Continuation of Air Services at

Berlin-Tegel and its Effects on Apartment Rental Prices

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# Abstract

The Berlin-Brandenburg airport (BER) has become well-known far beyond German borders due to substantial mis-planning and heavy delays in opening. Planned to open in March 2012, BER finally opened in 2020, after seven partly substantial and immediately announced delays. Focusing on the first two announcements, these unexpected delays form an exogeneous shock for residents surrounding the largest existing airport, Berlin-Tegel, which was expected to close immediately upon the opening of BER. We use this as a quasi-experiment to analyze the effect of airport noise and proximity to the airport on housing rental prices. The results suggest that there is a negative effect of noise on rental prices in the range of 2% to 5%, while there are positive effects from proximity to Berlin-Tegel of roughly 1% to 3%. We consider heterogeneity using quantile regression and find that the negative noise effects tend to be larger for higher priced apartments. We disentangle the effects of airport noise and other types of noise, and in this context find that airport noise lowers property values by 2% to 2.8% while those properties facing additional environmental noise experience a separate negative effect of approximately 1.7%.

**Keywords:** Real Estate Prices, Airports, Aviation Noise, Proximity, Germany

JEL-CODES: R3, R4

# Introduction

The well-known hedonic housing price model of Rosen (1974) postulates that the price of an apartment or a house equals the value of all its characteristics. As later developed by Banzhaf et al. (2006) and others, these characteristics include not only the physical attributes of the respective housing object (such as number of rooms, bathrooms, living area etc.), but also local amenity and disamenity factors that influence the value of living within a specific neighborhood. Such factors may affect prices either positively (amenities) or negatively (disamenities). The investigation of such local factors has a long history in the field of housing economics (e.g. Davis, 2011 and Debrezionet al., 2007). While some of them are clearly attributed as amenities (such as city parks) or disamenities (such as pollution), others have unclear effects on housing prices.

Such an unclear overall effect also holds true for the case of airports. On the one hand, airports offer potential job opportunities and better connectivity, supporting the argument that airports are an amenity in the context of housing prices. On the other hand, the literature also demonstrates their role as a disamenity since aircraft cause noise pollution (e.g. Boes and Nüesch, 2011 and Winke, 2016). Noise is a major concern in developed countries since it seems to be negatively correlated with health outcomes and can reduce the quality of life. A constant increase of flights and passengers (in Germany the number of passengers increased from about 120 million in 1997 to 235 million in 2017[[4]](#footnote-5)) also highlights the importance of external effects of airports on the property values in their local neighborhoods.

Aiming to provide causal evidence of how airports impact real estate prices regarding amenities and disamenities, our paper benefits from the unexpected events regarding the construction (and its delays) of the new Berlin “Berlin-Brandenburg” airport (BER). Before German reunification, there originally existed four airports in Berlin.[[5]](#footnote-6) After reunification, the government intended to subsume all aviation-services of Berlin at one airport – BER. Finally in 2004, after a long political process, the decision was made to erect BER close to the existing airport Berlin-Schoenefeld[[6]](#footnote-7). The construction work started on September 5th, 2006, also coinciding with termination-plans for the existing airports, namely Berlin-Tempelhof to be closed in 2008 and the biggest remaining airport Berlin-Tegel, to be closed right after the opening of BER, planned in November 2011. Over the course of the construction, the opening-date was adjusted to be in June 2012, which did not result in too much public interest and which was not expected to have further housing price-effects.

But, in May 2012 – still following the plans to open one month ahead of the announced schedule – substantial construction defects were detected. These defects made the planned opening impossible to hold and at the same time meant ongoing air-services at Tegel. Up to that time the planned opening date (June 2012) was very convincing for residents, which can be illustrated by three features. Contracts with firms providing services at BER were fixed, all passenger tickets were already assigned to the new airport, and invitations for the opening celebration had already been sent out to national and international government representatives. Regarding the old Tegel airport, up to this point, employees and employers, residents of the neighborhoods and others credibly expected that there would be no airport-activities at Tegel after the next few weeks. In the further course of the development, the management of the airport then admitted in January 2013 that also a completion in 2013 (planned for October 2013 at that time) was not tenable and a new opening date was not foreseeable. Although this announcement did not lead to an abrupt change such as the May 2012 event, it did make clear to residents and apartment seekers that Tegel Airport would continue to exist in the longer term. After many years of further delays, BER finally opened in November 2020. We also analyze effects of all delay announcements in this paper.

These delays form a set of exogenous events. The ongoing air-services announcements at Tegel (especially the announcement in May 2012) were not anticipated by any player in the housing markets – landlords, sellers, renters and buyers – and therefore, causal inferences of airport effects on housing prices in the neighborhood can be drawn from this event. As the delayed opening is more evident in a shorter perspective, we focus our estimations on the rental market as renters typically have shorter planning horizons than buyers. As 85%[[7]](#footnote-8) of households in Berlin are renters, this is the much more meaningful group than homeowners.

Regarding the amenity and disamenity of airports, our approach based on geo-located housing data allows us to separately analyze rental price discounts in the noise polluted areas (approach and departure routes of Tegel) and price premia in those areas not polluted by noise by benefitting from the proximity by jobs and connectivity after the unexpected extension of services. Running a difference-in-differences approach (diff-in-diff) reveals a 2% to 5% price-discount for rental apartments caused by noise pollution (related to a threshold of 55dB at daytime) and a 1% to 3% price premium for proximity (defined as less than 10 minutes, less than 15 minutes, or less than 20 minutes driving time to the airport) as long as the respective apartments are not affected by noise pollution.

Although there exists a range of studies that analyze different aspects of airport amenities and disamenities, our approach broadly contributes to the literature. In our framework with an airport that is expected to close, the effects of both proximity and noise come into play, and inhabitants have concrete information about both factors (i.e., specific jobs available, and detailed information about noise levels). This is not the case when an airport is newly opened. Jobs are only job opportunities and noise-pollution is only a theoretical projection for a new airport, which is not felt as strongly by residents. Moreover, the effects may become relevant at different points in time. With an airport closure, noise remains until the close-down, forward-looking employees may value the proximity less and less over time as the closure date approaches.

With our setup, having an existing airport which is announced to cease all operations permanently in very near future on the one hand, and unexpected announcements of delays on the other hand, allows us to estimate the overall effect of noise and proximity. This estimate of the overall effect enables us to address the question of whether positive or negative factors of the airport proximity dominate. This question is difficult to analyze credibly with other frameworks because prior to an ordinary opening, most job opportunities do not exist, and noise pollution is only a theoretical value. When we run the combined analyses in our setup, the results suggest that the noise pollution effect outweighs the proximity effect in the noisiest areas, especially when the expected continuation of services at the old airport (Tegel) is long-lasting. Furthermore, we can observe adaptation processes before delays come into play, meaning that noise-polluted apartments catch-up in their prices compared to similar apartments which are not affected by airport-noise. We also consider other types of noise, and find the properties exposed to noise from other sources experience a 1.7% additional rental price discount.

Finally, one might imagine that different apartments might be impacted in various ways by exposure to airport noise. To unmask this potential heterogeneity, we estimate a quantile regression model. These quantile regression estimates indicate that higher priced apartments tend to experience a larger noise discount than lower priced apartments. This implies that perhaps individuals seeking “nicer” apartments (proxied for by price) have a higher willingness to pay for avoiding airport-related noise than individuals seeking lower-quality apartments.

The remainder of this paper is structured as follows. First, we briefly summarize the literature before we present details of our data. In the fourth section the estimation strategy is displayed. Estimation results are reported in section 5 while section 6 concludes.

# Literature Review

Before the Covid-19 pandemic, air traffic was increasing in most countries. Airports had been characterized by good connections for travelers that can be used by residents, too. Further, airports were characterized by jobs but also noise for residents. Therefore, the overall willingness to pay for living in the surrounding neighborhoods of an airport is ambiguous. There already exists a large literature on the effects of aviation noise on housing prices. The meta-study of Nelson (2004) shows that there is a consensus of negative effects on housing prices. Jud and Winkler (2006) study an expansion of the Greensboro/High Point/Winston Salem airport in North Carolina. They find that the expansion announcement had a short-term house price impact of 9% within 2.5 miles of the airport.

Besides the disamenities from noise, the positive effects of the proximity to airports have also been investigated. Brueckner (2003) observes positive employment effects of increased airline traffic. Tomkins et al. (1998) and McMilllen (2004) show that there are positive effects of the proximity to airports on housing prices. Therefore, analysis focusing on only one of these potential effects are prone to neglect important findings. This was addressed by Espey and Lopez (2000), Lipscomb (2003), Cohen and Coughlin (2008, 2009), and Ahlfeldt and Maennig (2010). Cohen and Coughlin (2008, 2009) and Lipscomb (2003) consider the Atlanta, Georgia airport, which is one of the largest airports in the world and find evidence that the negative noise effects tend to outweigh positive proximity effects.

