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How New Airport Infrastructure Promotes Tourism: Evidence from a Synthetic Control Approach in German Regions

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Abstract

We examine how new airport infrastructure influences regional tourism. Identification is based on the conversion of a military air base into a regional commercial airport in the German state of Bavaria. The new airport opened in 2007 and promotes travelling to the touristic region Allgäu in the Bavarian Alps. We use a synthetic control approach and show that the new commercial airport increased tourism in the Allgäu region over the period 2008-2016. The positive effect is especially pronounced in the county where the airport is located. Our results suggest that new transportation infrastructure promotes regional economic development.

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1 Introduction

Transportation infrastructure connects regions and promotes regional (economic) development. Investments in roads, railroads and airports reduce transportation costs for products and people and help to attract new businesses, production plants and jobs. Moreover, infrastructure constitutes the basic determinant of (inter)national tourism flows. Tourists may well travel to rural areas when roads, railways and airports facilitate convenient and low-cost journeys. Tourists demand accommodation and amenities, cultural affairs such as theatres and exhibitions, amusement parks etc. and their expenditures in these areas often endorse regional economic development.

We examine how new airport infrastructure influences regional tourism. Empirical studies show that building or extending airports and airport services enhanced international tourism flows (Khadaroo and Seetanah, 2007; Eugenio-Martin, 2016; Khan *et al.*, 2017), increased production and employment (Hakfoort *et al.*, 2001; Klophaus, 2008; Zak and Getzner, 2014), endorsed regional economic development (Halpern and Bråthen, 2011; Mukkala and Tervo, 2013; Kazda *et al.*, 2017)[1], and might even generate positive spillover effects to neighboring regions (Percoco, 2010). There are, however, hardly any empirical studies identifying the causal effect of airport infrastructure on tourism or economic development. Empirical studies that examine how infrastructure influences economic development have to deal with identification issues. Transportation infrastructure is built to connect economic units, hence, disentangling causality between new infrastructure projects and economic development is difficult. New empirical studies use identification strategies such as instrumental variables (IV) or synthetic control to estimate causal effects of infrastructure programs on population and employment (Duranton and Turner, 2012; Möller and Zierer, 2018; Gibbons *et al.*, 2019), or economic development in individual regions (Chandra and Thompson, 2000; Ahlfeldt and Feddersen, 2018). Castillo *et al.* (2017) use a synthetic control approach for estimating the causal effect of an encompassing infrastructure program (including a new airport) on employment in the tourism sector in Argentina. The authors, however, do not isolate the effect of the airport. Scholars employing IV approaches show that airports or air passenger traffic increased local population (Blonigen and Cristea, 2015), employment in service-related industries (Brueckner, 2003; Green, 2007), and local employment in services that directly benefit from the air connection (Sheard, 2014). Koo

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[1]Tveter (2017), however, finds small positive effects of regional airports on employment and population in Norwegian municipalities.

et al. (2017), however, also use an IV and find no effect of direct air services on tourism inflow. Tsui (2017) uses IV and Difference-in-Differences approaches and shows that low-cost carriers (LCC) have a positive effect on domestic tourism demand.

We investigate how new airport infrastructure (specialized on LCC) influences additional guest arrivals in the tourism sector. Our identification is based on the conversion of the military air base "Memmingerberg" into the regional commercial airport Memmingen (*Munich-West*) in the German state of Bavaria. The military airfield was built by the Nazi-Regime in 1935/36 and was reused by the German Bundeswehr after World War II. In 2003, it was closed because the federal government decided to reorganize and consolidate the German Bundeswehr. We exploit the conversion of the airfield to a commercial airport specialized on low-cost carriers as exogenous positive infrastructure shock for the touristic sector in counties close to the airport. The commercial airport opened in 2007 and facilitates travelling to the touristic region *Allgäu* in the Bavarian Alps. We use a synthetic control approach comparing tourism inflows in counties close to the new commercial airport and their synthetic counterparts when the new commercial airport started operating. Counties from other regions in Bavaria that are not affected by the new airport constitute the donor pool to construct the synthetic counterfactuals. The results show that the new commercial airport increased incoming tourism from abroad in the *Allgäu* region over the 2008-2016 period. The positive effect is especially large in the county where the airport is located (*Lower Allgäu*): Memmingen Airport increased total arrivals of tourists and business travelers at touristic accommodations in *Lower Allgäu* on average by 54,000 (22%) and arrivals from abroad on average by 23,000 (69%) per year over the 2008-2016 period. Our results suggest that new transportation infrastructure may promote regional economic development.

2 Background: History, geography, airlines and passengers

The Regional Airport of Memmingen (FMM), internationally also known as *Munich-West* or *Allgäu-Airport*, was opened on the former military air base in Memmingerberg in the German state of Bavaria. The military air base was built by the Nazis in 1935/36 because of strategic military reasons and was reconstructed and reused by the German Bundeswehr and its NATO partners after World War II. In 2003, it was closed because the federal government decided to reorganize and consolidate the German

Bundeswehr. Local companies decided to start a commercial civil airport on the former NATO air base because of the high technical endowment and size of the runway. Local governments and the state government supported the civil airport with investments and subsidies for conversion and construction measures. Memmingen Airport, however, does not receive subsidies for its operating business and reports a positive operating result (earnings before interest and taxes, EBIT) since several years.[2]

FMM started operating commercial air service in mid-2007. The airport already had over 450,000 passengers in 2008 and over 800,000 passengers in 2009 with scheduled flights operated by TUIfly and Air Berlin in the first years. The regional airport is specialized on services by low-cost carriers such as the Irish airline Ryanair (scheduled flights since 2010) or the Hungarian airline Wizz Air (since 2009).[3] The number of passengers increased to 1.17 million by 2017, a decade after its opening (figure A1).[4]

The airport connects several countries in Europe and the Mediterranean region to the *Allgäu* region. German domestic flights were the most important ones in the first two years after launching air services at FMM but have been discontinued since 2011. In 2018, connections to and from Spain, Portugal, Romania, Bulgaria, Ukraine and the United Kingdom had the highest passenger volume at Memmingen Airport (table A1). A passenger survey conducted in 2018 has shown that 40% of all passengers at Memmingen Airport are incoming passengers, similarly during the winter (46%) and summer season (35%) (Bauer *et al.*, 2019).[5]

Memmingen Airport is located in the touristic region *Allgäu* in the southwest of the German state of Bavaria (figure A2). The *Allgäu* is a popular touristic region in Germany. It is famous, for example, for hiking and skiing in the Alps, wellness and health hotels, and Germany's most well-known castle Neuschwanstein. *Allgäu* ranks second after the state capital city Munich among the most popular touristic regions regarding arrivals and overnight stays in Bavaria. The 2018 passenger survey has shown that

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[2]Many regional airports do not report positive operating results and operate at inefficient levels (Adler *et al.*, 2013). One reason for inefficiency lies in the importance of LCC (Červinka, 2017). Their market power enables LCC to negotiate favorable agreements, e.g. marketing charges (Barbot and D'Alfonso, 2014).

[3]The emergence of LCC has led to an overall increase in the number of tourists (Rebollo and Baidal, 2009). Tourists choosing LCC are likely to have different preferences than tourists choosing other carriers (Eugenio-Martin and Inchausti-Sintes, 2016).

[4]All tables and figures denoted with an A are shown in the Online Appendix.

[5]Flight connections to the source regions Bulgaria, Poland, Romania and Russia had among the highest shares of incoming passengers ($> 50\%$) among all air services in 2018. Air services offered to Sweden and the Mediterranean region including Croatia, Greece, Italy, Portugal or Spain are mainly used by outgoing passengers (incoming share $< 30\%$).

Allgäu (21%) and Munich (33%) account for more than half of all overnight stays by incoming passengers via Memmingen Airport (Bauer *et al.*, 2019).[6] Growth rates in guest arrivals and overnight stays in the touristic region *Allgäu* exceeded those of Bavaria in total since 2007.

Connectivity via airport infrastructure depends on air services being offered (see Derudder and Witlox, 2005). An airport's attractiveness for airlines is influenced by its catchment area size (Humphreys and Francis, 2002; Lieshout, 2012) and airport competition in multiple airport regions (Pels *et al.*, 2001; Alberts *et al.*, 2009; Derudder *et al.*, 2010; Lian and Rønnevik, 2011; Wiltshire, 2018). Memmingen Airport is often advertised as *Munich-West* and Munich's low-cost carrier airport abroad. Flights to FMM tend to be cheaper than to Munich's International Airport (MUC). Travel times between Memmingen Airport and Munich's city center, however, last about 1.5 hours (by car and bus/railway likewise), i.e., about 0.5-0.75 hours longer than from Munich International Airport. On the contrary, travel times to several touristic places in the *Allgäu* are reduced when arriving at Memmingen Airport rather than at any other airport.[7]

3   Empirical strategy and data

Estimation strategy

We compare the development of tourism across counties in the German federal state of Bavaria. 96 Bavarian counties form 36 tourism regions (figure 1), which merchandise as Bavarian touristic destinations. Therefore, our treatment and control areas (donor

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[6]About 75% among all incoming passengers which stay in the *Allgäu* region report touristic or private motives, about 20% report business reasons.

