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## Estimating causal effects of BRI infrastructure projects based on the synthetic control method

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**ADB Working Paper Series**

**ESTIMATING CAUSAL EFFECTS OF BRI  
INFRASTRUCTURE PROJECTS BASED  
ON THE SYNTHETIC CONTROL METHOD**

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**Abstract**

This paper studies the regional treatment effects of infrastructure projects on employment and transport volumes by combining the quantitative econometric method with qualitative case studies. The quantitative method that we use is synthetic control, which allows us to analyze the causal effects on particular treatment groups. The regions of interest in our study are Duisburg and Piraeus. Both the quantitative and the qualitative evidence reveal that the impact on maritime transportation in Piraeus is very significant. Although the quantitative evidence shows a rather modest effect on employment before 2016, the qualitative evidence suggests a more significant effect in recent years. We interpret this as the postponed effects from infrastructure provision on various outcome variables. Moreover, we find that rail transport does not crowd out local road transport.

**Keywords:** infrastructure, employment, Belt and Road Initiative, Duisburg, Piraeus, maritime transportation, rail, road

**JEL Classification:** R4, N7, J6

# 1 Introduction

Infrastructure investment has recently become a new highlight of the regional development strategies of many East Asian countries, especially the People’s Republic of China (PRC) and Japan (Pascha 2020). The Belt and Road Initiative (BRI) was officially launched by PRC in 2013, which consists of a land route silk road (the ”belt”) and a maritime silk road (the ”road”). An important component of this initiative is infrastructure investment (National Development and Reform Commission 2017). This echoes the influential Asian Development Bank Institute report that was titled the ”Infrastructure for a Seamless Asia”, which emphasized the importance of infrastructure investment for economic growth and which found that 8 trillion USD investment was required in Asia between 2010–2020 (Asian Development Bank and Asian Development Bank Institute 2009). Indeed, improved infrastructure could reduce transport costs and provide better market access (Li and Schmerer 2017), which is hoped to spur the agglomeration of firms in the region and create new employment opportunities for local residents (for a recent overview of the role of infrastructure on local economic development, see Yoshino, Helble, and Abidhadjaev’s (2018) book for ADBI). The creation and extension of existing transport hubs has also fueled a lively debate about the geopolitical implications of these ventures. While the advocates argue that huge investments bring prosperity to the surrounding regions, many detractors are more worried about the higher dependency on the investor’s goodwill.

This paper studies the potential effects of transportation infrastructure by combining quantitative evidence (which is based upon the synthetic control method) and qualitative evidence (which is based on case study and interviews). Ideally, analysis should be executed in the laboratory using observations for statistical twins of treated and untreated regions. A placebo treatment should

then be given to all observations: neither the treated nor the untreated regions should be aware of their treatment status. However, such an experiment on the macro-level is hard to come by. The more aggregated the data, the less likely it will be that observations with similar characteristics exist. The synthetic control method circumvents this problem by creating an artificial control region for comparison. Existing data is used to create a statistical twin that behaves exactly as the treated region before the intervention. Systematic differences between the treated and the artificial control group after the intervention can be interpreted as causal effects when interactions between treatment and control group are implausible. While the synthetic control method can provide rigorous causal inference, it can only estimate the effects of the first three years of the BRI because of the data limitation (i.e., we only have a balanced panel data until 2016). Given that the BRI is growing rapidly and there might also be a time lag of the effects of infrastructure projects, we supplement the quantitative evidence by providing qualitative evidence on the impacts of the BRI projects in more recent years.

We restrict our analysis to two particular treatment regions, Duisburg and Piraeus, which represent different transport modes. Piraeus represents the impact of maritime transport, whereas Duisburg represents the impact of railway transport. The treatment effects are estimated separately. The quantitative and qualitative evidence reveals that the impact on maritime transportation in Piraeus is very significant. However, the effects on employment differ between the quantitative and qualitative evidence. While the quantitative evidence shows a rather modest effect on employment before the year of 2016, the qualitative evidence suggests that there has been a more significant effect in more recent years. We interpret this as follows: *i*) a major investment in Piraeus might materialize after 2016, so the potential positive employment effects are out of

the time scope of our data; *ii*) there is a lack of an agglomeration effect because the additional amount of maritime freight may be handled by the existing labor; and *iii*) the effects of infrastructure on employment may be postponed, as discussed in Yoshino and Abidhadjaev 2016, because businesses may have a delayed response to new infrastructure projects. Therefore, whereas improved port infrastructure can generate immediate effects on local maritime traffic, its impact on local employment may take years to realize. Moreover, we find that an enhanced local railway connection does not necessarily crowd out the traffic of the other transport modes, such as road transport.

This paper is organized as follows. The second section provides an overview of the effects of BRI projects in Piraeus and Duisburg based on the qualitative case study. The third section explains the empirical strategy of the synthetic control method. Section four provides an overview of the data, while section five presents the results. The final section provides a conclusion.

## 2 Case study of Piraeus and Duisburg

**Impact of BRI project in Piraeus** The Piraeus Port project is one of the most important joint ventures between Greece and PRC. COSCO Pacific Limited, which is a subsidiary of PRC Ocean Shipping Company (COSCO), won the bid for a 35-year concession for the operation of Pier 2 and Pier 3 in Piraeus port in 2008. However, when the economic and financial crisis hit Greece heavily, Greece found difficulty borrowing from other Euro-zone partners or from the international market. PRC's investment at that time was seen as an important support to help Greece out of the debt crisis (author's interview with former Greece government official, interview date October 3, 2018). In 2016, COSCO expanded its investment in Piraeus and it acquired a majority stake in the port through an investment of 368.5 million Euro (Koutantou 2016).