There are many existing analyses undertaking much effort in analyzing airport effects. Nevertheless, the implementation of causal identification strategies remains a challenging task in the context of airport effects because changes are plagued by endogeneity (Breidenbach, 2015). In general, the existence of an airport does not change over time. Even if an airport is newly constructed, its location is not randomly chosen. There are usually longstanding announcements (so people anticipate the airport effects, resulting in a slowly fading-in processes instead of a clear cut-off). The issue of simultaneity between airport noise and housing prices is another concern for identification of causal effects. We therefore analyze the effects of an unexpected non-closing of an airport. This strategy has the advantage that residents can already observe the aviation noise and the ongoing operation had not been expected.

Another issue to consider is the difference in noise exposure impacts on owner-occupied residential real estate, opposed to rental residential real estate. If a resident purchases a house that is exposed to a given level of noise, and expects to live in that house for decades, the present discounted value of the noise damage is expected to be greater than it would be if the homeowner was planning to stay for only 1 to 3 years. But the fixed costs involved with buying a house typically imply a homeowner would be planning to live in a house for at least several years. Therefore, those residents with a relatively short time horizon for living in a particular location tend to rent rather than purchase. This implies the present value of the expected damages from a given level of airport noise should be relatively low for renters. Some other papers analyze the effects of BER-opening on housing prices (e.g., Mense and Kholodilin, 2014). Mense and Kholodilin (2014) analyze the effects of the publication of future routing of the air traffic on the housing prices. Though their approach is a sensible framework, we believe that our approach relying on the exogenous character of the announcements of delayed openings and the immediate impact of ongoing noise serve a unique framework for important insights.

More generally, Ahlfeldt and Maennig (2015) have shown that homeowners react differently than renters when voting on the new “aviation concept” that was to create the Berlin-Brandenburg” (BER) airport. Renters expected the benefits of proximity to outweigh the noise costs, and therefore drive up the price of apartments relative to owner-occupied homes. On average, more renters were found to oppose the “airport concept” referendum and homeowners were found to be supportive. This leads one to ponder the question of how renters near Tegel might react to a delay in the opening of BER, compared with homeowners. Such a delay might prolong the exposure to noise for renters, and also might prolong the amount of time that they can access Tegel for employment opportunities and/or travel convenience. The authors’ objective was to examine whether homeowners - who were likely to benefit from the capitalization from proximity to BER and reduced noise after closure of Berlin-Tempelhof – more strongly supported the 2008 referendum than renters. They find highly significant (and positive) treatment effects from the announcement of this concept. Homeowners might be expected to benefit more. Renters tend to have a shorter time horizon to live in a property. Therefore, prolonged noise exposure for a renter might bring down their willingness to pay more than for a homeowner who might expect to be in the home for decades after the closure (and therefore benefit for a long period of time from the closure of Tegel).

There is an emerging literature on the impacts of the new BER airport on residential real estate prices. For instance, Mense and Kholodilin (2014) consider the announcement of the flight paths for BER as an exogenous event to identify the impacts of expected noise on real estate prices. The expected drop in house prices was in the range of 8%-13%, depending on the altitude of the flight paths near a given property.

Also in the European context, Boes and Nüesch (2011) examine apartment rents near Zurich, Switzerland’s airport. They find that for every additional decibel of noise, apartment rents fall by approximately 0.5%. In contrast to many of the airport noise studies that have been done for owners of houses, this estimate is relatively small. But that may be attributable to the fact that renters tend to have a shorter expected time horizon for living in the property. In a study of the Geneva, Switzerland airport, Baranzini and Ramirez (2005) find somewhat larger impacts, in the range of 1% per decibel, for impacts of airport noise on apartment rents. However, their results likely imply correlation rather than causality.

In our analysis, we consider both noise and proximity, using a solid identification strategy (i.e., several delay announcements) to pin down the causal relationship between noise and rental prices, and noise and for-sale prices. Our exogenous shocks are the series of delay announcements for the construction of the new BER airport. This approach provides us with a unique way to identify the causal impacts of noise on residential property rental prices, and of proximity on residential rental property prices.

# Data

For the analysis of the unexpected continuation of Berlin-Tegel (referring to the delayed opening of BER) on property prices surrounding Tegel, we merge data from several different sources, including geo-referenced Berlin housing data, small-scale drivetimes to the airport, data on aviation-noise pollution as well as some background characteristics of the neighborhoods. The data on housing prices stem from the **RWI GEO-RED** data, provided by the FDZ Ruhr at RWI (Boelmann et al 2019a, 2019b). It covers all advertisements of residential properties for sale and for rent throughout Germany between 2007 and March 2019 obtained from the real estate online platform ImmobilienScout24. ImmobilienScout24 is the biggest real estate online platform in Germany[[8]](#footnote-9). There are four different types of advertisements: houses for sale, apartments for sale, houses for rent and apartments for rent. The data for all four types of advertisements include characteristics such as size (plot size and number of rooms), year of construction, number of floors, and indicators for whether there is a balcony, a guest toilet, and others. Besides characteristics of the apartments and houses, the asking price is included in the dataset. Further, this dataset includes geo-coded address information for about 95% of the objects. Characteristics of rental properties are summarized in Table A.1 in the appendix. A detailed description of the data can be found in Boelmann and Schaffner (2019). We use the data from 2010 to March 2019 for the analysis.

We estimate the driving time from each property to Berlin-Tegel, which we include in our regressions as a control for proximity of the airport. This driving time is calculated from each offered apartment to the airport. The driving time is calculated by the FDZ Ruhr at RWI (**RWI GEO-GRID DRIVETIME**) and is based on OpenStreetMap data. Further, we estimate the travel time by public transport. For this purpose, the transportation time for apartments/houses is taken from the Berlin public transport provider www.bvg.de. It is the shortest travelling time for departures between 9:00 am and 9:30 am.

The noise data for aviation noise are taken from Senatsverwaltung für Umwelt, Verkehr und Klimaschutz in Berlin. Their webpage provides noise maps for every type of noise separately. Therefore, aviation noise can be separately collected, as well as separated from other types of noise (which we consider in our heterogeneity analysis). The noise pollution of 55dB and more are displayed in Figure 2 for all aviation noise resulting from Berlin-Tegel airport. This noise information can be linked to the housing objects obtained from RWI GEO-RED by the exact geo-code.

Finally, the dataset is enhanced by neighborhood characteristics taken from the **RWI-GEO-GRID** data. The RWI-GEO-GRID data cover socio-economic information of the residents for all populated 1x1km grid cells in Germany (based on the EU-regulation “INSPIRE”). As the geo-coded housing data (RWI-GEO-RED) also refers to these grid cells, the datasets can easily be merged to each other (specifically, each apartment can be assigned a grid-level value for the demographic characteristics). The RWI-GEO-GRID dataset comprises data on population by gender as well as by age group, purchasing power, credit default risk classes, unemployment, cars and migration background of the residents. The data are described in Breidenbach and Eilers (2018). We apply v8 of the data covering the years 2005 and 2009-2016 (RWI/microm 2019). Table 1 summarizes characteristics of the advertised rental properties and the local neighborhood by the different treatment groups.

**Table 1 Descriptive Statistics for Treated and Non-Treated Rental Properties**

|  |  |  |
| --- | --- | --- |
|   | ≤ 15 min drivetime | > 15 min drivetime |
| Variable |  Total | < 55dB | ≥ 55dB |  |
| Observations | 186 170 | 154 166 | 32 004 | 536 660 |
| Ln(rent per sqm) | 2.062 | 2.102 | 1.867 | 2.028 |
| Age | 48.448 | 48.909 | 46.225 | 40.192 |
| Floor size | 75.279 | 77.088 | 66.571 | 73.414 |
| Floor  | 1.721 | 1.787 | 1.401 | 1.922 |
| Number of floors | 3.036 | 3.295 | 1.792 | 3.324 |
| Number of rooms | 2.368 | 2.374 | 2.342 | 2.436 |
| Balcony | 0.66 | 0.644 | 0.74 | 0.675 |
| Quality of apartment |  |  |  |  |
| Unknown | 0.549 | 0.51 | 0.715 | 0.556 |
| Simple | 0.010 | 0.010 | 0.011 | 0.009 |
| Normal | 0.212 | 0.218 | 0.185 | 0.202 |
| Sophisticated | 0.205 | 0.231 | 0.083 | 0.205 |
| Deluxe | 0.027 | 0.031 | 0.006 | 0.028 |
| Quality of house |  |  |  |  |
| First occupancy | 0.051 | 0.061 | 0.006 | 0.049 |
| First occupancy after reconstruction | 0.094 | 0.1 | 0.065 | 0.079 |
| Like new | 0.034 | 0.038 | 0.017 | 0.053 |
| Reconstructed | 0.0652 | 0.07 | 0.043 | 0.102 |
| Modernized | 0.06 | 0.064 | 0.041 | 0.062 |
| Completely renovated | 0.134 | 0.141 | 0.103 | 0.097 |
| Well kempt | 0.23 | 0.216 | 0.299 | 0.204 |
| Needs renovation | 0.014 | 0.013 | 0.018 | 0.010 |
| By arrangement | 0.009 | 0.009 | 0.008 | 0.007 |
| Dilapidated | 0.000 | 0.000 |  | 0.000 |
| Unknown | 0.308 | 0.289 | 0.408 | 0.33 |
| Houses in neighborhood | 618.982 | 622.25 | 603.22 | 636.37 |
| Persons in neighborhood | 35991 | 37012 | 31072 | 34548 |
| Households in neighborhood | 6392 | 6773 | 4561 | 5651 |

SOURCE: Authors’ calculations based on RWI-GEO-RED

# Estimation Strategy

Our estimation strategy relies on the idea that (potential) renters of apartments expect that Tegel will close immediately after the opening of BER – following the previously decided-upon plans. Consequently, they assume for apartments affected by aviation noise from Tegel airport that the noise is going to vanish soon. Prices are assumed to adapt towards a new equilibrium without airport noise pollution. Vice-versa, similar mechanisms are expected for the positive features of the airport (labor demand and connectivity); prices are assumed to adapt towards a new equilibrium without the vanishing amenities after Tegel is closed.

