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Philipp Breidenbach, Jeffrey P. Cohen, and Sandra Schaffner[1]

Continuation of Air Services at Berlin-Tegel and its Effects on Rental Prices

Abstract

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 and to take over all air-transport services from Germany's capital city, with the other airports expected to close, construction work at BER is still ongoing in 2019. Four weeks before the expected opening of the airport, the opening was suddenly delayed by several months. This unexpected delay was an exogeneous shock for residents surrounding the largest existing airport, Berlin-Tegel, which is expected to close upon the opening of Berlin-Brandenburg. A series of additional delay announcements followed. We analyze the effect of airport noise and proximity to the airport on housing rental prices. Our identification strategy is based on the expectations regarding the closing of Berlin-Tegel airport. The results suggest that there is a negative effect of noise on housing rental prices while there are positive effects of proximity to Berlin-Tegel. These delays reduce rental prices by a small amount, when compared with the noise discounts in the literature for owner-occupied properties in studies of other cities. These findings likely occur because renters have a relatively short time horizon for their tenure in an apartment, on average, to benefit from the future noise reduction. For instance, a one-year delay for a renter who plans to stay in an apartment for only one or two years implies a very low benefit from the future noise reduction. We also find that the benefits from a delay announcement have a net negative effect on prices for rental properties that are in the noisier areas but further drive time from Tegel; and a net positive effect in the less noisy areas that are shorter drive time from Tegel. This likely reflects the disamenity from prolonged airport noise exposure, as well as the benefits from proximity due to expectation of continued ease of employment and travel access.

JEL Classification: R3, R4

Keywords: Real estate prices; airports; aviation noise; proximity; Germany

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Introduction

The hedonic housing price model of Rosen (1974) postulates that the price of an apartment or a house equals the value of all its characteristics. These characteristics include not only the physical attributes of the respective object (such as number of rooms, bathrooms, living area etc.), but also local 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 amenities or disamenities have a long history in the field of housing economics (e.g. Davis, 2011 and Debrezion et al., 2007). While some of those local factors are clearly attributed as amenities (such as city parks), others have unclear effects on housing prices.

Such an unclear 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 housing prices. On the other hand, the literature also demonstrates their role as a disamenity since aircraft cause noise pollution. Noise is a major concern in developed countries since it seems to be negatively correlated to 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]) also highlights the importance of external effects of airports on the property values in their local neighborhoods.

There are many existing analyses undertaking much effort in creating new ideas to analyze such airport effects, which also underpins the relevance of the research field. Nevertheless, the implementation of causal identification strategies remains a challenging task in the context of airport effects as changes are plagued by endogeneity (Breidenbach, 2015). In general, the existence of an airport does not change over time, precluding observation of a credible "without airport situation". Even if an airport is newly constructed, its location is not chosen randomly but for economic reasons, which influences both airport location and housing prices independently. There are usually far-before 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 house prices is another concern for identification of causal effects. For instance, some literature (such as Cohen and Coughlin, 2008 and 2009) has modelled property prices as the dependent variable in a hedonic model with noise as a regressor. On the other hand, some more recent research (such as Cohen et al., 2019) has considered how lagged house prices might impact the level of noise exposure across different Census tracts. While including a lagged regressor mitigates the simultaneity concern to some extent, nevertheless there could be the potential for bi-directional relationships between noise and house prices.

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 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. Also, this implies that a delay in permanent noise reduction should be costlier to renters than to owner-occupiers, because the owners would have a longer time horizon to benefit from the permanent noise reduction despite the delay in the start of the permanent reduction. Some other papers analyze the effects of BER-opening on housing prices (e.g., Mense and Kholodilin, 2014).

[4] https://www.deutschlandinzahlen.de/tab/deutschland/infrastruktur/verkehr-und-transport/luftverkehr

Though their approach is a sensible framework, we believe that our approach benefits from the exogenous character of the delay.

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 prolong the amount of time that they can access Tegel for employment opportunities and/or travel convenience. Also, using the Ahlfeldt and Maennig (2015) logic of the "homevoter hypothesis", homeowners might be expected to benefit more. But it is also the case that renters tend to have a shorter time horizon to live in a property. Therefore prolonged noise exposure for a renter can bring down their willingness to pay more than for a homeowner who might expect to be in the home for decades (and therefore benefit for a long period of time from the closure of Tegel).

Aiming to provide causal evidence of how noise impacts real estate prices, our paper benefits from the unexpected events regarding the construction (and its delays) of the new Berlin airport "Berlin-Brandenburg" (BER). In times before the German reunification, there originally existed four airports in Berlin.[5] 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]. 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 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 were not expected to have further housing price-effects.

But, in the beginning of 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. Regarding that, i) there were contracts with firms providing services at BER, ii) all passenger tickets were already assigned to the new airport, and iii) an opening celebration was planned, the opening (closing, respectively) was highly credible up to this point. Regarding the old airport Tegel, 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.

From a researcher's perspective, these delays form an exogenous event. The ongoing air-services at Tegel were not anticipated by all players in the housing markets – landlords, sellers, renters and buyers – and therefore, causal analyses of airport effects on housing prices in the neighborhood can be drawn from this event. We analyze the effect of the noise-pollution and the proximity of the airport on housing prices. 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.

[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.

[6] Berlin-Schoenefeld will be caught up by BER.

Further, 58% of all German households are living in dwellings for ren[7]t while the share in Berlin is about 85%[8]

Our approach allows us to analyze rental price discounts in the noise polluted areas (around Tegel) and price premia in those areas benefitting from jobs and connectivity after the unexpected extension of services. Running a difference-in-differences approach (diff-in-diff) reveals a 3%-4% price-discount for rental apartments caused by noise pollution (related to a threshold of 55dB at daytime) and a 0-2% price premium for proximity (defined as less than 10 minutes and less than 15 minutes driving time to the airport) as long as the respective apartments are not affected by noise pollution.