In recent years, Piraeus port has experienced rapid growth. In terms of total container volume, Piraeus port climbed the world ranking to number 32 in 2019. Meanwhile, traffic at the port increased by almost 50 percent compared to the year when COSCO became the majority stake holder (Lloyd's List 2019). The total throughput in Piraeus port broke the 5 million TEU limit in 2019 (Piraeus Port Authority 2019), making it the largest port in the Mediterranean area (Notteboom 2020).

PRC's interest in the port of Piraeus is likely to be related to its unique position in the region (Liu and Davarinou 2019). The port is located about 10 km southwest of Athens, and it is placed at an important intersection between the Mediterranean regions in Europe and the North of Europe. The geographic location of the port enables ships to access the port without having to make a significant deviation from the Far East trade routes. Goods can be transported by ship to Piraeus before they are carried onward to Central and Western Europe by railway. This connection shortens the time that it takes for goods to travel from PRC to the EU by around 4,500 km, and it reduces total shipping time by around 8–12 days (Jakóbowski et al. 2018). In 2013, COSCO, together with the Greek railway carrier TrainOSE, began offering block train services to multinational companies (e.g., Hewlett-Packard, Foxconn, Hyundai and Sony) who have established logistics centers in Piraeus. Their goods are then delivered to manufacturing plants in the Czech Republic, Slovakia and Hungary (Jakóbowski et al. 2018).

COSCO's investment has enhanced the port's competitiveness significantly by introducing the most advanced equipment and upgrading the infrastructure at the port (Liu and Davarinou 2019). The rapid increase in cargo volume handled at the port has even reached its capacity limit. Consequently, in 2019 the port authority proposed that a fourth container terminal should be built



(authors' interview with managing staff of the Piraeus Port Authority, interview date Feb 18, 2020). The performance of Piraeus in recent years has clearly made it a positive outlier when compared to the other ports in Europe.

COSCO's investment in Piraeus has encouraged other Chinese investors to come to Greece; for instance, the China Energy Investment Corporation has registered its new European energy headquarters in Greece, and Air China launched Beijing–Athens direct flights in September 2017 (Vlachou 2017). Piraeus port and the wider area around Athens are quickly becoming an anchor investment for attracting Chinese investment (Tonchev and Davarinou 2017).

This new development is supposed to affect the local economy and the labor market in particular. According to the Piraeus Port Authority, the revenues of the port amounted to 149.2 million Euro in 2019, compared to 132.9 million Euro in the period of 2018 (Piraeus Port Authority 2020). The port achieved a pre-tax profit of 47.6 million Euro in 2019, which represents a more than twofold increase from 21.2 million Euro in 2017 (Piraeus Port Authority 2020). In addition, in 2018 COSCO's investment in Piraeus created more than 4,000 jobs, and supported 1,200 local and national suppliers (authors' interview with managing staff of the Piraeus Port Authority, interview date Feb 18, 2020).

**Impact of BRI project in Duisburg** Duisburg is a German city that has a long industrial history, including steel blast furnaces, coal mines, and also because of its large inland port. The first China-Europe express train (CR Express) – the “Yu Xin Ou” train - arrived in Duisburg in 2011. This train connects Chongqing and Duisburg on an 11,179 km long railroad track that sets out from Chongqing (one of PRC's five national central cities) in Southwest PRC, and it then passes through Kazakhstan, the Russian Federation, Belarus, and Poland. The appeal of the rail connection between PRC and Duisburg is obvious: it is much faster than maritime transport and not as expensive as trans-

port by airplane. In comparison, the transportation time from Chongqing to Duisburg by ship is 45 days, while by rail it takes about 12 days. Notwithstanding a period of less departures, which has been caused by Chinese restrictions on empty containers (van Leijen 2019), the number of China-Europe trains in Duisburg has grown from three trains a month in May 2011 (only westbound), to 20 trains a week in 2017 (12 westbound and eight eastbound), and to more than 35 trains in 2019 (authors' interview with managing staff of Duisburg Rail Terminal, interview date Aug 7, 2019).

Duisburg was chosen thanks to its excellent location at the junction of the rivers Rhine and Ruhr, two of Europe's most important waterways. The Duisburg Intermodal Terminal (DIT) is located at the edge of the Rhine River. Arriving goods can be loaded straight on to ships or they can be further transported by other trains or trucks to more remote parts of Europe. Moreover, Duisburg is able to offer top-level multimodal networking: it is at the intersection of four international freeway axes (i.e., the A2, A3, A40, and A57), and it is one of Germany's biggest rail hubs. Because of its well-connected position, Duisburg can reach over 30 million consumers and 300,000 companies within a 150km radius.

The operation of the CR Express has shortened the market distance between Duisburg and its surrounding areas to PRC. Usually, PRC's connected cities have tens of millions of inhabitants and trillions of GDP output, the size of which is equivalent to medium-to-small sized nations. Thus, railway connections have created a vast potential market for European producers. Currently, the goods carried by the trains crossing the Eurasian continent include electronic products, machinery, finished vehicles, consumer goods, luxury goods, food, and wood (authors' interview with managing staff of Duisburg Rail Terminal, interview date Aug 7, 2019). More importantly, besides the direct effect on

trade volume, the opening of new railway lines enhances trade facilitation. For example, countries along the railway line have taken measures to reduce the time needed for clearing customs procedures (Esteban and Li 2019).

Each transportation mode has its own advantages, and they may compete or complement with each other. Therefore, it is possible that the introduction of the CR Express may both divert traffic from road freight to the railway, or it may bring more transport volume to both rail and road freight (Fang et al. 2019). However, there has been no direct evidence that rail transport has crowded out local truck transport. For example, containers discharged from freight trains need to be further transported to reach their final destination, and vice versa. In addition, the need for “shunting” by camions has increased (authors’ interview with managing staff of Duisburg Rail Terminal, interview date Aug 7, 2019).