[7]The only exception is the *West Allgäu* region close to Lake Constance. For several municipalities in *West Allgäu* travel times to the *Bodensee-Airport* Friedrichshafen at Lake Constance are faster than to Memmingen Airport. The airport in Friedrichshafen, located in the German state of Baden-Württemberg, was built in 1918 and is operating as commercial airport since 1929. *Bodensee-Airport*, however, cannot be described as low-cost carrier airport for Munich like Memmingen Airport. Passenger numbers at Friedrichshafen Airport are fluctuating around an annual number of 550,000 since 2005. Most importantly, passenger numbers of the airport in Friedrichshafen were not altered by the opening of Memmingen Airport (figure A1). St. Gallen Airport in Switzerland is another small regional airport close to Friedrichshafen, but has even smaller passenger numbers which are constantly around 100,000. Innsbruck Airport in Austria and Memmingen Airport might have some overlapping catchment area in the Alps. Innsbruck Airport, however, also increased passenger numbers since the opening of FMM. We conclude that other airports in the catchment area of Memmingen Airport are no close substitutes (figure A1 and figure A2).

pool) are counties belonging to different touristic regions. The Airport Memmingen is located in the touristic region *Allgäu* which consists of seven counties constituting our treatment group (light gray counties in figure 1). Counties in touristic regions located in the north and east of Bavaria form our control group (donor pool, dark gray counties). Counties from touristic regions bordering the *Allgäu*, as well as the capital Munich and its vicinity, are excluded from the analysis, i.e., they are neither in our treatment nor control groups (white counties). Touristic regions bordering the *Allgäu* are likely to be treated to some extent as well. Munich attracts most incoming passengers of Memmingen Airport and is by far the most populous and economically powerful area in Bavaria and therefore not comparable to other regions especially in terms of tourism inflows.

[Figure 1 about here]

Identification relies on the main assumption that sorting into treatment was exogenous. The placement of the military air base in 1935/36 and its closure by decision of the federal government in 2003, hence, the timing of treatment, are obviously independent of touristic considerations. What is more, other former air bases in Bavaria are located relatively close to the international airports in Munich and Nuremberg or the technical equipment and size of the airfield was not as suitable for a commercial airport. They are re-used as special airfields, sport airfields, or industrial areas. Memmingen Airport, however, has proximity to the catchment and metropolitan area of Munich. Thus, it was an ideal location for establishing a specialized low-cost carrier airport close to Munich. Its geographic location combined with the circumstances of its conversion renders FMM an ideal testing ground to examine how new transport infrastructure influences tourism indicators in the (peripheral) counties around the airport.

To identify how Memmingen Airport influences tourism in the *Allgäu* region, we use the synthetic control approach to compare actual developments in tourism with a hypothetical situation, which would probably have arisen without the opening of the commercial airport. The synthetic control method is a powerful approach for comparative case studies when the number of treated units is small, and only aggregated outcomes are observable (see Abadie and Gardeazabal, 2003; Abadie *et al.*, 2010, 2015; Chernozhukov *et al.*, 2018). The approach allows to construct accurate counterfactuals of the counties of interest.[8] The identifying assumption in our context is that tourism

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[8]The synthetic control approach using algorithm-derived weights is supposed to better describe the characteristics of the counties of interest than any single comparison or an equally weighted combination

in the treated counties close to the new commercial airport would have evolved in the same manner as in their synthetic counterfactuals in a hypothetical world without opening of the commercial airport. Synthetic controls for the treated counties are constructed by using lagged values of the outcome variable as predictors (Firpo and Possebom, 2018; Kaul *et al.*, 2018). The counterfactual outcome is determined as a weighted average of the untreated donor pool counties.[9] Counties from other Bavarian regions that are not affected by the new airport constitute the donor pool to construct the synthetic counterfactuals (figure 1). The difference in the outcome variable between treated counties and their synthetic counterfactuals following the treatment measures the causal effect of the airport if the following assumptions hold: first, there is a sufficient match between the trends in the outcome variable for synthetic and treated counties over a long pre-treatment period. We provide evidence for this fit in the next section. Second, there are no further interventions that affected treated and untreated counties differently in the treatment period. All counties are part of touristic regions in Bavaria. General policies of the Bavarian state government and actions of the Bavarian Tourism Marketing agency to attract tourists from abroad are supposed to target all Bavarian counties in the post-intervention period. Third, the counties of the donor pool are not affected by the treatment. Counties in touristic regions bordering the *Allgäu* and the capital Munich are not included in our donor pool. A passenger survey conducted at Memmingen Airport in 2018 has shown that only up to 7% of all incoming passengers visit one of the 69 donor pool counties in the rest of Bavaria (Bauer *et al.*, 2019).[10] By estimating placebo treatment effects in our robustness tests, we show that tourism in donor pool regions is not affected by the opening of the new commercial Memmingen Airport.

We provide parametric estimates from a traditional *difference-in-differences* model using Weighted Least Squares (WLS) to discuss the significance of our causal inference. When estimating the model with WLS, we weight all counties with the weights derived by our synthetic control approach. In our robustness tests, we also discuss results when estimating the difference-in-differences model with Ordinary Least Squares (OLS) where all counties receive an equal weight.[11]

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of several control counties. Scholars, however, discuss caveats in the optimal selection of economic predictors for counterfactuals to avoid biased estimates (Kaul *et al.*, 2018).

[9] The synthetic control approach is described in technical detail in the appendix.

[10] If at all, the airport effect might be biased towards zero if tourists travel to donor pool regions.

[11] The method is described in technical detail in the appendix.

Data

We use county-level data on registered guest arrivals at touristic accommodations, including business travelers and guests with touristic motives. Guests who do not stay at a touristic accommodation, for example guests staying with friends and relatives, are not registered.[12] Our main dependent variable is guest arrivals from abroad as domestic flights are discontinued since 2011. We also use data on total guest arrivals (including domestic and foreign arrivals). Our dataset encompasses the period 1996-2016.[13] We therefore cover 11 years before the opening of the commercial airport (pre-treatment) and 9 years afterwards (post-treatment). The year 2007, when commercial flights started operating, is excluded. We use four treatment regions: *East Allgäu*, *Lower Allgäu*, *Upper Allgäu* and *West Allgäu*.[14]

4   Results

Baseline

The results of the baseline synthetic control model are shown in figure 2 and table A2 (in the appendix). We report results for guest arrivals from abroad in the four regions *East, Lower, Upper* and *West Allgäu*. Table A2 shows that the fitting procedure yields comparable outcomes in treatment and synthetic control units over the pre-treatment period. The ratios of arrivals between the real *Allgäu* regions and their synthetic counterfactuals amount to almost 100% in all four regions before 2007 (table A2). Figure 2 shows the pre-treatment matching trends graphically. Table A3 shows the corresponding individual donor pool weights. The results indicate that the number of total arrivals increased in *Lower, Upper* and *East Allgäu* after FMM started operating, compared to their synthetic counterfactuals. The positive effect of Memmingen Airport on arrivals is in relative terms largest in Lower *Allgäu*, i.e. in the counties where Mem-

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[12]Using arrivals at touristic accommodations as the dependent variable underestimates the total effect of the airport on tourism as about half of all incoming passengers reported to visit friends and relatives in a 2018 passenger survey at FMM (Bauer *et al.*, 2019).

[13]For a raw data plot see figure A3.

[14]We merge rural counties and independent city counties in our treatment region because the independent city counties are regional centers and geographically enclosed by the rural counties: *East Allgäu* including the rural county Ostallgäu and the city of Kaufbeuren; *Lower Allgäu* including the rural county Unterallgäu and the city of Memmingen; *Upper Allgäu* including the rural county Oberallgäu and the city of Kempten and *West Allgäu* including the rural county Lindau-Bodensee. For a detailed map see figure A4.

mingen Airport is based. More precisely, Memmingen Airport increased arrivals from abroad in *Lower Allgäu* by 69% in the 2008-2016 period. The positive effect of the airport on guest arrivals from abroad in *Upper* and *East Allgäu* is 45% and 17% (compare the ratios in table A2, column 2). In *West Allgäu*, however, the results do not suggest that Memmingen Airport increased the number of arrivals from abroad.

[Figure 2 about here]

We compare our synthetic control results to estimates from a *difference-in-differences* model using WLS where we weight the observations in our regression with the weights derived by our synthetic control approach (for individual weights, see table A3). Hence, we apply the difference-in-differences estimation with the synthetic control group (Roesel, 2017). Estimating the effect of the airport on arrivals from abroad using WLS yields similar results to the pre-post-treatment differences of the synthetic control approach (panel A and B of table 1). When we use the parametric WLS model the effect of the airport on guest arrivals from abroad is positive and significant in *Upper* and *Lower Allgäu*, but does not turn out to be statistically significant in *East* and *West Allgäu* (panel B in table 1). Our results suggest that the opening of the commercial airport in Memmingen increased the number of guest arrivals from abroad compared to a counterfactual development without airport by roughly 42,000 in *Upper Allgäu* and by roughly 23,000 in *Lower Allgäu* per year over the 2008-2016 period.

[Table 1 about here]

We also examine whether the opening of Memmingen Airport influenced total arrivals at touristic accommodations in the *Allgäu* region (including guests from domestic and abroad). Synthetic control results for total arrivals are very similar to those for arrivals from abroad (figure A5). Estimates using WLS, however, do not turn out to be statistically significant in *East, West* and *Upper Allgäu*. The *Upper Allgäu* county is by far the most popular region for domestic tourists in Bavaria (next to the capital Munich). Thus, more arrivals from abroad may not translate into more total arrivals in *Upper Allgäu*. Our results suggest that the positive effect of Memmingen Airport on total guest arrivals is only significant in *Lower Allgäu*, i.e., in the counties where FMM is based. The opening of Memmingen Airport increased total guest arrivals in touristic accommodations in *Lower Allgäu* by yearly 54,000 over the 2008-2016 period (table A4). The ratio of real and synthetic total arrivals is 122% for *Lower Allgäu* over the treatment

8

period 2008-2016 (table A2). *Lower Allgäu* had the lowest number of guest arrivals among all *Allgäu* regions. Hence, increasing tourism because of the airport is large in relative terms for *Lower Allgäu*, but, for example, not for the *Upper Allgäu* (figure A3). Moreover, the counties where Memmingen Airport is based may likewise benefit from incoming and outgoing passengers, for example if passengers stay in accommodations close to the airport before departure or after arrival.

