Regional Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cres20

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To cite this article: Philipp Breidenbach (2020) Ready for take-off? The economic effects of regional airport expansions in Germany, Regional Studies, 54:8, 1084-1097, DOI: 10.1080/00343404.2019.1659948

To link to this article: https://doi.org/10.1080/00343404.2019.1659948

REGIONAL STUDIES
2020, VOL. 54, NO. 8, 1084–1097
https://doi.org/10.1080/00343404.2019.1659948

Routledge Taylor & Francis Group
RSA Regional Studies Association

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ABSTRACT
Airports are an important factor of regional connectivity. Following the literature, a sufficiently dense airport network is an important determinant for growth. However, regional airports in Germany exhibit financial losses and depend on subsidies. This paper analyses the potential spillover effects of airports on the surrounding economies that may justify those subsidies by exploiting the deregulation of the European aviation market as a quasi-natural experiment. Subsequent airport expansions are evaluated in a difference-in-differences framework, making use of the exogenous shift in airport demand for regional airports due to the deregulation. Results show no evidence for spillover effects of Germany's regional airports.

KEYWORDS
infrastructure investment; regional growth; airport effects

JEL H54, R51, R42
HISTORY Received 1 August 2018; in revised form 1 August 2019

INTRODUCTION

During the past decades, German regional airports have expanded substantially. During the late 1990s, regional policy-makers invested extensively in regional airport facilities, aiming to meet the requirements of a modern airport during a period when the aviation market grew rapidly (Heymann, Vollenkemper, Frank, & Walter, 2005). Contrary to those expectations, today nearly all German regional airports depend on substantial subsidies to cover their annual losses (Heymann, Karollus, Slomka, Ag, & Hoffmann, 2015). Since the European Union (EU) decided that these subsidies violate European competition law, subsidies covering operational losses will be prohibited after 2024. These legal requirements will cause existential problems for several of these regional airports.

Opponents of the subsidies support this decision since, in their assessment, regional airports will never find their niche in between the established large airports and, hence, will never reach profitability. In contrast, proponents argue that the narrow focus on the direct losses fails to recognize their importance for regional development. Evidence for international airports (especially in the United States) emphasizes these spillover effects for the surrounding economy, showing that service industries and high-tech sectors particularly benefit from airport proximity (Appold, 2015; Appold & Kasarda, 2013; Brueckner, 2003; Button & Taylor, 2000; Cidell, 2014; Sheard, 2014).

It is difficult to analyse these effects of airports empirically since typically the expansion of regional airports is due to economic and political considerations, and not the result of a randomized experiment. Therefore, the question of what counterfactual development an airport region would have realized without the expansion is not obvious. On the contrary, as many econometric evaluations of the (regional) growth effects of infrastructure investments demonstrate (e.g., Aschauer, 1989), the problems of reverse causality and unobserved (regional) heterogeneity are almost ubiquitous (e.g., Blonigen & Cristea, 2015; Button, Doh, & Yuan, 2010; Mukkala & Tervo, 2013; Green, 2007).

To overcome this issue, this paper exploits a substantial change in the regulation of the European aviation market which can be seen as a quasi-experiment increasing regional airport demand. In 1997, the deregulation of the European aviation market substantially redesigned the aviation market (Graham, 1995). Initially designed to strengthen competition on the airline market, this reform caused an increasing demand for take-off and landing slots at airports (Schenk, 2004). Established international airports in Germany were not able to serve this increasing demand

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Supplemental data for this article can be accessed at https://doi.org/10.1080/00343404.2019.1659948

(Schenk, 2004), causing particularly strong incentives to expand regional airports. Consequently, regional airports invested in their facilities to serve as attractive alternatives to the large and established airports (Graham, 1997b). Contrary to investments driven by positive regional developments, this reform thus led to investments which were caused by exogenous changes in the structure of the aviation market (Barrett, 2000; Graham, 1998) and can therefore be regarded as exogenous. As expected, most regional airports invested extensively to prepare their facilities for the needs of modern and international airlines and passengers.[1]

Moreover, the location of many regional airports in Germany is less based on economic factors since most of them were converted from military to civilian use (Behnen, 2004).[2] Their original location followed military strategies instead of economic reasoning (Cidell, 2003).[3] Both arguments, the exogenous incentive to invest and the exogenous location, lend credibility to a causal interpretation of the empirical results based on a difference-in-differences approach (Diff-in-Diff).

To the best of the author's knowledge, this is the first paper to analyse systematically the growth effects of regional airports using an exogenous event such as aviation market deregulation. The identification strategy is partly adapted from Blonigen and Cristea (2015), who analyse market liberalization in the United States, focusing on large international airports.[4] In contrast to their analysis which exploits various treatment intensities, the present paper applies a binary indicator for treated airports, which is extensively discussed in the methodological section on identification. Based on this identification, there is no evidence that the expansion of regional airports in Germany generated regional growth. This result is robust to a range of robustness checks, varying the underlying definitions as well as the chosen methodological concept. Overall, there is no evidence that spillovers spread out from such expansions.

The paper is organized as follows. The next section summarizes the existing literature and emphasizes endogeneity issues as well as the advantages due to the institutional settings of the deregulation. Subsequently, the data set and estimation strategy are outlined. The results section presents the main results and a broad set of robustness tests. The last section concludes.

EUROPEAN UNION AVIATION MARKET REFORM AS A SOURCE OF EXOGENOUS VARIATION

Existing literature and conceptual challenges

A broad strand of the literature attributes positive regional spillovers to airports (e.g., Blonigen & Cristea, 2015; Allroggen & Malina, 2014; Cohen & Paul, 2003; Brugnoli, Dal Bianco, Martini, & Scotti, 2018; European Union Committee of the Regions, 2004). Airports increase the connectivity of a region, and hence they facilitate national and international trade and exchange. Therefore, income and employment may increase in the local economy (European Low Fares Airline Association (ELFAA), 2004), which can be split into three transmission channels (see Button et al., 2010, for further subdivisions): (1) direct effects, realized through employment and investments at the airport; (2) indirect effects, in the chain of suppliers of goods and services related to the airport; and (3) induced effects, which comprise the surplus of employment through spending of directly and indirectly employed individuals. In addition to these three channels, airports are supposed to have a catalytic effect by improving productivity of companies.