The increased rail traffic with PRC has made Duisburg famous and it has acted as a “catalyst” for other investors. In particular, after the official visit by Chinese President Xi Jinping in 2014, Duisburg has often appeared in the headlines of Chinese media. In 2014, Nanjing High Accurate Drive Equipment Manufacturing, one of the most valuable companies in the Chinese mechanical engineering industry, established its European headquarters at Duisburg thanks to its direct railway connection to PRC (Rheinische Post 2015). In 2018, the Chinese technology giant Huawei signed a Memorandum of Understanding with Duisburg on jointly building a digital benchmark city (Huawei 2018). In December 2019, China Railway Container Transport—the operating and service platform of the CR Express—established its European headquarters in Duisburg (van Leijen 2019), thereby further strengthen Duisburg as an important hub for rail freight traffic between Europe and Asia. Expecting increased traffic from Asia, German investors have begun to invest funds in upgrading local

infrastructure. For example, Duisport is in the process of setting up new distribution centers and logistics warehouses in Duisburg, and in its nearby region in Oberhausen and Krefeld (Kurtzbach 2018). Moreover, Duisport has cooperated with PRC in expanding their business operations in Belarus by jointly investing in the “Great Stone” China-Belarus Industrial and Logistics Park (Duisport 2019).

Many expect that this rail connection will generate positive effects on local labor market. Indeed, in an interview with Xinhua News in May 2019, a Duisburg local official said that the rail connection with PRC has had a positive impact on the local port industry, which has created about 6000 new jobs in recent years (Ren and Lian 2020).

### 3 Empirical strategy

Following the logic of the synthetic control approach (Abadie and Gardeazabal 2003, Abadie et al. 2010, Abadie et al. 2015) the announcement of the initiatives in Piraeus and Duisburg at time  $T$  can be used to estimate causal treatment effects as  $\alpha_{it}$  in

$$Y_{it} = Y_{it}^N + \alpha_{it}D_{it} \quad , \quad (1)$$

where  $Y_{it}^N$  denotes the outcome without treatment. Notice that the observable outcome  $Y_{it}$  is equal to the nontreatment outcome  $Y_{it}^N$  if  $D_{it}$  is 0. This is the case for all observations other than observation 1. For observation 1, the nontreatment outcome is observable in the period before the intervention at  $t < T$ . After the intervention, the treatment effect is added to the nontreatment outcome for individuals belonging to the treatment group. Thus, the outcome  $Y_{it}$  is equal to  $Y_{it}^N$  for nontreated observations and it is also equal to the nontreatment outcome for the treated observations before the intervention. After the

intervention, the observed outcome is equal to the counter-factual nontreatment outcome plus the treatment effect for observations belonging to the treatment group. Taking observable covariates  $Z_i$  and a time-specific  $\delta_t$  into consideration allows us to predict the outcome for each observation  $i$  at time  $t$  as a function depending on observable covariates, its coefficients and the treatment effect:

$$Y_{it} = \delta_t + \theta Z_i + \alpha_{it} D_{it} + \epsilon_{it} . \quad (2)$$

Notice that only one individual is treated in this setup and that the treatment outcome is denoted by  $Y_{1t}^T$ . All other outcomes are used to construct an artificial individual with outcome  $Y_{1t}^N$ , which is equal to the treated individual before the intervention. This particular synthetic outcome is constructed as

$$Y_{it}^N = \sum_{j=2}^{J+1} w_j Y_{jt}^N = \delta_t + \sum_{j=2}^{J+1} w_j \theta Z_j + \sum_{j=2}^{J+1} w_j \epsilon_{it} \quad (3)$$

The weights  $w_j$  are estimated for all periods before the intervention  $t < T_0$  by minimizing the distance between the two outcomes:

$$\min_w (Y_{1t} - Y_{1t}^N) \quad (4)$$

and the distance between observed and artificial covariates:

$$\min_w \left( \sum_{j=2}^{J+1} w_j^* Z_j - Z_1 \right) \quad (5)$$

The solution can be found by alternating the weights until both conditions are as close to zero as possible. The treatment effect can be computed as the difference between observed outcome observed for treated individual 1 at time  $t > T$  and

artificial outcome in the synthetic group:

$$\alpha_{1t} = Y_{1t}^T - Y_{1t}^N = Y_{1t} - Y_{1t}^N \tag{6}$$

The difference between treatment on synthetic control outcomes must be invisible before, but significant and visible after the intervention. The respective numbers must coincide before  $T$  and diverge after  $T$ .

## 4 Data

Most data, including the dependent variables and the additionally selected predictors, have been extracted from Eurostat, the statistical office of the EU. Information is collected on the Nuts-level (Nomenclature of territorial units for statistics)<sup>1</sup>. We will use NUTS level 3 information when possible. If three-digit level data does not exist, then the analysis is based upon broader two-digit level information.

Essentially, we focus on the three main outcomes of interest: employment, maritime freight and road freight. Information on these three variables is available for most regions covering the time 2000–2016. For employment, both aggregate and sector level information is available for 1274 NUTS 3 regions in 22 countries. For maritime freight, information for 96 NUTS 2 regions in 11 countries can be utilized. Road freight information is available for 729 NUTS 3 regions in 14 countries.

It is important to note that data availability varies strongly by country and period. This implies that the data might be available for country  $i = 1$  in periods  $t$  to  $t+n$ , while country  $i = 2$  only has information on periods  $t+1$  to  $t+n$ . In a

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<sup>1</sup>NUTS is characterized as "a hierarchical system for dividing up the economic territory of the EU for the purpose of: The collection, development and harmonization of European regional statistics, [s]ocio-economic analyses of the regions [...], and] [f]raming of EU regional policies" (Eurostat 2019)

scenario where construction of the synthetic control can only factor in observed regions, then this necessitates caution in terms of determining the examined period. The period between 2000 and 2016 has been chosen by considering this trade-off between temporal and cross-sectional coverage.