Robustness

We submit our results to several robustness tests. First, following Abadie *et al.* (2015), we employ variations in the county weights by constructing *leave-one-out-distributions* of the synthetic control for the *Allgäu* regions. We re-estimate the baseline model for every treated region and iteratively omit one county from the donor pool that received a positive weight. Results for this robustness test are shown in figure 3, which reproduces the baseline results (black line) from figure 2 with the light gray lines representing the leave-one-out estimates. We focus on the gap in arrivals from abroad between each treated region and its synthetic counterfactual, i.e., we calculate the difference between the lines shown in figure 2. The estimates excluding individual donor pool counties follow the baseline estimates quite closely in all considered *Allgäu* regions. The leave-one-out distributions are particularly robust for the *Upper Allgäu* and *Lower Allgäu* regions. This finding is in line with our parametric WLS results that only show a significant effect of the airport on guest arrivals from abroad in the *Upper* and *Lower Allgäu* regions.

[Figure 3 about here]

Second, we estimate placebo specifications to verify the validity of the estimation design. We iteratively apply the synthetic control method on every county of the donor pool using them as a placebo-treatment group. If donor pool counties are not affected by the treatment, we should not observe any differences in the development of tourism between the placebo-treatment and control groups, i.e., we should estimate zero gaps in guest arrivals for every iteration. The results of this test are shown in figure 4, where every light gray line indicates one placebo estimate. This robustness check also corroborates our baseline findings showing that the previously estimated positive treatment effects on arrivals from abroad (black line) in the *Allgäu* regions are unusually large

9

when compared to the bulk of placebo estimates. What is more, the large majority of placebo estimates reveals a good fit and also produces estimated zero gaps for the control counties. Thus, the selected control counties seem to be a valid comparison group for the treatment regions, since the opening of Memmingen Airport did not influence tourism or coincide with other shocks to touristic inflows in the selected donor pool counties. The positive treatment effect of Memmingen Airport on guest arrivals is indeed considerably larger in *East, Lower,* and *Upper Allgäu* than in our placebo counties. On the one hand, this validates our choice of control units, but on the other hand this also increases confidence that our significant baseline estimates for the *Upper* and *Lower Allgäu* regions are indeed attributable to the opening of Memmingen Airport.

[Figure 4 about here]

Third, we compare our baseline results to estimates from a traditional *difference-in-differences* regression using OLS with equal weights of the counties in our control group. Estimating the impact of the airport using difference-in-differences gives rise to positive effects for arrivals from abroad in all our treated regions if we consider all 69 counties of our donor pool (panel A in table A5). Compared to our baseline results, also the regions *East* and *West Allgäu* experienced a significant positive increase of arrivals from abroad. For the regions *East* and *West Allgäu* the common trend assumption of the difference-in-differences estimation is, however, not fulfilled. Figure A6 shows the development of arrivals from abroad in our treatment and control regions between 1996 and 2016. Guest arrivals in the regions *East* and *West Allgäu* experience an increase some years before the airport started operating, compared to the rest of Bavaria. For *Upper* and *Lower Allgäu*, in contrast, the common trend assumption fits quite well. Guest arrivals develop similarly compared to the rest of Bavaria before 2007 and start to diverge and increase after Airport Memmingen was opened.[15] In addition, we restrict the counties in our control group to counties that received non-zero weights in the synthetic control approach (but contribute now with an equal weight). Our results turn out to be quite similar in economic terms and significance to the baseline estimates using WLS (table 1). When we use the restricted OLS model the effect of the airport on guest arrivals from abroad is again positive and significant in *Upper* and *Lower Allgäu*, but does not turn out to be statistically significant in *East* and *West Allgäu* (panel B in table A5).

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[15]Similar to Roesel (2017), we find that results from the difference-in-differences and synthetic control method yield similar results if pre-treatment outcomes follow a common trend. However, if pre-treatment trends are not alike, the synthetic control methods deliver more reliable results.

5 Effects on overall economic development

Our results show that new airport infrastructure increases registered arrivals at touristic accommodations. The synthetic control results suggest that every year around 95,000 additional registered guests from abroad arrived in the *Allgäu* region in the period of 2008 to 2016 than would have been the case if the airport had not been opened (table A2).[16] The effect is significant and robust for the *Upper* and *Lower Allgäu* regions which amounts to 65,000 additional arrivals from abroad per year. An important question is how the increasing guest arrivals translate into higher revenues in the regional tourist industry. More guests may influence revenues in the tourist industry via numerous channels: they spend some money for food and accommodation, go shopping and demand, among others, local transport, amenities, spa and skiing, or cultural affairs. At the same time, expenditures in the regional touristic industry induce multiplier effects on other regional industries and often endorse regional economic development. A passenger survey conducted at FMM in 2018 shows that incoming passengers from abroad via Memmingen Airport spent about 131 euros on average per day, whereas each additional euro in expenditure by an incoming passenger increased purchasing power inflows by a multiplier of around 1.43 euros in counties located around the airport (Bauer *et al.*, 2019). [17]

Increasing revenues in the tourism industry because of guest arrivals from abroad are arguably a lower bound of regional economic benefits generated by the opening of the commercial airport. Airport infrastructure is also likely to influence business location and investment decisions, and foster regional economic development by increased production and employment; accounting for the direct effects of production and employment at the airport itself, and indirect effects because of sub-contractors benefiting

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[16]The number of 95,000 refers to the sum of the differences between the actual and synthetic arrivals from abroad of the four treatment regions in the period of 2008 to 2016.

[17]The survey includes 1,002 incoming passengers at Memmingen Airport in 2018 (487 during the winter season; 515 during the summer season). Incoming passengers visiting the *Allgäu* region reported to stay around 6.4 days per visit. This would sum up to around 838 euros direct expenditures and additional 361 euros indirect multiplier effects in the Allgäu region per incoming passenger from abroad. Considering the total of yearly (significant) 65,000 additional guest arrivals from abroad at accommodations and employing a *back-to-the-envelope*-calculation, Memmingen Airport is supposed to increase direct and indirect tourism revenues by incoming guests from abroad in the *Allgäu* region by around 77.9 million euros per year (all in 2018 prices). The calculation must be interpreted with caution as interviewed incoming passengers at the airport and registered guest arrivals at accommodations are different concepts. On the one hand, one incoming passenger may well count twice in the guest arrivals statistics if they stay in two different accommodations within the same region. On the other hand, average expenditures refer to all surveyed passengers, staying at touristic accommodations or not. While the first could overestimate the economic effect, the latter would underestimate it.

from the new airport infrastructure (Hakfoort *et al.*, 2001; Klophaus, 2008; Zak and Getzner, 2014).[18] In any event, a commercial airport is attractive for tourists and business travelers and might influence business location decisions by helping to enhance a region's image or facilitate the recruitment of foreign professionals.[19] In 2018, Dorn *et al.* (2019) have conducted a survey asking local entrepreneurs about the extent to which their business benefits from Memmingen Airport and whether their investment decisions have been affected by the airport.[20] The results suggest some positive effects of Memmingen Airport on business connections. 21% of the respondents believe that Memmingen Airport improved business connections and about one third reported that the new airport infrastructure helped to improve conditions regarding location and to attract specialist workers from abroad. Breidenbach (2019), however, finds no evidence for spillover effects of regional airports on the surrounding economies in Germany.

Governments and public stakeholders often argue that subsidies and investments in new airport infrastructure pay off because of its regional economic impact. New airport infrastructure has many benefits, but also external costs: "the costs are clearly localized in terms of noise, reduced property values, and degradation of health and quality of life" (Cidell, 2015, 1125f, see also Boes and Nüesch, 2011; Ahlfeldt and Maennig, 2015). Politicians must consider the total cost-benefit ratio and sustainability of public investment decisions in infrastructure projects.

6 Conclusion

Scholars examine the extent to which new transportation infrastructure promotes economic development. Many studies describing effects of airport infrastructure on economic development employed input-output methods or show correlations. Clearly,

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[18]One may well want to investigate whether the Memmingen Airport had any effect on overall economic development in the *Allgäu* region. We cannot use synthetic control techniques to estimate the causal effect of the Memmingen Airport on overall economic development measures like GDP, because the military air base that operated until the year 2003 also had economic impacts on the *Allgäu* region. The former air base hosted some 2,200 soldiers who stimulated local consumption. They needed to be supplied with necessities including food etc. that have been provided by local enterprises.

[19]Scholars examine the extent to which business travelers and tourists have similar preferences regarding airports and airlines. In the San Francisco Bay Area, preferences of business travelers and tourists were quite similar (Pels *et al.*, 2001).

[20]The survey asked participants in the monthly ifo business survey whose enterprise is located in 28 counties around Memmingen Airport. The ifo business survey is conducted every month among 7,000 German firms, and provides the basis for the ifo Business Climate Index, Germany's leading business cycle indicator. Among a total of 7,000 German firms, 770 firms are located around Memmingen Airport and have been asked. The response rate was 30.5% (235 firms).

the input-output methods and correlations are useful in assessing benefits of new airport infrastructure, but they do not measure causal effects. Studies examining the causal effect of new airport infrastructure on regional tourism are scarce. We employ a synthetic control approach and estimate how new airport infrastructure increases arrivals of tourists in the Bavarian (peripheral) region *Allgäu*. Identification is based on converting a military air base into the regional commercial airport Memmingen. The results show that additional tourist inflows are particularly pronounced and robust in the county where the airport is located and are driven by guest arrivals from abroad. Our results suggest that new transportation infrastructure promotes regional economic development. The economic effects, however, might also differ among airports in their scale and direction (Allroggen and Malina, 2014), and may well depend on the geographical catchment area size and airport competition in multiple airport regions (see Pels *et al.*, 2001; Lian and Rønnevik, 2011; Wiltshire, 2018). Future research should employ empirical techniques to estimate causal effects of new airport infrastructure in other regions and on other economic outcome variables like employment and production.

