tomeš, 2012). As the incumbent railway operators were not yet able to compete and accumulate sufficient working capital, the negative economic consequences were significant and required state intervention (Tomeš, 2012; Ludvigsen, 2009). This explains partially the persisting dominance of former state-owned companies in Poland (Ludvigsen, 2009). Again, the effect is not clear. On the one hand, the increased standardization could increase competition, hence decrease prices, which would increase demand for rail freight and thus increases the number of tkm transported. On the other hand, the dominance of former state-owned companies and the preservation of monopoly positions reduce efficiency, and hence then number of tkm transported.

3.3.3 Air freight transport

The Polish government did not negotiate for a transition period for the air freight transport sector. This meant that Poland had to comply with the EU rules regarding full market access, environmental impact, aviation personnel, technical issues and stricter aviation administration through the establishment of a Civil Aviation Office (Laitinen, 2002). Due to the lack of adaptability, the poor infrastructure hindered further economic growth (Komornicki, 2005). This is expected to have a negative impact on the number of tkm transported, at least in the short term.

3.4 Access to funds

Good infrastructure is considered an essential element for the functioning of the European Single Market (Graham, 1998). Because of its membership, Poland gained access to large funds and resources (e.g., the Trans-European Transport Network) to invest in infrastructure and transport stock, which improved the quality of the transport sector (Button, 2005; Ludewig, 2006; Marciszewska, 2007; Połom & Goliszek, 2017). These funds were needed because the investment climate for both domestic and foreign private firms was very poor prior to the accession due to the dominance of inefficient, supply driven state-owned companies (Skowrońka, 2004; Taylor & Ciechański, 2018). However, these funds also have some drawbacks, as mentioned by Marciszewska (2007), mostly related to bureaucracy. This paragraph discusses the effects of the funds for each transport mode.

3.4.1 Road freight transport

Part of the EU funds could be spent freely, resulting in disproportionate investments in road infrastructure (Ludvigsen, 2009). Some consider these investments as an absolute necessity, as the development and modernization of the road infrastructure attract investors and improve Poland's competitiveness (Musiał-Malago, 2005). However, based on empirical analysis, only a positive effect of the investments on territorial cohesion is found at the international level, and no effect at the national level (Rokicki et al., 2021; Rosik et al., 2015). Although densely populated regions benefited most from the investments, a framework for a modern road network was created (Rosik et al., 2015). Since this study has a macroeconomic perspective, I expect a positive (indirect) effect on the number of tkm transported.

3.4.2 Rail freight transport

Although the Polish rail network is quantitatively well-developed, the quality is poor (Musiał-Malago, 2005). As mentioned before, adapting the rail network to EU legislation required large investments. Nevertheless, only a few major railway projects were completed by 2015 (Rosik et al., 2015). Połom & Goliszek (2017) suggest that the construction and maintenance projects of railway infrastructure discouraged the use of rail transport, which, together with the lack of standardization, explains the decline in use of rail freight transport since 2004 (Božičik, 2006; Eurostat, 2004). Nevertheless, Gricer et al. (2021) found a positive effect of investments in the development of the railway infrastructure. Thus, I expect a negative effect on the number of tkm transported in the short-to-mid run.

3.4.3 Air freight transport

EU funds were also used for the modernization and expansion of Poland's air transport infrastructure. However, the drawbacks of the European funds also apply to the air transport sector (Marciszewska, 2007). These problems were exacerbated by the need for continuous investment, the need for implementation in an intermodal transport network and the need to expand the infrastructure to meet the growing demand for air freight transport (Marciszewska, 2007). Given the demand for fundings, I expect a positive effect of the access to funds on the number of tkm transported.

3.5 Access to the European Single Market

Accession comes along with access to the European Single Market, into which the Polish transport sector is now integrated (Sadowski et al., 2020). Prior to the accession, transport services between countries were regulated by bilateral and multilateral agreements between countries. Using a multiple regression model, Naletina et al. (2020) show a negative effect between the institutional conditions associated with these agreements and the business success of Croatian road carriers. These agreements subordinate smaller companies (Naletina et al, 2020). Upon entering the European Single Market, these agreements were replaced by the general legislation of the EU.

Therefore, entering the European Single Market leads to fewer institutional barriers, such as permits to provide transportation services. Moreover, the expansion of the economy leads to higher incomes and therefore more demand for transport (Button, 2005). This not only increased traffic after accession, but also shifted the focus of trade to Member States (Komornicki, 2005). The downside of the European Single Market is the increased competition. Lejour, Mervar and Verweij (2009) estimated that Croatia's accession to the EU would reduce the output of the transport services by 0.2%. However, Poland's accession revealed its comparative advantage in the transport sector (Kuźnar, 2008). Therefore, there is no clear effect of Poland's accession.

3.5.1 Road freight transport

Since the entry barriers were lowered, the Polish transport sector was able to grow. Based on data from the Central Statistical Office and GITD (a Polish institute for road transport inspection) from 2005 to 2015, Gis and Waśkiewicz (2017) conclude that both the number of companies and the number of vehicles increased, which they attribute to Poland's accession to

the EU. Although Poland faced many costs and changes to gain access to the European Single Market, Platje (2006) concludes that Poland is cost-competitive in the European market and therefore able to compete with countries such as Germany. Furthermore, Platje (2006) expects that Poland will be able to reduce its costs even further in the following years due to increased labor productivity, the absence of border controls, the liberalization of haulage and investments in better quality trucks and equipment. Although EU regulations attempt to create a level playing field for operators from the Member States, Poliak et al. (2018) still warn for the inequalities, including the unequal tax burden and different laws on wages, which create monopoly positions. Therefore, I expect a moderate positive effect on the number of tkm transported.

3.5.2 Rail freight transport

Ludewig (2006) notes that the creation of the European Single Market does not only allow rail freight operators to better tailor their services to customer needs, but also allows them to defend their intermodal competitiveness. According to Ludewig (2006), the creation of a successful European Single Market goes hand in hand with liberalization, investment in infrastructure and the creation of a level playing field between the different transport modes through fair infrastructure pricing. Access to the European Single Market should therefore be an opportunity to internalize the costs of externalities which are inherent to transport (Ludewig, 2006). Due to its geographical location, Poland benefits from its essential position for trade between China and Europe. However, due to capacity problems, Poland has not yet been able to meet demand (Lobyrev et al., 2018). Thus, the effect of access to the European Single Market on the number of tkm transported is ambiguous.

3.5.3 Air freight transport

Micco and Serebrisky (2006) conclude that open skies agreements, i.e. the creation of an internal market for air freight transport, have decreased air transport costs in the United States by 9% and increased air transport imports by 7%. Conversely, Mason and Alamdari (2007), who attempt to forecast the structure of the European air transport sector in 2015, conclude from their Delphi panel and secondary research that the number of operators would be reduced to a maximum of five, of which two or three would be low-cost carriers due to the cost-based competition. This expected oligopoly is in line with the study by Laitinen (2002). Despite these expectations and the competition, especially from Berlin and Vienne, the Polish air cargo sector

grew in 2000-2007 (Komornicki, 2005; Caban et al., 2018). Access to the European Single Market encouraged innovation and the entry of new companies, resulting in a significant increase in traffic (Pisarek, 2009). All in all, the net effect seems to be positive for the Polish air freight sector, hence the number of tkm transported.

3.6 Interim conclusion

Table 4 shows all expected effects per transport mode as discussed in this Chapter. The Table shows that accession is expected to have a positive effect on the road freight transport sector. The effect on the rail freight transport sector is ambiguous, both the effect of EU legislation and access to the European Single Market are ambiguous, while the effect of liberalization is expected to be positive and the effect of access to EU funds negative. Something similar applies to the air freight transport sector. For this sector the expected effect of liberalization is ambiguous, the effect of EU legislation is negative, but the effect of EU funds and access to the European Single Market is positive.

Table 4: Overview of the effects of the four consequences on the number of tkm transported by each transport modes

	Market liberalization	**EU legislation**	**EU funds**	**Access to the European Single Market**
Road	+	±	+	+
Rail	+	±	-	±
Air	±	-	+	+

NOTE: Column (1) shows the effect of market liberalization, column (2) the effect of EU legislation, column (3) the effect of access to EU funds, column (4) the effect of access to the European Single Market. The effects are denoted by + for an increase, - for a decrease and, ± for no clear effect. The first row shows the effects for the road freight transport sector, the second row for the rail freight transport sector and the third row for the air freight transport sector.

4. Methodology

This Chapter presents the methodology used to estimate the effects of Poland's accession to the EU on its transport market. First, the suitability of the synthetic control method is discussed (4.1), then its model is provided (4.2). Paragraph 4.3 discusses the data used. Finally, the applicability of the synthetic control is discussed by checking all the assumptions (4.4).

4.1 Synthetic control method – suitability

Jong et al. (2004) provide a nice overview of various freight transport models used in the literature to forecast and evaluate the impact of projects on freight transport volumes. However, none of these models is suitable for policy evaluation, such as accessing the EU (Jong et al., 2004). In line with their recommendation to use a more general method for policy evaluation, this study makes use of the synthetic control method, hereafter referred to as 'SCM'.

SCM, introduced by Abadie and Gadeazabal (2003) and Abadie et al. (2010; 2015), is based on the idea of the difference-in-difference methodology with the main difference that it recognizes that a single control group is not a reliable counterfactual for the treatment group (Abadie et al., 2010; Van Kippersluis, 2021). Therefore, the SCM creates a synthetic control group based on the weighted average of comparable units, called the 'donor pool', constructed from a set of observable characteristics, called 'predictor variables'. Since the control group is constructed with pretreatment data, the SCM allows to relax the strict parallel trend assumption, which requires that the amount of freight transported by Poland and the control group (i.e., the donor pool) show parallel trends before treatment (Kreif et al., 2015; O'Neill et al., 2016; Bouttell et al., 2018; Rehkopf & Basu, 2018). Furthermore, the SCM allows to observe treatment effects over time as it captures the dynamic treatment effect by comparing the amount of freight transported per transport mode after the accession with the counterfactual outcome over the entire post-treatment period (Abadie et al., 2015).

4.2 Synthetic control method – the model

This paragraph presents the general framework of the SCM. The synthetic control is estimated in accordance with the methodological framework presented by Abadie et al. (2010; 2015) and Abadie (2021), so this section is very similar to the frameworks presented by Abadie et al. (2010; 2015) and Abadie (2021).

The SCM aims to estimate the effect of the policy for unit $i = 1$, in this study Poland, at time t for transport mode *m*, for which holds *m= {1=road freight transport sector, 2=*

rail freight transport sector, 3=air freight transport sector}. The donor pool consists of the countries $i=2,\ldots,J+1$. For each country $i=1,\ldots,J+1$ the outcome of interest, so all transported freight in millions of ton-kilometers for transport mode m by carriers of country i at time t, F_{mit}, is observed in pre-intervention periods $t=1,\ldots,T_0$ and post-intervention periods $t=T_0+1,\ldots,T$. Note that T_0 is defined as the first period in which the outcome might respond to the intervention (Abadie et al., 2010).

The outcome of interest in absence of treatment is denoted by F^N_{mit}. The potential outcome for transport mode m that is observed for country i at time t if country i received treatment is denoted by F^I_{mit}. Assuming that the outcome variable of the untreated countries is not affected by the intervention in the treated country ($i=1$), the effect of the intervention is given by:

$$\beta_{m1t}=F^I_{m1t}-F^N_{m1t}=F_{m1t}-F^N_{m1t} \quad (1)$$

However, F^N_{m1t} is never be observed for $t>T_0$, because we do not know what would have happened if Poland had not joined the EU in the post-intervention period. Therefore, a counterfactual for F^N_{m1t} is estimated by constructing a synthetic control based on weighting the observed characteristics ('predictor variables') of the untreated units ('donor pool') in the pre-intervention period using equation 2:

$$\widehat{F}^N_{m1t}= \sum_{j=2}^{J+1} w^*_{mj} F_{mjt} \;\; \forall t \quad (2)$$

By constructing the synthetic control for each transport mode m, each country j from the donor pool is assigned weight w_{mj}, where w^*_{mj} denotes the optimal weight for country j given transport mode m for which applies that $w^*_{mj}=[0,1] \;\forall j$ and $\sum_{j=2}^{J+1} w^*_{mj}=1$. First, W_m is defined as a $(J_m \text{ x} 1)$ vector of weights, i.e. $W_m=(w_{m2}, \ldots, w_{mJ+1})'$ with $w_{mj}=[0,1] \;\forall j$ and $\sum_{j=2}^{J+1} w_{mj}=1$. Each value of the vector W_m represents a potential synthetic control, i.e. a particular weighted average of the donor pool countries. The value of W_m should be selected such that the characteristics of the synthetic control are as similar as possible to the characteristics of the treated country. Therefore X_{m1} is defined as a (k_m x 1) vector consisting of the preintervention characteristics based on the predictor variables of the treated country and X_{m0} is defined as the $(k_m \; x \; J_m)$ matrix consisting of the preintervention characteristics based on the predictor variables for all

the countries in the donor pool. Hence, the optimal synthetic control that best approximates the pre-intervention values of the predictors of the outcome variable for Poland, denoted by W_m^*, given a set of non-negative constants, $v_{m1},\ldots,v_{mk}$, can be obtained by the minimizing equation 3 subject to the restrictions that the weights are non-negative and sum to one:

$$\sum_{l_m=1}^{k} v_{ml_m}\left(X_{m1l_m}\text{-}X_{m0l_m}W_m\right)^2 \qquad (3)$$

In this equation, l_m has a value of $[1,k_m]$ and refers to the set of predictor variables. Thus, X_{m1l} refers to the value of the l-th predictor variable for the treated country. So, the effect of the intervention, which is the difference between the treated country and the synthetic control in the post-intervention period, can be estimated using equation 4.

$$\hat{\beta}_{m1t}=F_{m1t}\text{-}\sum_{j=2}^{J+1} w_{mj}^{*} F_{mjt} \qquad (4)$$

4.3 Data and definitions

Table 5, 6 and 7 provide for each transport mode an overview of all variables used in the analyses. Only annual data are used. I select these variables from the full data set (see Appendix D for an overview) based on their potential explanatory power for the outcome variable (representativeness for the amount transported), data availability and adequate construction of a synthetic control group. See also Appendix D for more detailed definitions of the variables.

Table 5: Overview of used predictor variables for road freight transport

Variable	**Unit**	**Source**
Total exports of goods and services	%	WorldBank
Total imports of goods and services	%	WorldBank
CO2 emissions from transport	Million tons	WorldBank (IEA statistics)
Population size	Number	WorldBank
Regulation in transport	Index	OECD
GDP per capita	US$ (April 2022)	IMF

Percentage transport services of all exported and imported services	%	WorldBank
First registration of new vehicles	Number	OECD (ITF)
Investment in road infrastructure	€ (2022)	OECD (ITF)
Motor fuel deliveries	Million tons	OECD (ITF)
Share of road freight transport	%	OECD (ITF)
Density of road infrastructure	Km per 100km^2	OECD (ITF)
First lag of ton-kilometers for road	In millions	OECD (ITF)

NOTE: Column (1) shows the name of the variable, column (2) presents how this variable is measured, column (3) provides the source of the data.

Table 6: Overview of used predictor variables for air freight transport

Variable	**Unit**	**Source**
Total exports of goods and services	%	WorldBank
Total imports of goods and services	%	WorldBank
CO2 emissions from transport	Million tons	WorldBank (IEA statistics)
Population size	Number	WorldBank
Regulation in transport	Index	OECD
GDP per capita	US$ (April 2022)	IMF
Percentage transport services of all exported and imported services	%	WorldBank
Length of railways	Km	WorldBank (via UIC)
Investment in rail infrastructure	€ (2022)	OECD (ITF)
Share of rail freight transport	%	OECD (ITF)
Density of railways	Km per 100km^2	OECD (ITF)
First lag of ton-kilometers for rail	In millions	OECD (ITF)

NOTE: Column (1) shows the name of the variable, column (2) presents how this variable is measured, column (3) provides the source of the data.