In addition to the three main outcome variables of interest, the following control variables are included in the analysis: dummy variables on spatial information are used as indicators of urban, metropolitan, coastal and port regions, as well as various economic and demographic controls; that is, population size, the dependency ratio, per capita gross value added and gross value added growth rates are included in the analysis. These indicators are important determinants in the selection process for the appropriate control regions.

## 5 Results

For Piraeus, two outcome variables of interest are investigated sequentially: first, the total and sector level number of employed persons; and second, the total amount of freight handled in the Attica region.

For Duisburg, treatment effects are computed for employment and intra-regional transport volumes on the road.

### 5.1 Piraeus

**Employment effects.** We are faced with a substantial issue in the analysis of the case study of the port of Piraeus because the Greek sovereign debt crisis likely affected our variables of interest. Given that these ramifications are case-specific to Greece and that they coincide with the beginning of the treatment in Piraeus, observations from all other countries in the sample have been excluded from the control group. Furthermore, given this confinement, the focus of analysis is redirected to the NUTS 3 level, which gives us more observations

to construct an appropriate control region. Spill-overs from regions in the direct vicinity are ruled out by further restricting the pool of potential control units to regions that do not belong to the same NUTS 2 region as Piraeus.

The algorithm uses the predictor weights listed in Table 1 to produce the synthetic control group, which includes Thessaloniki (w.weight = 0.331), Karditsa and Trikala (w.weight = 0.518), as well as Korinthia (w.weight = 0.150). However, comparing the control to actual employment in Piraeus does not provide much evidence of a potential treatment impact (s. Figure 1). Employment seems to be slightly reduced by treatment but the differences are very small. Furthermore, both time series coincide before and after the treatment.



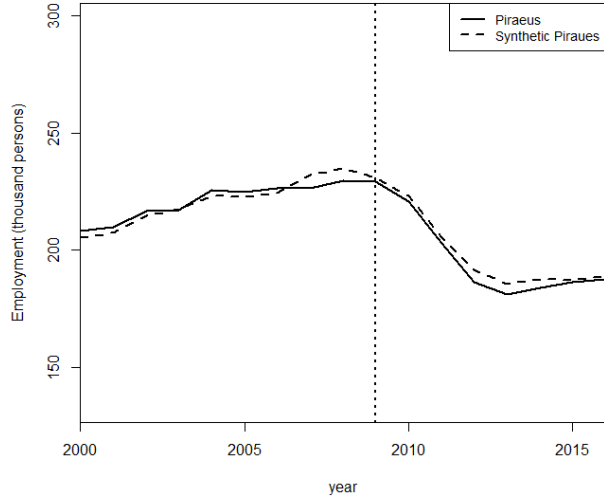


Figure 1: Path plot, Total Employment, Piraeus

Given that the additional covariates do not matter for the computation of the  $w.weights$ , a possible deviation from the baseline set-up would be to rely on all pretreatment values of employment as predictors instead. However, this adjustment only makes sense if no high relevance has been attested to the additional predictors. Using all outcome lags as separate predictors is not appropriate because all of the other covariates may become redundant (Kaul et al. 2015).

Botosaru and Ferman 2019 (p. 128) have shown that a synthetic control group solely based upon pretreatment outcomes can adequately proxy the treated unit with respect to many covariates. Therefore, a synthetic control group only relying on those pretreatment outcomes is found to be close to an alternative also considering covariates. Following this approach, both  $w.weights$  and the respective path plot are very similar to the baseline outcomes.

Instead of total employment effects, one may look at per capita employment. However, the baseline results do not change much. The choice of regions used

predictors	v.weights
population	0.002
coast	0.000
urban	0.000
port	0.000
dependency.ratio.new	0.000
metro	0.000
gva.TOTAL_capita	0.000
gva.TOTAL.growth	0.001
special.employment.TOTAL.2000	0.324
special.employment.TOTAL.2004	0.306
special.employment.TOTAL.2008	0.366

Table 1: Predictor weights, Total Employment, Piraeus

to construct the artificial control group is different but the two time series still coincide.

The finding that the treatment effect on aggregate employment in Piraeus is rather small motivates the analysis of sector level employment data. We have information on employed persons by sectors following the statistical classification of economic activities in the European Community (NACE)<sup>2</sup>. The data provides 21 different sectors. Unfortunately, not all of those are reported separately, which leaves us with 11 broader industry categories for Greece (s. Table 2).

We focus on information for sections G, H and I because section H includes freight transport and associated activities (Eurostat 2008, p. 235).

Results shown in Figure 2 are not too different from the results obtained based upon aggregate employment data. Thessaloniki (w.weight = 0.399), Achaea (w.weight = 0.596) and Kalymnos, Karpathos, Kos and Rhodes (w.weight = 0.005) are used to form the synthetic control group. However, after experi-

<sup>2</sup>NACE is the acronym used to designate the various statistical classifications of economic activities developed since 1970 in the European Union. NACE provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment, national accounts) and in other statistical domains." (Eurostat 2008, p. 13)

Section	Description
A	Agriculture, forestry and fishing
B, D & E	Mining and quarrying Electricity, gas, steam and air conditioning supply Water supply, sewerage, waste management and remediation activities
C	Manufacturing
F	Construction
G, H & I	Wholesale and retail trade; repair of motor vehicles and motorcycles Transportation and storage Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M & N	Professional, scientific and technical activities Administrative and support service activities
O, P & Q	Public administration and defense; compulsory social security Education Human health and social work activities
R, S, T & U	Arts, entertainment and recreation Other service activities Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use Activities of extraterritorial organizations and bodies

Table 2: Available Sections, NACE Rev. 2

encing the same downturn following the year 2009, employment recovery in the sector-level data in Piraeus is slightly more pronounced from 2011 on.