Empirical analyses of such airport effects need to account for unobservable heterogeneity, in particular regarding the regional conditions before the extension of the airport which are likely to be correlated with its extension. Since the expansion choice is not random, there might be a higher probability of expansion for airports in prospering regions.

Focusing on airport activities, such as flight numbers, passengers or cargo turnover (Florida, Mellander, & Holgersson, 2015), introduces further variation. However, as long as increased activities are not due to an exogenous shock, it could still be that improved regional conditions increase airport activities rather than the other way around. Such a relationship was found by Goetz (1992) and Dobruszkes, Lennert, and Van Hamme (2011). Bilotkach (2015) tries to address these endogeneity problems methodologically by generalized method of moments (GMM) estimators which are based on Arellano and Bover (1995) and Arellano and Bond (1991). Further approaches apply elements of time-series analyses, such as Mukkala and Tervo (2013) or Button and Yuan (2013). Besides this, the applied Granger causality tests only weakly indicate that a one-way interpretation should be appropriate (Mukkala & Tervo, 2013). However, such technical approaches are not designed to identify causal relationships when agents anticipate future regional developments and airport expansions are based on these anticipations.

In this case, quasi-experimental identification strategies that exploit exogenous events seem more appropriate. Brueckner (2003) and Sheard (2014),[5] for instance, apply the concept of instrumental variables using 1944's national airport plan for the United States. However, finding such exogenous events or instruments that can predict airport size but do not correlate with regional circumstances is a challenging task. Campante and Yanagizawa-Drott (2018) take advantage of discontinuities in the range of direct flights. They note that the distance between airports on intercontinental flights is exogenous, and that it forms thresholds for direct flights via a range of different types of aeroplanes and crew-operation hours. They take advantage of this exogenous discontinuity to analyse the effect of (long-range) air connectivity on the regional economy, finding positive effects of international airports. Similar to this, Blonigen and Cristea (2015) exploit the US Aviation Deregulation Act[6] passed in 1978 that aimed to promote competition in the aviation market. Acting under market pressure after the reform, airlines focused their activities on the central airports since subsidies for peripheral connections were cut. These shifts caused remarkable changes in the various airports' activities (Burghouwt & Hakfoort, 2001), which were not initiated by regional developments. Based on the Deregulation Act, Blonigen and Cristea (2015) observe that increasing airport activities affect population growth, per capita income and employment positively.

The methodological approaches described above are useful for the evaluation of general airport effects, yet they are less relevant for the examination of regional airport effects. All the studies discussed so far focus on the examination of an exogenously induced increase of large airports in metropolitan areas. By definition, regional airports (in the scope of this paper) are rather small and located in less populated areas. Furthermore, in the dense network of German airports, the surplus of connectivity due to one additional regional airport in a specific region is small. Hence, it is not clear how transferable the results from other countries (and from international airports) are in the German context. Therefore, the effects found in the previous literature, for example, from the US Deregulation Act, cannot be directly translated to the expansion of regional airports and the potential effects on growth in the surrounding regions in Germany.

Besides economic aspects, airports may affect quality of life in various dimensions. Vickerman, Spiekermann, and Wegener (1999), Nijkamp and van Geenhuizen (1997) as well as Graham and Guyer (1999) point to the social context of airports, especially in peripheral areas where they improve the mobility and communication opportunities of a region substantially. On the other hand, the negative effects of airports were found for property values and health outcomes caused by noise (e.g., Cidell, 2014; Cohen & Coughlin, 2008; McMillen, 2004; Pope, 2008; Püschel & Evangelinos, 2012; van Praag & Baarsma, 2005). The present paper focuses on regional growth measures, such as regional gross domestic product (GDP) and employment, to compare these benefits directly with the costs of investment faced by the regions.

European Union aviation market reform

The European Commission started a deregulation initiative in 1983: the Single European Aviation Market (Graham 1997b), following the apparent success of market deregulations in the United States (with increasing supply and decreasing prices). The deregulation of the European market was split into three steps. The first two were implemented in 1988 and 1990 (Graham, 1995) and characterized by rather small changes. The third step initiated substantial changes in the structure of the EU aviation market (see Graham, 1995, 1997a, 1997b, for more detailed information on the effects of the single reforms; and Schenk, 2004, for their concrete implementation in the German case).[7] Most importantly, it included a far-reaching market liberalization, namely the suspension of all cabotage restrictions, which prohibited non-domestic airlines from serving on national routes. Furthermore, for international routes only, the domestic airlines from one of the connected countries were allowed to provide the route. The suspension of the regulation opened the national markets to a range of new airlines (Schenk, 2004, p. 98). A substantial number of new airlines entered the national markets, leading to an increased number of competitors (Thompson, 2002).

As a consequence, the distribution of operation slots became a bottleneck at established airports.[8] National carriers enjoyed grandfathering rights for the slots and services without convincing 'use-it-or-lose-it' rules (Schenk, 2004).[9] Thus, the access of new competitors to the established airports was impeded and they had to divert their business to regional airports. This was seen as a great opportunity for regional development by many local policy-makers and they actively expanded regional airports as a consequence. Graham (1997b) documents the substantial benefits for regional airports and for the newly emerging regional airlines from these investments.[10] Moreover, the reform incentivized to expand the airports right in 1997 when new airlines entered the market to benefit from airlines entering the market. Table 1 documents the investments and expansions at the 24 German regional airports included in this study. These airports had substantial investments or improved air-traffic (the starting of charter or scheduled flights) in 1997 or the years closely around the liberalization. Only four airports had no substantial expansions during the period of liberalization; they are excluded in later robustness tests. Over the observed period after the reform until 2008, passenger number at these airports increased by about 60%.