Table 7: Overview of used predictor variables for air freight transport

Variable	**Unit**	**Source**
Total exports of goods and services	%	WorldBank

Total imports of goods and services	%	WorldBank
CO2 emissions	Million tons	Global Carbon Project
Population size	Number	WorldBank
Regulation in transport	Index	OECD
GDP per capita	US$ (April 2022)	IMF
Percentage transport services of all exported and imported services	%	WorldBank
Number of departures	Number	WorldBank
Investment in air infrastructure	€ (2022)	OECD (ITF)
First lag of ton-kilometers for air	In millions	WorldBank

NOTE: Column (1) shows the name of the variable, column (2) presents how this variable is measured, column (3) provides the source of the data.

Table 8 provides an overview of the countries that are used to form the donor pool for the synthetic control. As explained in paragraph 4.2, the synthetic control should resemble the true pre-treatment trend of Poland as good as possible. Since the construction of the synthetic control is highly dependent on the data used, the composition of the donor pool has as strong influence on the goodness of fit of the synthetic control. I selected the best combination of countries from the full dataset (see Appendix C for an overview) for the donor pool by "leave-one-out" by trial and error, as there is no other method (Klößner et al., 2018). First, following Abadie et al. (2010) I dropped all countries that show a significantly different pre-treatment trend than Poland. Then, I tried different compositions of the donor pool until I found the one with the best fit.

Table 8: An overview of countries used to form the synthetic control

Transport mode	**Control group**	**Pre-treatment period**	**Source**
Road	Albania, Australia, Japan, Mexico, Moldova, North Macedonia, Norway, Russia, Switzerland and Turkey	1981-2004	OECD, ITF, UNECE
Rail	Australia, Azerbaijan, Belarus, Georgia, Japan, Korea, North Macedonia, Norway,	1970-2004	OECD, ITF, UNECE

	Russia, Switzerland, Turkey, Albania, Bosnia-Herzegovina, Moldova		
Air	Algeria, Argentina, Australia, Bolivia, Brazil, Cameroon, Canada, Chile, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Ethiopia, Iceland, India, Indonesia, Iran, Israel, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Lao PDR, Lebanon, Libya, Madagascar, Malawi, Malaysia, Mexico, Morocco, Myanmar, Nepal, New Zealand, Nigeria, Pakistan, Panama, Peru, Philippines, Saudi Arabia, Singapore, South Africa, Sri Lanka, Sudan, Switzerland, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, United States	1970-2004	World Bank [World Development Indicators]

NOTE: Column (1) provides an overview of the countries that are part of the donor pool, in column (2) the total length of the pre-treatment period based on available data is provided, column (3) shows the source of the data of the transported freight in tkm for these countries. The first row provides the information for the road freight transport sector, the second row for the rail freight transport sector and the third row for the air freight transport sector.

4.4 Synthetic control method – applicability

In this paragraph, I discuss the six requirements formulated by Abadi (2021) for using the SCM to evaluate policy interventions regarding: i) size of the effect and volatility of the outcome, ii) no anticipation, iii) availability of a donor group, iv) no interference, v) Convex Hull Condition and vi) time horizon Note that some requirements can be relaxed by making adjustments.

First, the outcome variable should not be too volatile, while the effect of the intervention must be of significant size, i.e. there should be a change in the trend. If the outcome variable is too volatile, there may be too much noise to measure the effect of the intervention. If the effect is not of substantial size, it may not be picked up by the method. Appendix B provides a graphical overview of the trends in the road, rail, and air freight transport sectors for Poland since 1970. Figure 19 (Appendix B) shows this condition holds for the road freight sector. The trend is not that volatile and there is a clear effect at the time of treatment (see blue line, 2004). Although Figure 20 and Figure 21 (Appendix B) show a more volatile trend for the rail and air

freight transport sector, the volatility is still moderate enough to construct a synthetic control. Therefore, I assume this requirement is also met for these sectors. However, the trend of the rail and air freight sector does not show a clear effect at the time of treatment (see blue line, 2004), which could be due to anticipation effects.

This leads to the second requirement: there should be no anticipation effects, because the SCM is based on variation over time. In case of anticipation effects, the estimates are biased. Figure 19, 20, and 21 (Appendix B) suggest that there may be anticipation effects, because the change in the trend seems to occur before 2004. Therefore, following Abadie's suggestion (Abadie, 2021), I backdate the policy intervention date in the in-time placebo test (paragraph 6.1) to control for potential anticipation effects. Figure 19 (Appendix B) shows the effect of treatment on the road freight sector is likely to occur since 2003. Given that the accession treaty was approved in 2003, making the accession final, the true effect might have taken place in 2003. Hence, 2003 is used for the in-time placebo test.

Figure 20 (Appendix B) shows that it is difficult to determine the timing of the treatment effect on the rail freight transport sector. A small dip occurred immediately after 2004, but the main dip occurred in 1997. This can be explained by the fact that in 1997 the Polish government approved the national integration strategy to become part of the EU and the European Council confirmed the start of the official negotiations as well in 1997. Both events could increase investments in railway infrastructure, leading to lower railway usage (Połom & Goliszek, 2017), so I control for this by backdating the treatment date to 1997 in the in-time placebo test. Figure 21 (Appendix B) shows something similar for the air freight sector. The increase since the 1988s stops abruptly after 1997, and thereafter the graph shows a downward trend that can be traced back to the pre-accession events in 1997. Therefore, the treatment date for the air freight transport sector in the in-time placebo test is also 1997.

Third, an appropriate donor pool is required as they will be the counterfactual. The countries in the donor pool should not be treated, but they should be as similar as possible to the treated country. To meet this requirement, the donor units consist of countries that are not part of the EU and have not yet accessed the EU, so none of the donor pool countries received treatment (EU accession).

Fourth, I assume no interference. This means that the outcome variable of the donor pool countries should not be affected by the policy, i.e., no spillover effects. The donor pool consists exclusively of non-EU countries. Therefore, the donor pool countries are unlikely to be affected by Poland's accession.

Fifth, the Convex Hull condition must hold. The donor pool countries that form the synthetic control should be as similar as possible to the treated country in the pre-intervention period, to minimize the interpolation bias. The synthetic control is constructed using interpolation, which is more reliable than using extrapolation because the latter assumes that the generated data are comparable to the true data (Hollingsworth & Wing, 2020). Extrapolation is restricted by the restrictions on the donor pool countries' weights: they must sum up to one and be non-negative. However, interpolation bias can still occur because the SCM assumes a linear relationship between the outcome variable and predictor variables (Abadie, 2021). If the treated unit's data fall outside the range of the control units' data, the synthetic control is not a perfect match, and the estimates will be biased. Therefore, Poland's observed characteristics should not be disproportionately high or low compared to the donor pool countries. Additionally, the interpolation is sparse, because the SCM assigns weights to only a few countries. This could reduce the fit and hence the reliability of the estimates. The interpolation bias can be minimized by an appropriate donor pool, see the fourth requirement.

The necessity of this condition is debated in the academic literature. Greathouse (2022) developed a synthetic control based on LASSO (least absolute shrinkage and selection operator) estimators, called SCUL, that does not require the Convex Hull condition. Also, Doudchenko and Imbens (2016) advocate for the use of regularization methods that allow weights to be negative with a summation that is not equal to one. Although, this discussion itself is beyond the scope of this paper, an additional analysis with SCUL is provided in paragraph 6.4 to test formally for the Convex Hull condition. For now I assume this requirement is met.

Finally, there should be sufficient post-intervention data, as it may take some time for certain effects to become visible. I assume this requirement is met as well, since a post-treatment period of 15 years is used (until 2019). Furthermore, the synthetic control requires that the predictor variables co-move with the outcome variable (Abadi, 2021). Therefore, lags of the outcome variable are used as predictor variables (Abadie et al., 2010).

5. Results

This Chapter presents the results of the main analyses, estimated using the methodology and data described in Chapter 4. The synthetic control is based on the weights which are assigned to both the donor pool countries and the predictor variables. In this Chapter the treatment effects for each transport sector are provided graphically, however the exact treatment effects are also provided in separate tables in Appendix H. The summation of these treatment effects provides the answer to the main question of this research. Moreover, the graphical presentation is indicative for the goodness of fit of the synthetic control in the pre-treatment period. The better the pre-treatment fit, the more reliable the post-treatment results. Although the SCM allows treatment effects to be estimated over time, it should be noted that the reliability of the estimated results decreases over time. Obviously, the more time has passed since the treatment date, the more different types of interventions could have taken place that affect the outcome, in this case the ton-kilometers transported per transport sector.

The treatment effects shown in Figures 2, 3, and 4 below are estimated using equation (4). The treatment effects show the difference in transported freight per sector for Poland and the synthetic control ('synthetic Poland') and are expressed in terms of ton-kilometers (y-axis) at time *t* (x-axis). Each Figure consists of two extra vertical lines to improve readability: the navy-blue line indicates the treatment date (2004), while the light blue line indicates the year 2007. In 2007, both Romania and Bulgaria joined the EU. Given that the longer the post-treatment period, the more the treatment effects lose reliability, and given that this expansion of the EU changed the market, especially considering both Romania and Bulgaria are well represented in the transport sector, it seems accurate to assume that the treatment effects estimated after 2007 lose too much reliability to draw conclusions.

5.1 Road freight transport

In this analysis, the synthetic control is based on Australia, Mexico, North Macedonia and Turkey (see Appendix E for all assigned weights, Table 10). The most important predictor variables for the analysis are the first lag of the outcome variable, GDP per capita, investment in road infrastructure and capital stock (see Appendix F for all assigned weights, Table 13).

Table 19 of Appendix H and Figure 2 present the estimated treatment effects for the road freight transport sector. Figure 2 suggests the synthetic control follows the trend of Poland pre-treatment quite well. The root mean square prediction error is another indication of the quality of the fit of the synthetic control (Abadie, 2021). The lower the value, the better the fit.

Although I should note there is no threshold for a good or bad RMSPE. The RMSPE is calculated using equation (5):

$$RMSPE=\left(\frac{1}{T_0}\sum_{t=1}^{T_0}\left(F_{m1t}-\sum_{j=2}^{J+1}w_j^{*}F_{mjt}\right)^2\right)^{1/2} \qquad (5)$$

For the synthetic control performed, the RMSPE is 4,431.78. As the RMSPE is based on the variable of interest, ton-kilometers in millions, and the value of ton-kilometers in millions for Poland varies between 34,024 and 233,310 (Table 16 in Appendix G), this RMSPE is quite good. Ideally, one would like to see that the gap between the treated unit, in this case Poland, and the synthetic control pre-treatment is zero, because this would imply that the synthetic control perfectly matches the treated country before treatment. Table 19 in Appendix H shows that the gap is larger than zero pre-treatment, as indicated by the lefthand-side of the navy-blue line in Figure 2. Nevertheless, the synthetic control approaches the trend of Poland and there are no outliers.

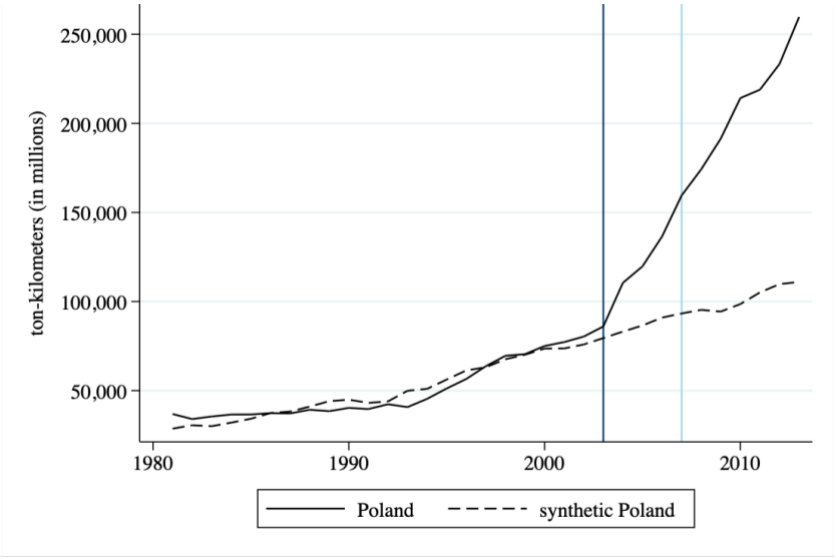

Figure 2: Treatment effects for the road freight transport sector; the navy-blue line indicates the treatment date and the light blue line marks 2007.

Table 9 shows the cumulative treatment effect pre-2007 and post-2007 of Poland's accession to the EU on its road freight sector. This cumulative treatment effect is the sum of the estimated treatment effects over the period 2004 to 2007 and up to 2013. The post-2007 period ends in 2013 because this was largest dataset available. From Table 9 follows that the Polish road freight sector experienced a net positive effect of the EU accession in terms of transported freight expressed in ton-kilometers for both the pre-2007 and post-2007 period.

However, as the synthetic control is not a perfect fit, one should be cautious in making statements about the exact size of this positive effect. A breach of the Convex Hull condition may cause the relatively poor fit of the synthetic control. This is formally tested with the additional test in paragraph 6.4. Nevertheless, the estimated positive net effect of the accession is in line with the expectations following from the literature (Belzer & Thörnquist, 2020; Boylaud & Nicoletti, 2001; Lafontaine & Valeri, 2008; Malkowska & Malkowski, 2021; Połom & Goliszek, 2017).[1]

Table 9: Cumulative treatment effects of accessing the EU on the number of tkm transported by each transport mode

Cumulative treatment effects (tkm in millions)	Road freight transport sector	Rail freight transport sector	Air freight transport sector	Total
Pre-2007	106,070.92	-94,549.02	-44.46	11,477.44
Post-2007	849,994.79	-369,912.82	-88.39	479,993.58

NOTE: In each column the cumulative treatment effect for one of the transport sectors is provided. The last column provides the cumulative effect of all sectors. Note, the post-2007 period for the road and rail freight transport sector is longer (till 2013) than the post-2007 period for the air freight transport sector (till 2008), therefore one should be careful with interpreting the total cumulative effect for the post-2007 period. The first row provides the cumulative effects over the period 2004-2007, the second row for the period 2004-2013 (in case of road and rail freight) or 2004-2008 (in case of air freight).

5.2 Rail freight transport

Azerbaijan, Japan and Russia form the synthetic control (Appendix E, Table 11). The most predictive variable in the analysis is the first lag of the outcome variable (Appendix F, Table 14). The exact estimated treatment effects can be found in Appendix H, Table 20. The graphical overview is presented in Figure 3. Looking at the graphical representation of the synthetic control the gaps between the synthetic control and the trend of Poland in the pre-intervention period indicate that the synthetic control is not flawless and one should be careful with its interpretation. Nevertheless, the RMSPE of the synthetic control is 15,931.66 which is not very high given the large values in the dataset (see Table 17 of Appendix G). Both a potential breach of the Convex Hull condition and anticipation effects may explain the relatively poor fit. Since large investments were needed, it may be that the real impact of the accession for the rail freight transport sector occurred before 2004. This is tested formally in Chapter 6.

[1] Note, only a selection of the literature is mentioned. For a full overview of the literature, see Appendix A.