Although our analysis would benefit from more detailed data (i.e., individual information for each section), our results support the aggregate effects, which indicate insignificant employment effects. Nevertheless, certain sectors may benefit from COSCO's investments.

There are several potential explanations for the insignificant employment effects documented in our baseline regressions. *i)* COSCO became the majority share holder of Piraeus Port in 2016, which means the major investment might materialize after this year. However, our data cannot document the effects after 2016. *ii)* Trade increased but there was no agglomeration effect. This happens because the additional amount of maritime freight may be handled

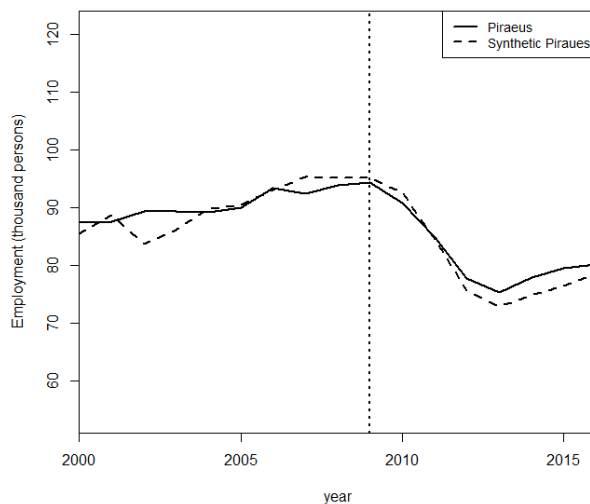


Figure 2: Path plot, Employment Sections G, H and I, Piraeus

by the existing labor. The amount of additional labor employed by the port is low and without additional agglomeration; therefore, the treatment effects may be too small to be visible in the treatment graphs. *iii*) There may be postponed effects of infrastructure on employment, as discussed in Yoshino and Abidhadjaev 2016, because businesses other than those directly related to the port industry may delay their response to new infrastructure projects.

**Maritime freight.** Once again, the level of analysis has to be adjusted to the limited availability of data. Maritime freight information is available at the NUTS 2 level only. The number of Greek regions that can be used to formulate the synthetic control outcomes are rather limited on the NUTS-2 level. Moreover, not all regions have access to the sea. Fortunately, the Greek sovereign debt crisis is less problematic in the analysis of this particular variable of interest and we are able to consider all European NUTS 2 regions with direct access to the sea. Eventually, this curtailment leaves us with the aforementioned

96 NUTS 2 regions, which report maritime freight for the years 2000–2016. Only pretreatment period values are included as predictors in the respective analysis of maritime freight, which aligns with the relevance of time-series models in predicting freight volumes (see Jong et al. 2004, p. 108).

The synthetic control group constructed for the Attica region, including the port of Piraeus, use the v.weights depicted in Table 3. This contains Western Greece (w.weight = 0.409), Asturias (w.weight = 0.025) and Andalusia (w.weight = 0.224) in Spain, Provence-Alpes-Côte d’Azur (w.weight = 0.087) in France, as well as Kent (w.weight = 0.095) and Highlands and Islands (w.weight = 0.159) in the United Kingdom.

predictors	v.weights
special.maritime_freight.2000	0.107
special.maritime_freight.2001	0.090
special.maritime_freight.2002	0.088
special.maritime_freight.2003	0.099
special.maritime_freight.2004	0.109
special.maritime_freight.2005	0.113
special.maritime_freight.2006	0.123
special.maritime_freight.2007	0.131
special.maritime_freight.2008	0.142

Table 3: Predictor weights, Maritime freight, Attica

The resulting path plot in Figure 3 shows the sharp increase in maritime freight handled in Attica. Interestingly, its pathway only deviates from its synthetic control after 2011. Potentially, this finding illustrates the cognition that although investments were made from 2009 onward, they only became effective from 2011 on. Another question raised by this piece of evidence is why this substantial growth in maritime freight fails to have a pronounced direct effect on aggregate employment in Piraeus.

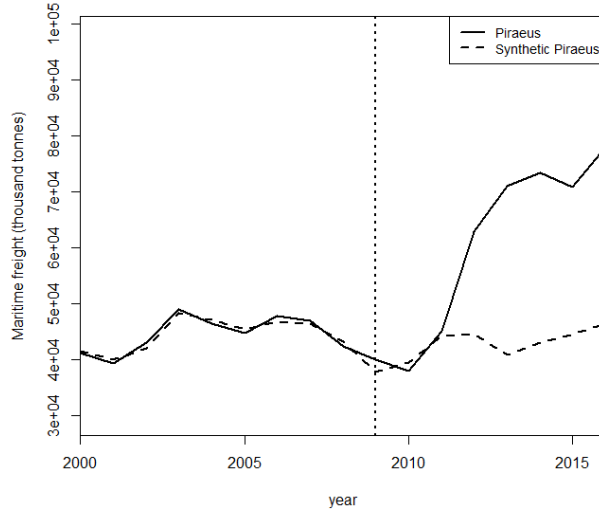


Figure 3: Path plot, Maritime freight, Attica

## 5.2 Duisburg

This subsection provides the results for the treatment effects of BRI on employment and transport volumes in Duisburg. The results for Duisburg are not directly comparable to the case of Piraeus. We do not observe the amount of goods transported by train but we do have information on the amount of goods transported on the road. Therefore, only the employment effects caused by the new train hub are directly comparable to the case of Piraeus.