Acknowledgments

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Figure 1: Treatment and donor pool regions
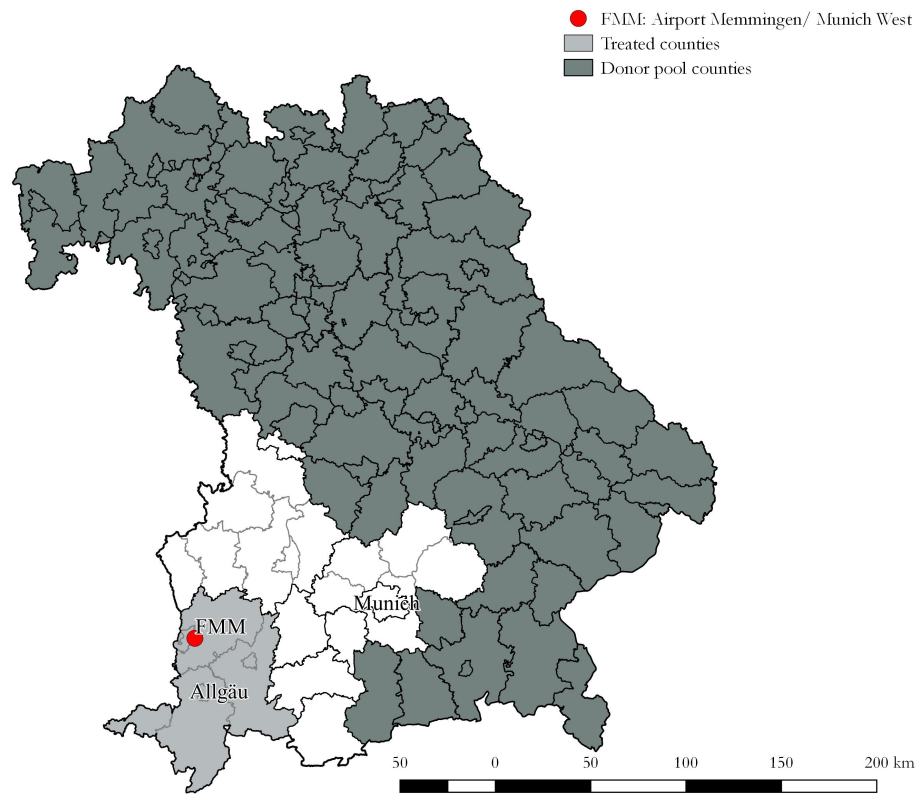
Notes: The map shows the federal state of Bavaria with its touristic regions (black boundaries) and the Bavarian counties (gray boundaries). Light gray counties form our treatment region Allgäu. Dark gray counties form our donor pool. White shaded counties are not included, because they are likely to be treated to some extent as well.

Figure 2: Synthetic control method, arrivals from abroad
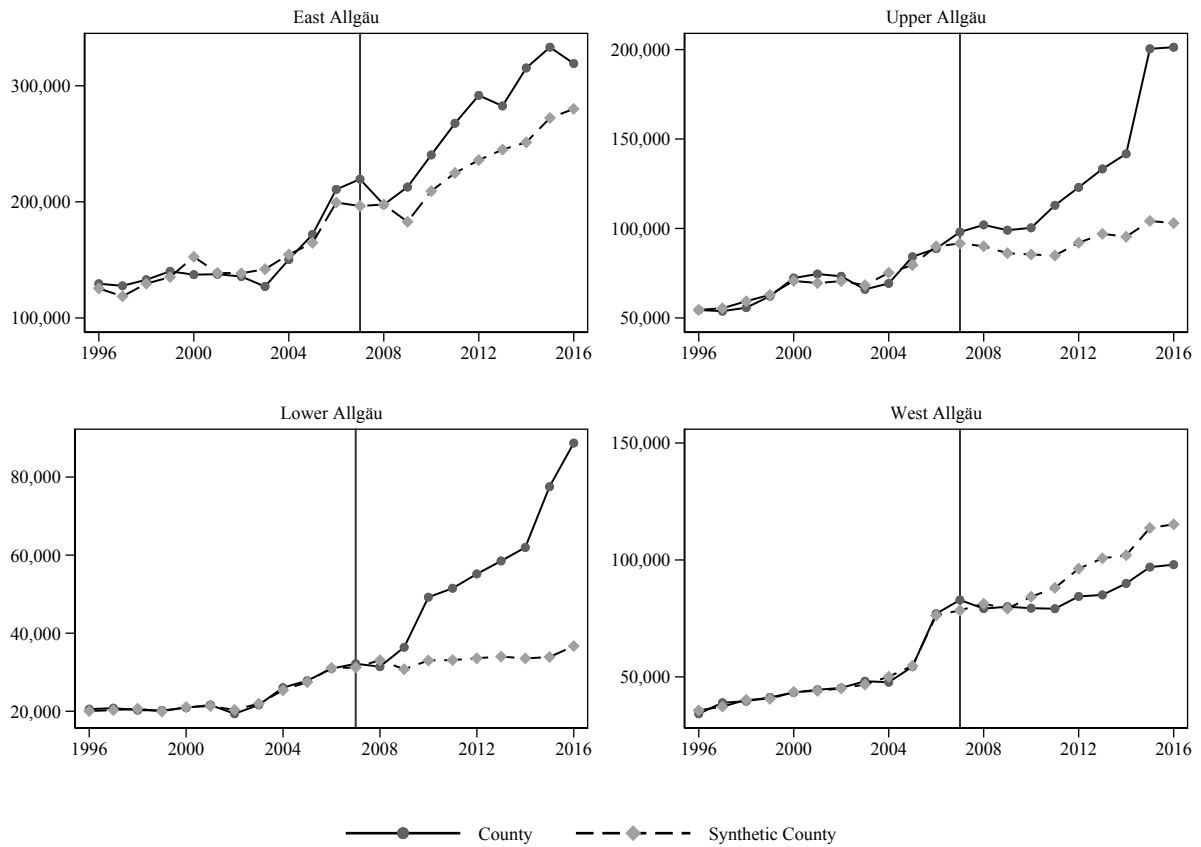
Notes: This figure shows arrivals from abroad in the four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu (dark gray) and in their synthetic counterparts (light gray). The donor pool consists of counties in Bavaria that were not treated. The vertical line in each graph marks the opening of the Airport Memmingen in 2007.

Figure 3: Robustness (I): Leave-one-out
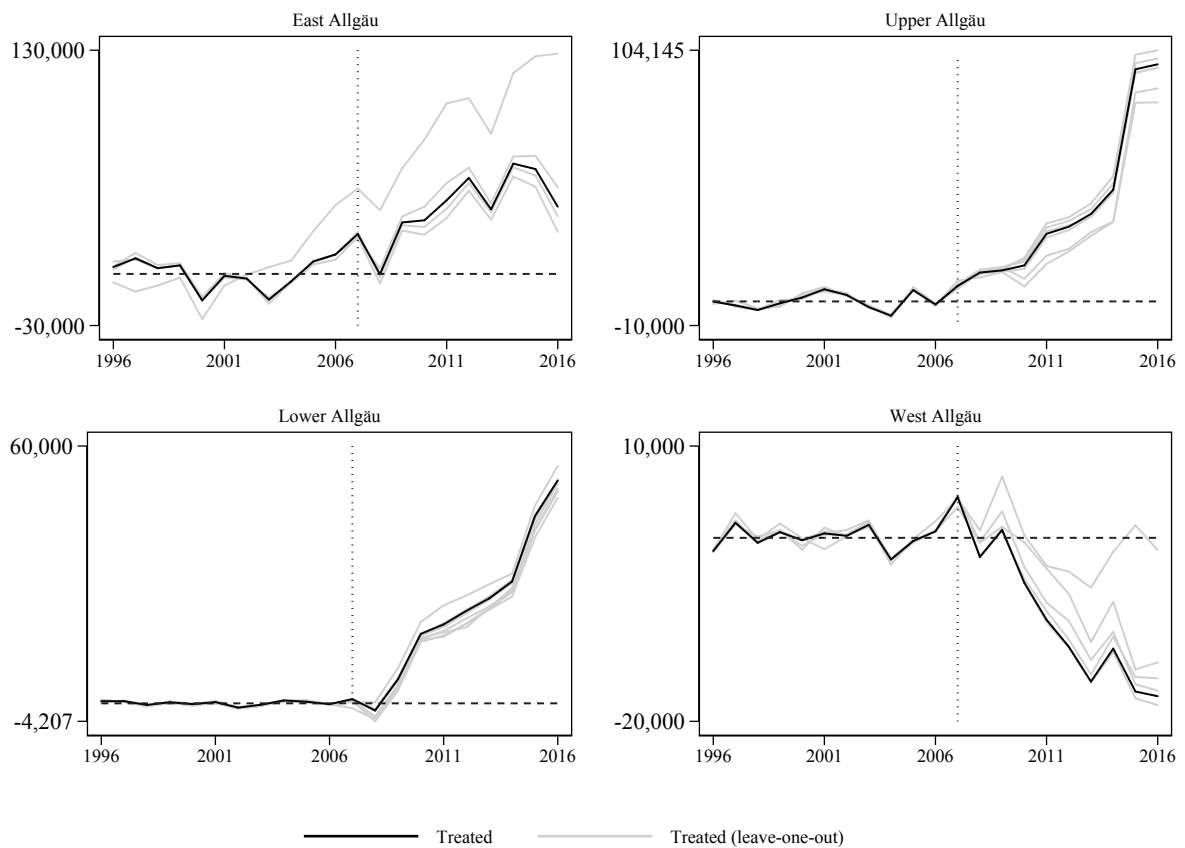
Notes: This figure shows the gap of arrivals from abroad between the treated regions and their synthetic counterfactuals. The black line represents the gap for the four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu (baseline synthetic control estimate). The light gray lines represent estimates from repeated synthetic control analyses while iteratively leaving out one donor pool county. The vertical line in each graph marks the opening of Memmingen Airport in 2007.