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 are 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.

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

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.

Ahlfeldt and Maennig, (2015) look at a 2008 public referendum on an "airport concept" consisting of the closing of Berlin-Tempelhof and Berlin-Tegel, which was linked to the approval for the new BER airport. They consider the capitalization of the benefits of accessibility from a new, larger airport, as well as the benefits from shifts in aircraft noise (which were mostly near Schoenfeld airport in the

[7] Statista: Verteilung der Haushalte in Deutschland nach Miete und Eigentum von 1998 bis 2018 https://de.statista.com/statistik/daten/studie/237719/umfrage/verteilung-der-haushalte-in-deutschland-nach-miete-und-eigentum/ (downloaded 27|08|2019)

[8] 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)

south part of Berlin). In other words, residents near Berlin-Tempelhof stood to benefit from its closure both from reduced aircraft noise and from better accessibility with the new BER airport. The announcement of this new “airport concept” in 1996 was to lead to the closure of Berlin-Tempelhof and Tegel, along with the construction of BER. 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. For renters, the positive amenity effect was expected to draw in more residents, which would drive up the price of rentals, making renters worse off. Therefore, it was expected that renters would oppose the referendum. The authors estimate a difference-in-differences hedonic model that includes separate controls for noise and accessibility. The hedonic estimation equation is a noise level variable (above 45 dB) for both Tempelhof and Tegel (and an indicator for being in a noisy area for Schoenefeld), each interacted with the 1996 announcement date of the new “airport concept”. After estimating the hedonic difference-in-differences equation, they obtain the fitted value of the “announcement effect of the aviation concept”, which is their treatment. They find highly significant (and positive) treatment effects from the announcement of this concept.

Ahlfeldt and Maennig (2015) note that the 2008 referendum did not pass. The authors also note that the German rental market is highly regulated, which implies there would be less effects of a referendum on rental prices than on purchase prices. Despite this mitigating force, the authors find strong evidence in support of their “homevoter hypothesis” – that homeowners tend to vote in favor, and renters against, this referendum.

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, so the present value of the expected future damages are smaller. 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 fact, there exists a large literature, beyond Europe, on the effects of aviation noise on housing prices. The meta-study of Nelson (2004) shows that there is 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 impact of about 9% on house prices 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, proximity of airports and aviation noise must be considered jointly. 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 significant evidence that the negative noise effects tend to outweigh the positive proximity effects.

Therefore, in our analysis below, we consider both noise and proximity, using a solid identification strategy (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. We distinguish between rental properties and owner-occupied properties, in order to examine how the shorter expected tenure of renters might impact the rental prices differently in response to a delay in the noise reduction. This approach provides us with a unique way to identify the causal impacts of noise on residential property prices, of proximity on residential property prices, and to generate separate effects for rental versus owner-occupied units.

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 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[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 the center of each 1x1km cell 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. 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 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 dataset can easily be merged to each other. 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.

[9] ImmobilienScout24 claims to represent 86% of all published advertisements.

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

Variable	Total	within 15 min drivetime < 55dB	within 15 min drivetime >=65dB	more than 15 min drivetime
Observations	142 912	112 893	4 519	552 355
Ln(rent per sqm)	2.026	2.076	1.837	2.011
Age	52.32	52.67	52.36	42.98
Floorsize	74.57	76.57	62.40	73.99
Floor	1.642	1.724	1.326	1.892
Number of floors	2.923	3.174	1.994	3.287
Number of rooms	2.355	2.352	2.150	2.449
Balcony	0.648	0.633	0.747	0.676
Quality of apartment				
Unkown	0.557	0.519	0.629	0.553
Simple	0.011	0.010	0.013	0.009
Normal	0.221	0.227	0.269	0.205
Sophisticated	0.191	0.219	0.086	0.204
Deluxe	0.020	0.024	0.004	0.029
Quality of house				
First occupancy	0.045	0.055	0.002	0.048
First occupancy after reconstruction	0.092	0.099	0.088	0.079
Like new	0.031	0.033	0.016	0.053
Reconstructed	0.061	0.067	0.050	0.103
Modernised	0.062	0.068	0.044	0.060
Completely renovated	0.136	0.142	0.140	0.102
Well kempt	0.229	0.217	0.218	0.211
Needs renovation	0.015	0.014	0.023	0.011
By arrangement	0.009	0.009	0.007	0.008
Dilapidated	0.000	0.000		0.000
Unknown	0.318	0.295	0.413	0.325
Houses in neighborhood	627.7	623.0	746.2	633.4
Persons in neighborhood	35199	36471	31047	33703
Households in neighborhood	6458	6850	5364	5657

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

Estimation Strategy

Our estimation strategy relies on the idea that (potential) renters of apartments expect – following the previously decided-upon plans – Tegel will close immediately after the opening of BER. Consequently, they assume for objects affected by aviation noise of Tegel airport that the noise is going to vanish soon. Prices are assumed to adapt towards a new equilibrium without a noise pollution. The same is 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 adaption processes are stopped (or impeded) when delays of the opening are announced. Therefore, the announcements constitute an important issue 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 1 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).

Estimation of the importance of each single announcement for the housing market is difficult as we cannot observe to which extent (potential) residents are aware of the delayed opening, and whether they still believe the announcements of the new openings once prior opening declarations did not occur on-time. As the importance of the single announcements remain unclear without empirical investigation, we test all of the delay announcement dates on their individual importance. Yet, we still have some prior hypotheses as to which circumstances define an important announcement. 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 neighborhood of 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.

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.