**Employment effects.** Observing the evolution of employment in Duisburg, a German specific shock to our variable of interest after treatment cannot be identified. However, we cannot completely exclude the possibility that including the entire sample might figure in any region exposed to such a shock. Moreover, only permitting German NUTS 3 regions as a potential control is to be preferred for the sake of comparability to the Piraeus case. Therefore, we initially restrict

the pool for our potential control group to Germany. In addition, this does not pose too much of a challenge because employment data for Germany is plentiful, with information for 375 NUTS 3 regions available from 2000–2016. Similar to our analysis for Piraeus, we exclude all NUTS 3 regions that are part of the same NUTS 2 area as Duisburg from the pool of potential controls to account for possible spillover effects of treatment. In addition, the same predictors as for the case of Piraeus are included. One major difference is that treatment is assigned to the year 2011. This gives us more observations for the pool of pretreatment observations that can be used for constructing the synthetic control outcomes.

The ensuing analysis gives us the unexpected finding of a slightly negative treatment effect (s. Figure 4). However, this effect largely disappears when investigating employment in per capita terms (s. Figure 5). The regions included into the synthetic control group based on the v.weights in Table 4 are Munich (w.weight = 0.008), Berlin (w.weight = 0.107), Salzgitter (w.weight = 0.322), Harburg (w.weight = 0.239), Ludwigshafen (w.weight = 0.043) and the Duchy of Lauenburg (w.weight = 0.276).

predictors	v.weights
population	0.094
coast	0.087
urban	0.110
port	0.075
dependency.ratio_new	0.113
metro	0.077
gva.TOTAL_capita	0.036
gva.TOTAL.growth	0.101
special.employment.TOTAL_capita.2000	0.121
special.employment.TOTAL_capita.2005	0.094
special.employment.TOTAL_capita.2010	0.093

Table 4: Predictor weights, Employment per capita, Duisburg

Similarly to our inspection of COSCO’s investments in Piraeus, we consider

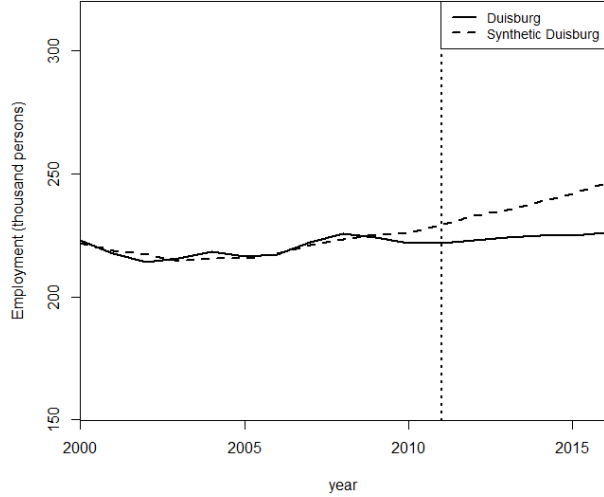


Figure 4: Path plot, Total Employment, Duisburg

sector level evidence for employment in Duisburg. Unfortunately, the data for Germany is even more coarse; for instance, section J of NACE is not reported separately and pooled together with sections G, H and I. Utilizing these rougher categories, we fail to identify any sector specific treatment effect.

**Road freight.** As mentioned earlier, this analysis is different compared to the effects presented for Piraeus where we observe maritime freight because data on rail freight is unavailable. However, we observe information on road freight at the NUTS 3 level. Therefore, it is possible to investigate whether rail transport crowd out road transport in Duisburg. As discussed in (Fang et al. 2019), each transportation mode has its own advantages, which may sometimes compete or complement with each other. Therefore, it is possible that the introduction of CR Express may generate indirect effects on local road freight. Nonetheless, the maximum degree of comparability is achieved by using the the same level of aggregation as we used for Piraeus. Both studies are based upon NUTS 2 level



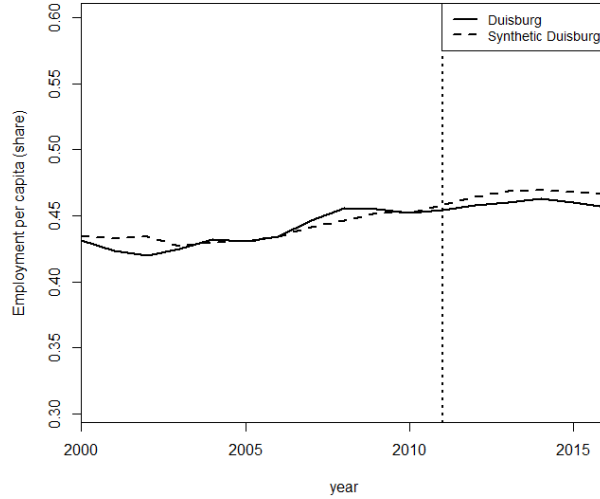


Figure 5: Path plot, Employment per capita, Duisburg

data. Again only pretreatment values of our variable of interest are considered as predictors in the analysis.

Figure 6 shows the ensuing results. At first glance, these results do not support the existence of any treatment effect. However, another important finding is the loose pretreatment fit of the synthetic control group at an MSPE of 0.126. As discussed earlier, a distinct feature of the underlying data is the high degree of fluctuation in terms of data availability by country and year. Therefore, we drop the year 2000 from our analysis, thereby enlarging our set of potential control units from 143 to 149. This alteration is depicted in Figure 7. The analysis is based upon a much lower MSPE of 0.391. However, we still fail to identify a significant treatment effect. The results suggests that CR express does not crowd out local truck transport, which confirms the finding from our previous qualitative evidence.