Consequently, the adaptation processes are stopped or impeded when delays of the opening are announced. Therefore, the announcements constitute an important aspect of our identification strategy. Yet, there were at least seven official announcements of delayed openings, which allow us to identify effects in the housing market. Table 2 gives an overview of all dates of delay-announcements that occurred during the construction work at BER (column 1). Moreover, Table 2 includes the planned opening (before the delay) in column 2 and the declared new opening (column 3).

As the announced delays are much more relevant in a short planning horizon rather than in a long run perspective, we focus our analyses on rents. Renters (and rent seekers) typically have a shorter planning horizon than buyers. Additionally, the majority of German households are renters (58%). This share is substantially larger in Berlin (where our analysis focusses) with a tenant share of 85%.[[9]](#footnote-10) Moreover, we focus on apartments instead of houses since houses for rent are a rather rare exception within metropolitan areas such as Berlin.

Table 2 Opening dates for airport Berlin-Brandenburg (BER)

|  |  |  |
| --- | --- | --- |
| Announcement date |  Planned Opening | Declared New Opening |
| Sep 2006 |   | Oct 30th 2011 |
| Jun 2010 | Oct 30th 2011 | Jun 3rd 2012 |
| May 2012 | Jun 03rd 2012 | Mar 17th 2013 |
| Sep 2012 | Mar 17th 2013 | Oct 27th 2013 |
| Jan 2013 | Oct 27th 2013 | not declared |
| Dec 2014 | not declared | 2nd half of 2017 |
| Jan 2017 | 2nd half of 2017 | 2018 |
| Dec 2017 | 2018 | Oct 2020 |
| Sep 2017 | Referendum: Citizen Movements achieved a referendum on the future status of Berlin-Tegel. The majority of Berlin’s inhabitants voted for “remaining Tegel open” after the opening of BER.  |

SOURCE: Authors’ research based on media articles.

We aim at building our estimation strategy on a diff-in-diff approach. For this purpose, we need a temporal differentiation of the pre- and post-treatment phase and a spatial differentiation into a treatment and a control group. Meaningful announcement dates (in the sense of our estimation strategy) need to fulfill two criteria. First, the announcements should have higher relevance for our empirical analysis if they are made close to the original planned (or rescheduled) opening date. This ensures that market participants react directly after the delay was declared. Potential residents searching for housing in the neighborhoods near Berlin-Tegel expect that the airport will close within the subsequent weeks after the opening of the new airport. Second, the announced time span until the new declared opening must be sufficiently long. Otherwise, market participants may not react to the delay.

Following these two criteria, the first announcement (in June 2010) should be of low importance. The announcement was made quite long before the planned opening (seventeen months ahead of October 2011), making it hard to interpret when market participants reacted. Furthermore, the announced delay was rather short (eight months), therefore it is unclear if market participants reacted at all. This kind of delay is quite common for big building projects.

From this perspective, the announcements in May 2012 and in January 2013 form good candidates for stronger reactions in the rental housing market because they were made closely before the planned opening (especially in the case of May 2012)[[10]](#footnote-11) and the declared opening was far ahead (especially in the case of January 2013 when no new opening was declared).[[11]](#footnote-12) Additionally, we run setups controlling for each announced delay shown in Table 2.

**Figure 3 Google trends searches for “BER”**

SOURCE: Google Trends; searching for “BER” in the period January 2010 to March 2019 (covering our observed period). Executed on August, 29th 2019.

The prominence in the media also underpins the importance of the announcements in May 2012 and in January 2013. We quantify this relevance by Google Trends analyses (Figure 3) showing that the search for the term “BER” had two outstanding peaks over time, the first around May 2012 and the second around January 2013. Before the beginning of May 2012, newspaper articles focused on the opening and the corresponding ceremonies. This changed when the delay was declared four weeks before the planned opening, forming nationwide and international media attention. This attention was accelerated further when more skepticism regarding the construction was spread in German media during the following months (especially with the announcement in January 2013, giving no new planned opening).

Following the idea to implement a diff-in-diff strategy, we need to define a spatial control group, which credibly reflects developments in a counterfactual situation without a treatment. As we follow two different identifications – the case of analyzing effects of the noise-pollution on housing prices, and for the case of analyzing effects of the connectivity to an airport on housing prices – a control group needs to be defined separately for each approach.

For the case of noise-analysis, we know that nearly all objects suffering from noise (typically located in the approach and take-off routes) also benefit from the airport proximity at the same time (as they are located close to the airport). Thus, a control group which is not affected by the airport at all is not suitable as it implicitly refers to the situation without both – noise and connectivity. Therefore, we focus the noise-analysis on objects which are in proximity to the airport (defined by a maximum drivetime). In this sense, both – control and treatment group – are affected by the proximity to the airport but only the treatment group is also affected by the noise pollution. The noise-pollution is defined by thresholds of 55dB and 60dB.

Figure 4 Noise and drive time around Tegel



Noise Pollution ≥ 55dB

Drivetime ≤ 10 minutes

Drivetime ≤ 15 minutes

Drivetime ≤ 20 minutes

Drivetime > 20 minutes

SOURCE: RWI-GEO-RED, drivetime to Berlin-Tegel calculated by algorithm obtained from RWI-GEO-DRIVETIME. Noise-pollution obtained from Senatsverwaltung Berlin.

For the case of job/connectivity analysis, we define our control group by all objects in Berlin which are not located in the proximity of Tegel (defined by a threshold of maximum drivetime to Tegel). Vice versa, the treatment group is defined by those objects within a certain proximity. The twofold effects of the airport are also present in this setting since the properties that benefit from jobs and connectivity also suffer from noise pollution. In the job/connectivity analysis, to avoid biases by the noise pollution we exclude all properties affected by noise (above 55dB) in the treatment and control group.

Figure 4 illustrates this setting on the level of 1x1 km grids for Berlin. The color scheme from yellow to red marks the drivetime to Tegel airport (marked by the icon in the northwest). Grids filled with the grey layer are affected by noise pollution of at least 55dB. This grey area marks the treatment group as long as it is located within a drivetime of at most 20 minutes (yellow to dark-orange areas). The control group is defined by apartments in the yellow to dark-orange area (drivetime at most 20 minutes). In our empirical results below, we also consider a robustness check with drivetime at most 15 minutes. All objects in the red area are excluded from the noise-analysis, even if they are noise polluted.

Figure 5 illustrates our hypothesis graphically for noise effects (Panel A) and proximity effects (Panel B) and thus provides a helpful overview for effects we have to model in the estimations. In general, we assume an increasing price trend all over Berlin. Regarding the apartments treated by noise from the Berlin-Tegel airport, we assume that rents are on a lower level since noise-pollution forms a disamenity (Panel A). Following the idea that the projected close of Tegel (opening of BER) influences rents, we expect rent prices of treated apartments to catch up against untreated apartments over time. The treatment (announcements of a delay) is mapped by the vertical line. Once the delay is announced, noise is supposed to remain longer and the catching-up of rents in treated areas is assumed to be shifted back. This is the key effect our noise analysis focusses on.

By contrast to noise pollution, Panel B illustrates rent effects of close proximity to the airport before and after the announced delays. Again, both groups are characterized by an increasing price trend, but the rent level for the treated group (close to the airport without high noise pollution) is higher since the proximity (without noise pollution) is an amenity. However, it is assumed that prices will converge between the treated and untreated because Tegel will close and the amenity disappears then. At the time of the delayed opening announcement, prospective residents’ expectations change, leading to an upward shift in prices for the treated group, followed by the converging process starting again after this shift.