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] and the declared opening was far ahead (especially in the case of January 2013 when no new opening was declared). Similar reasoning is true for December

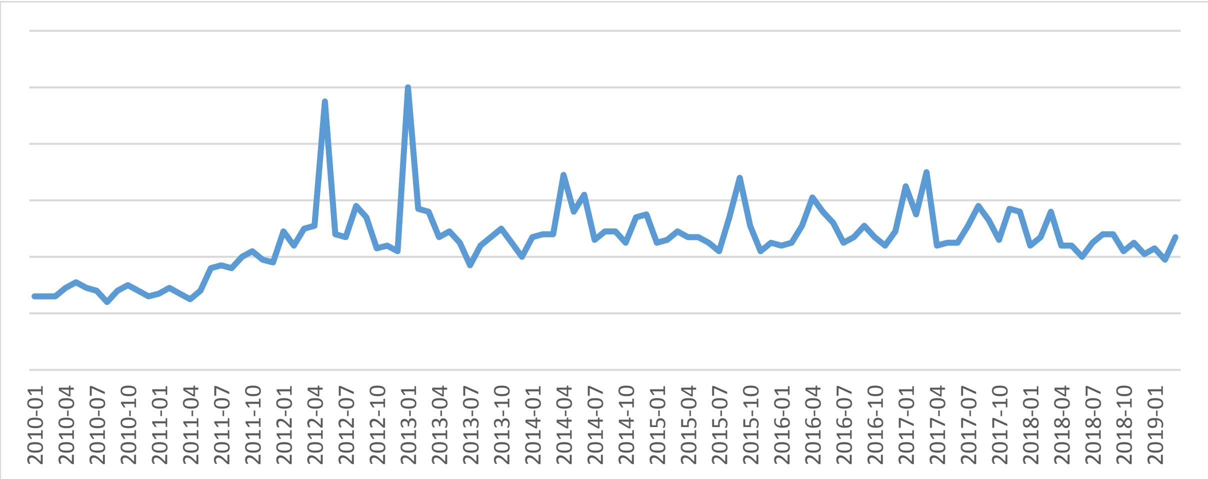
[10] Tickets for a flight after the opening were all assigned to the new airport (BER). There were no signs that the opening would be shifted and that Berlin-Tegel would continue operating.

2017, since the announced delay accounts for two years. However, compared to the prior announcements, fewer people may have believed that the prior opening date will hold.

In this context, the December 2014 announcement forms an interesting example. 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.

Given their prominence in the media, the announcements in May 2012 and in January 2013 are expected to have the highest effects. We quantify this relevance by Google Trends analyses (Figure 3) showing that the search for the terminus "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).

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.

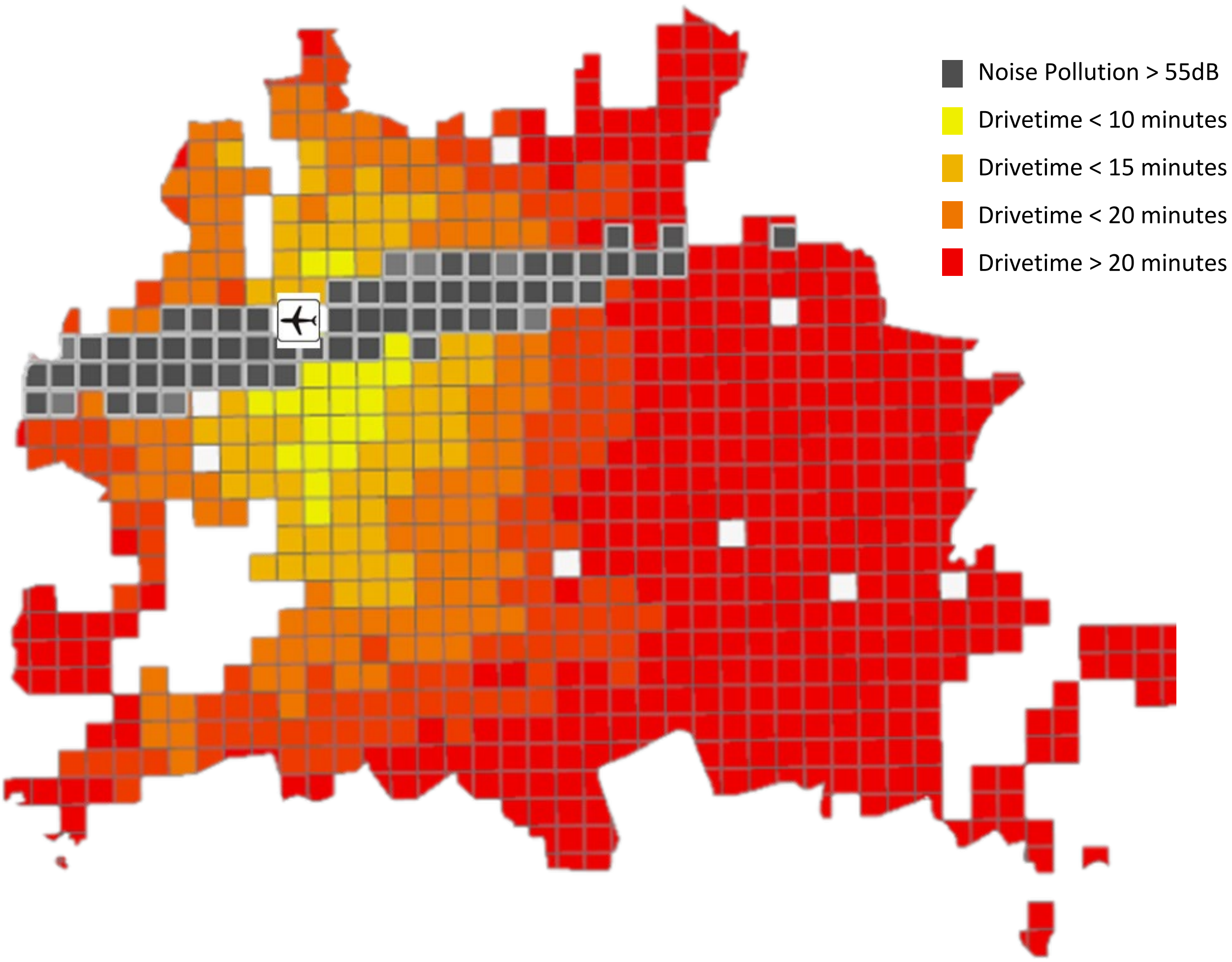
Although BER is still not operational and construction is steadily plagued with further problems, the airport authorities plan to close Tegel right after BER eventually opens. Thus, noise-pollution and jobs/connectivity are not assumed to remain permanently, but they will vanish over a certain (yet unknown) time-period. This basic assumption was challenged by a referendum in Berlin hold in September 2017. This referendum was successful as the majority voted for keeping Tegel open. Thus, September 2017 also marks an important date which we consider in our analyses, although no new announcement was made at that time. However, local authorities in Berlin already claimed beforehand that a new decision is not feasible from a legal perspective and finally confirmed this perspective in June 2018 by a majority vote in the parliament.