The two main challenges in analysing causal treatment effects associated

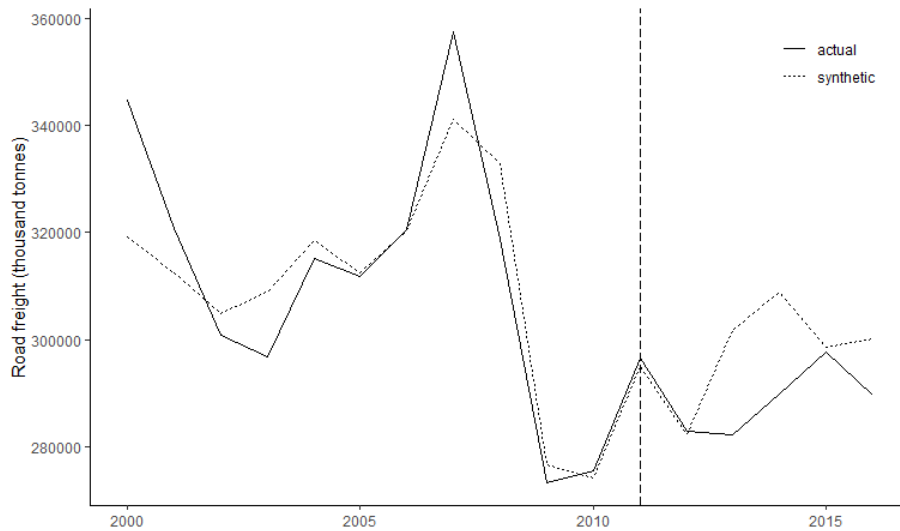


Figure 6: Path plot, Road freight, Düsseldorf area, 2000 - 2016

with road freight are the lack of good data and (in relation) the substantial lag between initial project promulgation and significant accumulation of yearly shipments. As can be seen in Figure 8 CR Express trains began to operate in 2011, the year we assign treatment in Duisburg, but the amount of shipments only began to accumulate much later.

### 5.3 Robustness checks

We presented two noteworthy findings: first, the amount of maritime freight handled in the region of Attica has increased substantially after the initial investment of the Chinese SOE COSCO into the Piraeus port in 2009, although the effect emerges with a lag of two years (see Figure 3); and second, there may be a positive impact of treatment on certain specific sectors in Piraeus (see Figure 2). However, the effect identified in our analysis is less pronounced and may be spurious.

To test the robustness of these findings, we follow the approach proposed by

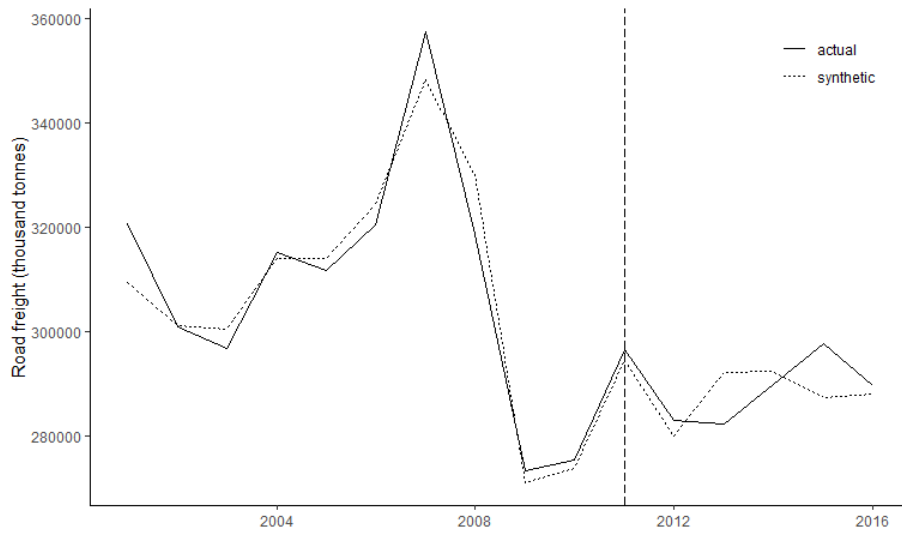


Figure 7: Path plot, Road freight, Düsseldorf area, 2001-2016

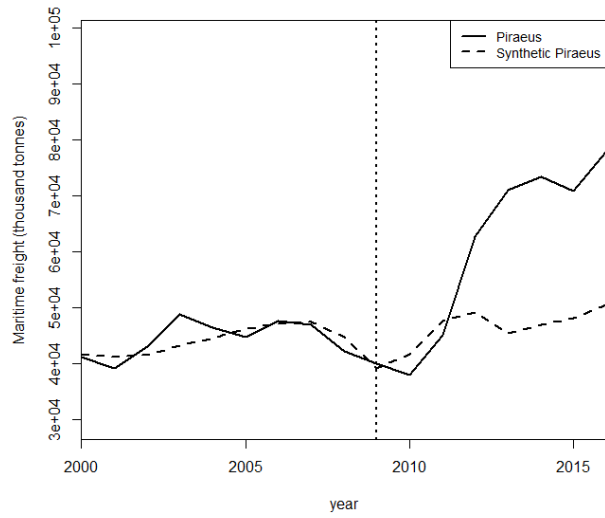


Figure 8: Number of trains under CR Express

Abadie et al. 2011 (p.14). The random reassessment of the treatment status to each observation in the sample can be used to construct a fake synthetic control

group. The identified effects are reassessed based upon this random assignment to predict the likelihood to observe a similar effect with random treatment.

Figure 9 depicts the results for the first result discussed earlier. As recommended in **Abadie 2010**, it excludes 11 NUTS 3 regions with a poor pretreatment fit (i.e. a MSPE that is five times higher than for the Attica region). The pictures show that random assignment of the treatment reduces the probability to achieve a gap as large as that for Attica in 2016 to only 2.35 %. This results supports robustness of our first finding.