Since the expansion of regional airports was determined by EU legislation, which is not correlated with regional developments, it can be seen as a (quasi-)natural experiment. The European Commission intended to intensify competition between airlines (Graham, 1998), while the incentives for regional airport expansions were only side effects of the reform. This is different from regional policy measures specifically designed to compensate for disadvantages of the targeted regions. As Behnen (2004) points out, the reform not only caused a revolution in the sky but also, especially in Germany, on the ground. Germany implemented the regulation as late as possible in the beginning of 1997, four years after it was passed by the European Council in 1993. This long period in between ensures that planners had enough time to prepare the airports for the increasing demand for services. The timing hence further strengthens the interpretation as an exogenous event with respect to regional development.

Moreover, the initial locations of German regional airports are not due to the economy in the surrounding regions, since most of today's regional airports were part of military bases before being converted to civilian use (Behnen, 2004). Of the 24 regional airports, 15 have a military background. Thus, initial locations were not driven by the economic needs of a region or its favourable economic conditions (Cidell, 2003), but rather based on military strategies and the associated distribution of the air force. Nevertheless, the decision to implement the transformation from a military towards a civilian use

Table 1. Investments and expansion of regional airports.

Airport	Investments/expansion, 1997 ± two years	Major investments during the pretreatment phase	Candidates for the robustness test
Neubrandenburg	Opening of terminal building in 1995		No
Altenburg	Investments in ATC and terminal buildings from 1992 to 1997	Investments in ATC and terminal buildings from 1992 to 1997	Yes
Rostock-Laage	New ATC, expansion of charter flights		No
Braunschweig-Wolfsburg	No		Yes
Dortmund	Extended runway, increasing maximum take-off weight		No
Frankfurt-Hahn	Operation of scheduled flights starting in 1998		No
Friedrichshafen	Connection to (public) transport infrastructure		No
Heringsdorf (Usedom)	Finalized maintenance and expansion of operations zones and instrumental flight systems		No
Karlsruhe/Baden-Baden	Permit for civil operations in 1996; first operations of scheduled and charter flights in 1997		No
Kiel	Completed civil usability in 1997		No
Kassel-Calden	Extended charter flights	Charter flights starting in 1994	Yes
Lübeck-Blankensee	Opening of the terminal building		No
Paderborn/Lippstadt	Opening of the new terminal building in 1998		No
Schwerin-Parchim	Opening of terminal building in 1998		No
Siegerland	No		Yes
Zweibrücken	Establishing of charter flights in 1998		No
Augsburg	New ATC in 1997 and custom clearance facilities in 1998 to improve international competitiveness		No
Bayreuth	No	Inner-German scheduled flights from 1993 to 1998	Yes
Erfurt	Opening of ATC in 1996, opening of terminal building in 1995		No
Mönchengladbach	First scheduled flights in 1996		No
Hof	No		Yes
Münster	Opening of terminal building in 1995		No
Saarbrücken	Gaining Fraport as an investor in 1997		No
Magdeburg	New ATC and operation areas in 1997	(No flights until 1999 due to new runway)	Yes

Notes: Information is taken from the internet database and chronical information of the airports.
ATC, air-traffic control.

remains endogenous. Consequently, further exogenous variation – as given by the deregulation – is needed to establish an exogenous set-up.

In summary, the military background of the initial locations of regional airports, the encompassing scope of the aviation market reform that was not intended to support regional airports, but which led to large regional investments into regional airport expansion, provide a solid basis for the examination of the causal effects of airport expansions on regional prosperity.

DATA AND IDENTIFICATION STRATEGY

The potential regional growth effects of regional airports are examined in a Diff-in-Diff set-up relying on the deregulation of the aviation market as treatment. This identification strategy requires pre- and post-treatment observations as well as treatment and control groups. Based on data availability, the period 1993–96 served as the pretreatment period and the years 1997–2008 constitute the treatment period.

The classification into treatment and control regions is more challenging. The data are a panel of all German counties (*Kreise*). Counties with a regional airport are regarded as the treatment group.[11] However, the county in which an airport is located might not be the right regional scope for capturing the airport's economic effect, since spillovers may spread across county borders. This problem is tackled by defining buffer zones (with a radius of 15 km) around the airport's reference point (see Paloyo, Vance, & Vorell, 2010, for a similar design). The chosen 15 km adequately defines the 'local economy', which is expected to benefit from regional airport expansions. Since potential hinterland effects might be neglected in this definition, 30 km buffers and continuous weighted treatments are also defined, which do not change the later results.[12] All counties that (partly) fall within a buffer zone are part of the treatment group. The economic characteristics of these airport buffer zones are defined by the weighted means of county characteristics within the buffer, while spatial shares of the total buffer zone area serve as weights.

Counties within the buffer of an international airport are omitted in the analyses since the research question explicitly focuses on the effects for regional airports.[13] This requires distinguishing between regional and international airports, which is done based on the pre-reform passenger figures provided by the German Airport Association (Arbeitsgemeinschaft Deutscher Verkehrsflughäfen (ADV), 2015). All airports with fewer than 1 million passengers in 1996 are defined as regional airports.[14] Counties without any airport (outside of the defined buffers) serve as control group. These definitions and restrictions reduce the original sample size of 413 German counties to 271 observed regional units. For an overview of the regional and international airports as well as a map with the buffers, see Figure A1 in Appendix A in the supplemental data online.

The estimated model is described as

$$gy_{i,t} = \mu_i + t_t + \delta DiD_{it} + \beta_1 \ln(y_{i,t-1}) + X_{i,t-1}\beta_k + \varepsilon_{i,t} \quad (1)$$

where $i = 1, \ldots, N$ is the cross-sectional and $t = 1, \ldots, T$ is the time dimension. The outcome $gy_{i,t}$ is the growth of GDP per employed person (GDPpe), which is expected to capture the spillovers from regional airports to regional prosperity.[15] DiD_{it} is the main variable of interest and equals 1 for treatment regions in the post period. Hence, δ captures the increase in regional growth due to airport expansions induced by the deregulation of the European aviation market.