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 renters. They typically have a shorter planning horizon than buyers. Moreover, we focus on apartments instead of houses since single-family houses are a rather rare exception within metropolitan areas such as Berlin.

Regarding the time differentiation, we have a fixed set of seven announcements which respectively define pre- and post-treatment periods for a solid identification strategy. Following the idea to implement a difference-in-differences strategy, we need to define a 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 threshold of 55dB and 60dB.

Figure 4 **Noise and drive time around Tegel**

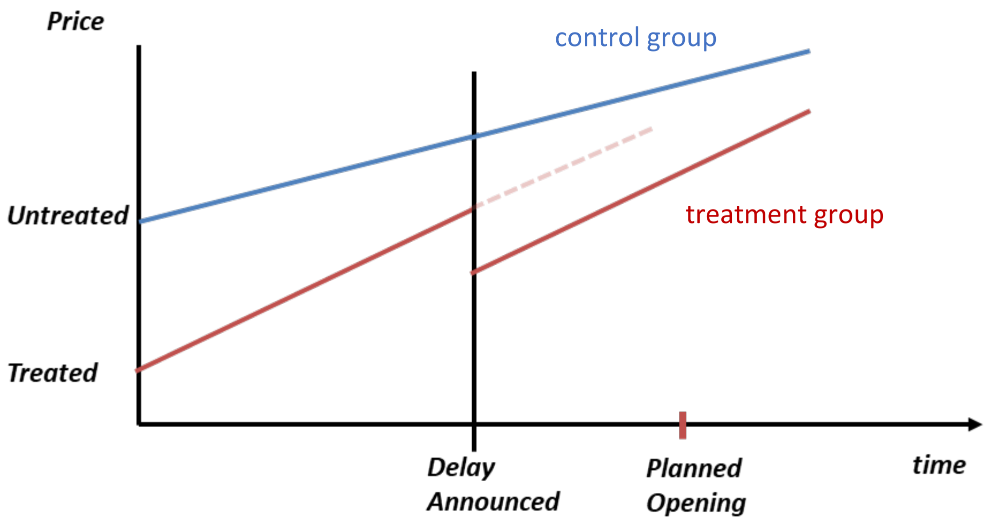


SOURCE: RWI-GEO-RED, drivetime to Berlin-Tegel calculated by algorithm obtained from RWI-GEO-DRIVETIME. Noise-pollution obtained from Senatsverwaltung Berlin.

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 objects in the yellow to dark-orange area (drivetime at most 20 minutes). All objects in the red area are excluded from the noise-analysis, even if they are noise polluted.

Figure 5 shows how we expect prices of treated (by aviation noise) and untreated objects to evolve over time. In general, we assume an increasing price trend for Berlin. Moreover, we assume that local rents are lower in regions with noise-pollution by Tegel but converge to the overall development in Berlin when services in Tegel are stopped. Our analyses focus on the development after a delay decision is announced, where we expect a downward shift of prices in the treated group since the affected objects are expected to suffer longer from noise pollution. Figure 5 also shows that we expect the prices of the two groups to converge after some time following a particular delay announcement.

Figure 5 Expected price development by noise treatment



First, we apply difference- in-differences approaches for each announcement with group specific time trends, which is able to reflect the expected catch-up process of treated objects prior to each respective announcement:

$$y_{ignt} = \alpha_1 N_n + \alpha_2 T_t + X_i \beta_1 + Z_g \beta_2 + \gamma_1 trend_t + \gamma_2 trend_{nt} + \boldsymbol{\delta Treat_{nt}} + u_{ignt}\ , \quad (1)$$

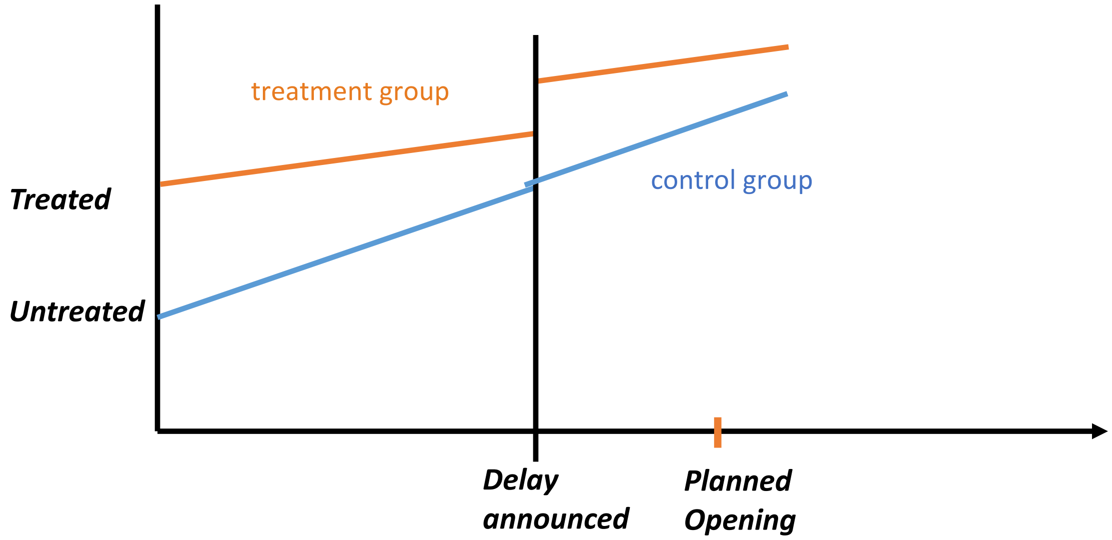
with y_{ignt} being the price per square meter (log), N_n is a dummy for noise-polluted locations, T_t takes the value 1 if the property was advertised after the respective announcement and 0 otherwise. Characteristics of the property are covered in X_i and characteristics of the 1x1km cell (number of households, number of inhabitants, purchasing power, drivetime to Tegel) are included in Z_g (grid-characteristics). The time trends are defined as a monthly overall linear time trend, $trend_t$ and an additional monthly time-trend for all noise-polluted objects, $trend_{nt}$. Finally, $Treat_{nt}$ (N_n*T_t) is the difference-in-differences dummy that takes the value 1 for noise-polluted properties after the respective announcement and zero otherwise.