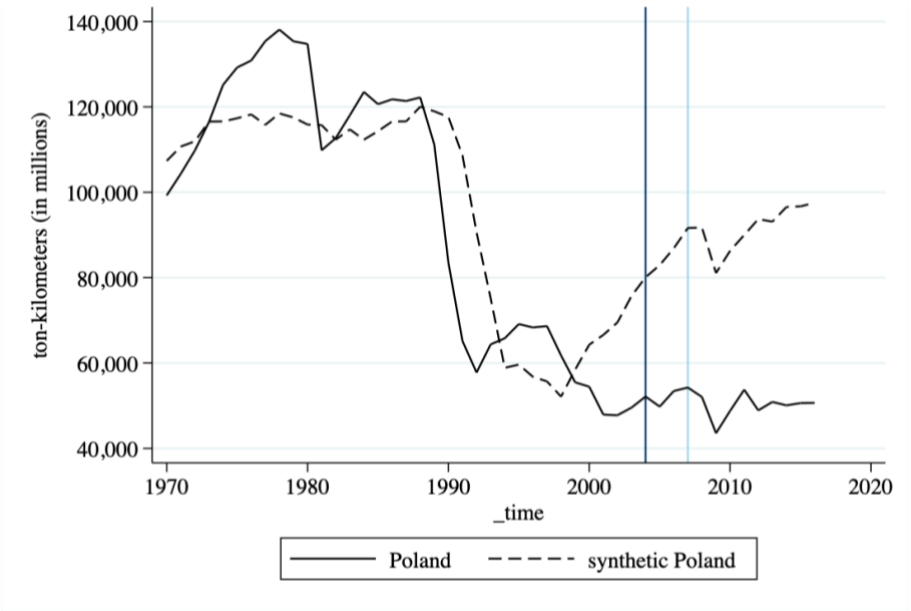

Figure 3: Treatment effects for the rail freight transport sectort; the navy-blue line indicates the treatment date and the light blue line marks 2007.

Table 9 shows that the cumulative treatment effects are negative in both the pre-2007 and post-2007 period. The expected zero effect of liberalization as established by Simola and Szekely (2007), and the expected decrease in the use of rail freight transport due to cheaper alternatives, as stipulated by Božičik (2006) and Połom and Goliszek (2007) can explain this negative net effect.[2]

5.3 Air freight transport

Algeria, Argentina, Myanmar, Panama and Turkey form the synthetic control in this analysis (Appendix E, Table 12). The most important predictor variables are the lag of the outcome variable, population size and employment (Appendix F, Table 15). Figure 4 shows the graphical representation of the treatment effects of the analysis for the air freight transport sector, the exact numbers can be found in Appendix H, Table 21. As follows from the left-hand side of the navy-blue line (the pre-treatment period), the fit of the synthetic control is not that good, but also not as bad as the one for rail. The RMSPE for this analysis is 10.46, which is not that high. Again, caution should be exercised in interpreting the results. This time, the post-intervention period is a little bit shorter than for the road and rail freight transport sector, namely until 2008

[2] Note, only a selection of the literature is mentioned. For a full overview of the literature, see Appendix A.

because of the dataset. The poor fit might again be explained by a potential breach of the Convex Hull condition as well as anticipation effects (see Chapter 6).

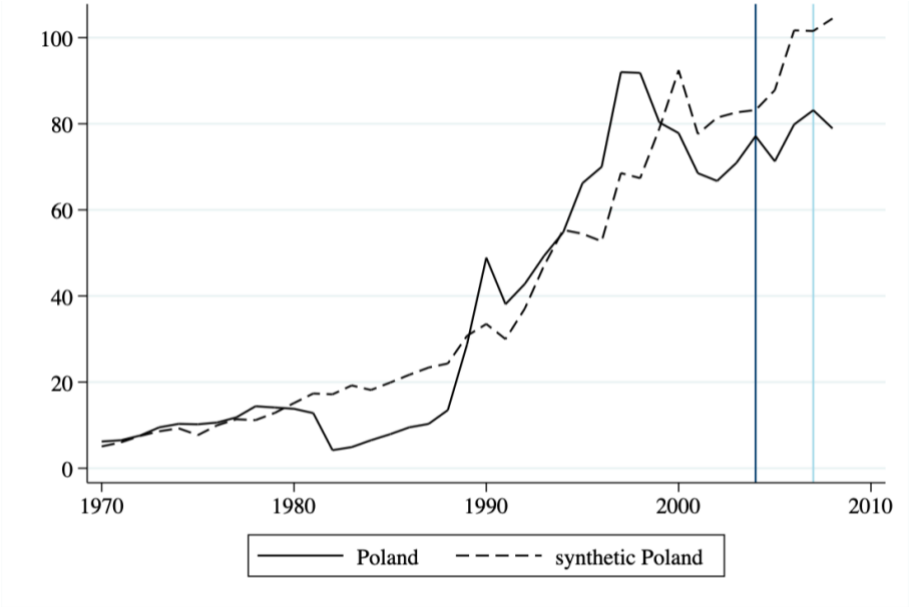

Figure 4: Treatment effects for the air freight transport sector; the navy-blue line indicates the treatment date and the light blue line marks 2007.

Based on both the pre-2007 and post-2007 periods, I conclude that the net cumulative effect of treatment is negative (Table 9). Interestingly, this is contrary to the expected increase in the literature (Caban et al., 2018; Fu et al., 2010; Hagemejer et al., 2014; Micco & Serebresky, 2006). Nevertheless, this net negative effect could be explained by dominant restricting factors as mentioned by Graham (1998), cheaper alternatives (Wąsowska, 2017) and lack of adaption (Komornicki, 2005). Moreover, the estimated net negative effect is consistent with the spatiotemporal analysis conducted by Sadowski et al. (2010).[3]

5.4 Overall effect

The three sectors are not one-to-one comparable because of sector-specific characteristics. Moreover, the reliability of the estimated synthetic controls varies. Ignoring the caveats for a moment, Table 9 shows that the overall cumulative net effect would be positive. This finding is consistent with the findings in the literature (Malkowska & Malkowski, 2021; Połom & Goliszek, 2017; Kovacs & Spens, 2006).[4] Given the possible caveats, I cautiously conclude that

[3] Note, only a selection of the literature is mentioned. For a full overview of the literature, see Appendix A.
[4] Note, only a selection of the literature is mentioned. For a full overview of the literature, see Appendix A.

the sign of the net effect of Poland's accession on its freight transport sectors is positive, but nothing can be said about the exact size.

6. Robustness analysis

In this Chapter, I conduct some additional analyses to test the robustness of the results of Chapter 5. First, the potential problem of anticipation effects is addressed by backdating the treatment as explained in paragraph 4.4. In paragraph 6.2, I discuss the results of the leave-one-out test, i.e., removing one of the donor pool countries. Lastly, SCUL (synthetic control using LASSO) is used to control for the potential violation of the Convex Hull condition.

6.1 In-time placebo tests (backdating)

6.1.1 Road

It is unlikely that Poland's accession affected road freight transport before 2004, because EU rules on customs documentation, access to the European Single Market, etc. only came into force in 2004. However, the actual approval by the European Parliament and the referendum in Poland on accession took place in 2003. The approval and referendum might have stimulated domestic transport due to expected economic growth, leading to a pre-treatment increase in road freight transport (see Appendix B, Figure 19). But it is beyond the scope of this study to distinguish between domestic transport and haulage.

If the treatment effects of the in-time placebo test are similar to the main analysis, there is no evidence of anticipation effects. Figure 5 looks almost identical to Figure 2 of the main analysis, which means that there is no evidence of anticipation effects, hence biased results.

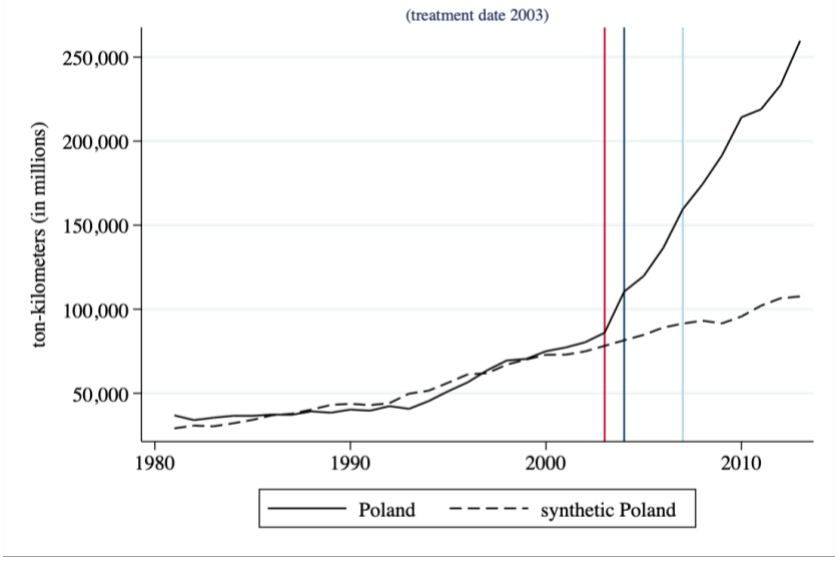

Figure 5: Treatment effects of in-time placebo test for road freight transport; the red line indicates the placebo treatment date, the navy-blue line the true treatment date and the light blue line marks 2007.

6.1.2 Rail

The large investments in rail infrastructure can explain the decrease in the use of rail transport (Połom & Goliszek, 2017; Božičik, 2006). Therefore, anticipation effects could be caused by large EU investments through the 'Agenda 2000' project, that was approved by the Polish government in 1997 (Tomaszewski, 2015). This project included investments in infrastructure. To test for these potential anticipation effects, the treatment date is backdated to 1997. Comparing Figure 6 with Figure 3 of the main analysis, the treatment effects almost look identical, which means there is again no evidence of anticipation effects.

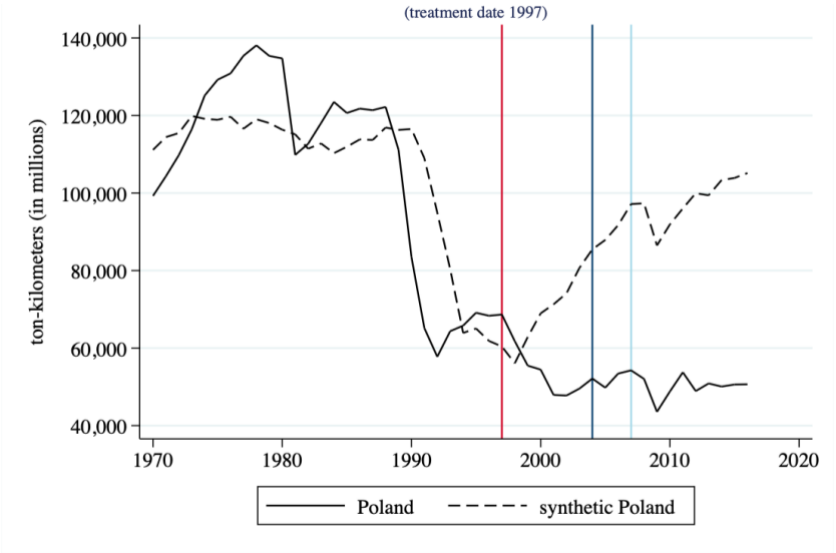

Figure 6: Treatment effects of in-time placebo test for rail freight transport; the red line indicates the placebo treatment date, the navy-blue line the true treatment date and the light blue line marks 2007.

6.1.3 Air

For the air freight sector, the same applies as for the rail freight transport sector. Therefore, the treatment date is again backdated to 1997. Comparing Figure 7 with Figure 4 of the main analysis, I conclude the positive effect is slightly larger in Figure 7, but it seems reasonable to assume that there are no anticipation effects.

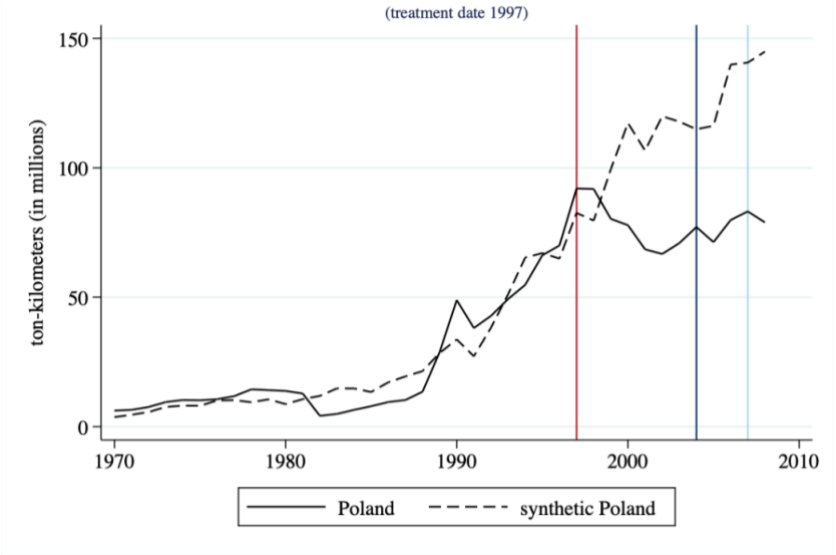

Figure 7: Treatment effects of in-time placebo test for air freight transport; the red line indicates the placebo treatment date, the navy-blue line the true treatment date and the light blue line marks 2007.

6.2 Leave-one-out

With this robustness test, I test whether the synthetic control depends too heavily on one of the donor pool countries, while that dominant country experienced an idiosyncratic shock, thus biasing the estimates (Abadie, 2021). Only the countries that were assigned weights are considered.

6.2.1 Road

Looking at Appendix C, Figure 25, it looks like a few countries faced idiosyncratic shocks. However, only Turkey is one of these countries that received a weight in the calculation (see Table 10, Appendix E). Therefore, Turkey is dropped from the dataset for the leave-one-out test.

Comparing Figure 8 with Figure 2 of the main analysis, there is no significant difference between the treatment effects. Thus, there is no evidence that Turkey dominates the synthetic control in a negative way.

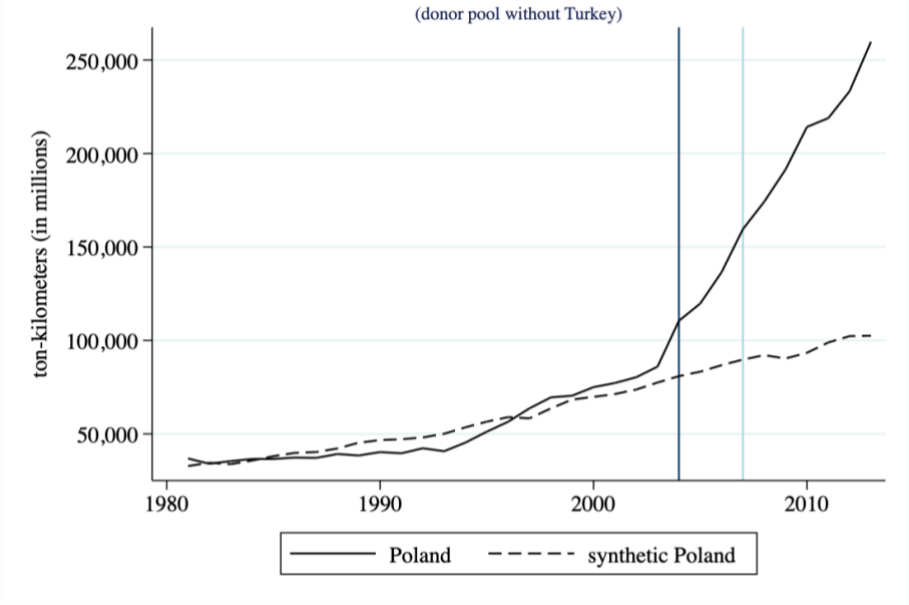

Figure 8: Treatment effects of leave-one-out placebo test for road freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.2.2 Rail

Looking at Appendix C, Figure 26, it appears a few countries in the donor pool experienced idiosyncratic shocks. Although Azerbaijan faces a similar slump around 1990 as Poland, the large shocks experienced by Russia are striking. Therefore, Russia is removed from the donor pool first. However, it is not possible to run the synthetic control without Russia, because the data are too flat. This is an indication that the synthetic control depends highly on Russia, although one cannot say that the treatment effects would be different without Russia. However, it should be noted that Russia received very little weight in the analysis (see Table 11, Appendix E). Therefore, its impact is not that large.