The estimation includes regional fixed effects (μ_i) that capture time-constant unobserved heterogeneity between regions; and time fixed effects (t_t) that capture time-varying unobserved heterogeneity between years across all regions. $X_{i,t-1}$ marks a set of time-varying regional control variables which are lagged by one year. The time period of one year, starting two years after German reunification, does not allow one to observe many county-specific control variables. For example, any human capital or investment indicator at the county level is characterized by a large number of missing values in the sample period. Therefore, the controls are limited to population, employment and population density.[16] Moreover, the model includes temporal dynamics by controlling for the lagged level of the dependent variable, taking care of potential problems coming along with dynamic models (Nickell, 1981).[17] β_1, β_k and δ are coefficients to be estimated; and $\varepsilon_{i,t}$ is the error term.

There are different ways to implement the variable of interest (DiD_{it}). For this paper, using the intensity of the treatment maximizes the variation that can be exploited. This could either be realized by concrete figures on investments or by changes in the planned air-traffic supply of airlines. However, it is not feasible to obtain reliable numbers for both measures. Investments were financed by different sources (e.g., national level, state level, county level, public companies or partly private funding) which are not collected in any data set. Data on airlines' supply of air-traffic are not available and – emphasizing the important distinction – their planned supply is not directly reflected by realized flights or passengers. Since actual flight and passenger numbers are also based on reactions of the demand side, they are endogenous to the economic performance of a region.

Therefore, instead of using the treatment intensity, the main analysis relies on a binary indicator that captures the main exogenous variation of the deregulation reform. The indicator DiD_{it} turns 1 for treated regions after the treatment, and 0 otherwise. The dummy indicator has the additional advantage of being more able to capture a broader set of potential transmission channels from airport expansion to regional growth. For example, the relevant variation for the formation of specific industrial or commercial sites close to an airport (e.g., aviation industry) is not likely captured adequately via passenger terms or flights (Klophaus, 2006). Firms may also benefit from improved infrastructures (e.g., the establishment of industrial zones) that came along with expansions. Additionally, from an investor's perspective, the optional demand for air-services, which does not necessarily mean actually to use them, cannot be captured by the actual supply of air-traffic.

Overall, the binary indicator seems to be the best feasible solution. However, the indicator is not without limitations regarding the broad definition and a lack in distinguishing between smaller and larger expansion processes of individual airports. This requires a careful interpretation of the general results and intensive robustness checks to ensure the results are not sensitive to changes in the set-up.[18]

All described variables are taken from the Federal Office for Building and Regional Planning (BBR) (2011). Descriptive statistics of the sample are provided in Table 2. It appears that regions with a regional airport and those without these facilities do not differ substantially

Table 2. Descriptive statistics for airport and non-airport regions.

	Airport regions (n = 24)		Non-airport regions (n = 247)		
	Mean (SD)	Minimum/maximum	Mean (SD)	Minimum/maximum	*t*-statistic
GDP (growth)	0.030 (0.039)	−0.041/0.218	0.028 (0.039)	−0.260/0.252	−0.505
GDPpe (growth)	0.027 (0.037)	−0.036/0.211	0.025 (0.039)	−0.262/0.294	−0.621
GDPpc (growth)	0.033 (0.039)	−0.040/0.222	0.029 (0.040)	−0.241/0.261	−1.065
GDPpe ($\times 10^3$)	48.725 (8.333)	21.502/68.455	49.804 (8.650)	17.702/90.099	1.808*
GDPpc ($\times 10^3$)	23.431 (6.399)	7.429/37.273	23.608 (9.071)	6.230/76.558	−0.102
ln*(employment) lagged*	4.258 (0.884)	1.807/5.739	4.100 (0.540)	2.915/6.861	−9.198***
ln*(Population)*	5.007 (0.793)	2.821/6.525	4.893 (0.546)	3.649/7.184	−7.904***
Density ($\times 10^3$)	0.006 (0.009)	0.000/0.066	0.010 (0.033)	0.001/1.027	2.061**

Notes: ***, **, *Significant differences at the 1%, 5% and 10% levels, respectively.
GDP, gross domestic product.
Source: All variables are taken from Federal Office for Building and Regional Planning (BBR) (2011).

as documented by the *t*-test in the last column, when comparing the airport and non-airport regions. The mean GDP per employed person growth is 0.002 percentage points higher in the airport regions.

ESTIMATION RESULTS

The results are presented in three subsections. While the first focuses on the main identification strategy based on the Diff-in-Diff strategy outlined in equation (1), the second subsection accounts for variation in temporal and spatial dynamics. The temporal approach disentangles the post-treatment years to analyse the dynamics in the effects of the regional airport expansions. The spatial approach relaxes the assumption of an unaffected control group (one of the main assumptions in a Diff-in-Diff approach), which may result in a downward bias of the results if it does not hold. The spatial approach assumes that regions located closer to a regional airport are affected more strongly by the expansion than those further away. The third subsection provides additional robustness tests.

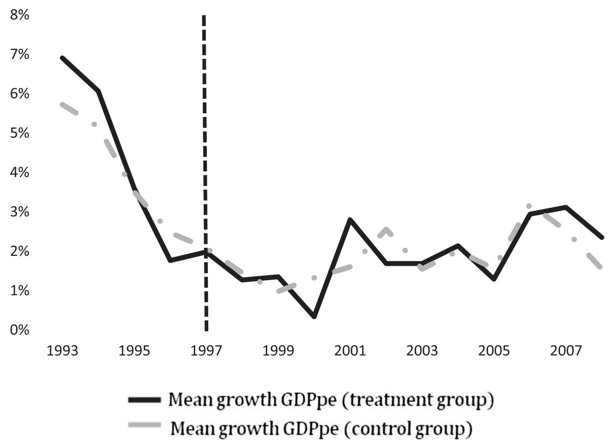

Figure 1. Common trend assumption for treated and non-treated regions.
Note: Mean annual growth rate of gross domestic product (GDP) per employed person for treated and non-treated regions.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

Estimation based on the difference-in-difference framework

Figure 1 displays the growth of the GDP per employed person (GDPpe) separately for treated and non-treated regions. The basic assumption of the Diff-in-Diff approach is that both groups would have evolved in the same way in the absence of the treatment (common time trend assumption – CTT). Since this is an assumption on the counterfactual, it cannot be tested statistically. A visual inspection of Figure 1 shows only minor-level differences in the pretreatment development which are captured by the regional fixed effects in the estimation. More importantly, in both treatment and control groups, GDPpe growth follows a very similar pattern in the years before the reform. Therefore, the CTT assumption seems likely to hold in the current setting. Furthermore, findings from the existing literature regarding the first and second steps of the reform seem to be confirmed. The implementation of these steps (before 1997) seems to have no influence in the pretreatment period.