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. To avoid biases by the noise pollution, we exclude all properties affected by noise (above 55dB) in the treatment and control group. The difference-in differences estimation is defined similarly to equation (1) again including group specific time trends, covering potential price adaptions prior to the announcement:

$$y_{igdt} = \alpha_1 N_d + \alpha_2 T_t + X_i\beta_1 + Z_i\beta_2 + \gamma_1 trend_t + \gamma_2 trend_{dt} + \boldsymbol{\delta Treat_{dt}} + u_{idt} \qquad (2)$$

By contrast to the noise pollution it is now assumed that the housing prices within the treatment group (high proximity to airport) are higher due to the amenities like jobs and transportation services. However, it is assumed that prices will converge to the local price level (similar to the effect described above) once Tegel is closed, since the amenity disappears then. This theoretical scenario is displayed in Figure 6. Prior to the delay announcement, prices are converging between the treated and untreated groups. 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 6 Expected price development by proximity treatment



Both these approaches allow to identify the effect of only one announcement. We therefore include all announcements into one regression to identify a dynamic treatment effect.

$$y_{igdt} = \alpha_1 N_n + X_i\beta_1 + Z_i\beta_2 + \gamma_1 trend_t + \gamma_2 trend_{dt} + \textstyle\sum_a (\boldsymbol{\delta_a Treat_{ant}} + \alpha_{2a} T_{at}) + u_{idt} \qquad (3a)$$

$$y_{igdt} = \alpha_1 N_d + X_i\beta_1 + Z_i\beta_2 + \gamma_1 trend_t + \gamma_2 trend_{dt} + \textstyle\sum_a (\boldsymbol{\delta_a Treat_{adt}} + \alpha_{2a} T_{at}) + u_{idt} \qquad (3b)$$

with a being the different announcements. T_{at} takes the value 1 if the property was advertised after announcement a and zero otherwise. $\boldsymbol{Treat_{ant}}$ $(N_n * T_{at})$ 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. $\boldsymbol{Treat_{adt}}$ $(N_d * T_{at})$ is the difference-in-differences 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:

$$y_{igdt} = \alpha_{1d}N_d + \alpha_{1n}N_n + \alpha_{1nd}N_nN_d + \alpha_2T_t + X_i\beta_1 + Z_i\beta_2 + \gamma_1 trend_t + \gamma_2 trend_{dt} + \boldsymbol{\delta_d Treat_{dt}} + \boldsymbol{\delta_d Treat_{nt}} + \boldsymbol{\delta_{dn} Treat_{ndt}} + u_{idnt} \quad (4)$$

with $\boldsymbol{Treat_{ndt}}$ $(N_n * N_d * T_t)$ taking value 1 for noise-polluted properties close to the airport after the announcement and zero otherwise.

Results

First, we estimate eq. (1) for noise pollution on apartment rents. 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 (Table 3 panel a) and 60dB (panel b), respectively. The control group is defined by all apartments that also benefit from the short driving time but experience less than 55dB of aviation noise. The results in Table 3 indicate a positive time trend for all apartments (nominal prices in Berlin) as expected for the particular market. Those apartments treated with noise have lower prices, indicated by the negative sign on the noise dummy in the cases that are statistically significant, but an additional positive time trend. These two findings indicate that there is a converging process as expected.

The key-indicator, the coefficient on the difference-in-differences term (Noise*Post-announce) shows the expected negative significance for the announcements in May 2012 (-2% for 55db) and December 2017 (about -3.6% and -4.6% for 55dB and 60dB, respectively). Moreover, we find negative effects for September 2017 (about -3.1% and -4.2% for 55dB and 60dB, respectively) which is not associated with a further delay announcement, but the implementation of the referendum on continuation of air-services at Tegel. On the contrary, we find a positive effect for December 2014, which was the declaration of an opening announcement that followed an indefinite delay announcement in January 2013. In this context, the positive effects for December 2014 are plausible. Apparently, these positive effects for December 2014 (5.3% and 4.4% for 55dB and 60dB, respectively) outweigh all other announcement effects. The June 2010 and January 2013 delay coefficients are insignificant.

The magnitude of each of the coefficients for the individual announcements is difficult to interpret and compare among each other. Since the respective value of the announcement dummy becomes one after the announcement was made, effects of all previous announcements are necessarily also captured by the coefficient under consideration. In order to obtain meaningful coefficients that allow for comparisons between single announcement, we include all announcements in a joint estimation (see equation 3a). Effects of each of the announcements are captured by the individual respective indicators. Table 4 reveals that the May 2012 and the December 2017 announcements are most powerful regarding the negative price effects from noise pollution. These effects are significant with a magnitude of around 2% (May 2012) and around 4% (December 2014). The negative effects of the referendum only become significant for those objects suffering from higher noise pollution (60 dB). Probably, local authorities pretended that Tegel will close definitely. However, the referendum gives an uncertainty and only those who suffer stronger react on this uncertainty. The positive effect of setting a new opening date in December 2014 had strong effects for those objects with lower noise pollution (3%). In comparison, the strongest effects are linked to the latest delay-announcement in December 2017.