The second leave-one-out test is performed without Azerbaijan. However, Figure 9 looks again similar to Figure 3 of the main analysis. So, there is no evidence that Azerbaijan dominates the synthetic control in a negative way.

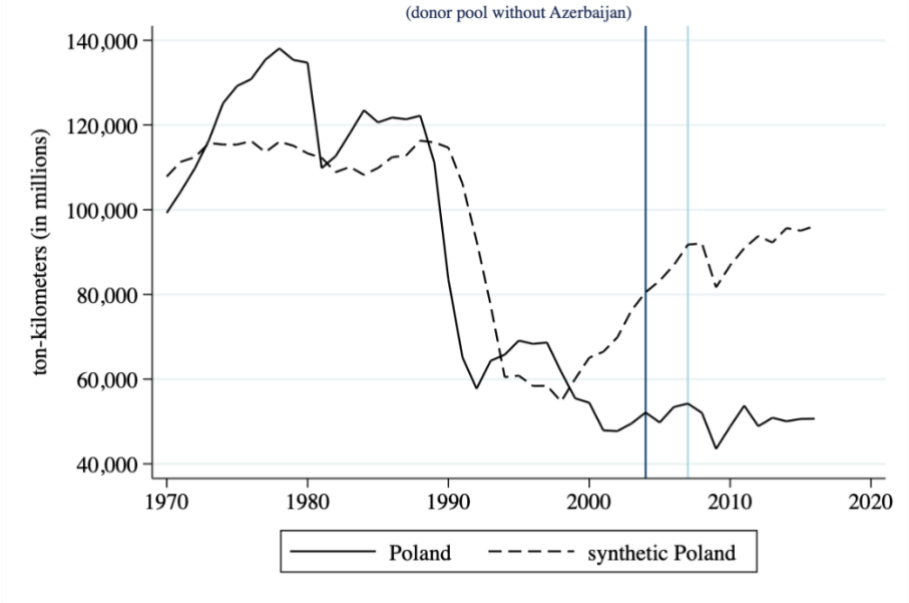

Figure 9: Treatment effects of leave-one-out placebo test for rail freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

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6.2.3 Air

Figure 27 of Appendix C indicates that a few countries experienced idiosyncratic shocks. Of these countries, only Argentina and Panama are assigned weights (see Table 12, Appendix E). Therefore, three leave-one-out tests are performed: one without Argentina (Figure 10), one without Panama (Figure 11), and one without Argentina and Panama (Figure 12). All Figures are not significantly different from Figure 4 of the main analysis, the treatment effects look only slightly larger. Thus, there is no evidence that Argentina and/or Panama negatively dominate the synthetic control.

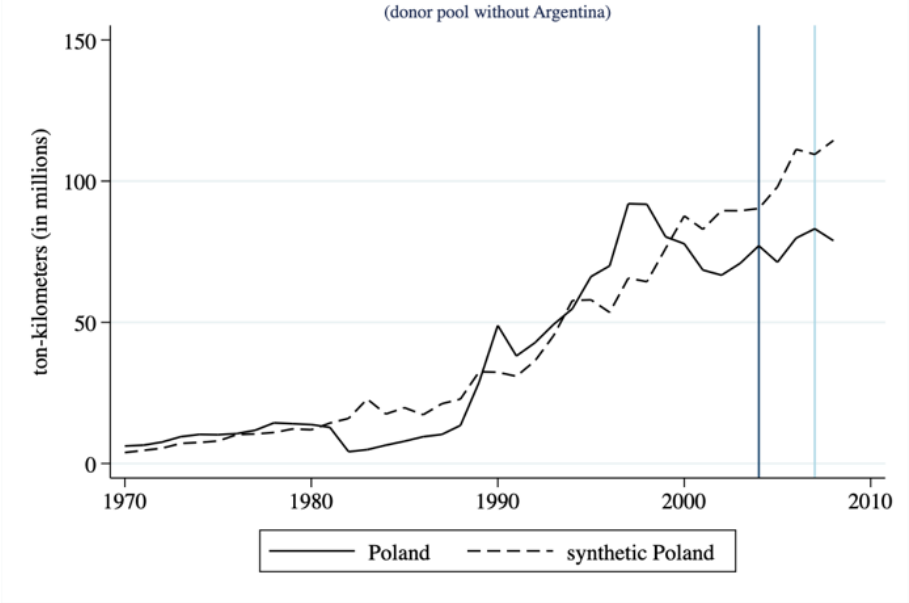

Figure 10: Treatment effects of leave-one-out placebo test for air freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

Figure 11: Treatment effects of leave-one-out placebo test for air freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

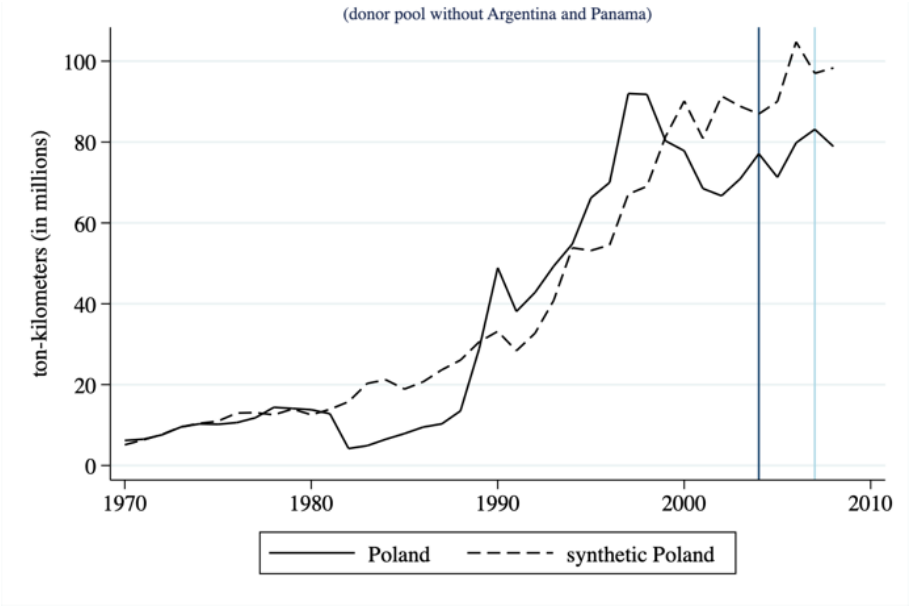

Figure 12: Treatment effects of leave-one-out placebo test for air freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.3 In-space placebo test

In this paragraph, following Abadie et al. (2010; 2015), I perform an in-space placebo test to check whether the estimated effect at the treatment date (2004) is really due to the accession of Poland or whether something more general has been going on that explains the trend in transported freight. For this test, many placebo tests are run, with each donor pool county being assigned treatment once, the other countries and Poland form the donor pool. This way, the treatment effects are estimated for each country following the procedure as described in paragraph 4.2. If the estimated treatment effects for these donor countries (the placebo tests) are not significantly different from the estimated treatment effects for Poland, it is unlikely that the estimated treatment effects are due to Poland's accession.

The treatment effect is again expressed in terms of ton-kilometers (in millions), but this time the gapfigure is provided. This means that the net effect (the difference between the actual trend in Poland and the trend of the synthetic control) is shown. Moreover, the p-value corresponding to the treatment effects is given in each graph. As before, the navy line marks the treatment date (2004) and the light blue line marks 2007.

6.3.1 Road

Figure 13 shows the results of the in-space placebo test for the road freight sector. The thick black line shows 'synthetic Poland', while the gray lines in the background show the synthetic controls for each donor pool country. As can be seen the gaps of the donor pool countries are very similar to synthetic Poland in the pre-treatment period, except for one country. However, in the post-treatment period the estimated gap for Poland is substantially larger than the gaps for the donor pool countries. This suggests that the increase in road freight transport is indeed due to Poland's accession. However, the p-value is 0.11. Conventional tests of statistical significance typically use levels of 1%, 5%, and 10%, but the results for the road freight sector are not significant at any of these levels (Abadie et al., 2010). Therefore, I cannot conclude that the estimated treatment effects can be attributed to Poland's accession.

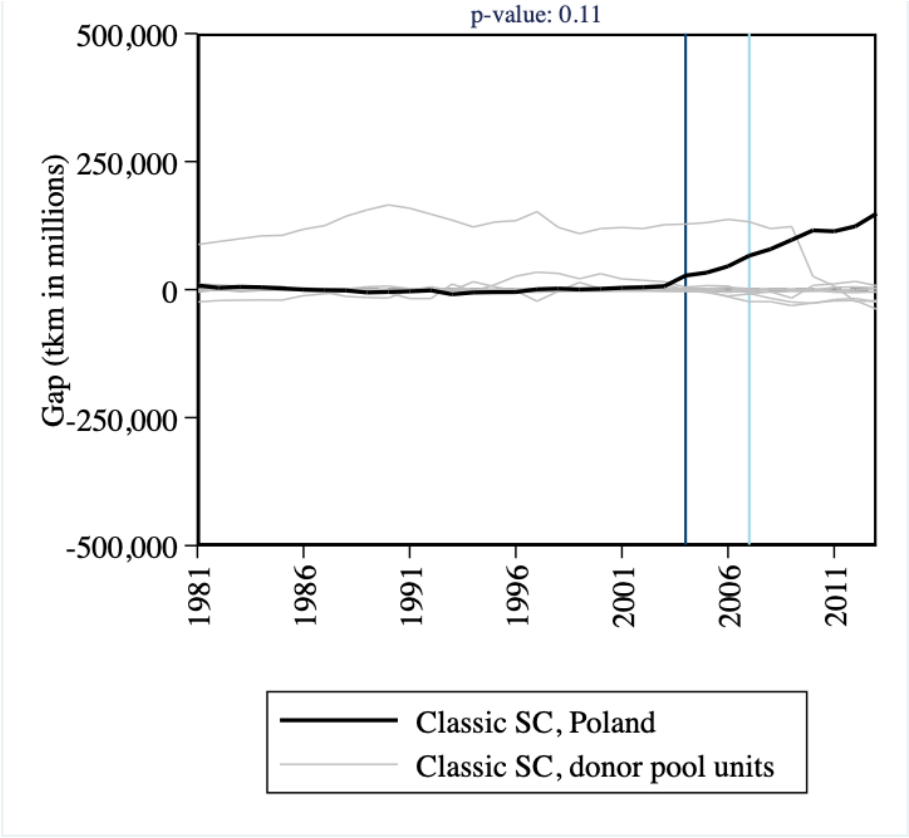

Figure 13: Gapfigure of the in-space placebo test for road freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.3.2 Rail

Figure 14 shows the results of the in-space placebo test for the rail freight sector. The pre-treatment gaps of treatment effects of synthetic Poland are very volatile, which indicates that the synthetic control is not a good fit. Nevertheless, the post-treatment treatment effects for

synthetic Poland are substantially different from the treatment effects of the placebo tests. This indicates that the estimated treatment effects are due to Poland's accession. However, the p-values for the gaps pre-2007 are 0.22 and the p-values for the gaps after 2007 are even larger. Again, the treatment effects are not significant at the 1%, 5%, or 10% significance levels. Therefore, I cannot conclude that the estimated treatment effects are due to Poland's accession.

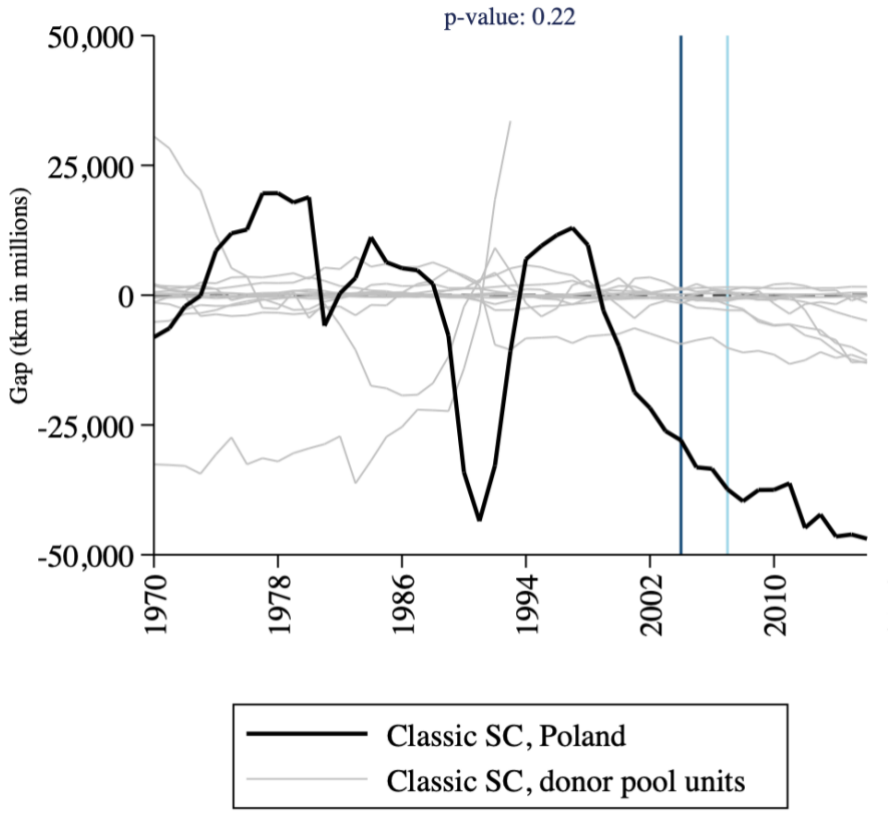

Figure 14: Gapfigure of the in-space placebo test for rail freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.3.3 Air

Figure 15 shows the results of the in-space placebo test for the air freight transport sector. The pre-treatment gaps of treatment effects for Poland are volatile, but more interesting is the fact that the placebo tests also have very volatile gaps and the treatment effects for Poland in the post-treatment period are not substantially different from them. These indications are consistent with the p-value of 0.85, which means that the results are not statistically significant at the 1%, 5%, or 10% significance levels. So, the treatment effects in the main analysis are not statistically significant, hence they cannot be interpreted.