Figure 4: Robustness (II): Placebo test
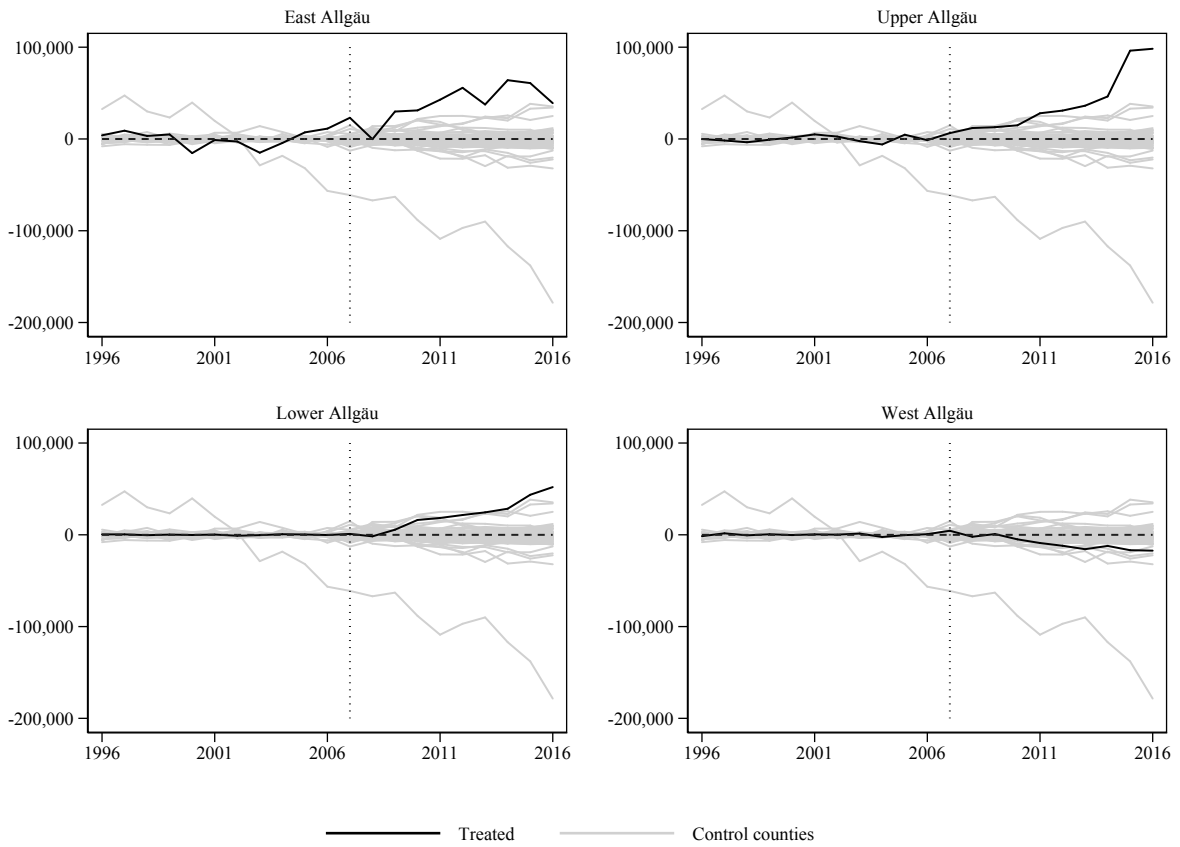
Notes: This figure shows the gap of arrivals from abroad between the treated regions and their synthetic counterfactuals. The black line shows the gap for our four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu. The light gray lines show 72 placebo gaps for each county in the donor pool. Nuremberg is omitted as an outlier, since it is the upper bound in guest arrivals of the donor pool counties. The vertical line in each graph marks the opening of Memmingen Airport in 2007.

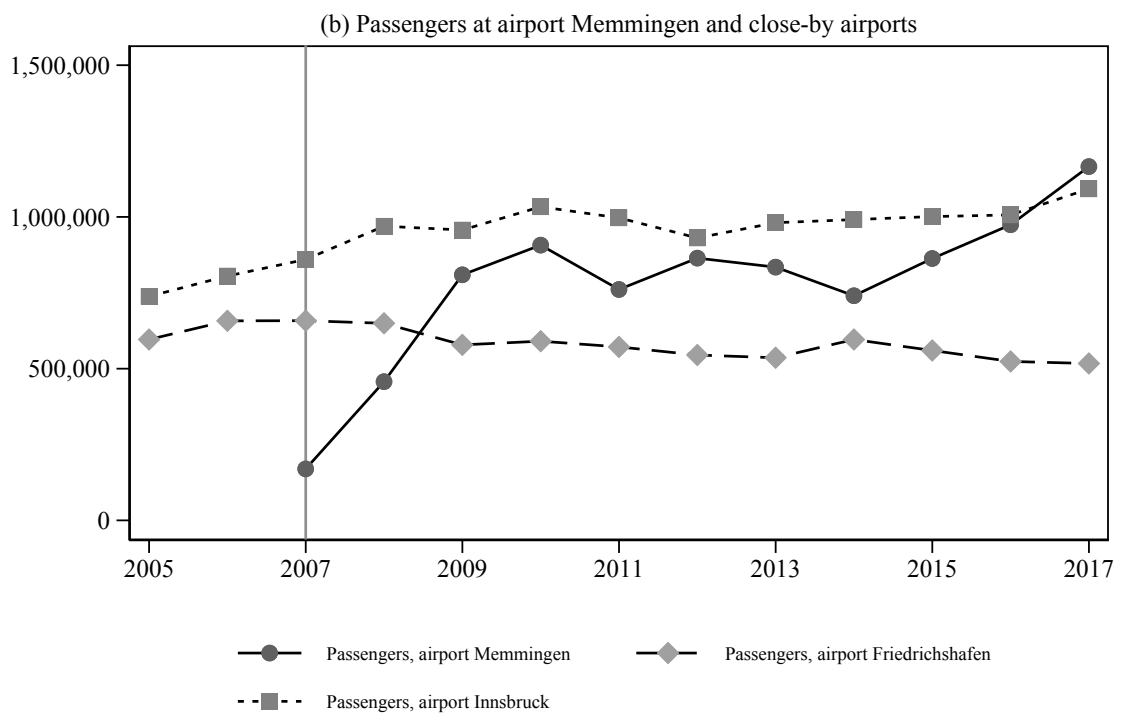## Table 1: Difference-in-differences results using WLS

	Arrivals from abroad			
	(1) East Allgäu	(2) Upper Allgäu	(3) Lower Allgäu	(4) West Allgäu
Panel A: Synthetic control group				
Pre-Post-Treatment difference	40,001	41,906	23,141	-9,863
Panel B: Difference-in-differences (WLS)				
Allgäu · Airport	40,001	41,930***	23,141***	-9,911
	(44,659)	(3,422)	(4,968)	(11,059)
County fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	100	140	180	120
Within R^2	0.821	0.852	0.793	0.854

Notes: The table compares results from our synthetic control approach to difference-in-differences results. Synthetic control approach results in Panel A are calculated from Table A2 as the difference in before-after treatment differences of our treated regions and their synthetic counterparts. Panel B shows the results of difference-in-differences estimations using a WLS regression with weights derived from our synthetic control method (see Table A3 in the appendix). We use yearly data over the period of 1996 to 2016 (without 2007). Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

Appendix (for online publication only)

A Figures and tables

Figure A1: Passengers at Memmingen Airport and close-by airports

(a) Passengers at airport Memmingen

- ●—— Passengers, national air connections
- ◆—— Passengers, international air connections

(b) Passengers at airport Memmingen and close-by airports

- ●—— Passengers, airport Memmingen
- ◆—— Passengers, airport Friedrichshafen
- ▪--- Passengers, airport Innsbruck
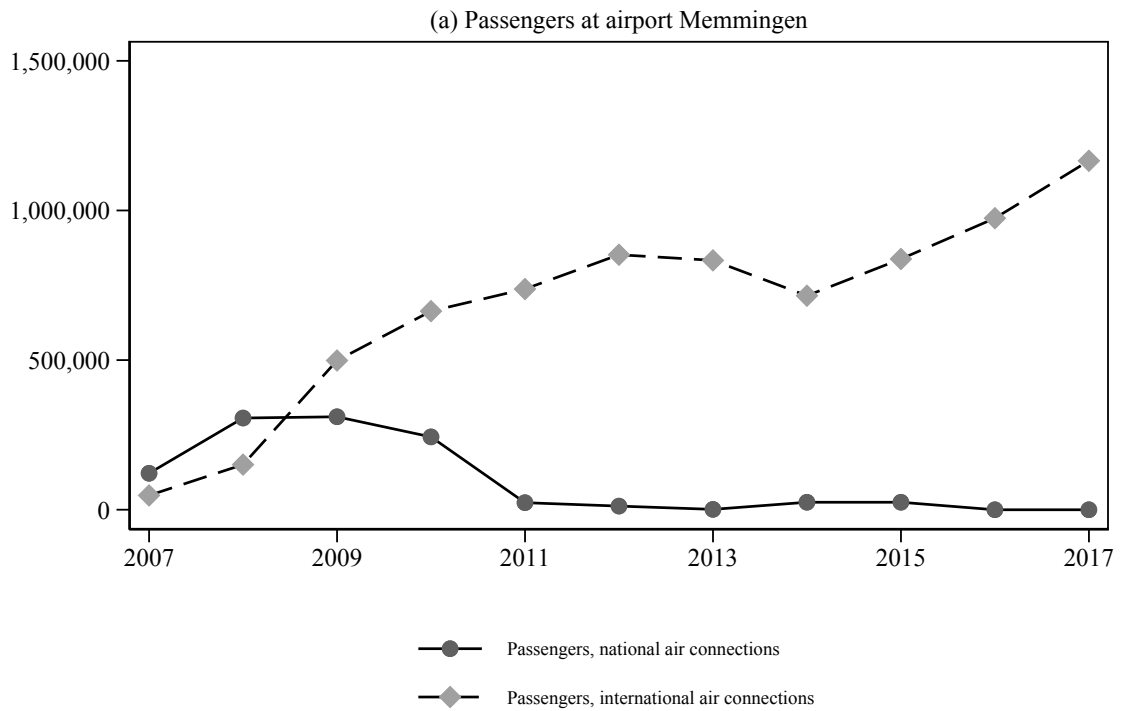
Notes: Panel (a) shows the development of passengers at national air connections (dark gray) and international air connections (light gray) at the Memmingen Airport. Panel (b) shows the development of passengers overall at Memmingen Airport and the close-by airports Friedrichshafen and Innsbruck.