Figure 5 Expected rent price development by announcements

|  |  |
| --- | --- |
| Panel A: By noise treatment | **Panel B: By proximity treatment** |
|  |  |

Our diff- in-diff approach for the noise effect is defined by

$y\_{ignt}=α\_{1}N\_{n}+α\_{2}T\_{t}+X\_{i}β\_{1}+Z\_{g}β\_{2}+γ\_{1}trend\_{t}+γ\_{2}trend\_{nt}+δTreat\_{nt}+u\_{ignt}$ , (1)

with yignt being the log of price per square meter of rental apartment i, Nn is a dummy for noise-polluted locations, Tt takes the value 1 if the property was advertised for rent after the respective announcement and 0 otherwise. Characteristics of the property are covered in Xi and characteristics of the 1x1km cell (number of households, number of inhabitants, purchasing power, drivetime to Tegel) are included in Zg (grid-characteristics). The time trends are defined as a monthly overall linear time trend (trendt) and an additional monthly time-trend for all noise-polluted objects, trendnt. This group specific time trend is able to reflect the expected catch-up process of treated apartments.[[12]](#footnote-13) Finally, Treatnt (Nn\*Tt) is the difference-in-differences dummy that takes the value 1 for noise-polluted properties after the respective announcement and zero otherwise.

Switching the perspective considering the airport as an amenity having positive effects on the apartments close by, we define the following model. The diff-in diff estimation is defined similarly to equation (1) again including group specific time trends, covering potential price adaptions prior to the announcement (see Figure 5). The treatment group specific variables here are defined by the group specific fixed effect (*Nd*), the group specific time trend (*trenddt*) and the treatment effect (*Treatdt*). The model is estimated for different driving time cut-offs (*d*).

$y\_{igdt}=α\_{1}N\_{d}+α\_{2}T\_{t}+X\_{i}β\_{1}+Z\_{i}β\_{2}+γ\_{1}trend\_{t}+γ\_{2}trend\_{dt}+δTreat\_{dt}+u\_{idt}$ (2)

We estimate the models (1) and (2) for both announcements (May 2012 and January 2013) separately. Using a fixed observation period, results from the separate estimation for each event may be biased since the treat by the first event (May 2012) is depicted in the pre-treatment period for the case of January 2013 estimations. We therefore include both announcements into one regression to identify a dynamic treatment effect and additionally build up a model in the same way including all announcements shown in Table 2. The model is

$y\_{igdt}=α\_{1}N\_{n}+X\_{i}β\_{1}+Z\_{i}β\_{2}+γ\_{1}trend\_{t}+γ\_{2}trend\_{dt}+\sum\_{a}^{}(δ\_{a}Treat\_{ant}+α\_{2a}T\_{at})+u\_{idt}$ (3a)

$y\_{igdt}=α\_{1}N\_{d}+X\_{i}β\_{1}+Z\_{i}β\_{2}+γ\_{1}trend\_{t}+γ\_{2}trend\_{dt}+\sum\_{a}^{}(δ\_{a}Treat\_{adt}+α\_{2a}T\_{at})+u\_{idt}$ (3b)

with $a$ being the different announcements. Tat takes the value 1 if the property was advertised after announcement $a$ and zero otherwise. $Treat\_{ant}$($N\_{n}\*T\_{at}$) is the difference-in-differences dummy (i.e., the treatment effect) that takes the value 1 for noise-polluted properties after the announcement $a$ and zero otherwise.$Treat\_{adt}$($N\_{d}\*T\_{at}$) is the diff-in-diff dummy (i.e., the treatment effect) that takes the value 1 for properties close to the airport after the announcement $a$ and zero otherwise.

All analyses examine the effects of a treatment by either noise or by jobs/connectivity. Moreover, we want to make use of the unique event we can observe in our data, to quantify if one of these two effects outweigh the other one. Due to the unexpectedness of the delay, both effects come up at the same time, allowing us to identify them within the same setup. For this purpose, we define a triple-differences (diff-in-diff-in-diff) approach in the following specification:

$y\_{igdt}=α\_{1d}N\_{d}+α\_{1n}N\_{n}+α\_{1nd}N\_{n}N\_{d}+α\_{2}T\_{t}+X\_{i}β\_{1}+Z\_{i}β\_{2}+γ\_{1}trend\_{t}+γ\_{2}trend\_{dt}+δ\_{d}Treat\_{dt}+δ\_{d}Treat\_{nt}+δ\_{dn}Treat\_{ndt}+u\_{idnt}$ (4)

with$Treat\_{ndt}$($N\_{n}\*N\_{d}\*T\_{t}$) taking value 1 for noise-polluted properties close to the airport after the announcement and zero otherwise.

# Results

We start with the effects of (unexpected) ongoing noise pollution, focusing on the two major announcements of delays (May 2012 and January 2013). After testing potential effects for each announcement (including the shorter delays and the less ad-hoc announcements), we test for heterogeneities in our results. Making use of the detailed small-scale information at hand, we test other noise pollutants, object characteristics or socio-economic characteristics of the neighborhood affect or main findings. Hereafter, we switch to the drivetime effects following the same agenda (main announcements, all announcements, heterogeneities). Finally, we combine drivetime and noise pollution effects.

Starting with the noise pollution of eq. (1), we restrict the analysis to all observations that are within a driving time of 15 minutes to Berlin Tegel airport. We also consider public transport travel times, but this has negligible effects on the results (results are available on request). Within this area the treatment group consists of all apartments that suffer from aviation noise of at least 55dB or 60dB. Focusing on the main announcements of delays identified for May 2012 and January 2013, we estimate six models shown in Table 3. Column 1 and 2 focus on the 55dB threshold for May 2012 and January 2013. Columns 3 and 4 focus on the 60dB for both announcements. Finally, columns 5 and 6 reflect the model from eq. (3a) including both announcements (May 2012 and January 2013) defining treated apartments by either 55dB (column 5) or 60dB (column 6). The control group is defined by all apartments that experience less than 55dB of aviation noise but have a similar driving time to the airport (maximum 15 minutes). The results in Table 3 indicate a positive time trend of slightly less than 0.5% for all apartments (nominal prices in Berlin) as expected for the particular market. In general, those apartments treated with noise have lower prices, indicated by the negative sign of the noise dummy in the range of approximately -2% to -4%, but show a positive catching-up process, indicated by the trend for noise polluted apartments. These three general findings indicate negative price premia of noise pollution and the converging process towards the closing of Tegel as expected in Figure 3.

The key-indicator, the coefficient on the difference-in-differences term (Noise\*Post-announcement) for the 55dB area shows the expected negative significance for the announcements in May 2012 (-3.85% for 55db) and January 2013 (about -3.2%). The corresponding treatment effects for the 60dB area are slightly less negative for these two announcements; in other words, considering both events separately, the May 2012 event shows stronger effects (for 55 and 60dB). When both events are included together in the same regression, January 2013 has stronger effects for the lower noise pollution (3.1% vs. 4.9%) and the May 2012 event has the stronger effect for the case of 60dB. This implies that apartment prices react more strongly to the January 2013 announcement, by lowering prices more with the indefinite opening date of BER. But the opposite was true for the apartments in the noisier area (60dB) – the May 2012 announcement led to a greater reduction in the prices of apartments for those noisier dwellings.

Table 3 Noise effect on rent prices for May 2012 and January 2013

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | (1) | (2) | (3) | (4) | (5) | (6) |
| Dep. Variable: ln(rent/sqm) | May1255dB | Jan1355dB | May1260dB | Jan1360dB | Both55dB | Both60dB |
|   |   |   |   |   |   |   |
| Trend | 0.0044\*\*\* | 0.0046\*\*\* | 0.0044\*\*\* | 0.0046\*\*\* | 0.0043\*\*\* | 0.0044\*\*\* |
|  | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| Noise Dummy | -0.0194\*\*\* | -0.0245\*\*\* | -0.0397\*\*\* | -0.0445\*\*\* | -0.0219\*\*\* | -0.0406\*\*\* |
| (55dB/60dB) | (0.0033) | (0.0033) | (0.0064) | (0.0064) | (0.0033) | (0.0035) |
| Noise specific  | 0.0009\*\*\* | 0.0008\*\*\* | 0.0009\*\*\* | 0.0009\*\*\* | 0.0011\*\*\* | 0.0009\*\*\* |
| Trend | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| May 12 | 0.0346\*\*\* |  | 0.0348\*\*\* |  | 0.0327\*\*\* | 0.0298\*\*\* |
|  | (0.0016) |  | (0.0017) |  | (0.0017) | (0.0017) |
| Jan 13 |  | 0.0170\*\*\* |  | 0.0170\*\*\* | 0.0391\*\*\* | 0.0345\*\*\* |
|  |  | (0.0018) |  | (0.0018) | (0.0021) | (0.0021) |
| **DiD May 12** | **-0.0385\*\*\*** |  | **-0.0337\*\*\*** |  | **-0.0311\*\*\*** | **-0.0240\*\*\*** |
|  | **(0.0037)** |  | **(0.0051)** |  | **(0.0042)** | **(0.0056)** |
| **DiD Jan 13** |  | **-0.0320\*\*\*** |  | **-0.0275\*\*\*** | **-0.0493\*\*\*** | **-0.0376\*\*\*** |
|  |  | **(0.0041)** |  | **(0.0055)** | **(0.0046)** | **(0.0061)** |
|  |  |  |  |  |  |  |
| Observations | 186,170 | 186,170 | 170,658 | 170,658 | 186,170 | 186,170 |
| Number of grids | 162 | 162 | 159 | 159 | 162 | 162 |
| Month & Grid FE | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors clustered on grid level in parentheses. All included apartments have a maximum driving distance to Berlin-Tegel of 15 minutes; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Figure 7 Noise effect on logarithmic rent prices (all announcements – 55dB cutoff)

Figure 7 (based on equation 3a) illustrates the effects we obtain from an estimation including all announcements in the 55dB area.[[13]](#footnote-14) negative effect of announcements becomes significant for May 2012 and increases for January 2013 when the second substantial delay was announced, without an announcement of a new planned opening. Once a new opening date was planned (in December 2014) the effects return to insignificance. Results also remain insignificant for September 2017, which is not associated with a further delay announcement, but the implementation of the referendum on continuation of air-services at Tegel.