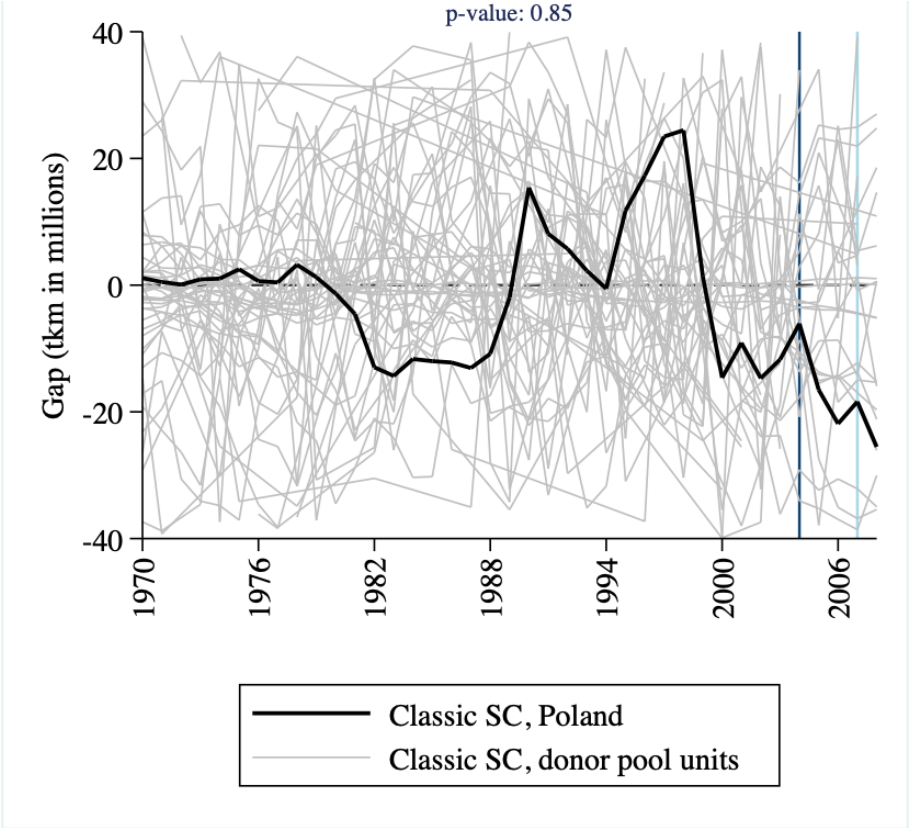

Figure 15: Gapfigure of the in-space placebo test for air freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.4 Synthetic control using LASSO

One of the limitations of the standard SCM is that it imposes additional restrictions on the weights, i.e., they should be non-negative and sum to one (Greathouse, 2022; Hollingsworth & Wing; 2020). As discussed in paragraph 4.4, this restriction is related to the Convex Hull condition. A more detailed discussion of the literature about the meaning and scale of this restriction is beyond the scope of this paper, but an alternative methodology is proposed: SCUL. SCUL constructs a synthetic control with LASSO estimators instead of OLS (Greathouse, 2022; Hollingsworth & Wing; 2020). In this context, I would like to refer to the work of Greathouse, in which he shows that SCUL is an even more accurate estimator than the standard SCM (Greathouse, 2022). In this paper, additional tests with SCUL are used to test the robustness of the signs of the estimated results and to account for the potential violation of the Convex Hull condition.

6.4.1 Road

Figure 16 shows the treatment effects using SCUL. Figure 16 is very similar to Figure 2 of the main analysis, although the synthetic control seems to fit Poland better in the pre-treatment period. In particular, the synthetic control based on SCUL fits the real trend of Poland during the 1990s better. However, one should be careful as the scale on the y-axis differs slightly from Panel A. The estimated treatment effects with SCUL are somewhat lower, but still substantially positive. This indicates that there is no violation of the Convex Hull condition, so the conditions for the SCM seem to hold for the road freight transport sector. Thus, the lack of fit of the synthetic control cannot be explained by a breach of the Convex Hull condition.

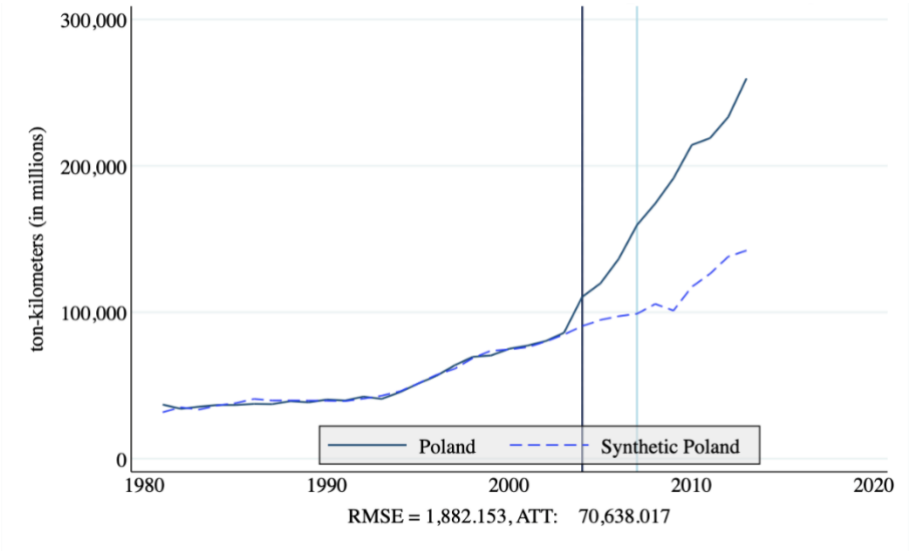

Figure 16: Treatment effects of SCUL for road freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.4.2 Rail

Figure 17 shows the treatment effects using SCUL. Again, one should be careful when comparing this figure to Figure 3 of the main analysis because of the slightly different scale on the y-axis. The graph looks very similar, although the fit of the synthetic control is still not perfect. Since the graph is similar, there is no indication that there is a breach of the Convex Hull condition in the main analysis.

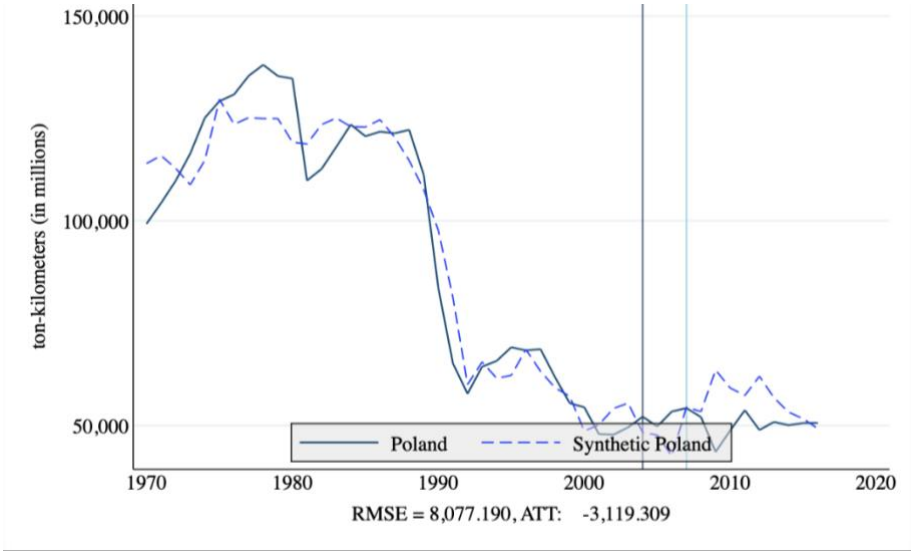

Figure 17: Treatment effects of SCUL for rail freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.4.3 Air

Figure 18 shows the treatment effects using SCUL. Although the scale on the y-axis is slightly different from the main analysis, it is noteworthy how well the synthetic control of Figure 18 fits the pre-treatment trend of Poland. This is a serious indication that the Convex Hull condition does not hold for the air freight transport sector, and thus one of the necessary conditions for the SCM is violated. Figure 18 also shows that the treatment effects of the accession are small. Therefore, one can say that the robustness of the main analysis for the air freight transport sector is very low, and one should be very careful when interpreting the results.

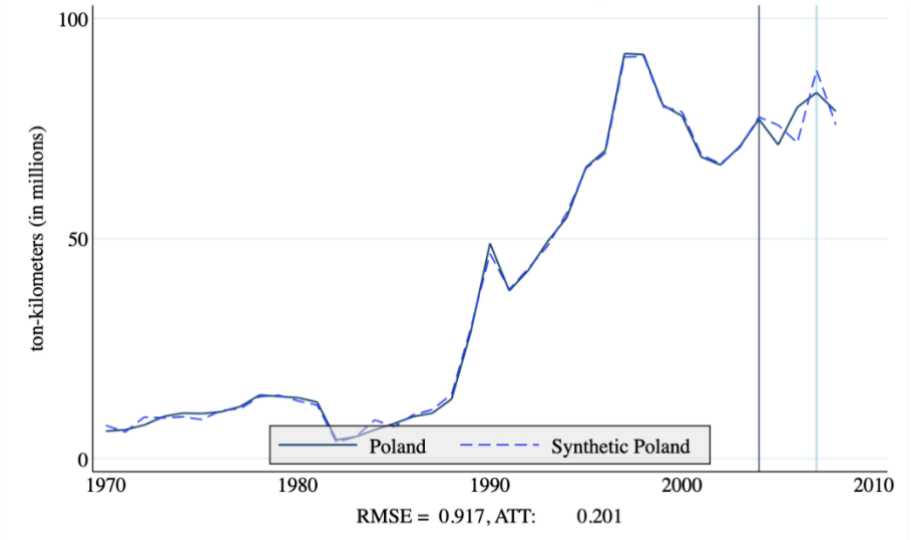

Figure 18: Treatment effects of SCUL for air freight transport; the navy-blue line marks the treatment date (2004) and the light blue line marks 2007.

6.5 Implications for the results

In this Chapter, I have tested the robustness of the results of the main analysis as presented in Chapter 5. Based on the in-time placebo tests of paragraph 6.1, I conclude that there is no evidence of anticipation effects for any of the three sectors. This means that the condition of no anticipation effects holds. The results should be robust in that respect. In paragraph 6.2 I have tested whether one of the donor pool countries, which faced idiosyncratic shocks, dominated the synthetic control of Poland, leading to biased results. This was not the case for the road and air freight transport sector. For the rail freight transport sector, it was not possible to run the main analysis without Russia, because the remaining dataset was too flat to estimate effects. This may indicate that Russia's dominance in the synthetic control biases the estimates, given the volatility of Russia's trend, even though the weight assigned is very small. However, this cannot be formally tested. Therefore, the results for the rail freight sector should be interpreted with caution.

In paragraph 6.3 I have tested whether the accession was really the main driver of the results by comparing the estimated treatment effects for Poland with the treatment effects for all placebo tests with the donor pool countries. Although the graphs indicate that the difference is driven by the accession, the p-value is not significant for all sectors. Therefore, I cannot conclude that the results of the main analysis are not significantly different from their placebos.

An additional test is performed in paragraph 6.4. From this test follows there is no evidence of a violation of the Convex Hull condition for the road and rail freight transport sectors. The additional test confirmed the results, especially the signs of the results, as estimated in the main analyses. However, this test indicates a potential breach of the Convex Hull condition for the air freight transport sector. So, I conclude that the results for the air freight sector cannot be interpreted.

7. Discussion and policy implications

This study is an attempt to estimate the effect of Poland's accession to the EU on its transport sector using SCM. The results of this study are presented in Chapter 5. Extensive robustness analyses, in particular the in-space placebo tests of paragraph 6.3, show that the results of Chapter 5 are not statistically significant. Therefore, I discuss the caveats of this study in paragraph 7.1. Despite the insignificance of the results, I do not believe that we can learn nothing from this study. Since this study contributes to the literature as a steppingstone, I provide some suggestions for follow-up research in paragraph 7.2. The estimated sign of the effects, a large positive net effect for the road freight sector and a negative net effect for the rail and air freight sector, is consistent with the literature. Therefore, I discuss some policy implications in paragraph 7.3.

7.1 Caveats

Most of the caveats of this research are related to the methodology used and the setting in which the methodology is applied. First, the SCM does not account for idiosyncratic shocks, when they are not captured by the control units and covariates (Abadie et al., 2015). Examples of these idiosyncratic shocks, which sometimes lead to structural changes in economic patterns, are the global financial crisis of 2007/2008 and the accession of Bulgaria and Romania to the EU in 2008. Dividing the post-treatment period into two periods, pre-2007 and post-2007, addresses this caveat. As discussed before, one should be very cautious when interpreting the results of the post-2007 period. The predictive power of the synthetic control declines with time after the treatment date, hence the synthetic control may become unrepresentative for the treatment group.

Second, the more general criticism that macroeconomic effects of policies should not be estimated solely with historical data, to so-called Lucas critique, also applies for this study. Accession involves many (structural) changes, which make it impossible to attain unbiased estimates. Moreover, it is not clear whether the effect is fully driven by the accession -and which part of the accession- and, for example, whether Poland is no longer part of the Soviet Union or whether other processes are at work.

Leaving aside the Lucas critique for the moment, the SCM depends heavily on the donor pool countries and predictor variables. If the composition of the donor pool changes, the synthetic control is likely to change as well. In this paper, the composition of the donor pool is based on the availability of the data for both the variable of interest and the (potential) predictor

variables. It may be that this composition is unintendedly biased by unobservable characteristics, because why are data available for these countries and not for others?

One of the reasons could be unstable institutions. This brings me to the fourth point, the reliability of the data. Although the dataset is obtained from reliable sources such as the OECD and the World Bank, the reliability of data from the Soviet era or other countries with unstable institutions is questionable. As mentioned in Chapter 4, the synthetic control requires a sufficient number of data points. Hence, there is a trade-off between the reliability of data and the number of data points, assuming that more recent data are more reliable.

For the SCM, a balanced sample is essential because the synthetic control is estimated based on all observed units in all time periods (Abadie et al., 2015). Appendix G shows substantial differences between Poland and synthetic Poland for some variables. This could lead to overfitting or ill-fitting. The trade-off between overfitting and using good predictors is challenging. On the one hand, including more variables could lead to a better fit. One could add more variables that have a greater predictive power for the outcome variable, such as the number of vehicles (trains/trucks), number of firms in the specific sectors, revenues of the sectors, and public and private investment in the sector. Furthermore, one could add more general variables, such as data on the quality of government, (transport) policies and corruption, to get a better fit of the synthetic control in a broader context than economic. Additionally, one could use quarterly data to get a better fit. On the other hand, including more variables could lead to over-fitting, resulting in biased estimates.

In this paper, I have mentioned the debate in the literature about SCUL and SCM a few times. Although this discussion itself is beyond the scope of this paper, it is worth noting that some of the caveats, such as the Convex Hull condition of the SCM, are accounted for in SCUL. Furthermore, SCUL includes techniques for calculating confidence intervals that can be used to determine whether the results are statistically significantly different from zero (Greathouse, 2022).

Lastly, I would like to make a few comments about the external validity of the results and the possibility of extrapolating the results. Obviously, accessing the EU in 2023 is totally different from accessing the EU in 2004 because of the dynamic nature of the EU itself and economic circumstances. Treatment (accessing the EU) differs from country to country. The external validity is limited because of the strong country-specific characteristics that affect both the accession process and internal markets, hence the estimated effects. Nevertheless, I believe this paper still contributes to the literature, at least in terms of its comprehensive literature review.

7.2 Suggestions for follow-up research

As I consider this paper as a steppingstone, I would like to propose some suggestions for follow-up research. First, this paper is limited to road, rail and air freight transport. Follow-up research should include transport by inland waterways and coastal shipping. Additionally, it would be interesting to distinguish between domestic transport and haulage in order to better distill the effects of the accession.

As mentioned before, the SCM is still evolving, leading to better techniques that reduce biases, such as SCUL and the bias-controlled synthetic control of Wiltshire (2022). Using these methods for the main analyses could provide better fits, and hence statistically significant results. Furthermore, the main analysis can be extended by using more prediction variables. Additionally, it would be interesting to repeat the analysis with microeconomic data, to investigate differences on company-level.

Last but definitely not least, SCM can also be used when multiple units are treated. Hence, one can repeat my analysis including all countries that joined the EU in 2004 to estimate a more general effect, which might have a higher external validity. Moreover, the research can be extended by re-running the analysis for Bulgaria and Romania in 2007. This would provide a better insight into the heterogeneity of the effects and the role of country-specific factors.

7.3 Policy implications

Because of the insignificant results, I cannot make claims based on the main analysis. However, based on the literature and trends in the data, this study shows a few things. First, it is quite difficult to measure the exact impact of an accession, because so many things are going on at the same time. This may explain why the literature is still limited. Nonetheless, the alleged impact of accession on the economy is a frequently used argument in discussions about EU enlargement, both by acceding and incumbent countries. This stresses the importance of literature to underpin arguments.