Table 3 Noise effect on rent prices – individual announcements

Panel a: Noise-pollution defined by 55 dB threshold

Dep. Variable: ln(rent/sqm)	June 2010	May 2012	Jan 2013	Dec 2014	Jan 2017	Sep 2017	Dec 2017
Noise	-0.0001	-0.0088	-0.0112	0.0043	-0.0134	-0.0166	-0.0168
(Dummy)	(0.0151)	(0.0129)	(0.0130)	(0.0132)	(0.0130)	(0.0134)	(0.0132)
Noise-specific	0.0003	0.0005	0.0004	-0.0004	0.0003	0.0004*	0.0005*
Trend	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
Post-Announce	0.0043	0.0071	-0.005	-0.0482***	0.0376 ***	0.0451***	0.0515***
(Dummy)	(0.0046)	(0.0049)	(0.0054)	(0.0074)	(0.0070)	(0.0080)	(0.0083)
DiD: Noise*	-0.0135	-0.0202**	-0.0129	0.0533***	-0.0092	-0.0312**	-0.0364**
Post-Announce	(0.0115)	(0.0101)	(0.0107)	(0.0114)	(0.0147)	(0.0141)	(0.0142)
Trend included	Y	Y	Y	Y	Y	Y	Y
Object characteristics	Y	Y	Y	Y	Y	Y	Y
Observations	203 266	203 266	203 266	203 266	203 266	203 266	203 266
Treated before	3 273	14 642	17336	24 679	30086	31 477	31 911
Treated after	31 454	20 085	17391	10 048	4641	3 250	2 816
Control before	11 010	56 829	72466	116 428	144056	151 155	153 541
Control after	157 529	111 710	96 073	52 111	24483	17 384	14 998

Panel b: Noise-pollution defined by 60 dB threshold

Dep. Variable: ln(rent/sqm)	June 2010	May 2012	Jan 2013	Dec 2014	Jan 2017	Sep 2017	Dec 2017
Noise	-0.0078	-0.0183	-0.0197	-0.0076	-0.0217	-0.0273	-0.0273
(Dummy)	(0.0267)	(0.0242)	(0.0242)	(0.0246)	(0.0246)	(0.0244)	(0.0243)
Noise-specific	0.0003	0.0005	0.0004	-0.0003	0.0004	0.0005**	0.0005**
Trend	(0.0002)	(0.0003)	(0.0004)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
Post-Announce	0.0045	0.0069	-0.0053	-0.0481***	0.0376 ***	0.0451***	0.0514***
(Dummy)	(0.0046)	(0.0048)	(0.0053)	(0.0073)	(0.0070)	(0.0080)	(0.0082)
DiD: Noise*	-0.0155	-0.0152	-0.0073	0.0435**	-0.01	-0.0416***	-0.0455***
Post-Announce	(0.0153)	(0.0130)	(0.0141)	(0.0177)	(0.0185)	(0.0140)	(0.0141)
Trend included	Y	Y	Y	Y	Y	Y	Y
Object characteristics	Y	Y	Y	Y	Y	Y	Y
Observations	186 420	186 420	186 420	186 420	186 420	186 420	186 420
Treated before	1 739	7 499	8 852	12 732	15 539	16 227	16 446
Treated after	16 142	10 382	9 029	5 149	2 342	1 654	1 435
Control before	11 010	56 829	72 466	116 428	144 056	151 155	153 541
Control after	157 529	111 710	96 073	52 111	24 483	17 384	14 998

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 (1). *Source: RWI-GEO-RED*.

Table 4 Noise effect on rent prices – grouped estimations with all announcements

Dep. Variable: ln(rent/sqm)	55dB	60dB
Noise	-0.0005	-0.0091
(Dummy)	(0.0157)	(0.0275)
Noise –specific	0.0007	0.0011
Trend	(0.0005)	(0.0007)
Post-Jun2010	0.0089*	0.0091*
(Dummy)	(0.0050)	(0.0050)
Post-May2012	0.0219***	0.0218***
(Dummy)	(0.0052)	(0.0052)
Post-Jan2013	0.007	0.0066
(Dummy)	(0.0048)	(0.0047)
Post-Dec2014	-0.0313***	-0.0312***
(Dummy)	(0.0086)	(0.0085)
Post-Jan2017	0.0362***	0.0358***
(Dummy)	(0.0060)	(0.0060)
Post-Sep2017	-0.0044**	-0.004
(Dummy)	(0.0067)	(0.0067)
Post-Dec2017	0.0483***	0.0479***
(Dummy)	(0.0084)	(0.0083)
DiD	-0.0143	-0.0215**
Jun2010	(0.0089)	(0.0102)
DiD	-0.0208**	-0.0236**
May2012	(0.0094)	(0.0093)
DiD	-0.016	-0.0164
Jan2013	(0.0130)	(0.0181)
DiD	0.0313***	0.0162
Dec2014	(0.0111)	(0.0179)
DiD	-0.0058	0.0055
Jan2017	(0.0156)	(0.0190)
DiD	-0.018	-0.0408**
Sep2017	(0.0188)	(0.0197)
DiD	-0.0378***	-0.0384**
Dec2017	(0.0140)	(0.0155)
Trend included	Y	Y
Noise Trend	Y	Y
Object characteristics	Y	Y
Observations	203 266	186 420

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 (1). *Source: RWI-GEO-RED*.