Figure A2: Map of Bavaria
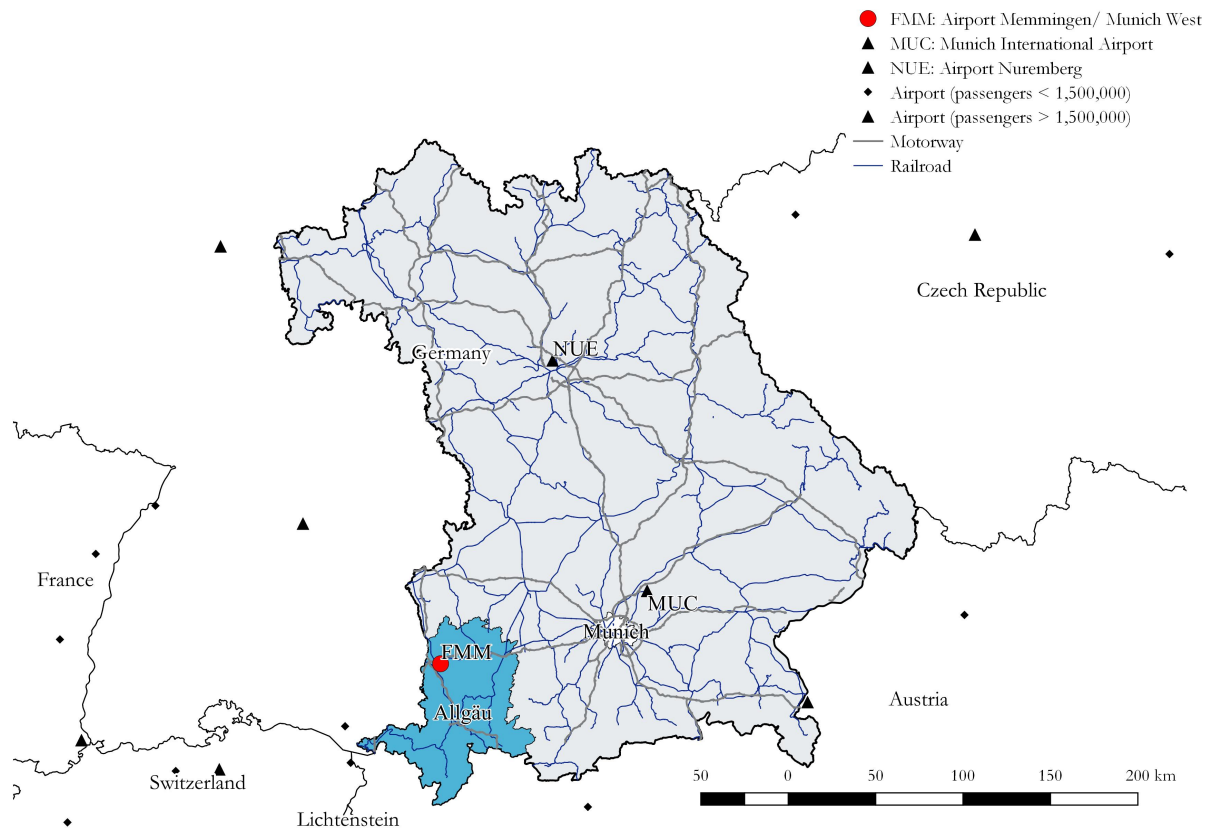
Notes: The map shows the federal state of Bavaria (light gray) with its two international airports in Munich and Nuremberg and the regional airport in Memmingen (red circle). Gray lines show the motorway network, blue lines the railroad network in Bavaria. The blue region (Allgäu) is our treatment region. Passenger numbers of 2018.

Figure A3: Raw data plots

(a) Arrivals from abroad

East Allgäu · · · Upper Allgäu — — Lower Allgäu ——— West Allgäu ——— Control counties

(b) Total arrivals

East Allgäu · · · Upper Allgäu — — Lower Allgäu ——— West Allgäu ——— Control counties
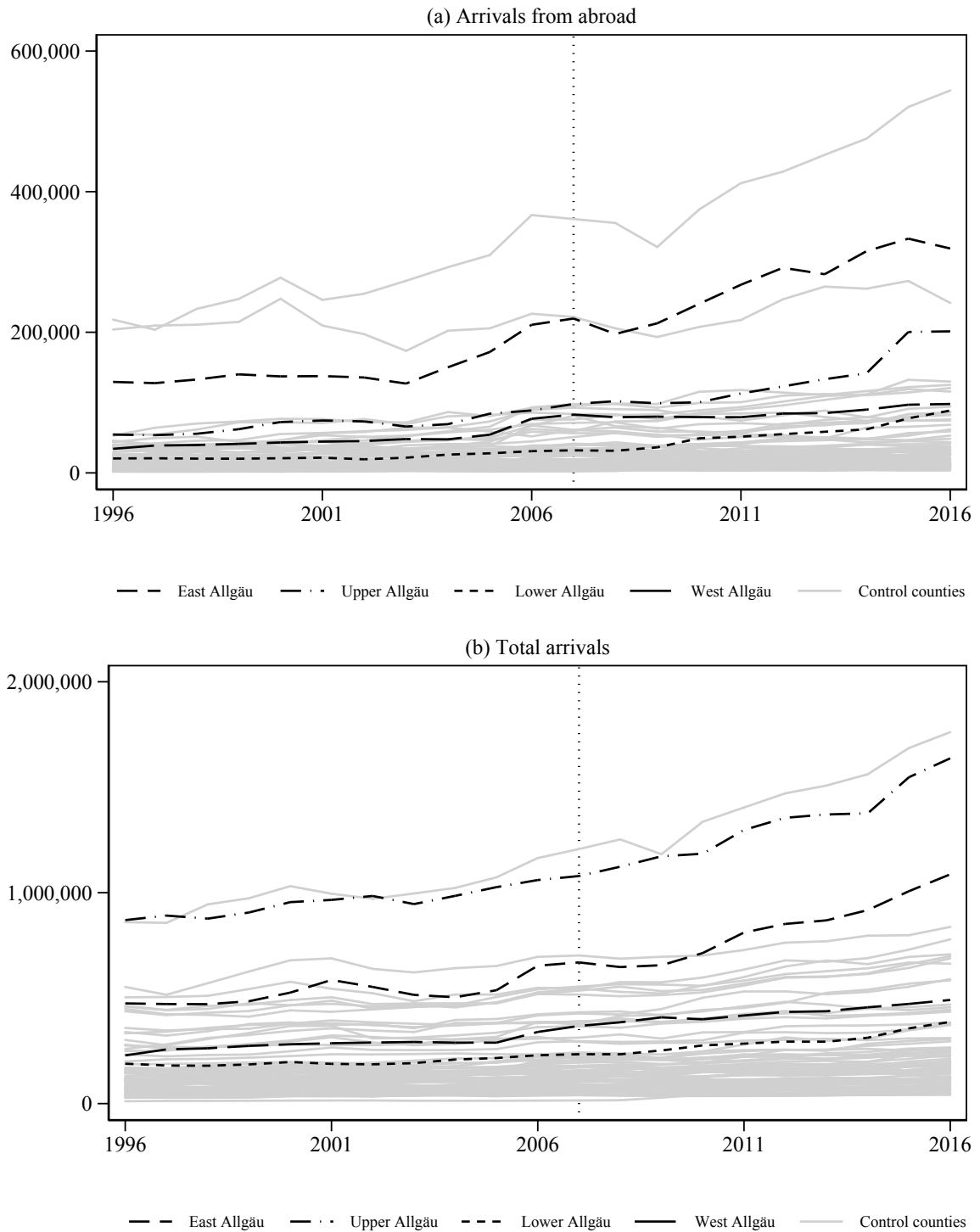
Notes: This figure shows how our two dependent variables evolve over our period of investigation. Black lines represent treated counties, light gray lines control counties (see Figure 1).