Because of the large impact of an accession, it is useful to have more case studies of the impact on specific sectors in order to make better decisions, both as incumbent country, the EU, and acceding country. Policy makers make use of cost-benefit analyses. An accurate cost-benefit analysis requires information about the potential effects. This paper shows that for rigid sectors, such as the rail freight transport sector, it is difficult to benefit from accessing the EU in the short run. This is consistent with the findings in the literature. However mixed results in the literature may lead to overly optimistic expectations due to the lack of hard data. This paper

shows that one should be cautious about relying too much on theoretical papers in policy making, because empirical evidence is lacking.

This paper only estimates net effects, which are highly sensitive to pre-treatment country-specific characteristics. Apart from the fact that the results are insignificant, one should be cautious extrapolating the results to other countries. Nevertheless, I believe the results can be used, with caution, to indicate lower or upper bounds of the effects of accessing the EU on transport sectors. In conclusion, I think this paper should be used mainly as a steppingstone and inspiration for further research on this topic. More research in this area can improve the quality of discussions, and hence decision-making, and provide evidence on the cost-effectiveness of policy interventions.

8. Conclusion

Discussions about EU enlargement are ongoing. Recently, Russia's invasion of Ukraine reignited the debate, raising questions as: Does the non-EU country benefit from the accession? What is the impact on incumbent Member States? What is the impact of accession on specific sectors, e.g. transport? This paper attempts to estimate the effect of Poland's accession to the EU in 2004 on its freight transport sector using the SCM.

Chapter 3 shows that the existing literature on the impact of EU accession on the transport sector in general is very limited. Most studies are literature-based and refer to potential effects without quantifying them. Some studies have tried to estimate the effects ex ante and some have an ex post perspective. However, in almost all cases a proper methodology or a good baseline scenario is missing. Therefore, this study tries to fill this gap in the literature with a case study on Poland.

Chapter 5 presents the results of the main analysis. The results are embedded in the existing literature, making a distinction between pre-2007 and post-2007 because of the accession of Bulgaria and Romania in 2007. A net positive effect is estimated for the road freight transport sector, while the net effect was negative for the rail and air freight transport sectors. However, the in-space placebo tests (paragraph 6.3) show that none of the results are statistically significant, because they are not statistically significantly different from the treatment effects from the placebo tests with donor pool countries. Additionally, using SCUL shows that the Convex Hull condition is unlikely to hold for the air freight transport sector, leading to biased results.

Despite the insignificant results, Chapter 7 presents lessons that can be learned from this paper. This paper should primarily be considered as a steppingstone for further research. The caveats as discussed in paragraph 7.1 and the suggestions for follow-up research in paragraph 7.2 should be seen in this context. This paper contributes to the literature by providing a comprehensive overview of the relevant literature, thereby separating the different processes involved in accessing the EU. Moreover, the framework provided in this study can be used for further research as it implements the SCM in a new setting and, as a side effect, contributes to the debate in the literature about SCM versus SCUL, although this debate is mainly beyond the scope of this paper. Regarding policy implications, this paper shows it is risky to base policy making purely on theoretical papers. The lack of empirical evidence indicates the extent of the complexity of intervention and may lead one to assume overly optimistic estimates.

Returning to the question of the title ('Is the Polish transport sector a winner or loser?'), I have to be cautious of the statistically insignificant results. Although the results are not reliable, based on the literature as well as the trends in the data, I cautiously conclude that the net effect of the accession is positive for the Polish road freight transport sector, while the net effect is negative for the rail transport sector. The effect for the air freight transport sector is unknown. Poland has some dominant country-specific characteristics that explain the results, such as the unfortunate infrastructure policies in the 1990s and the dominance of (former) state-owned companies. Given the limitations of the study, it is not possible to extrapolate or interpolate the results. Moreover, this study has a macroeconomic perspective, so the question if the Polish carriers themselves benefitted from the accession remains unanswered, but as the Poles themselves say: *Polak potrafi* ("A Pole Can", i.e. Poles will always find a way to make it work).

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Appendices

Appendix A: An overview of related literature

Appendix A.1: Overview of literature measuring effects of accessing the EU on the transport sector

Study	Topic	Data and methodology	Findings[5]
Francois (2013)	The possible effects of the accession to the EU on the Turkish transport sector	Data: - Methodology: theoretical discussion followed by a brief quantitative discussion	Because of the duration and intensity of the accession process the impact of the accession on the domestic transport sector is minimal
Gis & Waśkiewicz (2017)	Development of the Polish international (haulage) freight transport sector in the light of the EU	Data: Central Statistical Office and GITD (Polish institute for inspection of road transport) over the period 2005-2105 Methodology: descriptive analysis	Poland is one of the largest players in the world regarding haulage work, it performs more haulage transport than domestic transport. Due to the accession, both the number of companies and the number of vehicles increased between 2005-2015.

[5] Only the findings that are relevant for this study are presented.

Kovacs & Spens (2006)	The state of the transport infrastructure in Estonia, Latvia and Lithuania after their accession to the EU in 2006	Data: - Methodology: theoretical research	Although business relationships can develop apart from the transport sector, transport infrastructure is evident to make the business work; rising trade volumes and increasing freight transport are expected
Kuźnar (2008)	The effect of accessing the EU on the competitiveness of the Polish service sectors	Data: With data from the Eurostat database (since 2004) the revealed comparative advantage (RCA) index and Grubel-Lloyd index are computed Methodology: descriptive analysis + comparison of RCA index over time	The accession increased the RCA in some sectors. This lead to more specialization, conversely competition with other EU members increased. Especially the transport sector specialized due to the accession.
Lejour, Mervar & Verweij (2009)	The economic implications of Croatia's possible accession to the EU on the internal market	Data: GTAP database used, 2001 is used as base year Methodology: WorldScan Model (CGE model on world-level); assumptions: a theoretical baseline scenario with a yearly	The EU economy would hardly be affected. The effect on the transport services sector would be negative (-0.2% decrease of production within the sector).

		GDP growth rate of 4.3%; year of treatment (accession) is 2009, was in fact 2015	Due to the accession Croatia will increase her position on the Corruption Perceptions Index which leads to an increase of transport services of 11%.
Malkowska & Malkowski (2021)	Transport services in Polish foreign trade with EU countries and the role of these services in Polish economy	Data: For four types of transport (maritime, air, other transport services, postal and courier services) data is collected over the period 2010-2018 from official statistics National Bank of Poland and Central Statistical Office. Methodology: critical analysis of source literature, analysis of secondary data, graphic methods	Between 2010 and 2018 the Polish export and import of transport services rose substantially in which the role of EU countries was significant and increasing. The accession of Poland to the EU market is considered as the main determinant for this increase.
Połom & Goliszek (2017)	Transport in Poland during the period of accession to the EU	Data: For four types of transport (road, rail, inland waterways and air transport) over the period 2005-2015 (no data source mentioned) Methodology: descriptive analysis	Accessing to the EU had a significant positive impact on the Polish transport and logistics sector, from which the most significant effects are: 1) threefold increase in road performance;

			300% increase in passenger traffic at Polish airports; almost fivefold increase in number of containers in intermodal railway transport; sixfold increase in container transshipment in sea ports. Moreover, the accession made it possible to invest intensively in transport infrastructure, which led to saver transport.

NOTE: *Column (1) shows the reference of the study, column (2) the topic of the study, column (3) the used data and methodology in the study, column (4) the relevant findings and conclusions for this study.*

Appendix A.2: Relevant literature on the road freight sector

Type of consequence	**Positive / Negative effects[6]**	**Study**	**Data and methodology**
Liberalization	Increase business entry rates	Boylaud & Nicoletti (2001); Mačiulis, Vasiliauskas, & Jakubauskas (2009)	Literature review (scope: whole world); descriptive analysis with data from Eurostat for Lithuania over the period 2003-2007 (effects are measured in euros and share in GDP)

[6] Only the findings that are relevant for this study are presented.

Liberalization	Decrease prices	Boylaud & Nicoletti (2001)	Literature review (scope: whole world)
Liberalization	Increase service quality amongst others by improved competition, increased business contracts and increased development of transport	Boylaud & Nicoletti (2001); Mačiulis, Vasiliauskas, & Jakubauskas (2009)	Literature review (scope: whole world); descriptive analysis with data from Eurostat for Lithuania over the period 2003-2007 (effects are measured in euros and share in GDP)
Liberalization	Stimulation of innovation which encourages firms to improve their services which leads to a specialized and sophisticated transport services	Boylaud & Nicoletti (2001); Mačiulis, Vasiliauskas, & Jakubauskas (2009)	Literature review (scope: whole world); descriptive analysis with data from Eurostat for Lithuania over the period 2003-2007 (effects are measured in euros and share in GDP)
Liberalization	No evidence for destructive competition, instability and/or reduction in safety standards	Boylaud & Nicoletti (2001); McKinnon (1998)	Literature review (scope: whole world); literature review (scope: EU)
Liberalization	Increase of annual growth rates of in commercial (international) road freight transport (in the EU)	Belzer & Thörnquist (2020); Lafontaine & Valeri (2008)	Literature review (scope: US and EU); Fixed effects model and first-difference regressions, data from Eurostat for 12 countries that were member of the EU before 1990 over the period 1982-2002
Liberalization	Haulage transport increased significantly, dominating both international and domestic transports (in the EU)	Belzer & Thörnquist (2020); Sternberg, Hofmann, & Overstreet (2020)	Literature review (scope: US and EU)
Liberalization	Transport rates declined due to productivity gains and increased competition (in the EU)	Belzer & Thörnquist (2020)	Literature review (scope: US and EU)

Liberalization	Large companies gained strong market positions (in the EU)	Belzer & Thörnquist (2020)	Literature review (scope: US and EU)
Liberalization	Small carriers and owner-drivers were able to enter the market (in the EU)	Belzer & Thörnquist (2020)	Literature review (scope: US and EU)
Liberalization	Social and economic arbitrage between Western and Central and Eastern European countries. This worsened the working conditions in these countries.	Belzer & Thörnquist (2020); Hilal (2008)	Literature review (scope: US and EU); Literature review (scope: EU)
Liberalization	Increase in outsourcing of transport services from Western European countries towards Central and Eastern European countries	Lafontaine & Valeri (2008)	Fixed effects model and first-difference regressions, data from Eurostat for 12 countries that were member of the EU before 1990 over the period 1982-2002
Liberalization	Liberalization of the service market only leads to minimal welfare gains for Poland	Hagemejer et al. (2014); Lafontaine & Valeri (2008)	Revealed comparative advantage analysis and a GTAP model using the GTAP database; Fixed effects model and first-difference regressions, data from Eurostat for 12 countries that were member of the EU before 1990 over the period 1982-2002
Liberalization	Increase in trade (an 1.6% increase in output for the road freight transport market in the most optimistic scenario according to Hagemejer et al., 2014)	Belzer & Thörnquist (2020); Hagemejer et al. (2014); Lafontaine & Valeri (2008)	Literature review (scope: US and EU); Revealed comparative advantage analysis and a GTAP model using the GTAP database; Fixed effects model and first-difference regressions, data from Eurostat for 12

			countries that were member of the EU before 1990 over the period 1982-2002
EU legislation	An increase of regulations in the road haulage market negatively impacts the business success of small transport companies and companies from the periphery region of the EU; mostly because of regulation regarding labor circumstances and limiting cabotage	Borkowski and Bąk (2018)	Qualitative research using modified Likert scales for evaluation (scope: core versus periphery countries in the EU)
EU legislation	Polish road carriers were able to comply with most of the EU regulations during the transition period, and are still operating cost-competitive	Platje (2006)	Literature review (scope: Poland and Germany)
EU funds	EU funds and projects have some major drawbacks: i) they are limited to a range of projects, ii) political criteria dominate economic criteria, iii) they lead to mistrust of private investors, iv) the procedures to get access to these funds are complex and cost-absorbency, v) they lack balance among priorities of European and regional	Marciszewska (2007)	Literature review (scope: Poland)

	projects, vi) lack of innovative financial solutions and vii) the large number of funds leads to uneasy access because of complicated infrastructure.		
EU funds	Poor road infrastructure discouraged foreign direct investments, hindered international trade and decreased the mobility of freight	Musiał-Malago (2005)	Literature review and descriptive analysis over period 2000-2003 with data from the Polish statistical office
EU funds	A positive effect of the investments on territorial cohesion on the international level, but on the national level there is no effect. Nevertheless, a framework for a modern road network has been established The EU funds were mostly used to improve the general efficiency of the road infrastructure, however the impact of the EU funds is mainly visible in regions with high population density and provinces which are part of the Operational Programme Development of Eastern Poland	Rosik et al. (2015)	Empirical analysis on different geographical levels using a potential model with municipal data

EU funds	No effect of the investments on accessibility on national level	Rokicki et al. (2021)	Reginal dynamic CGE model using municipal data on investment spending and accessibility improvement over the years 2005-2015
European Single Market	Both the number of companies and the number of vehicles increased because of the accession	Gis & Waśkiewicz (2017)	Descriptive analysis over 2005-2015 with data from the Central Statistical Office and GITD (Polish institute for inspection of road transport).
European Single Market	Poland is cost-competitive on the European market and therefore able to compete with countries like Germany. Moreover, Platje (2006) expects that Poland in the upcoming years would even be able to further decrease the costs due to increased labor productivity, no border controls, liberalization of haulage and investments in better quality trucks and equipment.	Platje (2006)	Literature review (scope: Poland and Germany)

NOTE: *Column (1) shows to which of the four consequences the findings are related, column (2) the estimated positive or negative effect, column (3) the reference of the study, and column (4) the used data and methodology in the study.*

Appendix A.3: Relevant literature on the rail freight sector

Type of consequence	Positive / Negative effects[7]	Study	Data and methodology
Liberalization	Large former state-owned firms might push out smaller private rail operators because of their main market share and lack of entry barriers	Eisenkopf (2006); Laisi (2011)	Economic assessment; Qualitative analysis and descriptive analytical approach
Liberalization	Increase efficiency	Eisenkopf (2006); Mäkitalo (2011)	Economic assessment; Quantitative scenario analysis (scope: Finland & Russia)
Liberalization	Decrease prices	Eisenkopf (2006); Mäkitalo (2011)	Economic assessment; Quantitative scenario analysis (scope: Finland & Russia)
Liberalization	Increase intermodal and intramodal competition, though Eisenkopf (2006) expects a positive net effect	Eisenkopf (2006)	Economic assessment
Liberalization	Liberalization does not automatically lead to more competition because of exogenous entry barriers (such as significant necessary investments, acquisition of rolling stock and bureaucracy). In countries with a history of	Laisi (2011)	Qualitative analysis and descriptive analytical approach

[7] Only the findings that are relevant for this study are presented.

	state-planned economies former monopoly companies are an entry barrier as well		
Liberalization	No effect of liberalization, probably due to the larger negative effect of globalization on the rail freight sector	Simola & Szekely (2007)	Quantitative (descriptive) analysis and qualitative analysis with UIC data and interviews (scope: Germany and Hungary)
Liberalization	Liberalization has positive effects on the performance in the long-term but several problems in the short- and medium-term. Note: this study lacks a good baseline scenario, so be cautious with interpreting the results	Hilmola et al. (2007)	Literature and second-hand quantitative analyses based on countries that adopted liberalization or privatization earlier
Liberalization	Liberalization increased costs in the short-term, but costs decreased in the long term. The net effect is a decrease of costs	Jensen & Stelling (2007)	Longitudinal econometric model, with data from officials statistics published by SJ, BV and SIKA over the period 1970-1999 (scope: UK, Germany and Sweden)
Liberalization	Negative correlation between the degree of regulation and the share of rail freight transport, i.e. the more liberalized the higher the share of rail freight transport	Esposito, Cicatello, & Ercolano (2020)	Empirical assessment using fixed effects in a Policy Framework Reform model with data from the OECD over the period 1993-2013
Liberalization	The size of the effects varies significantly between countries	Profillidis (2004)	Literature review (scope: UK, Germany and USA)