Table 3 presents the main results. They do not suggest that any expansion effect of the regional airports on growth

Table 3. Expansion effect of regional airports.

Dependent variable: *GDPpe growth*	**(i)**	**(ii)**	**(iii)**	**(iv)**
DiD-estimator	−0.004	−0.004	−0.003	−0.002
	(0.008)	(0.004)	(0.005)	(0.003)
Post-Treat	−0.023***	0.004***	0.002	0.003
	(0.002)	(0.001)	(0.002)	(0.002)
ln*(GDPpe) lagged*		−0.160***	−0.149***	−0.295***
		(0.008)	(0.009)	(0.012)
ln*(employment) lagged*		0.092***	0.054**	−0.079***
		(0.017)	(0.022)	(0.022)
ln*(Population) lagged*			0.084***	0.126***
			(0.026)	(0.032)
ln*(Density) lagged*			−0.000	−0.001**
			(0.001)	(0.001)
Constant	0.042***	0.261***	−0.035	0.844***
	(0.002)	(0.076)	(0.105)	(0.134)
Time dummies	No	No	No	Yes
Regions	271	271	271	271
Observations	4352	4352	4288	4288

Note: ***, **, *Significant differences at the 1% 5% and 10% levels, respectively. Robust standard errors clustered at the county level are shown in parentheses. Estimations are based on difference-in-differences from equation (1). Table A4 in Appendix A in the supplemental data online shows that changing the definitions of the size of the treatment group does not change the results remarkably.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

exists. The estimate of the variable of interest (Diff-in-Diff estimator), which estimates reform-induced growth, is very small and not statistically different from zero in the basic set-up (column (i)). This finding is robust to the inclusion of additional control variables and time dummies (columns (ii) to (iv)).[19]

Disentangling temporal and spatial dynamics

Further insights might be gained from a closer inspection of the temporal evolution of the generally insignificant treatment effect. Potentially, it takes a certain fading-in period until the expansion of regional airports translates into measurable regional growth effects. Therefore, the following analyses are based on an event study, including a treatment indicator for each post-year defined by an interaction of each year dummy (t_t) and the dummy of the treatment group (a_i) (e.g., Gathmann, Helm, & Schönberg, 2016). This set-up allows one to detect a delayed effect that only emerges after a certain time and hence might not be detected using an aggregated post-treatment indicator pooling early non-responses with later positive changes.

Figure 2. Temporal disentangled spillover effect.
Note: Figure 2 shows the coefficients of δ_t from equation (2). Table A2 in Appendix A in the supplemental data online shows all estimated coefficients of the underlying estimation.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

$$gy_{i,t} = \mu_i + t_t + \sum_{t=1}^{T} \delta_t(a_i t_t) + \beta_1 \ln(y_{i,t-1}) + X_{i,t-1}\beta_k + \varepsilon_{i,t} \quad (2)$$

The estimation results are presented graphically for ease of interpretation (for the estimation tables, see Table A3 in Appendix A in the supplemental data online). Figure 2 depicts the estimation results from equation (2). The results do not suggest an increasing effect of the expansion over time. The baseline year is given by the last pretreatment observation (1996) and all other effects are related to 1996. Most of the annual effects are moderately positive, but insignificant, which does not hint at any effect of the treatment. Only 1999 and 2001 turn into a slight significance, which is not consistent over time.

Changing the focus to the spatial dimension of the analysis relaxes the assumption of predefined treatment regions (necessary in a Diff-in-Diff setting). While the Diff-in-Diff approach explicitly allows for a counterfactual evaluation design yielding causal estimates, it is not straightforward to extend this method when the treatment may have regional spillovers as it is not clear which regions should be classified as treated and which as control regions. This problem is relevant in the context of regional airports as substantial hinterland effects have been found in the literature. Based on passenger catchment areas, Lieshout (2012) shows substantial hinterland effects for the airport of Amsterdam. If regional airports in Germany also produce such far away hinterland effects, the presented Diff-in-Diff framework will not only fail to identify such potential effects but also the estimated effect of the treated region will also be downward biased if the control group is also positively affected.

To test this, a model is implemented that explicitly allows for such hinterland effects. The model approach is in the spirit of Tobler's First Law of Geography: 'Everything is related to everything else, but near things are more related than distant things' (Tobler, 1970, p. 236). As shown in equation (3), each region is treated by the expansion of regional airports. However, the treatment intensity varies by region using spatial weights which are defined by the inverse distance of a region's i centroid to the next regional airport j ($w_i = 1/dist_j$). This variable capturing treatment intensity is interacted with annual dummies, which allow one to analyse changes of the influence of regional airport's proximity over time, in a similar vein to equation (2):

$$gy_{i,t} = \mu_i + t_t + \sum_{t=1}^{T} \delta_t(\mathrm{w}_j t_t) + \beta_1 \ln(y_{i,t-1}) + X_{i,t-1}\beta_k + \varepsilon_{i,t} \quad (3)$$

Overall, spatial econometric approaches are not in the focus of this paper, as such models do not come without drawbacks (Gibbons & Overman, 2012). In these models, there is no clear untreated control group. Therefore, these do not explicitly model the counterfactual situation. Nevertheless, the spatial approach from equation (3) is a valuable robustness check to test for potential hinterland effects that go beyond the chosen buffer of 15 (30) km in the previous Diff-in-Diff analysis.