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 5 focus on the rent effects of 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 treatment groups. Objects with noise pollution by Tegel airport are not included in the regressions here to avoid biased estimates.

Table 5 Proximity effect on rent prices – grouped estimations with all announcements

Dep. Variable: ln(rent/sqm)	15 Min	20 Min
Drive	-0.0326**	-0.0162
(Dummy)	(0.0161)	(0.0113)
Drive –specific	0.0001	-0.0002
Trend	(0.0003)	(0.0003)
Post-Jun2010	0.0080***	0.0076**
(Dummy)	(0.0029)	(0.0031)
Post-May2012	0.0102***	0.0056*
(Dummy)	(0.0031)	(0.0030)
Post-Jan2013	-0.0012	-0.0031
(Dummy)	(0.0034)	(0.0041)
Post-Dec2014	-0.0193***	-0.0150***
(Dummy)	(0.0051)	(0.0049)
Post-Jan2017	0.0213***	0.0135**
(Dummy)	(0.0059)	(0.0062)
Post-Sep2017	0.0048	0.0049
(Dummy)	(0.0061)	(0.0079)
Post-Dec2017	0.0202***	0.0082
(Dummy)	(0.0057)	(0.0062)
DiD	0.0007	0.0016
Jun2010	(0.0060)	(0.0050)
DiD	0.0129*	0.0168***
May2012	(0.0068)	(0.0054)
DiD	0.0066	0.0078
Jan2013	(0.0069)	(0.0058)
DiD	-0.0118	-0.0152
Dec2014	(0.0098)	(0.0093)
DiD	0.0130	0.0246***
Jan2017	(0.0086)	(0.0092)
DiD	-0.0091	-0.0049
Sep2017	(0.0091)	(0.0092)
DiD	0.0273**	0.0418***
Dec2017	-0.0326**	-0.0162
Trend included	Y	Y
Drive Trend	Y	Y
Object characteristics	Y	Y
Observations	753 688	753 688

Note: ***,**,* denote significance at the 1 %- 5 %- and 10 %-level. Robust standard errors clustered on 1x1km-grid level in parentheses. Estimations based on difference-in-differences from equation (2). *Source: RWI-GEO-RED*.

To obtain comparable results, we focus on presenting the joint estimation of all announcements (following equation 3b).[11] Similar to the noise-estimations, the announcements in May 2012 and December 2017 turn out to significantly affect rent prices in these drive time treatment models. In this case the expected effect is positive since the benefits of the airport proximity are available longer when a delay occurs. Compared to the noise-estimations, the effects for May 2012 are smaller in their magnitude (1.3% and 1.7% for 15 and 20 minutes driving time, respectively). The effects for December 2017 are comparable in their size (2.8%, respectively 4.2%). Note that also the January 2017 announcement has significant treatment effects within 20 minutes' drive time, which might also be

[11] Estimations of equation 2, for each announcement separately, are presented in the appendix.

caused by the initiation of the petition for the September 2017's referendum. The initiative for the petition started in late 2016.

Yet, our results suggest that positive economic effects (by the proximity to the airport) do not affect rent prices in the first round as strong as the negative effects do, as suggested by the smaller effect of drive time for the May 2012 announcement (Table 5). In contrast, we observe stronger positive effects when focusing on the inter-announcement time in the post treatment period in January 2017 and beyond. Also, negative effects due to the noise pollution did not evolve until later in the time horizon (see Table 3). The negative effects also evolve more strongly over a longer period. This slower evolution may either indicate that it takes longer until negative amenities transform into prices.

Ultimately, one of the most important economic questions of a new airport is whether the positive and negative effects outweigh each other (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.

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 they know about 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 only that 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 housing-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 reveal evidence that one of the effects outweighs the other one when both treatments are at work for a property. Table 6 shows the results for these estimations in six separate columns which vary over two drivetime categories (15 and 20 minutes) and two categories of noise intensity (55dB or 60 dB).

Results from the unilateral exposure to either noise or drivetime are mostly in line with the prior individual quasi-experimental setups. Focusing on the overall effect presented in the lowest block (Joint Significances) for each announcement indicates that the effect for the May 2012 announcement is very mixed. None of the two effects dominate and even the signs changes over the different definitions. The May 2012 announcement was for a very short delay. Moreover, in January 2017 (marked by a shorter delay of approximately half a year) positive effects of the delay prevail. In contrast, this finding does not hold true when the effect is expected to be long lasting. This is illustrated by the effect of the referendum (with a majority voting for "remain Tegel open") which clearly is negative and robust over most specifications. The domination of the noise effect is also supported by the announcements in December 2014 and December 2017. Nevertheless, the importance of the December 2017 announcement which was indicated by large coefficients in the individual noise evaluation cannot be confirmed by the overall approach.

Table 6 Overall effect on rent prices – individual announcements
Noise defined by two categories (55/60 dB); Proximity by two categories (15 and 20 minutes)