EU legislation	17% of the difference in rail freight transport usage between the USA and Europe can be explained by the difference in public policies	Vasallo & Fagan (2007)	Step-by-step calculation of changing transportation volumes with data form Eurostat and Rebbie Associates' Transearch Database and US Census of Transportation
EU legislation	Countries implement directives in different manners at different times, which creates heterogeneity, neglects possible side effects and removes both soft and hard entry barriers creating a negative effect on the market	Jarzembowski (2006); Kircher (2006)	Economic assessment (scope: EU); Economic assessment (scope: EU)
EU legislation	Some Member States must still create a legal framework for the establishment of a European Single Market	European Commission (2006)	Report
EU legislation	The incumbent railway operators were not able to compete and accumulate sufficient working capital, the negative economic consequences were significant and state interventions were required, reason why the former state-owned companies still dominate the market	Tomeš (2012); Ludvigsen (2009)	Literature review (scope: Central European countries); Used the empirical findings of the European research project REORIENT

EU funds	Construction and maintenance projects decreased the average speed of trains and leads to hindrance which make the Polish railway infrastructure less attractive. Moreover, the lack of standardization of the railway sector makes road freight a more attracting alternative	Połom and Goliszek (2017) & Božičik (2006)	Descriptive analysis for 4 types of transport over the period 2005-2015; Literature review
EU funds	Positive effect of investments on the development of the railway infrastructure	Gricer et al. (2021)	Survey over the period 2014-2020, held in April 2020, 100 respondents
European Single Market	Due to ESM services fit better to the customer's needs and it is an opportunity to compete with road freight sector. Not only liberalization is needed, but also investment in infrastructure and creation of a level playing field between various transport modes by fair infrastructure pricing. The ESM offers the unique opportunity to internalize the costs of externalities such as congestion, air pollution, noise, accidents, etc.	Ludewig (2006)	Economic assessment

NOTE: *Column (1) shows to which of the four consequences the findings are related, column (2) the estimated positive or negative effect, column (3) the reference of the study, and column (4) the used data and methodology in the study.*

Appendix A.4: Relevant literature on air freight transport

Type of consequence	Positive / Negative effects[8]	Study	Data and methodology
Liberalization	Establishment of new (low-cost) carriers which increase the competition and eventually reduce the costs of aviation	Neiberger (2008); Reynolds-Feighan (1991); Wąsowska (2017)	Experts interviews in 2003/2004 with 60 air freight companies; Literature review (scope: USA); Literature review (scope: 2005-2015)
Liberalization	Gains in airport accessibility due to increased connectivity in the intermodal transportation network	Fu et al. (2010); Neiberger (2008); Reynolds-Feighan (1991); Wąsowska (2017)	Literature review; Experts interviews in 2003/2004 with 60 air freight companies; Literature review (scope: USA); Literature review (scope: 2005-2015)
Liberalization	Financial and technical efficiency increase, resulting in the increase of the quality of aviation services	Augustyiak et al. (2015); Wąsowska (2017)	Two-stage PCA–DEA with data from Germany and Poland from 2000-2010 from private dataset; Literature review (scope: USA)
Liberalization	Substantial economic and traffic growth, because of increased competition and price reductions	Fu et al. (2010)	Literature review
Liberalization	No proof for destructive or excessive competition	Fu et al. (2010)	Literature review
Liberalization	Positive effect on the general economy by offering job opportunities, stimulating	Fu et al (2010)	Literature review

[8] Only the findings that are relevant for this study are presented.

	trade, and increasing the quality of transport and logistics services		
Liberalization	There is a two-way relationship between low-cost carriers and liberalization (low-cost carriers enhance traffic growth, which increases the need for liberalization; a high degree of regulation hinders the growth of low-cost carriers)	Fu et al. 2010)	Literature review
Liberalization	The impact of liberalization is restricted by factors such as geography of population, production, urbanization, and wealth. This explains why the airport of Warsaw benefitted most of the accession to the EU (Barczak, 2019).	Graham (1998)	Literature review
Liberalization	In the most optimistic scenario of full liberalization of services the Polish air transport sector would get the largest boost in output with an increase of 5.6%.	Hagemejer et al. (2014)	Fixed effects model and first-difference regressions, data from Eurostat for 12 countries that were member of the EU before 1990 over the period 1982-2002
Liberalization	The air freight transport sector in Poland between 2010-2018 grew with a slower pace than road, rail and sea transport did	Sadowski et al. (2020)	Spatiotemporal analysis

EU legislation	More competition (of low cost) carriers, better quality, higher efficiency, lower aviation costs and price cuts. Still little development, because of cheaper transport modes (road and rail)	Wąsowska (2017)	Literature review (scope: 2005-2015)
EU legislation	Increased number of environmental regulations which will change the industry	Laitinen (2002)	Literature review
EU legislation	Lack of adoptability to the new socio-economic and political situation by the institutional infrastructure is the main reason why the poor infrastructure is the main barrier for further economic growth in Poland	Komornicki (2005)	Literature review
EU funds	The problems mentioned by Marciszewska (see appendix A.2) were for the air transport sector exacerbated by the need of i) continuous investment in modernization and expansion of air transport infrastructure, ii) the necessity of the implementation of Polish airports in an intermodal transport network and iii) the	Marciszewska (2007)	Literature review

	necessary growth of the infrastructure to meet the increasing demand for air freight transport. Proposed solution: change the Polish law system to allow for public-private partnerships and investments by (local) governments. EU funds can be spent more optimally by substituting part of it by government's and/or private capital.		
European Single Market	Open skies agreements in the United States decreased of air transport costs with 9% and increased imports of air transport with 7%	Micco & Serebrisky (2006)	Empirical analysis (standard reduced form approach) with data form the Aviation and International Affairs of the U.S. Department of Transportation (1990-2003)
European Single Market	The number of operators would decrease to a maximum of five of which two or three would be low-cost carriers because of the competition based on prices	Mason & Alamdari (2007)	Delphi panel (26 experts) and secondary research (43% response rate)
European Single Market	ESM would lead to oligopoly in air freight sector	Laitinen (2002)	Literature review
European Single Market	Despite the competition, especially from Berlin and Vienna, due to access to the ESM, the Polish air freight sector has	Komornicki (2005); Caban et al. (2018); Pisarek (2009)	Literature review; Descriptive analysis with data from the Polish Civil Aviation Office and International

	increased over the period 2000-2007. The largest airports reported larger traffic density and regional airports reported an increase in air freight transport		Civil Aviation Organization (2000-2017); Descriptive analysis based on ULC data
European Single Market	Innovation is encouraged which led to new companies (competition increased). Poland could make use of its high market potential for air transport services: Poland faced one of the highest increases in traffic movements in the EU	Pisarek (2009)	

NOTE: *Column (1) shows to which of the four consequences the findings are related, column (2) the estimated positive or negative effect, column (3) the reference of the study, and column (4) the used data and methodology in the study.*

Appendix B: Trends of transported freight by Poland

The graphs in this appendix show the trend of freight transported for each transport mode. These graphs are used to check whether the SCM is applicable to this study. In particular, the second requirement of no anticipation effects must be examined. Therefore, the years 1994, 1997, 1998 and 2003 are marked for better readability.

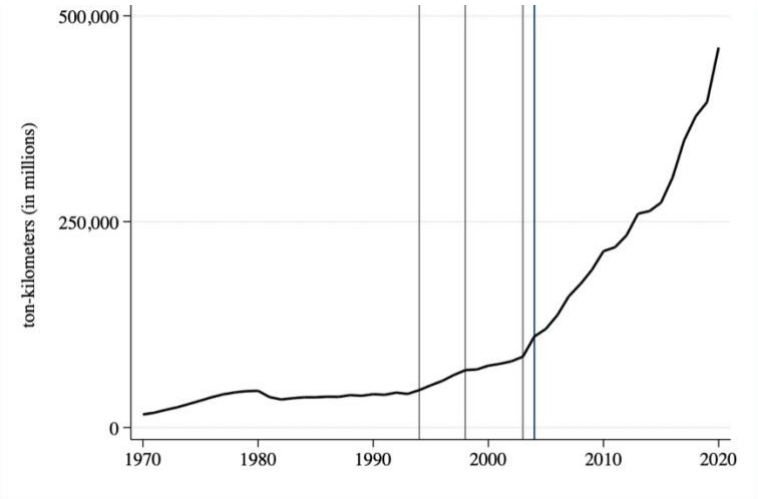

Figure 19: Transported road freight by Polish carriers between 1970-2020 expressed in tkm. The navy-blue line indicates the treatment date, the gray lines mark 1994, 1998 and 2003.

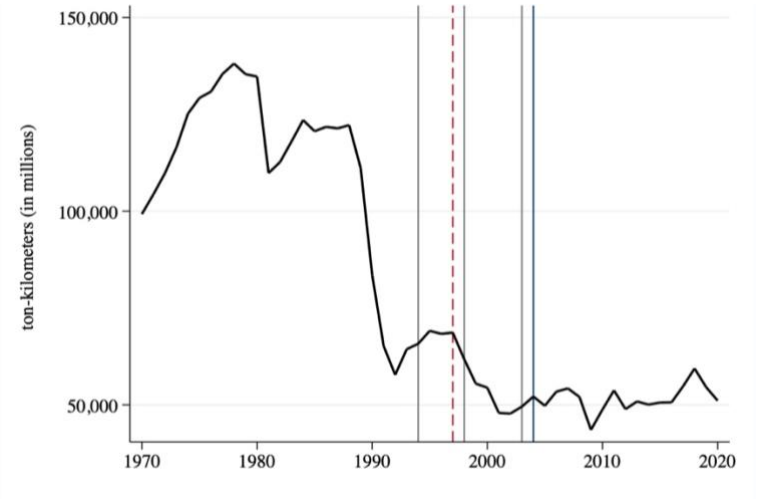

Figure 20: Transported rail freight by Polish carriers between 1970-2020 expressed in tkm. The navy-blue line indicates the treatment date, the gray lines mark 1994, 1998 and 2003. The dashed red line marks 1997.

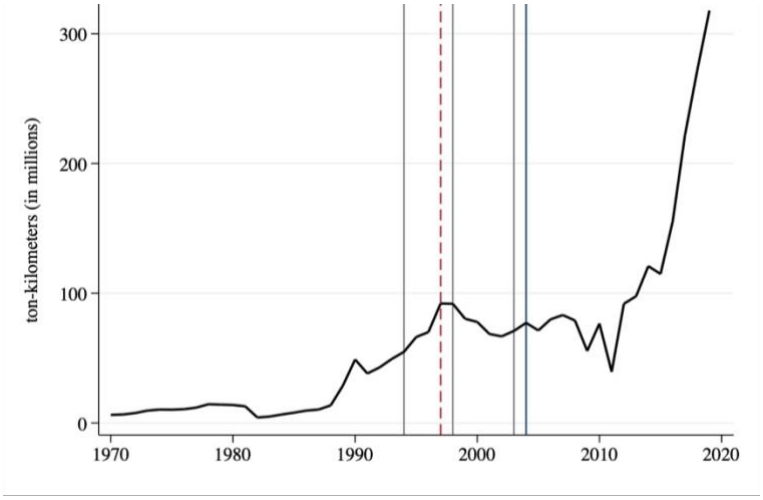

Figure 21: Transported air freight by Polish carriers between 1970-2020 expressed in tkm. The navy-blue line indicates the treatment date, the gray lines mark 1994, 1998 and 2003. The dashed red line marks 1997.

Appendix C: Trends in freight

The graphs in this Appendix show the trends of both Poland and the full dataset or the subset used as donor pool countries for each transport sector.

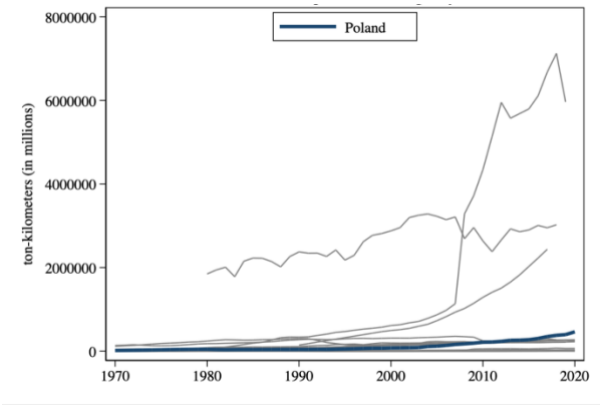

Figure 22: Trends in transported road freight; full dataset

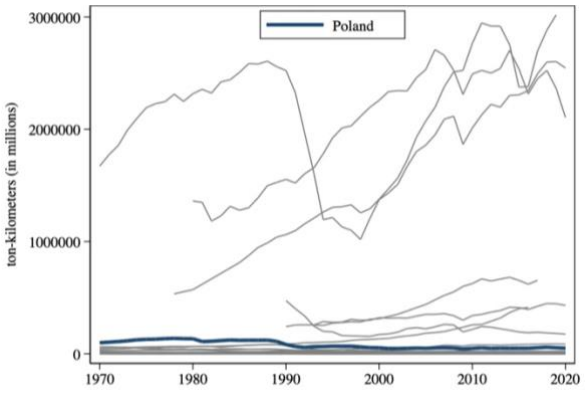

Figure 23: Trends in transported rail freight; full dataset

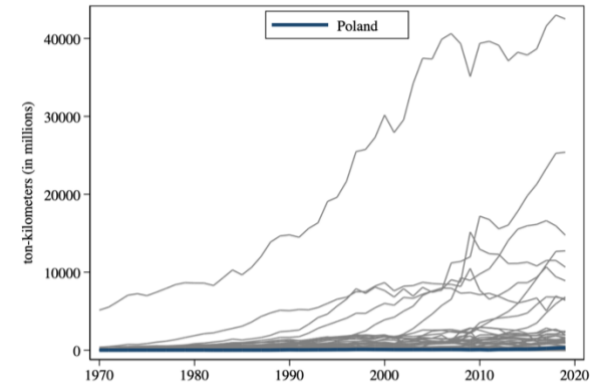

Figure 24:Trends in transported air freight; full dataset

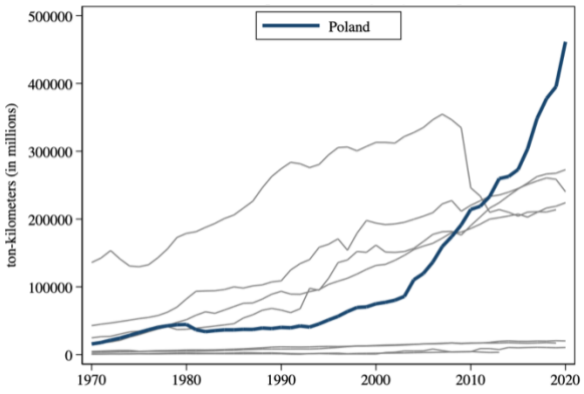

Figure 25: Trends in transported road freight; donor pool countries

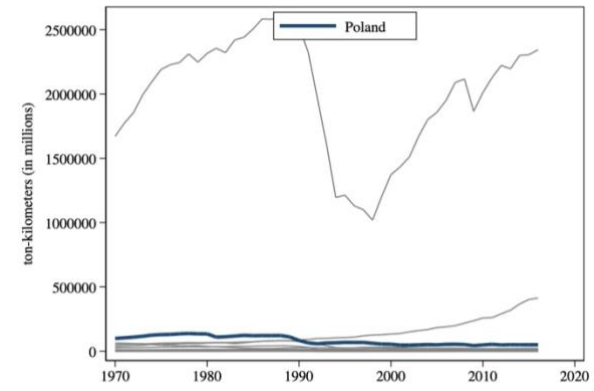

Figure 26: Trends in transported rail freight; donor pool countries

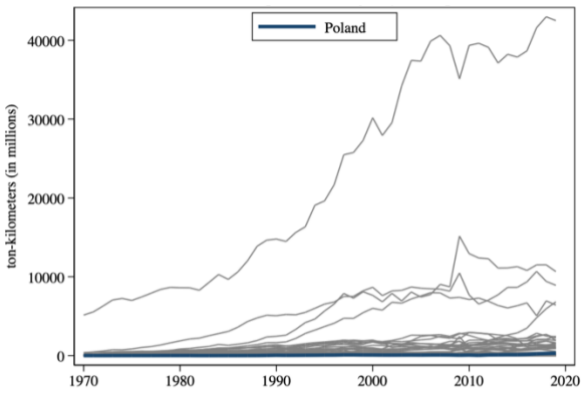

Figure 27: Trends in transported air freight; donor pool countries

Appendix D: Definitions of the variables

Variable	Definition	Unit	Source
Ton-kilometers	The number of freight transported by air measured in transported weight (tons) times transported distance (kilometers)	In millions	WorldBank
Ton-kilometers	The number of freight transport by road or rail in transported weight (tons) times transported distance (kilometers)	In millions	OECD
Population size	The total population in a country, including all residents regardless of their legal status or citizenship; midyear estimates.	Number	WorldBank
CO2 emissions (general)	CO2 emissions from the whole economy	Million tons	Global Carbon Project (Friedlingstein et al., 2021; Andrew and Peters, 2021; Global Carbon Project, 2021)
CO2 emissions from transport	CO2 emissions from the combustion of fuel for all transport activity except for international marine bunkers and international aviation.	Million tons	WorldBank (IEA statistics)
Transport services	Transport services (% of commercial service exports) covers all transport services (sea, air, land, internal waterway, space, and pipeline) performed by one economy for another.	% of commercial service exports/imports	WorldBank
Transport services	This one covers all transport services (sea, air, land, internal waterway, pipeline, space and electricity transmission) performed by one economy for another.	% of services export/import	WorldBank/IMF (via BOPS)
Total exports/imports	Exports/imports of goods and services represent the value of all goods and other market services	% of GDP	WorldBank