Figure 3 shows the estimated coefficients of δ_t as a measure for a change of the spatial importance of regional airports over time. As shown, the coefficients for the annual distance measure remain insignificant (again contrasted with 1996). Over the course of the observed years, the estimated coefficients of δ_t do not show any trend or hint at structural breaks after the expansion. Therefore, hinterland effects do not seem to play an important role for the regional growth effects in the case of regional airports. This finding is not necessarily contradictory to the existing literature as previous papers focus on the effects of international airports (Lieshout, 2012), which have much larger catchment areas.

ROBUSTNESS TESTS

The potential weaknesses of the basic results are tested in the following robustness checks, which are divided into three strands. First, the CTT assumption of the Diff-in-Diff design is tested further by a placebo test in the pretreatment period and the inclusion of group-specific trend variables.

For the placebo analysis, the sample is truncated only to include the pretreatment period (1991–96), with a placebo treatment in 1994. This does not reveal any growth differences between treatment and control group before the treatment (column (i) of Table 4).

Further, a linear trend for the treated group is added to the basic model of equation (1). This tests whether the

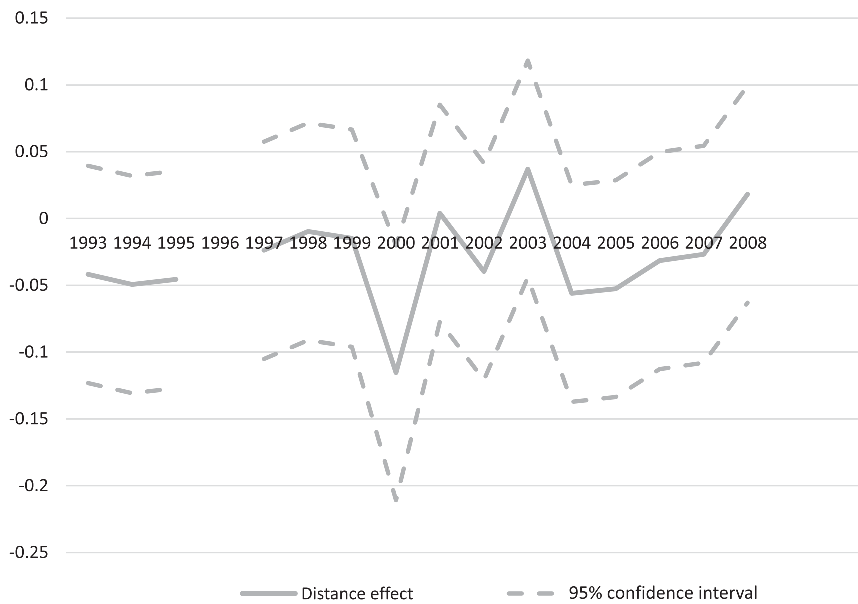

Figure 3. Spatial dimensions of regional airport expansions.
Note: Figure 3 shows the coefficients of δ_t from equation (3). Table A2 in Appendix A in the supplemental data online shows all estimated coefficients of the underlying estimation.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

Table 4. Robustness tests: common trend assumption and sharp intervention.

	1991–96 (pretreatment placebo test[a])	Trend variable	Without, 1995 and 1996	Without, 1997 and 1998
DiD-estimator	−0.007	−0.0027	−0.007	−0.002
	(0.006)	(0.0037)	(0.005)	(0.003)
Post-Treat	0.010***	0.0641***	0.019***	0.010***
	(0.004)	(0.0041)	(0.004)	(0.003)
ln*(GDPpe) lagged*	−0.433***	−0.295***	−0.305***	−0.291***
	(0.0213)	(0.0123)	(0.013)	(0.012)
ln*(employment) lagged*	−0.097	−0.0792***	−0.077***	−0.075***
	(0.600)	(0.0225)	(0.026)	(0.024)
ln*(Population) lagged*	0.674*	0.1265***	0.133***	0.134***
	(0.388)	(0.0317)	(0.035)	(0.032)
ln*(Density) lagged*	−0.622	−0.0014**	−0.001*	−0.002***
	(0.418)	(0.0006)	(0.001)	(0.001)
Trend (Reg. Airport)		0.0000		
		(0.0004)		
Time dummies	Yes	Yes	Yes	Yes
Groups	263		271	271
Observations	1052		3760	3754

Note: ***, **, *Significant differences at the 1%, 5% and 10% levels, respectively. Robust standard errors clustered at the county level are shown in parentheses. Estimations are based on difference-in-differences fixed effects.
[a]Placebo treatment in 1994.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

treated group follows a separate trend over the whole period (controlling for influences of the controls), which is not caused by the actual expansions. As column (ii) shows, this trend remains insignificant and does not hint at any problems considering the underlying CTT assumption. Hence, this strengthens the assumption that both groups (treated and non-treated regions) do not differ substantially in terms of GDPpe growth in the absence of treatment. This can be linked to the non-economic rationale behind the airports' locations due to their military backgrounds.

Second, concerns may arise as the Diff-in-Diff design technically assumes a sharp change after market liberalization. The expansion effects might be less sharp due to belated completion of the expansions or (vice versa) disturbed air-services due to construction works before the treatment year. These concerns are addressed by the exclusion of years around the treatment, namely excluding 1995 and 1996 (Table 4, column (iii)), and excluding 1997 and 1998 (column (iv)). None of these changes affects the estimated coefficient, which remains insignificant.

Third, the paper allows for heterogeneities in the treatment effect. In the previous analysis, the treatment indicator DiD_{it} was defined as a binary variable turning 1 for regions with a regional airport in the years after 1997. The methodological section outlines the reasons for such a binary definition of the treatment within the scope of this paper which evaluates the policy stimulus, arguing that the expansion in public funding results in regional growth stimuli. However, concerns may arise that this broad definition of the indicator, which assumes the equal treatment of each regional airport, neglects important deviations in treatment intensity. In particular, regions might decide to invest more in airports that are already larger to begin with, hence the growth impact on the reform is expected to be larger in these regions.