# Heterogeneity – Noise Results

The general negative effect of the delay in the opening on apartments which are affected by aviation noise is well documented in the results presented above. Going more into detail, we test if the general effect of about -3% to -5% varies by characteristics of either the apartment or the neighborhood. Thereby, we test four hypotheses.

First, we test for other sources of noise (which we call “environmental noise”), assuming that prices in quieter areas react stronger on the remaining aviation noise. Getting the environmental noise in a testable setup, we define a dummy taking the value of 1 if environmental noise is below the median environmental noise, and 0 otherwise. Apartments with low environmental noise show an additional negative price reduction (shown in the first two columns of Table 4), summing up to a total effect of 3.7% to 4.5%.

Second, we split the sample by the apartment size (with results in Table 4). Regarding the heterogeneity by apartment size, we split the sample in the below and above median group. Here, the announcement effect increases to the range of -6% to -7% for apartments with above-median size, while the remaining effect for small apartments is only about 1% to 2%. This result seems plausible as tenants of larger apartments (more likely for families) tend i) to spend more time at home, ii) stay longer in the rented apartments and iii) have higher preferences for quiet residential areas than other groups.

Third, we test whether there is heterogeneity regarding the economic neighborhood characteristic, which is the unemployment rate. We distinguish above and below-median unemployment rate. In general, the announcement effect is about 3% to 4% for neighborhoods with above-median unemployment rate. Results are shown in Table 4. Apartments in neighborhoods with low unemployment have an additional effect of about 2% (which is significant for the May 2012 announcement but insignificant for the January 2013 announcement).

Finally, we consider heterogeneity with respect to apartment prices (Table 5). For this, we run a quantile regression approach in the noise effects model. Doing so, we find that higher priced apartments experience a larger noise discount. Assuming higher priced apartments are also of higher quality, this implies that renters of higher quality apartments demonstrate a greater willingness to pay for noise reduction than renters of lower quality apartments.

**Table 4 Heterogeneity of Noise effects:** Environmental noise, Apartment size, Local unemployment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
|  | Environmental Noise | Apartment Size | Neighborhood  |
|  Dependent variable: ln(rent/sqm) | May1255dB | Jan1355dB | May1255dB | Jan1355dB | May1255dB | Jan1355dB |
| Noise-Dummy | -0.0209\* | -0.0251\*\* | -0.0172 | -0.0212\* | -0.0204\* | -0.0246\*\* |
| (55dB) | (0.0114) | (0.0118) | (0.0110) | (0.0115) | (0.0105) | (0.0109) |
| May12/ Jan13 | 0.0331\*\*\* | 0.0123\*\* | 0.0330\*\*\* | 0.0129\*\* | 0.0340\*\*\* | 0.0145\*\* |
|  | (0.0051) | (0.0057) | (0.0050) | (0.0055) | (0.0051) | (0.0056) |
| **DiD May 12/Jan 13** | **-0.0282\*\*** | **-0.0201** | **-0.0667\*\*\*** | **-0.0579\*\*\*** | **-0.0405\*\*\*** | **-0.0320\*\*\*** |
|  | **(0.0110)** | **(0.0137)** | **(0.0123)** | **(0.0128)** | **(0.0106)** | **(0.0112)** |
| High noise  | -0.0201\*\*\* | -0.0198\*\*\* |  |  |  |  |
| (other sources) | (0.0047) | (0.0047) |  |  |  |  |
| Large apartments |  |  | -0.0420\*\*\* | -0.0429\*\*\* |  |  |
|  |  |  | (0.0044) | (0.0044) |  |  |
| High  |  |  |  |  | -0.0079 | -0.0084 |
| Unemployment |  |  |  |  | (0.0098) | (0.0105) |
| **DiD May 12/Jan 13**  | **-0.0171\*** | **-0.0167\*** |  |  |  |  |
| **x low noise** | **(0.0091)** | **(0.0092)** |  |  |  |  |
| **DiD May 12/Jan 13**  |  |  | **0.0498\*\*\*** | **0.0485\*\*\*** |  |  |
| **x small apartments** |  |  | **(0.0079)** | **(0.0081)** |  |  |
| **DiD May 12/Jan 13**  |  |  |  |  | **-0.0262\*** | **-0.0238** |
| **x low unemployment** |  |  |  |  | **(0.0154)** | **(0.0154)** |
| Additional controls | X | X | X | x | X | x |
| Observations | 186,170 | 186,170 | 186,170 | 186,170 | 186,170 | 186,170 |
| R-squared | 0.5161 | 0.5152 | 0.5197 | 0.5187 | 0.5149 | 0.5141 |
| Number of grids | 162 | 162 | 162 | 162 | 162 | 162 |
| Month & Grid FE | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 5 Quantile Regressions of Noise Impacts

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| Dependent variable: | **May12** | **Jan 13** |
| ln(rent/sqm) | **p25** | **p50** | **p75** | **p25** | **p50** | **p75** |
| Noise dummy | -0.0107\*\*\* | -0.0168\*\*\* | -0.0230\*\*\* | -0.0134\*\*\* | -0.0213\*\*\* | -0.0293\*\*\* |
| (55dB) | (0.0039) | (0.0029) | (0.0038) | (0.0039) | (0.0030) | (0.0038) |
| Dummy May 12/ Jan 13 | 0.0363\*\*\* | 0.0337\*\*\* | 0.0311\*\*\* | 0.0143\*\*\* | 0.0142\*\*\* | 0.0141\*\*\* |
|  | (0.0024) | (0.0018) | (0.0023) | (0.0026) | (0.0020) | (0.0025) |
| **DiD May 12/Jan 13** | **-0.0308\*\*\*** | **-0.0382\*\*\*** | **-0.0455\*\*\*** | **-0.0148\*\*\*** | **-0.0310\*\*\*** | **-0.0472\*\*\*** |
|  | **(0.0043)** | **(0.0032)** | **(0.0042)** | **(0.0047)** | **(0.0035)** | **(0.0045)** |
| Additional controls | X | x | X | x | X | x |
| Observations | 186,170 | 186,170 | 186,170 | 186,170 | 186,170 | 186,170 |
| R-squared | 0.5148 | 0.5140 |
| Number of grids | 162 | 162 |
| Grid FE | Yes | Yes |

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

# Drive Time

As described in the previous sections, airports are not only linked to negative effects on housing prices (via noise pollution) but also to positive effects, e.g. via a better connectivity or job opportunities. Therefore, estimations in Table 6 focus on the rent price effects for apartments which benefit from being located within a short driving time to the airport, but which do not suffer from noise pollution. The applied sample covers all offered apartments in Berlin and defines those with a driving time to Berlin-Tegel below 15 minutes and below 20 minutes as two alternative treatment groups. Apartments with longer driving times mark the control group, and any apartments indicated with noise pollution by Tegel airport are not included in the regressions here to avoid biased estimates.[[14]](#footnote-15)

Table 6 Drivetime effect on rent prices

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | (1) | (2) | (3) | (4) | (5) | (6) |
| Dep. Variable: ln(rent/sqm) | May1215 min | Jan1315 min | May1220 min | Jan1320 min | Both15min | Both20min |
| Trend | 0.0043\*\*\* | 0.0045\*\*\* | 0.0044\*\*\* | 0.0045\*\*\* | 0.0044\*\*\* | 0.0045\*\*\* |
|  | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Short Drivetime  | -0.0331\*\* | -0.0304\*\* | -0.0184\* | -0.0160 | -0.0322\*\* | -0.0178\* |
| Dummy | (0.0152) | (0.0153) | (0.0105) | (0.0106) | (0.0151) | (0.0105) |
| Trend short | 0.0002 | 0.0003 | -0.0001 | 0.0000 | 0.0001 | -0.0001 |
| Drivetime | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Dummy May 12 | 0.0084\*\*\* |  | 0.0030 |  | 0.0111\*\*\* | 0.0063\*\* |
|  | (0.0031) |  | (0.0035) |  | (0.0030) | (0.0031) |
| Dummy Jan 13 |  | -0.0054 |  | -0.0087\* | 0.0027 | -0.0032 |
|  |  | (0.0036) |  | (0.0045) | (0.0044) | (0.0053) |
| **DiD May 12** | **0.0187\*\*\*** |  | **0.0205\*\*\*** |  | **0.0159\*\*\*** | **0.0180\*\*\*** |
|  | **(0.0067)** |  | **(0.0057)** |  | **(0.0060)** | **(0.0051)** |
| **DiD Jan 13** |  | **0.0129\*** |  | **0.0132\*\*** | **0.0222\*\*** | **0.0234\*\*\*** |
|  |  | **(0.0077)** |  | **(0.0065)** | **(0.0093)** | **(0.0079)** |
|  |  |  |  |  |  |  |
| Observations | 690,826 | 690,826 | 690,826 | 690,826 | 690,826 | 690,826 |
| Number of grids | 741 | 741 | 741 | 741 | 741 | 741 |
| Month & Grid FE | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Again, we test for rent price effects of the two major announcements in May 2012 (column 1 and 2) and January 2013 (column 3 and 4) and combine both effects in a joint estimation (column 5 and 6). In general, we observe the expected positive effect of the announcements for apartments which benefit from short driving times. The effects remain quite stable in size and significance of the coefficients for both thresholds (15 and 20 minutes) while the effects for the first announcement in May 2012 are slightly larger (1.9% to 2.1%) than those effects for January 2013 (1.3%). Pooling both announcements also shows significance for both coefficients between 1.6% and 2.4%.