	provided to the rest of the world, including the transport of freight.		
Air transport registered carrier departures worldwide	Registered carrier departures worldwide are the number of domestic takeoffs and takeoffs abroad of air carriers registered in the country.	Number	WorldBank
GDP per capita	Gross Domestic Product (GDP) is expressed in current U.S. dollars per person. First the GDP in the national currency are converted to US dollars, thereafter it is divided by its total population. (calculation is performed by IMF)	Current US$ (April 2022)	IMF
Regulation in transport	This indicator measures the degree to which policies promote or inhibit competition in seven sectors, from which relevant: air, rail and road. Based on a questionnaire and reformed to score using a schemata. It is an average of regulations regarding entry, public ownership, market structure and vertical regulations.	Score between [1,6]	OECD
Rails	Number of kilometers of railway in a country	Km	WorldBank (via UIC)
Road investment	The investment in euros (2022) in road infrastructure by both public and private financial sources	Euros (2022)	OECD (ITF)
Fuel deliveries	Total motor fuel deliveries to the road sector	Million tons	OECD (ITF)
First registration of new vehicles	Number of first registrations of new vehicles for freight transport by road in a country	Number	OECD (ITF)
Airport infrastructure investment	The investment in euros (2022) in airport infrastructure of all sources of financing (both public and private)	Euros (2022)	OECD (ITF)
Rail infrastructure investment	The investment in euros (2022) in airport infrastructure of all sources of financing (both public and private)	Euros (2022)	OECD (ITF)

Share railway/road in total inland freight transport	Share of rail/road freight transport in total inland freight transport	Percentage	OECD (ITF)
Density of road/rail	The density of road/rail measured by dividing total length by surface of the country	Km per one hundred squared kilometers	OECD (ITF)
Share of value added by transport sector	Contribution of the transport sector to GDP of a country	Percentage	OECD (ITF)
Total value of export	The aggregated value of export, reported on free on board (FOB) basis	US Dollars, millions	IMF
Total value of import	The aggregated value of import, reported on cost, insurance and freight basis	US Dollars, millions	IMF
FDI (Foreign Direct Investment)	FDI refers to direct investment equity inflows, which is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment.	Current US dollars	Worldbank
Employment	Number of people working in formal sectors	In millions	Penn World Table
Capital stock	Capital stock	Current PPPs (in mil. 2017US$)	Penn World Table
Price level of exports	Price level of exports	Price level of USA GDP (in 2017US$)	Penn World Table
Price level of imports	Price level of imports	Price level of USA GDP (in 2017US$)	Penn World Table

NOTE: This table provides the definitions of the variables used for the analyses. Column (1) provides the name of the variable, column (2) the definition, column (3) the unit in which the variable is measured, and column (4) the source from which the data is derived.

Appendix E: weights of donor pool countries

Table 10: Weights given to countries in donor pool in the main analysis of the road freight sector

Donor pool country	Unit weight	Donor pool country	Unit weight
Albania	0	North Macedonia	0.489
Australia	0.336	Norway	0
Japan	0	Switzerland	0
Mexico	0.022	Turkey	0.153

NOTE: Column (1) provides the name of the donor pool country, column (2) the weight which is assigned to this country by constructing the synthetic control.

Table 11: Weights given to countries in donor pool in the main analysis of the rail freight sector

Donor pool country	Unit weight	Donor pool country	Unit weight
Albania	0	Korea	0
Australia	0	North Macedonia	0
Azerbaijan	0.312	Norway	0
Belarus	0	Russia	0.035
Bosnia-Herzegovina	0	Switzerland	0
Georgia	0	Turkey	0
Japan	0.653		

NOTE: Column (1) provides the name of the donor pool country, column (2) the weight which is assigned to this country by constructing the synthetic control.

Table 12: Weights given to countries in donor pool in the main analysis of the air freight sector

Donor pool country	Unit weight	Donor pool country	Unit weight	Donor pool country	Unit weight
Algeria	0.14	Japan	0	Saudi Arabia	0
Argentina	0.05	Jordan	0	Singapore	0
Australia	0	Kenya	0	South Africa	0
Bolivia	0	Korea	0	Sri Lanka	0
Brazil	0	Kuwait	0	Sudan	0
Cameroon	0	Lao PDR	0	Switzerland	0
Canada	0	Lebanon	0	Tanzania	0
Chile	0	Madagascar	0	Thailand	0
Colombia	0	Malawi	0	Trinidad and Tobago	0
Costa Rica	0	Malaysia	0	Tunisia	0
Ecuador	0	Mexico	0	Turkey	0.19
Egypt	0	Morocco	0	Unites States	0
El Salvador	0	Myanmar	0.57		
Ethiopia	0	Nepal	0		
Iceland	0	New Zealand	0		
India	0	Nigeria	0		
Indonesia	0	Pakistan	0		
Iran	0	Panama	0.04		
Israel	0	Peru	0		
Jamaica	0	Philippines	0		

NOTE: Column (1) provides the name of the donor pool country, column (2) the weight which is assigned to this country by constructing the synthetic control.

Appendix F: weights of predictor variables

Table 13: Weights given to predictor variables in the main analysis of the road freight sector

Predictor variable	Unit weight
Lag of road tkm	0.24
GDP per capita	0.28
Investments in road	0.20
Share of road	0.00
FDI	0.00
Employment	0.00
Capital stock	0.27
Price level of exports	4.24e-06
Price level of imports	0.00

NOTE: Column (1) provides the name of the predictor variable, column (2) the weight which is assigned to this variable by constructing the synthetic control.

Table 14: Weights given to predictor variables in the main analysis of the rail freight sector

Predictor variable	Unit weight
Lag of rail tkm	1.00
Second lag of rail tkm	0.00
Length of rails in km	4.98e-08
Co2 emissions of transport	1.18e-08

NOTE: Column (1) provides the name of the predictor variable, column (2) the weight which is assigned to this variable by constructing the synthetic control.

Table 15: Weights given to predictor variables in the main analysis of the air freight sector

Predictor variable	Unit weight
Lag of air tkm	0.27
Air departures	0.00
GDP per capita	0.00
Population	0.28
Employment	0.45
Price level of exports	1.48e-06
Price level of imports	4.17e-06

NOTE: Column (1) provides the name of the predictor variable, column (2) the weight which is assigned to this variable by constructing the synthetic control.

Appendix G: overview and comparison of Poland, the synthetic control and the averages of the donor pool countries

Table 16: An overview of summary statistics and predictor balance for the road freight transport sector (main analysis)

	Panel A: Summary Statistics for Poland				**Panel B: Predictor balance**		
					Poland		*Donor pool*
	Mean	Std. Dev.	Min	Max	Real	Synthetic	Average
Lag of ton-kilometers	84,028.7	61,468.27	34,024	233,310	49,070.04	48,552.45	86,726.11
GDP per capita	5,527.03	4,309.98	1,497.84	13,999.5	2,981.85	7,516.15	70,548.52
Road investment	2.45e+09	2.37e+09	1.80e+08	8.32e+09	2.55+e09	2.85e+09	8.29e+09
Share of road transport	57.83	13.75	35.93	78.35	57.83	71.22	75.9091
FDI	6.10e+09	7.17e+09	1.10e+07	2.50e+10	9.92e+09	3.03e+14	2.57e+14
Employment	14.93	0.82	13.55	16.20	14.58	7.46	17.52
Cn	1,488,667	445,891.5	737,899.8	2,569,085	1,655,175	1,770,345	4,278,534
Pl_x	0.49	0.11	0.32	0.70	0,54	0.51	0.50
Pl_m	0.49	0.08	0.34	0.64	0.52	0.52	0.51

NOTE: Panel A provides the summary statistics of the variables for Poland, Panel B provides the predictor balance. Column (1) provides the mean, column (2) the standard deviation, column (3) the minimum value, column (4) the maximum value, column (5) the real value (so Poland), column (6) the value calculated for the synthetic control, and column (7) the average of the donor pool.

Table 17: An overview of summary statistics and predictor balance for the rail freight transport sector (main analysis)

	Panel A: Summary Statistics for Poland				**Panel B: Predictor balance**		
					Poland		*Donor pool*
	Mean	Std. Dev.	Min	Max	Real	Synthetic	Average
Lag of rail tkm	84,513.98	33,830.31	43,554	138,101	97,875.76	98,237.91	173,993

Second lag of rail tkm	85,267.56	33,819.89	43,554	138,101	99,442	99,136.40	173,042.5
Kilometers of rail	20,499.59	1,783.932	18,429	23,986	22,183.56	19,093.42	11,524.33
CO2 by transport	9.21	3.26	5.56	15.73	10.60	18.10	23.02

NOTE: Panel A provides the summary statistics of the variables for Poland, Panel B provides the predictor balance. Column (1) provides the mean, column (2) the standard deviation, column (3) the minimum value, column (4) the maximum value, column (5) the real value (so Poland), column (6) the value calculated for the synthetic control, and column (7) the average of the donor pool.

Table 18: An overview of summary statistics and predictor balance for the air freight transport sector (main analysis)

Panel A: Summary Statistics					**Panel B: Predictor balance**		
					Poland		*Donor pool*
	Mean	Std. Dev.	Min	Max	Real	Synthetic	Average
Lag of air tkm	37.97	31.32	4.2	92	32.14	32.51	767.95
Air departures	42,528.26	20,338.40	16,400	90,031	36,445.56	32,127.81	206,155
GDP per capita	4,109.32	3,114.27	1,497.84	13,999.5	2,924.07	89,019.96	3.48e+15
Population	3.68e+07	1,956,596	3.27e+07	3.87e+07	3.66e+07	3.66e+07	5.24e+07
Employment	14.97	0.82	13.55	16.20	14.84	14.84	20.22
Pl_x	0.43	0.09	0.32	0.69	0.43	0.40	0.40
Pl_m	0.44	0.07	0.33	0.64	0.44	0.43	0.41

NOTE: Panel A provides the summary statistics of the variables for Poland, Panel B provides the predictor balance. Column (1) provides the mean, column (2) the standard deviation, column (3) the minimum value, column (4) the maximum value, column (5) the real value (so Poland), column (6) the value calculated for the synthetic control, and column (7) the average of the donor pool.

Appendix H: treatment effects

Table 19: Estimated treatment effects for the road freight transport sector

Year	Gap	Year	Gap
1981	8,187.40	1998	1,933.82
1982	3,465.66	1999	304.11
1983	5,437.47	2000	1,426.23
1984	4.546.85	2001	3,561.49
1985	2,386.64	2002	4,433.75
1986	-42.09	2003	6,521.69
1987	-1,058.61	2004	27,363.45
1988	-1,778.77	2005	33,193.77
1989	-5,620.96	2006	45,513.70
1990	-4,621.74	2007	66,242.07
1991	-3,456.34	2008	78,925.48
1992	-1,615.18	2009	97,124.42
1993	-9,169.61	2010	115,637.50
1994	-5.623.55	2011	113,793.50
1995	-4,988.88	2012	123,525.60
1996	-4.823.57	2013	148,675.30
1997	600.55		

Note: This table shows the difference between Poland and the synthetic control for each year in the road freight sector. Column (1) shows the year, column (2) the treatment effects (i.e., the difference between the synthetic control and Poland) measured in tkm in millions. The navy-blue line indicates the treatment date (2004). The light blue line marks 2007.

Table 20: Estimated treatment effects for the rail freight transport sector

Year	Gap	Year	Gap
1970	-8,090.26	1994	6,922.29
1971	-6,368.96	1995	9,493.55
1972	-2,155.12	1996	11,567.69
1973	-122.58	1997	12,969.30
1974	8,550.31	1998	9,642.07
1975	11,903.83	1999	-2,983.64

1976	12,623.43	2000	-9,839.26
1977	19,611.06	2001	-18,671.62
1978	19,640.89	2002	-21,730.41
1979	17,846.12	2003	-26,156.04
1980	18,880.30	2004	-27,947.10
1981	-5,896.75	2005	-33,155.08
1982	360.69	2006	-33,446.84
1983	3,308.56	2007	-37,382.90
1984	11,175.59	2008	-39,685.12
1985	6,336.39	2009	-37,527.36
1986	5,198.26	2010	-37,494.68
1987	4,771.53	2011	-36,234.56
1988	2,156.39	2012	-44,810.32
1989	-7,820.70	2013	-42,228.86
1990	-34,098.73	2014	-46,477.31
1991	-43,503.86	2015	-46,094.60
1992	-32,829.63	2016	-46,898.99
1993	-10,797.88		

NOTE: This table shows the difference between Poland and the synthetic control for each year in the rail freight sector. Column (1) shows the year, column (2) the treatment effect (i.e., the difference between the synthetic control and Poland) measured in tkm in millions. The navy-blue line indicates the treatment date (2004). The light blue line marks 2007.

Table 21: Estimated treatment effects for the air freight transport sector

Year	Gap	Year	Gap
1970	1.14	1990	15.40
1971	0.50	1991	8.11
1972	0.09	1992	5.73
1973	0.92	1993	2.28
1974	1.03	1994	-0.54
1975	2.51	1995	11.75
1976	0.64	1996	17.30
1977	0.43	1997	23.46

1978	3.23	1998	24.44
1979	1.25	1999	1.39
1980	-1.34	2000	-14.61
1981	-4.56	2001	-9.11
1982	-12.96	2002	-14.70
1983	-14.33	2003	-11.74
1984	-11.66	2004	-6.07
1985	-11.99	2005	-16.52
1986	-12.21	2006	-21.87
1987	-13.08	2007	-18.40
1988	-10.83	2008	-25.53
1989	-1.97		

NOTE: This table shows the difference between Poland and the synthetic control for each year in the air freight sector. Column (1) shows the year, column (2) the treatment effect (i.e., the difference between the synthetic control and Poland measured in tkm in millions). The navy-blue line indicates the treatment date (2004). The light blue line marks 2007.