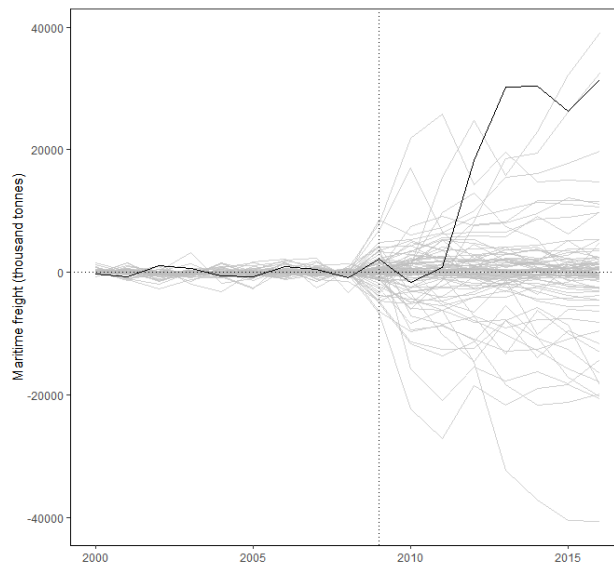


Figure 9: Gaps plot, maritime freight, Attica (bold) and control regions

The same approach is implemented to the sector level employment effects in Piraeus but this robustness check does not support the benchmark findings due to the unfavorably high MSPE for the pretreatment period. Examining the gap after and before 2009 more closely (see Figure 10) shows that the variation is not substantially different. However, Figure 10 also reveals that this outcome may be different for some other NUTS 3 regions in Greece. As hypothesized,

not only employment but also its immediate vicinity in Piraeus are expected to experience an impact from COSCO's investments.

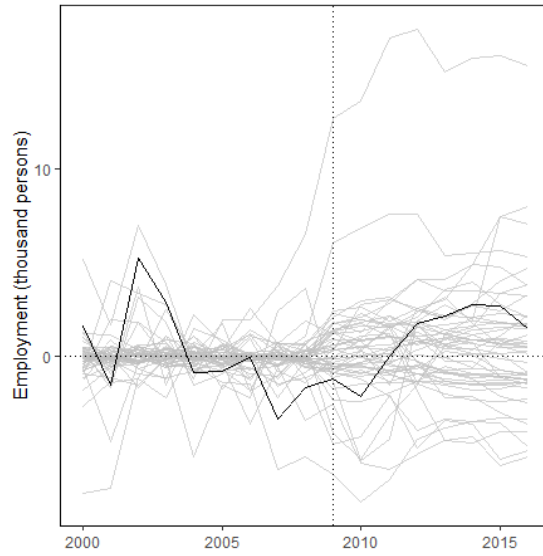


Figure 10: Gaps plot, Employment Sections G, H and I, Piraeus (bold) and control regions

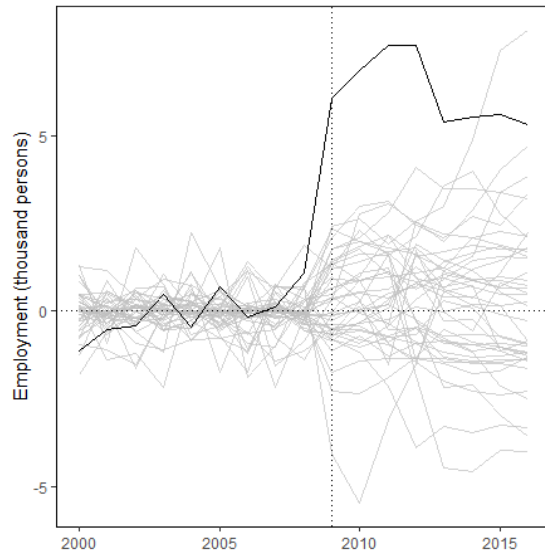


Figure 11: Gaps plot, Employment Sections G, H and I, West Attica (bold) and control regions

Therefore, we have redrawn the graph for West Attica, which is located to the North of the Piraeus port (see Figure 11). Here, findings are more conclusive because the pretreatment MSPE is much smaller and a deviation in the treatment year is clearly distinguishable. The probability of achieving a gap as large or larger than that for West Attica in 2016 if randomly reassigning treatment to another NUTS 3 area is only 2.44 %.

## 6 Conclusion

This paper studies the causal effects of BRI infrastructure projects on regional development in Piraeus and Duisburg by combining synthetic control method with qualitative case studies. Generally, our findings suggest that the BRI infrastructure projects have already generated real impacts on local economic activities in the cities and areas receiving these projects. Both quantitative and qualitative evidence reveal that the impact on maritime transportation in Piraeus is very significant and positive. We also find rather modest short-run effects on employment in both treatment regions in the data at hand. This may be due to the limited number of observations available for the treatment effects, as well as the postponed effects of infrastructure provision. Meanwhile, the suggestive evidence presented in the interviews conducted in the two treatment regions suggests more pronounced effects on employment in the most recent years. Moreover, we find that rail transport does not crowd out local road transport in Duisburg.

The BRI is still evolving. Many investment projects are in the pipeline and will be materialized in the future. In September 2019, COSCO proposed a 600-million-Euro investment master plan in the Piraeus port, which includes the construction of Pier IV container terminal, the upgrade of shipyard area, expansion of Ro-Ro (car) terminal, construction of new oil terminal, enlargement of

the cruise passenger terminal, additional warehouses, four hotels, a commercial center, a museum and eco buses. Also, more and more new rail connections will be established between PRC and Europe. Therefore, we can expect Cosco's investment in Piraeus and the CR Express in Duisburg will generate larger effects on the local regions in the future.



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