To obtain comparable results, we focus on presenting the joint estimation of all announcements (following equation 3b).[[15]](#footnote-16) In Figure 8 we graphically depict the drive time regression coefficients over time for all announcements. According to the prior estimations focusing on May12 and January13, coefficients for both events also turn into significance when we include all announcements. In line with the prior results for the noise effects, the drive time effects also gets insignificant in December 2014 when a new opening date is announced. Regarding the drive time, also the later announcements and referendum in September 2017 seem to affect rent prices.

Figure 8 Drivetime effect on rent prices (all announcements – 20 Minutes cutoff)

# Heterogeneity – Drive Time Results

We also consider heterogeneity in the drive time estimations. We expect employed inhabitants to benefit more from the short drive time to the airport (e.g. people employed at the airport, or those using the airport regularly for business reasons). As we do not have information on individual employment status of tenants (or seekers) we apply the local unemployment rate in the neighborhood as best proxy, splitting the sample in the grids below/above median unemployment rate.

Regarding columns 1 and 2 of Table 7, the results contradict our hypothesis in the first view. We observe the basic positive effect of the announcements (varying between 3.3% and 3.6%), but for apartments in neighborhoods with low unemployment the additional effect is negative by -2.7% (May 2012) and -3.9%% (January 2013). In sum, we obtain no effects for neighborhoods with lower unemployment. However, as we are not able to observe individual employment status, the neighborhood unemployment might be misleading. Higher unemployment rates are rather an indicator for inhabitants working in less qualified jobs. From this perspective, it again makes sense that such neighborhoods with lower-skilled jobs would benefit from the further opening of the airport. After all, such low-skilled jobs (especially in the service sector) are frequently found at airports. At least the airport still had about 7000 employees.

We also subdivide the drive time analysis according to the size of the apartments (Table 6, columns 3 and 4). Here, the results show that the positive effect exists especially for larger apartments. For the smaller ones, which are also included separately in the interaction, the results tend toward zero. Finally, in Table 8, we estimate quantile regressions using the drive time treatment effect cutoffs of 20 minutes. For both treatment effects, May 2012 and Jan 2013 the effects are positive and statistically significant. The treatment effects are smaller for the lower quantiles and increase for the higher quantiles. This implies that higher priced apartments near the airport after a delay in the closure have higher price changes than lower priced apartments within similar driving distances. Perhaps more residents desiring “nicer” apartments value airport proximity for travelling and employment opportunities.

Table 7 Heterogeneity of Drive effects

Apartment size, Local Unemployment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dep.Vble: ln(rent/sqm) | (1) | (2) | (3) | (4) |
|  | May 1220 min | Jan1320 min | May 1220 min | Jan1320 min |
| Short driving time | -0.0184\* | -0.0167 | -0.0193\* | -0.0168 |
|  | (0.0102) | (0.0102) | (0.0105) | (0.0105) |
| Dummy May 12/ Jan 13 | 0.0039 | -0.0077\* | 0.0033 | -0.0079\* |
|  | (0.0034) | (0.0046) | (0.0034) | (0.0044) |
| **DiD May 12/Jan 13** | **0.0330\*\*\*** | **0.0360\*\*\*** | **0.0266\*\*\*** | **0.0168\*\*** |
|  | **(0.0070)** | **(0.0087)** | **(0.0067)** | **(0.0075)** |
| Large apartment |  |  | -0.0533\*\*\* | -0.0518\*\*\* |
|  |  |  | (0.0037) | (0.0036) |
| High unemployment rate | -0.0102\* | -0.0108\*\* |  |  |
|  | (0.0055) | (0.0053) |  |  |
| **DiD May 12/Jan 13**  | -0.0273\*\*\* | -0.0396\*\*\* |  |  |
| **x low unemployment** | (0.0078) | (0.0085) |  |  |
| **DiD May 12/Jan 13**  |  |  | -0.0152\*\* | -0.0108\* |
| **x small apartments** |  |  | (0.0060) | (0.0061) |
| Additional controls | X | X | X | x |
| Observations | 690,826 | 690,826 | 690,826 | 690,826 |
| R-squared | 0.4864 | 0.4864 | 0.4909 | 0.4906 |
| Number of grids | 741 | 741 | 741 | 741 |
| Month & Grid FE | Yes | Yes | Yes | Yes |

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 8 Quantile Regressions of Drive times

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   |  1 |  2 |  3 |  4 |  5 |  6 |
| Dep. Variable: ln(rent/sqm) | **May12** | **Jan 13** |
| **20 min** | **20 min** |
| **p25** | **p50** | **p75** | **p25** | **p50** | **p75** |
| Short driving time | -0.0185\*\*\* | -0.0184\*\*\* | -0.0184\*\*\* | -0.0171\*\*\* | -0.0159\*\*\* | -0.0148\*\*\* |
|  | (0.0026) | (0.0019) | (0.0024) | (0.0025) | (0.0019) | (0.0024) |
| Dummy May 12/ Jan 13 | 0.0105\*\*\* | 0.0030\*\*\* | -0.0045\*\*\* | -0.0027\* | -0.0088\*\*\* | -0.0148\*\*\* |
|  | (0.0013) | (0.0010) | (0.0013) | (0.0014) | (0.0011) | (0.0014) |
| **DiD May 12/Jan 13** | **0.0136\*\*\*** | **0.0206\*\*\*** | **0.0275\*\*\*** | **0.0062\*\*\*** | **0.0133\*\*\*** | **0.0202\*\*\*** |
|  | **(0.0020)** | **(0.0015)** | **(0.0019)** | **(0.0021)** | **(0.0016)** | **(0.0020)** |
| Additional controls | X | x |
| Observations | 690,826 | 690,826 |
| R-squared | 0.486 | 0.4858 |
| Number of grids | 741 | 741 |
| Grid FE | Yes | Yes |

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Ultimately, one of the most important economic questions of a new airport is whether the positive and negative effects outweigh each other for the residents nearby (measured by rent prices). In general, such a question is difficult to answer since (e.g. in case of newly opened airports) noise pollution is only a theoretical value which is not experienced yet by potential inhabitants. Moreover, positive effects due to job opportunities at the airport cannot materialize until the operations of an airport have started. Therefore, standard airport openings do not allow one to conclude whether advantages or disadvantages of the proximity to an airport dominate.

Table 9 Noise and drivetime effects on rent prices

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
| Dep. Variable: ln(rent/sqm) | May 1255dB | Jan 1355dB |
| General Trend | 0.0044\*\*\* | 0.0046\*\*\* |
|  | (0.0002) | (0.0002) |
| Noise Dummy | 0.0036 | -0.0072 |
|  | (0.0167) | (0.0163) |
| Short Drive Time Dummy | -0.0222 | -0.0152 |
|  | (0.0157) | (0.0152) |
| Noise specific Trend | 0.0009\*\*\* | 0.0008\*\* |
|  | (0.0003) | (0.0003) |
| Dummy May 12/Jan 13  | 0.0334\*\*\* | 0.0139\*\* |
|  | (0.0051) | (0.0055) |
| **DiD Noise May 12/Jan 13** | **-0.0805\*\*\*** | **-0.0652\*\*\*** |
|  | **(0.0161)** | **(0.0196)** |
| **DiD Drivetime May 12/Jan 13** | **0.0468\*\*\*** | **0.0375\*\*** |
|  | **(0.0151)** | **(0.0171)** |
| Constant | 1.6234\*\*\* | 1.6793\*\*\* |
|  | (0.3221) | (0.3385) |
| Observations | 186,170 | 186,170 |
| R-squared | 0.5149 | 0.5140 |
| Number of grids | 162 | 162 |
| Month & Grid FE | Yes | Yes |

Note: \*\*\*, \*\*, \* denote significance at the 1 %-, 5 %- and 10 %-level. Robust standard errors clustered on 1\*1km-grid level in parentheses. Estimations based on difference-in-differences from equation (2). Source: RWI-GEO-RED.