To allow for such heterogeneities, the main variable of interest DiD_{it} is redefined in the following estimation to include passenger numbers, similar to a continuous Diff-in-Diff set-up. For example, Allroggen and Malina (2014) find important differences in the regional effects between German airports depending on airport size. To capture some of that heterogeneity, the treatment intensity is based on the difference between pretreatment passengers in 1996 and passengers at the end of the observation period in 2008. By this definition, the variable captures a more intensive treatment for those regional airports that gained more passengers after the reform. Since the growth of passengers may already be an outcome of the policy stimulus, this estimation does not hold for a causal evaluation. Yet, it can reveal potential effects that remained unobserved by the broad definition of the initial binary treatment indicator. However, column (i) of Table 5 shows that this redefinition does not lead to changes in the results.[20]

Column (ii) of Table 5 shows the results going one step further and is reduced to those regional airports for which a de facto enlargement is documented by passenger figures. Re-estimating equation (1) with this subsample (column (ii) of Table 5) does not change the results of the main Diff-in-Diff analysis.

Table 5. Robustness checks: treatment.

	Passenger-weighted treatment	Passenger-weighted (de facto enlarged)	Varying definitions of regional airports		
			0.5 million passengers	1 million passengers	Legally defined
DiD-estimator	0.0001	−0.0001	−0.007	−0.002	−0.0000
	(0.0000)	(0.0000)	(0.005)	(0.003)	(0.0000)
Post-Treat	0.0640***	0.0620***	0.019***	0.010***	0.0921***
	(0.0041)	(0.0042)	(0.004)	(0.003)	(0.0114)
ln*(GDPpe) lagged*	−0.295***	−0.290***	−0.305***	−0.291***	−0.3610***
	(0.0122)	(0.0126)	(0.013)	(0.012)	(0.0232)
ln*(employment)*	−0.0796***	−0.0755***	−0.077***	−0.075***	−0.1244*
lagged	(0.0224)	(0.0227)	(0.026)	(0.024)	(0.0628)
ln*(Population)*	0.1275***	0.1253***	0.133***	0.134***	0.1383
lagged	(0.0313)	(0.0321)	(0.035)	(0.032)	(0.1021)
ln*(Density) lagged*	−0.0014**	−0.0016**	−0.001*	−0.002***	0.0006
	(0.0006)	(0.0006)	(0.001)	(0.001)	(0.0017)
Time dummies	Yes	Yes	Yes	Yes	Yes
Groups	271	268	270	276	264
Observations	4288	4040	4253	4368	4160

Note: ***, **, *Significant differences at the 1%, 5% and 10% levels, respectively. Robust standard errors clustered at the county level are shown in parentheses. Estimations are based on difference-in-differences fixed effects.
Source: Federal Office for Building and Regional Planning (BBR) (2011).

Lastly, the definition of regional airports (up to here 1 million passengers per year in 1996) is varied. Columns (iii) to (v) present the results with a changed threshold (0.5 and 2 million passengers per year) and with a definition of regional airports by legal definition given by the law status. The results are remarkably robust to these changes.

Further robustness checks are provided in Appendix A in the supplemental data online. As the baseline outcome (GDP per employed person) may not entirely cover potential expansion effects,[21] Table A3 (columns (i) to (iii)) online reports estimations with varying outcomes (employment growth, growth of total GDP and growth of GDP per capita). These alternate estimations are in line with the baseline estimation and do not indicate any positive effects.

CONCLUSIONS

The European Commission has recently announced that the subsidization of airports that merely survive due to substantial public support will be prohibited after 2024. Since most of the smaller and regional airports in Germany are currently subsidized, they are facing severe problems for their future existence. Proponents of regional airports emphasize the importance of positive spillovers on employment and economic growth throughout the region. This paper investigates whether German regional airports indeed contribute to a better regional economic performance.

Investments in infrastructure such as airports are an outcome of economic performance and future economic expectations. Therefore, evaluations have to regard this potential channel of endogeneity for a meaningful assessment (e.g., see Baum-Snow, 2007, for the effects of highways on population patterns). The analysis performed here makes use of the deregulation of the European aviation market which exogenously opened the German aviation market to new competitors, This, in turn, can be seen as a (quasi)-natural experiment for the expansion of regional airports. An increasing number of airlines demanded further operation slots in Germany and shifted to the regional airports. These regional airports updated and improved their infrastructure with substantial investments to meet the airlines' increased demand. Furthermore, the military background of most regional airports makes their location less dependent on the economic conditions of their environment, further lessening endogeneity concerns.

Exploiting the deregulation reform, a Diff-in-Diff identification strategy relying on a binary treatment indicator is applied using the four years before the reform in 1997 and 12 years after it (1993–2008). For the spatial definition of the treatment, regional buffers with a radius of 15 km are constructed around the airports. Based on this identification strategy, there is no empirical evidence that the expansion of regional airports translates into regional growth.

A more precise treatment indicator based on treatment intensities at each airport cannot be applied due to a lack of data on investments and an exogenous increase in demand for air-traffic slots by airlines. Yet, the paper tested for heterogeneous effects in the treatment intensity in a non-causal way, proxying for the intensity by observing changes in the number of passengers over treatment period. This does not indicate any heterogeneities. The paper further analyses heterogeneities along the spatial and temporal dimension of potential spillovers.

Several reasons could drive these results. In the existing dense network of German airports, there might be an excess supply of air-traffic slots in some regions that may make particular airports less necessary, and hence their effects on the local economy is limited. This interpretation is in line with a report of the European Court of Auditors (2014) that describes unsuccessful subsidized airport projects in highly funded European regions with unfavourable cost–benefit relations.

However, one has to be aware of the large opportunity costs of airport operations. Since many municipalities have spent high amounts in the operation of the airports, this capital is tied up by these investments. In the light of opportunity costs, the investments into the airport facilities impede other investments. The counterfactual would have been to make these other investments, as the control group would have done. From this point of view, the insignificant results suggest that airport investments do not perform better than other investments in the sense of regional spillovers, but also not worse.

Note that the evidence presented here does not suggest any conclusions regarding the effects of international airports. It may be that airports need to exceed a certain threshold in order to generate regional spillovers. Furthermore, the high density of airports in Germany may be a reason for the results, since the further benefits of an expanded airport might be rather low in a dense airport network. Besides differences in the applied identification strategy, this might be a further explanation for the differing findings in this paper compared with the existing literature for other countries. Based on the economic effects, this paper does not confirm that the provision of better regional air transport infrastructure in Germany is a promising instrument to stimulate above-average growth in lagging regions.