Dep. Variable: ln(rent/sqm)	55 db 15 Min	55 db 20 Min	60 db 15 Min	60 db 20 Min
DiD Noise				
Jun 2010	-0.02009 **	-0.04247 ***	-0.02167 **	-0.02266
	(0.0079)	(0.0151)	(0.0099)	(0.0148)
May2012	-0.00666	-0.02762 *	0.00106	-0.01739 *
	(0.0085)	(0.0168)	(0.0136)	(0.0129)
Jan 2013	-0.00946	-0.02359 *	-0.01796 *	-0.02265 **
	(0.0079)	(0.0133)	(0.0104)	(0.0110)
Dec2014	0.00218	-0.00311	0.00212	0.00254
	(0.0117)	(0.0176)	(0.0137)	(0.0262)
Jan 2017	-0.0246 **	-0.01544	-0.01777	-0.08966 ***
	(0.0109)	(0.0184)	(0.0141)	(0.0269)
Sep 2017	-0.02546 **	-0.04639 *	-0.00637	0.06354
	(0.0118)	(0.0258)	(0.0127)	(0.0598)
Dec 2017	0.00036	-0.0443 **	-0.00419	-0.07543
	(0.0128)	(0.0221)	(0.0130)	(0.0660)
DiD Drive				
Jun 2010	0.00091	0.00174	0.00034	0.00182
	(0.0059)	(0.0050)	(0.0060)	(0.0050)
May2012	0.01294 **	0.01698 ***	0.01231 *	0.01698 ***
	(0.0066)	(0.0054)	(0.0067)	(0.0054)
Jan 2013	0.00687	0.00806	0.00605	0.00797
	(0.0068)	(0.0058)	(0.0069)	(0.0058)
Dec2014	-0.01158	-0.01517	-0.01262	-0.01505
	(0.0095)	(0.0093)	(0.0097)	(0.0093)
Jan 2017	0.01349	0.02482 ***	0.0125	0.02481 ***
	(0.0084)	(0.0092)	(0.0085)	(0.0092)
Sep 2017	-0.00938	-0.0051	-0.00951	-0.005
	(0.0091)	(0.0092)	(0.0091)	(0.0092)
Dec 2017	0.02777 **	0.04239 ***	0.02722 **	0.04222 ***
	(0.0110)	(0.0093)	(0.0110)	(0.0093)
DiDiD				
Jun 2010	0.00591	0.02634 *	0.00533	0.00342
	(0.0117)	(0.0155)	(0.0148)	(0.0159)
May2012	-0.01743	0.00746	-0.02144	0.00144
	(0.0135)	(0.0180)	(0.0161)	(0.0131)
Jan 2013	-0.00514	0.0093	0.00776	0.00684
	(0.0123)	(0.0143)	(0.0141)	(0.0129)
Dec2014	0.02803 **	0.02542	0.01975	0.01462
	(0.0138)	(0.0186)	(0.0176)	(0.0258)
Jan 2017	0.01867	-0.00921	0.02996	0.07808 ***
	(0.0194)	(0.0212)	(0.0231)	(0.0293)
Sep 2017	0.00521	0.02436	-0.03307	-0.08736
	(0.0211)	(0.0275)	(0.0217)	(0.0618)

Dec 2017	-0.03574 **	0.01189	-0.03051	0.04003
	(0.0179)	(0.0242)	(0.0192)	(0.0667)
Joint Coefficient				
Jun 2010	-0.01327	-0.01439 **	-0.016	-0.01742 **
	(0.0083)	(0.0065)	(0.0106)	(0.0077)
May 2012	-0.01115	-0.00318	-0.00808	0.00104
	(0.0094)	(0.0066)	(0.0089)	(0.0083)
Jan 2013	-0.00773	-0.00623	-0.00415	-0.00784
	(0.0110)	(0.0084)	(0.0147)	(0.0112)
Dec2014	0.01863 **	0.00713	0.00925	0.00211
	(0.0092)	(0.0087)	(0.0142)	(0.0112)
Jan 2017	0.00756	0.00017	0.02469	0.01323
	(0.0162)	(0.0116)	(0.0184)	(0.0138)
Sep 2017	-0.02963 *	-0.02713 **	-0.04896 **	-0.02882 *
	(0.0175)	(0.0132)	(0.0193)	(0.0159)
Dec 2017	-0.00761	0.00998	-0.00748	0.00682
	(0.0113)	(0.0103)	(0.0135)	(0.0106)
Object characteristics	Y	Y	Y	Y
Observations	815 985	815 985	786 170	786 170

*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.*

Conclusion

We consider the impacts of an exogenous and unanticipated shock through noise and connectivity associated with the continued operation of Tegel airport. Since the closing of Tegel is planned 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 difference-in-differences approach as our identification strategy and rely on rental asking price data for Berlin, Germany covering a period of 2010-2017. We find that noise at levels above some thresholds reduces rental prices by approximately 2% to 4%, depending on the level of noise chosen as the threshold.

We also examine the potential benefits from proximity due to continued operations at Tegel, and find an effect of approximately 0 to 2%, depending on the exact location of the properties chosen as the drive time threshold. 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. 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. Further, incorporating all announcements into one regression shows that the later announcements tend to have the most significant effects on rent prices. 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. The positive effects show up mostly after the later announcements as well.

There can be two explanations for this result. First, in a market with increasing prices like Berlin, negative shocks like the (remaining) noise disamenity manifests itself in market prices slowly. Second, the proximity to the airport has a value in the very long-time horizon – also for those renters who plan to stay for a relatively long period - and the negative amenity (noise) only becomes significantly negative when its termination appears to be less credible. Perhaps it takes time for residents to actually believe the new airport may never open at all.

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. This is especially true for the referendum on whether or not to close Berlin-Tegel or keep it open, where a majority voted to remain Tegel open. Overall, this had a negative impact on prices of 3% to nearly 7%. 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.

While the literature on airport noise and house prices in other cities has demonstrated discounts in the range of 8%-10% for owner-occupied properties, our estimates are smaller (in the range of 2%-4%). Our results are expected to reflect the fact that renters tend to occupy the properties for less time than homeowners, so the drawbacks from the noise as well as the gains from the proximity could be felt for the entire period of occupancy for renters. This may be especially true when the renters begin to believe that Tegel may never close because the new airport will never open. Turning to this setting, the overall effects of noise and proximity become much bigger. In other words, our results support the notion that renters tend to have a short planning horizon, compared with owner-occupiers.

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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
Floorsize	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 unkown	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					
Unkown	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 h	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 occupancy 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
Modernised	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	-0.0333**	-0.0347**	-0.0335*	-0.0390**	-0.0315**	-0.0313**	-0.0308**
(Dummy)	0.0159	0.0151	0.0151	0.0153	0.0154	0.0155	0.0155
Drive –specific	0.0004***	0.0003*	0.0003**	0.0007***	0.0003*	0.0003*	0.0003*
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.*