The unique setting in Tegel (with several delays in the closure) forms an exception from this timing problem since inhabitants know about the noise as well as the jobs and it is known that both factors will vanish immediately, once the airport closes. The delay-announcements tackle both effects at the same time, and consequently, allow us to compare both effects since they come into play simultaneously. Up to now, we estimated the effects for those suffering from noise additionally to close proximity compared to those that only gain from proximity to extract potential negative noise effects. Further, we estimate the effects for all dwellings that are in close proximity to the airport but not treated by noise to isolate the effects of closeness.

Ultimately, based on the rich dataset we have at hand with detailed information on geo-location, we can estimate comprehensive rent price effects of the airport by combining both treatments. This leads into a diff-in-diff-in-diff specification with different types of treatment. We are able to estimate effects from the pure noise-pollution while controlling for the proximity to the airport at the same time; and vice versa, estimating proximity effects while controlling for noise. Moreover, the combination of all three indicators (Noise, Drivetime and their interaction) enables us to generate evidence that one of the effects outweighs the other one when both treatments are at work for a. In Table 9, we consider both the noise and drivetime variables together in one model, to obtain an overall effect. In this variation of the model, we include in our sample the same dwellings as were used in the baseline-noise regression – specifically, all rental properties within 20 minutes drivetime to Tegel. Based on that sample, we split the noise treated dwellings by those with drivetime to Tegel below median and those above median drivetime. We find a substantially larger negative noise-effect in general (-8% to -7%). But for those with a short driving time to Tegel, the effect gets much smaller by a positive interaction of short drivetime and noise-treatment (4% to 5%). We see that the noise effect is larger than the drivetime effect, but we can clearly detect both effects in our data.

# Conclusion

We consider the impacts of exogenous and unanticipated shocks through noise and connectivity associated with the continued operation of Tegel airport. Since the closing of Tegel was planned (and happened) to occur at the same time as the opening of BER, we use the delay announcements for the BER opening as part of our approach to generate causal estimates. We use a diff-in-diff approach as our identification strategy and rely on rental asking price data for Berlin (Germany) covering a period of 2010-2017. There have been at least seven delay announcements for the opening of BER and meanwhile one referendum considering whether Tegel should be closed at all. Our main estimations focus on the announcements in May 2012 (which was very close to the planned opening one month later) and January 2013 (which did not refer to a new scheduled opening date). We have very good data and a strong empirical framework to consider these delay announcements as exogeneous shocks, as they were not anticipated by any involved actor.

We find that noise at levels above thresholds of 55dB/60dB reduces rental prices by approximately 2% to 5%, depending on the level of noise chosen as the threshold. Further, incorporating all announcements into one regression shows that later announcements have negligible effects (tending into the same direction but remain insignificant) on rent prices. We also examine the potential benefits from proximity due to continued operations at Tegel, and we find a positive effect of approximately 1% to 3%, depending on the exact location of the properties chosen as the drive time threshold.

These results confirm the findings in the airport noise and access literature that higher noise lowers property prices, controlling for proximity, but enhanced proximity leads to higher property prices, if the property is not affected by noise. We also test for heterogeneities in our results, observing that effects of noise pollution are strongest in areas where other noise pollution is not present. Additionally, the noise effects are stronger for larger dwellings and in neighborhoods with low unemployment. Higher priced apartments have a larger noise discount than lower priced apartments, implying a greater willingness to pay for noise avoidance in “nicer” apartments (assuming price is correlated with quality). On the other hand, higher priced apartments have larger price effects for proximity, implying that the effects for well-paid jobs and travel opportunities are larger than for lower paid jobs.

Arguably, one of the strongest contributions of our analyses is that, due to the unique setting in Tegel, prices are influenced by positive and negative effects simultaneously. Thus, we can consider both effects – noise and proximity – into one analysis and credibly evaluate an overall effect of airport proximity. Doing so, the negative effect (noise) mostly dominates the results. The longer the continuation of the service is expected, the more the negative effect dominates. Furthermore, our focus on the noise and proximity effects due to the closure of Tegel, opposed to considering expected noise and job creation at BER, provides tangible information for our quasi-experiment. The noise and job opportunities for residents near Tegel are well-known, while near BER these are only based on forecasts. Therefore, a delay announcement for the closure of Tegel can generate more reliable estimates of the impacts on property values, than an estimate of the effects of delays in opening of BER on property values near that new airport.

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time

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# Appendix

Table A.1: Summary statistics on characteristics for rent objects

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Obs  | Mean | Std. Dev. | Min | Max |
| Ln(rent/sqm) |  695 267  | 2.01 | 0.29 | 1.27 | 2.87 |
| Month |  695 267  | 635.88 | 23.13 | 600 | 683 |
| Age |  695 267  | 44.90 | 44.41 | 0 | 460 |
| Age² |  695 267  | 3988.45 | 5326.91 | 0 | 211600 |
| Age UNKNOWN |  695 267  | 0.30 | 0.46 | 0 | 1 |
| Floor size |  695 267  | 74.11 | 28.30 | 28.52 | 196 |
| Floor  |  695 267  | 1.84 | 3.17 | -4 | 16 |
| Floor unknown  |  695 267  | 0.14 | 0.35 | 0 | 1 |
| Number of floors  |  695 267  | 3.21 | 3.03 | 0 | 15 |
| Number of floors unknown |  695 267  | 0.33 | 0.47 | 0 | 1 |
| Number of rooms |  695 267  | 2.43 | 1.20 | 0 | 8 |
| Number of rooms UNKOWN |  695 267  | 0.12 | 0.32 | 0 | 1 |
| Balcony |  695 267  | 0.67 | 0.47 | 0 | 1 |
| Balcony unknown |  695 267  | 0.05 | 0.22 | 0 | 1 |
| Kitchen |  695 267  | 0.44 | 0.50 | 0 | 1 |
| kitchen unknown |  695 267  | 0.14 | 0.35 | 0 | 1 |
| Garden |  695 267  | 0.12 | 0.32 | 0 | 1 |
| Garden unknown |  695 267  | 0.25 | 0.43 | 0 | 1 |
| Cellar |  695 267  | 0.50 | 0.50 | 0 | 1 |
| Cellar unknown |  695 267  | 0.06 | 0.25 | 0 | 1 |
| Quality of apartment |  |  |  |  |  |
| Unknown |  695 267  | 0.55 | 0.50 |  |  |
| Simple |  695 267  | 0.01 | 0.10 | 0 | 1 |
| Normal |  695 267  | 0.21 | 0.41 | 0 | 1 |
| Sophisticated |  695 267  | 0.20 | 0.40 | 0 | 1 |
| Deluxe |  695 267  | 0.03 | 0.16 | 0 | 1 |
| Heating type |  |  |  |  |  |
| Cogeneration/combined heat and power pl |  695 267  | 0.00 | 0.04 | 0 | 1 |
| Electric  |  695 267  | 0.00 | 0.01 | 0 | 1 |
| Self-contained central |  695 267  | 0.12 | 0.32 | 0 | 1 |
| District  |  695 267  | 0.03 | 0.17 | 0 | 1 |
| Floor heating |  695 267  | 0.01 | 0.09 | 0 | 1 |
| Gas heating |  695 267  | 0.01 | 0.09 | 0 | 1 |
| Wood pellet |  695 267  | 0.00 | 0.01 | 0 | 1 |
| Night storage |  695 267  | 0.00 | 0.02 | 0 | 1 |
| by stove |  695 267  | 0.00 | 0.04 | 0 | 1 |
| Oil heating |  695 267  | 0.00 | 0.05 | 0 | 1 |
| Solar |  695 267  | 0.00 | 0.01 | 0 | 1 |
| Thermal heat pump |  695 267  | 0.00 | 0.01 | 0 | 1 |
| Central heating |  695 267  | 0.63 | 0.48 | 0 | 1 |
| Unknown |  695 267  | 0.20 | 0.40 | 0 | 1 |
| Quality of house |  |  |  |  |  |
| First occupancy |  695 267  | 0.05 | 0.21 | 0 | 1 |
| First occ. after reconstruction |  695 267  | 0.08 | 0.27 | 0 | 1 |
| Like new |  695 267  | 0.05 | 0.21 | 0 | 1 |
| Reconstructed |  695 267  | 0.09 | 0.29 | 0 | 1 |
| Modernized |  695 267  | 0.06 | 0.24 | 0 | 1 |
| Completely renovated |  695 267  | 0.11 | 0.31 | 0 | 1 |
| Well kempt |  695 267  | 0.21 | 0.41 | 0 | 1 |
| Needs renovation |  695 267  | 0.01 | 0.11 | 0 | 1 |
| By arrangement |  695 267  | 0.01 | 0.09 | 0 | 1 |
| Dilapidated |  695 267  | 0.00 | 0.00 | 0 | 1 |
| unknown |  695 267  | 0.32 | 0.47 | 0 | 1 |
| Houses in neighborhood |  695 267  | 632.24 | 222.69 | 1 | 1333 |
| Persons in neighborhood |  695 267  | 34010.30 | 5833.93 | 19265 | 72899 |
| Households in neighborhood |  695 267  | 5821.50 | 3524.60 | 1 | 14685 |