ACKNOWLEDGEMENTS

Former versions of this paper were published by the author as both a working paper and a thesis (Breidenbach, 2015a, 2015b).

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

NOTES

1. In the time of the liberalization, 17 of 24 considered regional airports had major investments in their facilities (shown in Table 1).
2. The great numbers of German, Allied/NATO and Soviet troops stationed in Germany during both the Second World War and the Cold War meant Germany has had extensive military facilities.
3. Nevertheless, not all former military airports were transformed into civilian use. Although the location itself may be exogenous – from an economic perspective – the decision to transform a particular airport to civilian use is not exogenous. Therefore, further arguments strengthening an exogenous event are needed – in this case the deregulation.
4. The US Aviation Deregulation Act (1978) has been exploited as exogenous changes of air-services (Blonigen & Cristea, 2015), but as shown below, this reform did not result in comparable changes for regional airports. In essence, large airport gained from the US reform while smaller ones experienced losses in air services. The European case had the opposite effect: smaller airports gained, while larger ones had unclear consequences.
5. Sheard (2014) exploits the US 1944 National Airport Plan, which is an exogenous determinant of the size of today's airports without being directly influenced by the later development of the US cities.
6. Since the pre-reform aviation market in the United States was not an open market but rather featured a high degree of governmental regulation, the deregulation act led to substantial shifts in market structure. The pre-reform market situation was characterized by obstacles such as peripheral connections with higher governmental subsidies than attained ticket turnarounds, on the one hand, and other connections in high demand where only a limited number of flights were allowed, on the other (Blonigen & Cristea, 2015). Since this set-up was not sustainable for the rapid development of the aviation industry, the US government passed a radical reform of the system starting in 1978. See Blonigen and Cristea (2015) for a detailed description of this reform.
7. The subsequent empirical analyses of this study support the argumentation of the mentioned authors. Neither the common trend analysis nor pretreatment placebo tests show any effects of the first two steps of the reform before the third step was implemented in Germany (see the Results section).
8. See Cohen, Coughlin, and Ott (2009) for an extensive discussion on efficient allocation systems of slots and a broad discussion of slot allocation for the United States.
9. These rights were ensured by group exemptions from the new regulations that were partly active until 2005 (Regulation 1105/2002 of the European Council).
10. The data section provides evidence for actual investments at German regional airports in this time.
11. Although Weeze and Memmingen are regional airports today, they are ignored in the empirical analyses since they did not support civilian use at the time of treatment (1997). Weeze was opened in 2003, and civilian use at Memmingen started in 2004. The respective counties are excluded from the analysis. If a county is located within the buffer of a regional and an international airport, it is dropped from the sample (as done for all counties in the buffer of international airports). The paper does not treat counties that are in the buffer of two regional airports differently from those treated by one regional airport.
12. The results are available from the author upon request.

13. Reactions of established (international) airports to the deregulation remain unclear. Possibly they were also positively affected by the reform and their traffic gained higher efficiency.
14. This arbitrary definition was tested with thresholds between 0.5 and 5 million passengers per year and using the legal definition (law status). Later results do not change with this variation. The results are available from the author upon request.
15. This measure may have some shortcomings: under the strict assumption of a fixed capital stock, the productivity may decrease by the increase of employment. Therefore, further outcomes are tested in the robustness checks, using the growth of total GDP, GDP per capita and employment as dependent variables.
16. The robustness tests do not hint at any problems for the small number of controls. Therefore, further controls are not assumed to be necessary. Owing to the small number of treated regions, it would be very 'costly' to lose observations due to missing data in the controls. Moreover, a more precise estimation by more control variables (e.g., regional investments) is problematic as they might themselves be an outcome of the treatment, forming a 'bad control' problem (Angrist & Pischke, 2008; Becker, Boeckh, Hainz, & Woessmann, 2016).
17. Since the outcome ($g_{yi,t} = \ln(y_{i,t}) - \ln(y_{i,t-1})$) correlates with the model's error term (ε_{it}), the regressor ($y_{i,t-1}$) also correlates with the error term, leading to biased estimates (see Nickell, 1981; and Baltagi, 2008, for overviews). As Bruno (2005) shows, the dynamic corrected fixed effect estimator based on the estimator developed by Blundell and Bond (1998) provides satisfactory results for rather short sample periods. Results based on this estimation method are presented in Table A1 in Appendix A in the supplemental data online.
18. In the course of the robustness checks, the general approach is challenged in order to reveal time and spatial dynamics. Moreover, the treatment indicator is changed to a passenger-based indicator and the outcome is changed to employment-based measures. Finally (data not presented but available from the author upon request), subgroups of airports are defined that have reacted more intensively to the reform and which had better prerequisites for reacting to the reform (e.g., longer runways). None of these robustness checks changes the basically insignificant results.
19. These results are confirmed by rather similar findings in Table A1 in Appendix A in the supplemental data online, which considers the dynamic correction of the fixed effect model as proposed by Bruno (2005). Since the dynamic correction initially starts from a Blundell and Bond (1998) estimation that also faces some shortcomings, for example, potentially imprecise estimators for rather small cross-sectional dimensions (Bruno, 2005), and since the dynamic bias seems not to influence the standard fixed effect estimations substantially, the further estimations are based on the standard fixed effect model.
20. Moreover, the author has tested the effect of each regional airport separately, following the idea that a subgroup of regional airports has positive spillovers which are not identified here since others do not have such effects. This range of test did not lead to further insights. The chosen methods and results are available from the author upon request.
21. Airport expansions may come along with the creation of new jobs which have a lower productivity than the existing jobs. Therefore, positive employment effects may come along with a negative effect in the GDP per employed person. The paper tests for effects in other outcomes to see whether this should be considered a relevant issue. Since other employment-related outcomes do not react to the reform, this does not seem to be the case here.

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