Figure A4: Treatment regions
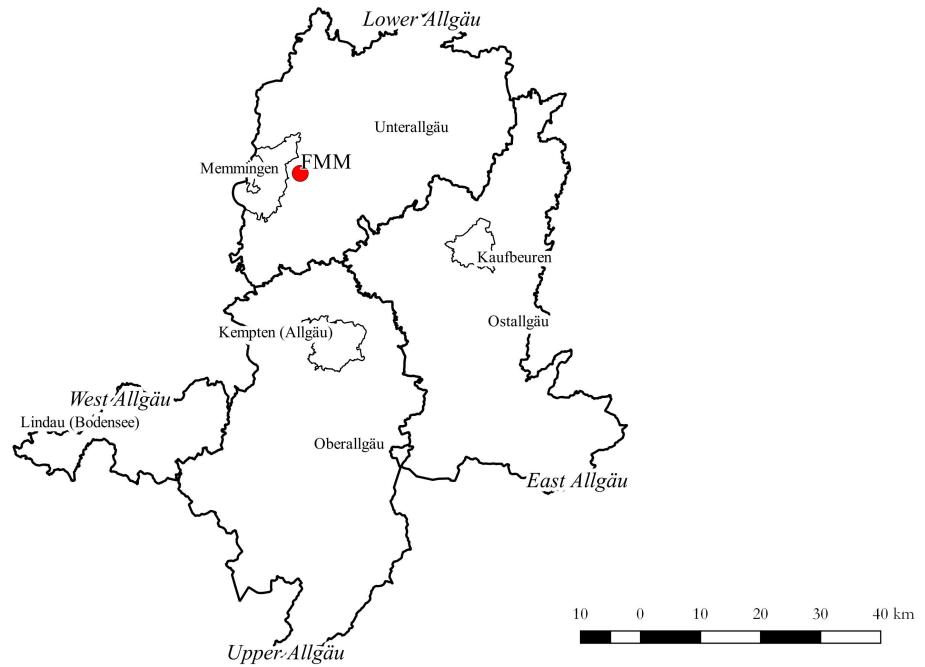
Notes: This map shows our treatment regions (italic, thick boundaries) and their counties (thin boundaries) Lower Allgäu (Memmingen and Unterallgäu), East Allgäu (Kaufbeuren and Ostallgäu), Upper Allgäu (Kempten (Allgäu) and Oberallgäu) and West Allgäu (Lindau (Bodensee)).

Figure A5: Synthetic control method, total arrivals
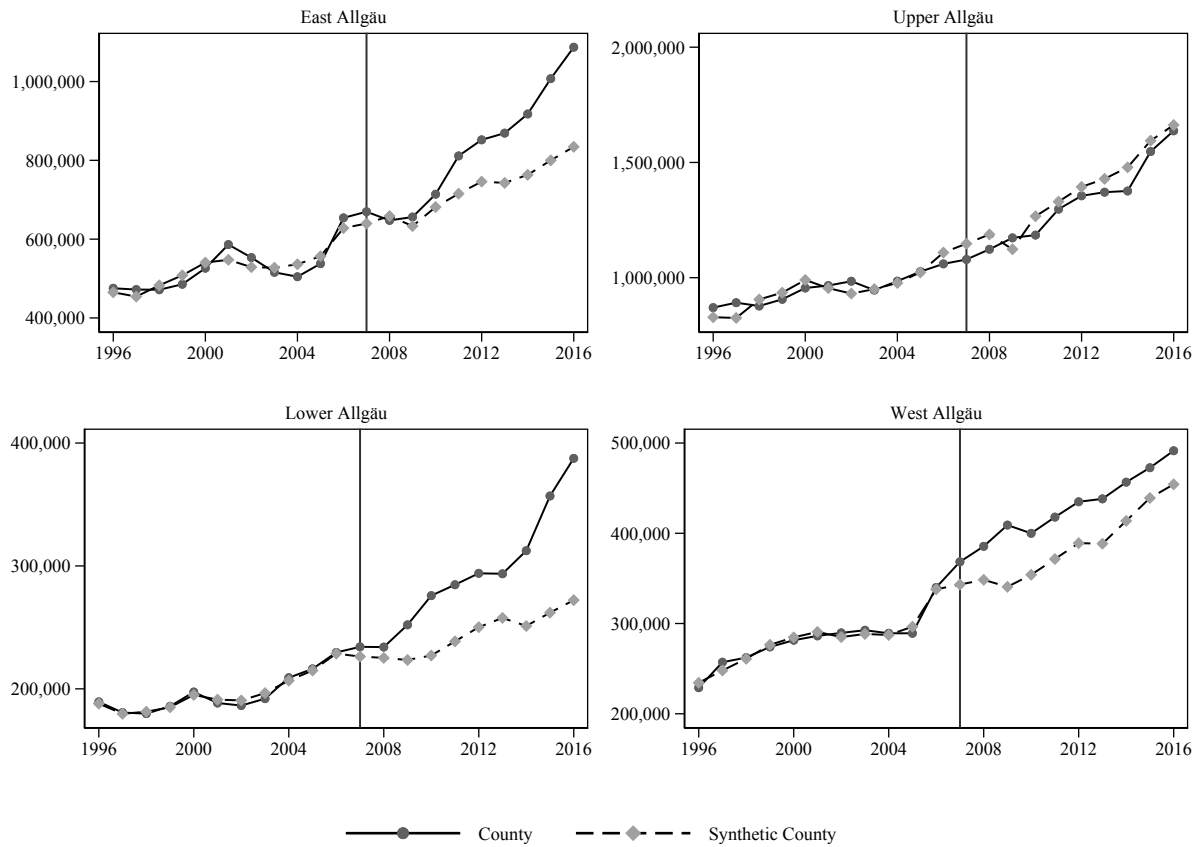
Notes: This figure shows total arrivals in the four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu (dark gray) and in their synthetic counterparts (light gray). The donor pool consists of counties in Bavaria that were not treated. The vertical line in each graph marks the opening of Memmingen Airport in 2007.

Figure A6: Development of arrivals in Bavarian regions (1995-2016, 2007=100)

(a) Arrivals from abroad
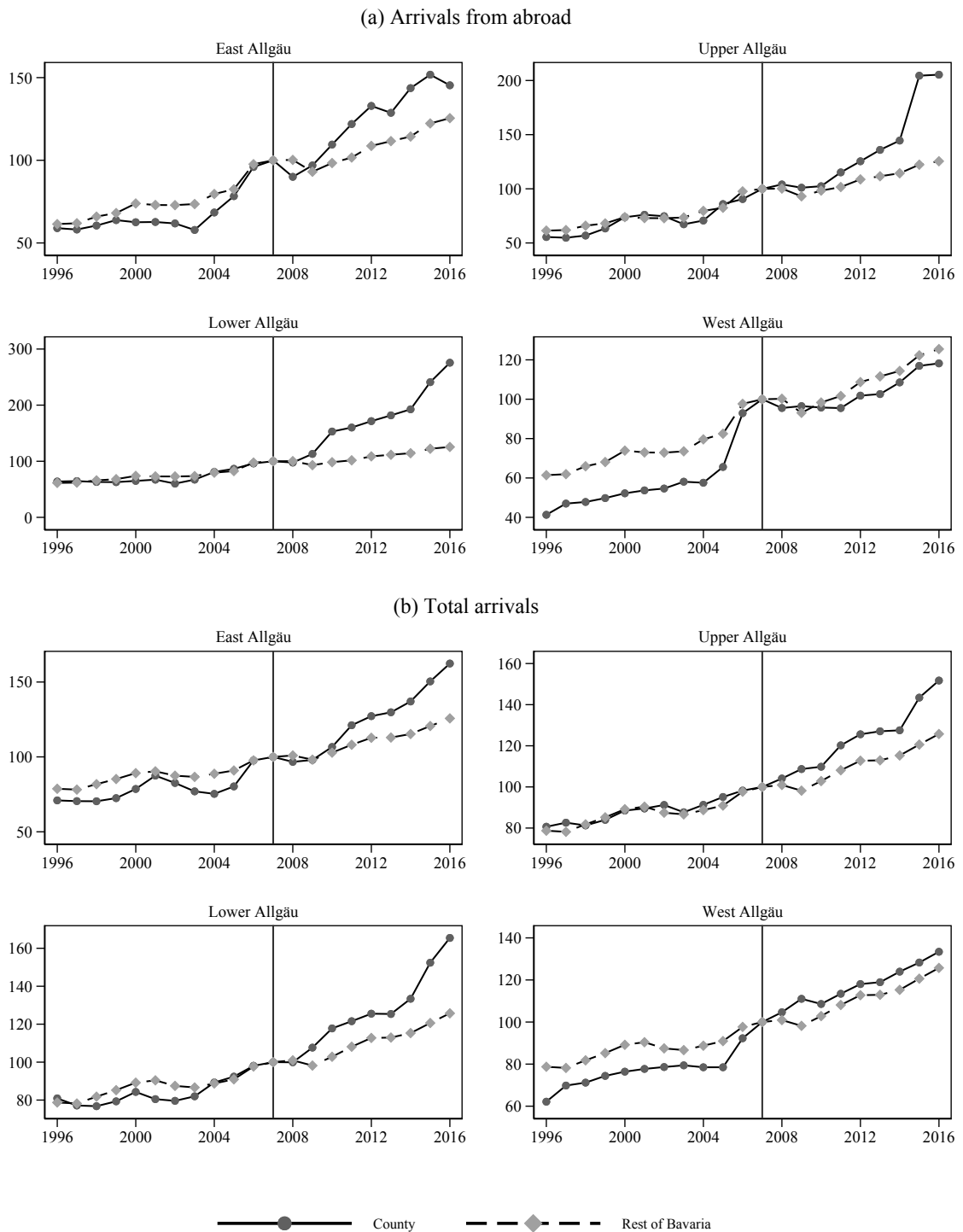
(b) Total arrivals

Notes: This Figure shows the development of total and abroad arrival in our four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu (2007=100). Donor pool counties form our control group (see Figure 1). The vertical line in each graph marks the opening of Memmingen Airport in 2007. We use yearly data over the period of 1996 to 2016.