Table A2: Proximity effect on rent prices – individual announcements

Panel a: Proximity defined by less than 15 minutes’ drive time

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dep. Variable: ln(rent/sqm) | June 2010 |  | May 2012 |  | Jan 2013 |  | Dec 2014 |  | Jan 2017 |  | Sep 2017 |  | Dec 2017 |  |
| Drive Time | -0.0333 | \*\* | -0.0347 | \*\* | -0.0335 | \* | -0.0390 | \*\* | -0.0315 | \*\* | -0.0313 | \*\* | -0.0308 | \*\* |
| Dumm) | 0.0159 |  | 0.0151 |  | 0.0151 |  | 0.0153 |  | 0.0154 |  | 0.0155 |  | 0.0155 |  |
| Drive Time | 0.0004 | \*\*\* | 0.0003 | \* | 0.0003 | \*\* | 0.0007 | \*\*\* | 0.0003 | \* | 0.0003 | \* | 0.0003 | \* |
| specific Trend | 0.0001 |  | 0.0002 |  | 0.0002 |  | 0.0002 |  | 0.0002 |  | 0.0002 |  | 0.0002 |  |
| Post-Announce | 0.0053 | \* | -0.0012 |  | -0.0101 | \*\*\* | -0.0273 | \*\*\* | 0.0269 | \*\*\* | 0.0312 | \*\*\* | 0.0331 | \*\*\* |
| (Dummy) | 0.0030 |  | 0.0034 |  | 0.0037 |  | 0.0053 |  | 0.0052 |  | 0.0052 |  | 0.0052 |  |
| DiD: Drive\* | -0.0003 |  | 0.0098 |  | 0.0055 |  | -0.0208 | \*\* | 0.0085 |  | 0.0122 |  | 0.0167 |  |
| Post-Announce | 0.0057 |  | 0.0069 |  | 0.0080 |  | 0.0091 |  | 0.0097 |  | 0.0107 |  | 0.0110 |  |
| Trend included | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  |
| Object characteristics | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  |
| Observations | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  |
| Treated before | 11010  |  | 56829  |  | 72466  |  | 116428  |  | 144056  |  | 151155  |  | 153541  |  |
| Treated after | 157529 |  | 111710 |  | 96073 |  | 52111 |  | 24483 |  | 17384 |  | 14998 |  |
| Control before | 41992  |  | 202381  |  | 250365  |  | 395255  |  | 497836  |  | 525459  |  | 534501  |  |
| Control after | 543157 |  | 382768 |  | 334784 |  | 189894 |  | 87313 |  | 59690 |  | 50648 |  |

Note: \*\*\*, \*\*, \* denote significance at the 1 %-, 5 %- and 10 %-level. Robust standard errors clustered on 1\*1km-grid level in parentheses. Estimations based on difference-in-differences from equation (2). Source: RWI-GEO-RED.

Panel b: Proximity defined by less than 20 minutes’ drive time

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dep. Variable: ln(rent/sqm) | June 2010 |  | May 2012 |  | Jan 2013 |  | Dec 2014 |  | Jan 2017 |  | Sep 2017 |  | Dec 2017 |  |
| Drive  | -0.0177 |  | -0.0215 | \*\* | -0.0211 | \*\* | -0.0287 | \*\*\* | -0.0145 |  | -0.0143 |  | -0.0140 |  |
| (Dummy) | (0.0112) |  | (0.0104) |  | (0.0102) |  | (0.0104) |  | (0.0108) |  | (0.0107) |  | (0.0106) |  |
| Drive –specific | 0.0003 | \*\* | 0.0002 |  | 0.0003 | \*\* | 0.0006 | \*\*\* | 0.0001 |  | 0.0001 |  | 0.0001 |  |
| Trend | (0.0001) |  | (0.0001) |  | (0.0001) |  | (0.0002) |  | (0.0002) |  | (0.0002) |  | (0.0001) |  |
| Post-Announce | 0.0070 | \*\* | -0.0011 |  | -0.0081 | \* | -0.0196 | \*\*\* | 0.0171 | \*\*\* | 0.0192 | \*\*\* | 0.0195 | \*\*\* |
| (Dummy) | (0.0033) |  | (0.0037) |  | (0.0045) |  | (0.0048) |  | (0.0050) |  | (0.0054) |  | (0.0051) |  |
| DiD: Drive\* | -0.0041 |  | 0.0047 |  | -0.0016 |  | -0.0272 | \*\*\* | 0.0271 | \*\*\* | 0.0341 | \*\*\* | 0.0400 | \*\*\* |
| Post-Announce | (0.0050) |  | (0.0057) |  | (0.0064) |  | (0.0092) |  | (0.0088) |  | (0.0091) |  | (0.0091) |  |
| Trend included | Y |  | Y |  | Y |  | Y |  | Y  |  | Y |  | Y |  |
| Object characteristics | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  | Y |  |
| Observations | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  | 753688 |  |
| Treated before | 21866  |  | 113195  |  | 143810  |  | 232582  |  | 290104  |  | 304250  |  | 308997  |  |
| Treated after | 315942 |  | 224613 |  | 193998 |  | 105226 |  | 47704 |  | 33558 |  | 28811 |  |
| Control before | 31136  |  | 146015  |  | 179021  |  | 279101  |  | 351788  |  | 372364  |  | 379045  |  |
| Control after | 384744 |  | 269865 |  | 236859 |  | 136779 |  | 64092 |  | 372364  |  | 36835 |  |

Note: \*\*\*, \*\*, \* denote significance at the 1 %-, 5 %- and 10 %-level. Robust standard errors clustered on 1\*1km-grid level in parentheses. Estimations based on difference-in-differences from equation (2). Source: RWI-GEO-RED.

1. RWI - Leibniz Institute for Economic Research; FDZ Ruhr, philipp.breidenbach@rwi-essen.de [↑](#footnote-ref-2)
2. Professor of Finance and Real Estate; School of Business, and Center for Real Estate; University of Connecticut; Visiting Research Fellow, RWI - Leibniz Institute for Economic Research; Jeffrey.Cohen@uconn.edu [↑](#footnote-ref-3)
3. RWI - Leibniz Institute for Economic Research; FDZ Ruhr, schaffner@rwi-essen.de [↑](#footnote-ref-4)
4. https://www.deutschlandinzahlen.de/tab/deutschland/infrastruktur/verkehr-und-transport/luftverkehr [↑](#footnote-ref-5)
5. Because the Berlin hinterland was territory of the German Democratic Republic (GDR), West-Berlin government had to establish their airports (Tegel and Tempelhof) in very close proximity to densely populated parts of the city. [↑](#footnote-ref-6)
6. Berlin-Schoenefeld is be caught up by BER. [↑](#footnote-ref-7)
7. Statistisches Jahrbuch 2018 – Berlin, table 19.05 values for 2013; source: <https://www.statistik-berlin-brandenburg.de/produkte/Jahrbuch/BE_Kap_2018.asp> (downloaded 27|08|2019) [↑](#footnote-ref-8)
8. ImmobilienScout24 claims to represent 86% of all published advertisements. [↑](#footnote-ref-9)
9. Statistisches Jahrbuch 2018 – Berlin, table 19.05 values for 2013; source: <https://www.statistik-berlin-brandenburg.de/produkte/Jahrbuch/BE_Kap_2018.asp> (downloaded 27|08|2019) [↑](#footnote-ref-10)
10. Tickets for a flight after the opening were all assigned to the new airport (BER). There were no signs that the opening would be shifted and that Berlin-Tegel would continue operating. [↑](#footnote-ref-11)
11. In this context, the December 2014 announcement forms another interesting date. Going back to the delay that occurred two prior years beforehand (January 2013), no rescheduled opening date was announced. Thus, the announcement in December 2014 is expected to have a reverse effect, since the opening becomes more concrete. Noise polluted objects are expected to be positively affected after the December 2014 announcement, and vice-versa for objects which benefit from jobs and connectivity. [↑](#footnote-ref-12)
12. Due to these expected group specific trends, which we model in our specification, we do not build or identification strategy on a standard diff- in-diff parallel trend assumption before the announcements of the delays. [↑](#footnote-ref-13)
13. The magnitude of each of the coefficients for the individual announcements is difficult to interpret and compare among each other. The respective value of the announcement dummy becomes one after the announcement was made and returns zero after a new announcement was made. This definition ensures that only the respective announcement dummy captures effect from the announcement. However, prior announcements may still affect rent prices after the next announcement. [↑](#footnote-ref-14)
14. Note that our data on noise pollution are truncated on the left side of the noise distribution at a level of 55dB. We cannot identify apartments with noise pollution below this threshold. [↑](#footnote-ref-15)
15. Estimations of equation 2, for each announcement separately, are available from the authors upon request. [↑](#footnote-ref-16)