Table A1: Passengers at Memmingen Airport in 2018, by destination and source country

	Passengers			Incoming Share of Passengers	
	Total Volume	Outbound Flights	Incoming Flights	Winter Season	Summer Season
Total	1 486 493	737 908	748 585	46%	35%
Spain	241 465	121 097	120 368	26%	18%
Romania	178 347	87 041	91 306	58%	52%
Bulgaria	142 208	70 001	72 207	58%	40%
Portugal	99 223	49 767	49 456	28%	15%
United Kingdom	92 635	47 241	45 394	35%	30%
Ukraine	89 977	44 056	45 921	70%	58%
Serbia	78 556	38 869	39 687	74%	45%
Italy	74 007	37 010	36 997	22%	25%
Macedonia	59 575	29 349	30 226	69%	30%
Greece	55 831	27 955	27 876	25%	15%
Poland	48 659	24 032	24 627	33%	53%
Ireland	45 189	22 604	22 585	50%	24%
Bosnia and Herz.	43 491	21 309	22 182	37%	34%
Russia (Europe)	43 074	22 025	21 049	71%	64%
Marocco	36 586	18 495	18 091	50%	30%
Montenegro	32 710	15 803	16 907	50%	30%
Sweden	32 137	16 115	16 022	19%	25%

Source: Bauer *et al.* (2019); Federal Statistical Offices (2019), Verkehr – Verkehr auf Luftverkehrsflughäfen 2018, Fachserie 8 Reihe 6.1, Wiesbaden.

Notes: This table shows passenger numbers for outbound and incoming flights in total and for selected countries as well as the share of incoming passengers in the winter and summer season at Memmingen Airport in 2018.

Table A2: Descriptives

	Arrivals from abroad		Total arrivals	
	(1) Before 2007	(2) After 2007	(3) Before 2007	(4) After 2007
West Allgäu	46,768	85,797	280,982	434,06
Synthetic West Allgäu	46,756	95,647	280,946	388,83
Ratio	100.03%	89.70%	100.01%	111.63%
East Allgäu	145,527	273,391	525,653	840,258
Synthetic East Allgäu	145,405	233,268	525,031	730,588
Ratio	100.08%	117.20%	100.12%	115.01%
Upper Allgäu	68,588	134,901	951,71	1,340,634
Synthetic Upper Allgäu	68,734	93,141	948,213	1,385,142
Ratio	99.79%	144.83%	100.37%	96.79%
Lower Allgäu	22,745	56,714	195,918	299,033
Synthetic Lower Allgäu	22,699	33,527	196,173	245,308
Ratio	100.20%	169.16%	99.87%	121.90%

Notes: This table shows the absolute numbers of arrivals from abroad and total arrivals for the four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu and their synthetic counterparts. For the composition of the synthetic regions see Table A3 in the appendix. We use yearly data over the 1996-2016 period (without 2007).

Table A3: Synthetic control donor pool weights

Donor pool	Weights							
	Arrivals from abroad				*Total arrivals*			
	(1) West Allgäu	(2) East Allgäu	(3) Upper Allgäu	(4) Lower Allgäu	(5) West Allgäu	(6) East Allgäu	(7) Upper Allgäu	(8) Lower Allgäu
Rosenheim	0	0	0.057	0	0	0	0	0
Berchtesgadener Land	0.447	0	0	0	0.100	0	0	0
Ebersberg	0	0	0	0.144	0	0	0	0
Eichstätt	0	0.355	0.065	0.106	0.002	0.580	0	0
Miesbach	0	0	0.454	0	0.011	0	0	0.160
Rosenheim	0.369	0.167	0	0	0	0.020	0	0
Landshut	0	0	0	0.153	0	0	0	0.095
Passau (city)	0	0	0.133	0	0.217	0	0	0
Freyung-Grafenau	0	0	0	0	0	0	0	0.265
Passau (county)	0	0	0	0	0	0.156	0	0
Dingolfing-Landau	0	0	0	0.091	0	0	0	0
Regensburg	0.166	0	0	0	0.020	0	0	0
Hof	0	0	0	0	0	0	0	0.127
Erlangen	0	0	0	0.168	0	0	0	0
Fürth (city)	0	0	0	0.091	0	0	0	0
Nuremberg	0.010	0.381	0	0	0.097	0.244	0.910	0
Ansbach	0.007	0.097	0.082	0.004	0	0	0.090	0.009
Fürth (county)	0	0	0	0	0	0	0	0.320
Weißenburg-Gunzenhausen	0	0	0	0	0.553	0	0	0
Würzburg	0	0	0.210	0	0	0	0	0.024
Schweinfurt	0	0	0	0.243	0	0	0	0

Notes: This table shows the weights derived from the synthetic control approach for the four treated regions East Allgäu, Upper Allgäu, Lower Allgäu and West Allgäu, and the two dependent variables total arrivals and arrivals from abroad. We omit counties that have never received a positive weight in any specification.

Table A4: Difference-in-differences using WLS

		Total arrivals		
	(1) East Allgäu	(2) Upper Allgäu	(3) Lower Allgäu	(4) West Allgäu
Panel A: Synthetic control group				
Pre-Post-Treatment difference	109,048	-48,006	53,979	45,194
Panel B: Difference-in-differences (WLS)				
Allgäu · Airport	109,048	-48,006	53,979*	45,194
	(106,094)	(69,229)	(27,25)	(49,923)
County fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	100	60	160	160
Within R^2	0.826	0.960	0.761	0.675

Notes: The table compares results from our synthetic control approach to difference-in-differences results. Synthetic control approach results in Panel A are calculated from Table 1 as the difference in before-after treatment differences of our treated regions and their synthetic counterparts. Panel B shows the results of four difference-in-differences estimations using a WLS regression with weights derived from our synthetic control method (see Table A3 in the appendix). We use yearly data over the 1996-2016 period (without 2007). Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

Table A5: Robustness (III): Difference-in-differences using OLS

	Arrivals from abroad			
	(1) East Allgäu	(2) Upper Allgäu	(3) Lower Allgäu	(4) West Allgäu
Panel A: All counties from donor pool				
Allgäu · Airport	116,015***	54,465***	22,121***	27,180***
	(2,632)	(2,632)	(2,632)	(2,632)
County fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	1.460	1.460	1.460	1.460
Within R^2	0,348	0,25	0,217	0,222
Panel B: Only synthetic counterpart counties				
Allgäu · Airport	57,268	44,058***	19,873***	-22,589
	(34,967)	(5,147)	(4,721)	(30,018)
County fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Obs.	100	140	180	120
Within R^2	0.688	0.683	0.501	0.531

Notes: The table reports difference-in-differences results using OLS. In Panel A all counties from our donor pool form the control group (see Figure 1). In Panel B only the counties that received a weight in our synthetic control approach form the control group (see Table A3 in the appendix) but each receive a weight of 1. We use yearly data over the 1996-2016 period (without 2007). Significance levels (standard errors robust to heteroskedasticity in brackets): *** 0.01, ** 0.05, * 0.10.

B Synthetic control approach

The synthetic counterfactual is calculated as a weighted average of the untreated control counties from the donor pool such that the fit in the variable of interest in the pre-treatment period is maximized. The counterfactual outcome $\hat{Y}_{it}$ of county i in period t is determined by a weighted average of the untreated donor pool counties j:

$$\hat{Y}_{it} = \sum_{i \neq j} w_j Y_j, \qquad \sum w_j = 1 \tag{1}$$

The counterfactual weights w across all donor pool counties j sum up to unity and are selected to minimize the pre-treatment Root Mean Square Prediction Error (RMSPE) of the observed pre-treatment outcome of the treated county Y_{it} and the counterfactual pre-treatment outcome of its synthetic county $\hat{Y}_{it}$

$$\min RMSPE_i = \min \sqrt{\sum_{t=1}^{T_0} \frac{(Y_{it} - \hat{Y}_{it})^2}{T_0}} \tag{2}$$

The synthetic control estimator is given by the comparison between the outcome for the treated county and the outcome for the synthetic control county at the post-treatment period t (with $t \geq T_0$):

$$Y_{it} - \hat{Y}_{it} \tag{3}$$

The difference in the outcome variable between treated counties and their synthetic counterfactuals following the treatment measures the causal effect of the airport if the following assumptions hold: first, there is a sufficient match between the trends in the outcome variable for synthetic and treated counties over a long pre-treatment period. That is, the RMSPE in equation (2) is sufficiently minimized.

C Difference-in differences approach

Our difference-in-difference model takes the following form:

$$Y_{it} = \alpha_i + \theta_t + \gamma(Allgäu_i \cdot Airport_t) + \epsilon_{it} \tag{4}$$

where Y_{it} describes our dependent variables arrivals in county i and year t (1996-2016). $Allgäu_i$ is a dummy variable that takes on the value one for our treatment counties in the touristic region Allgäu and zero otherwise, while $Airport_t$ is a dummy variable denoting the years after the Memmingen Airport was opened (2008-2016) with one, and zero otherwise. $Allgäu_i \cdot Airport_t$ measures the interaction of the two dummies and γ thus estimates our treatment effect. We include county and year fixed effects (α_i and θ_t). The coefficient γ can be interpreted as a causal effect of the airport if the common pre-trend assumption between the treated counties and the control group holds.

We estimate equation (4) with Weighted Least Squares (WLS) and Ordinary Least Squares (OLS) and use three different control groups. WLS and OLS regressions differ in their regression weights. First, we estimate WLS where we combine the synthetic control approach with the difference-in-differences estimation. We use the donor pool weights derived from the synthetic control approach as regression weights (the counties in the control group are weighted according to Table A3 in the appendix). Second, we estimate a difference-in-differences model using OLS where all counties from our donor pool are included (dark gray counties, see Figure 1) and contribute with equal weights to the control group. Third, we estimate a difference-in-differences model using OLS where only the counties that received a weight in our synthetic control approach are included in our control group, but all with an equal weight.