European Review of Economic History Advance Access published July 28, 2016

European Review of Economic History, 1–23 © The Author 2016. Published by Oxford University Press on behalf of the European Historical Economics Society. All rights reserved. For permissions, please e-mail: journals.permissions@oup.com
doi:10.1093/ereh/hew008

War, housing rents, and free market: Berlin's rental housing during World War I

KONSTANTIN A. KHOLODILIN
DIW Berlin, Berlin, Germany, mailto:kkholodilin@diw.de, kkholodilin@diw.de

New archival evidence on housing rents in Berlin over 1909–1917 is presented. The data are extracted from newspaper announcements and georeferenced. Using hedonic regressions, quality-adjusted rent indices are constructed and employed to analyze the rental dynamics during World War I, when housing market experienced several shocks. The outbreak of the war led to an outflow of men from cities. Toward the end of the war, the construction freeze together with an inflow of workers and discharged soldiers resulted in a housing shortage. The analysis shows a rent decline (particularly for cheap dwellings) during the first half of the war, followed by a moderate increase. In 1917, given a dramatic overall price increase, real rents lost half of their value. Thus, regulatory policy did not emerge as a result of market failure, but rather the fear of rapid rent increases as a consequence of the supply stagnation despite growing housing demand.

1. Introduction

On the eve of World War I (WWI), housing rent was the largest component of private consumption. Its share was higher for low-income households. In 1907–1910, rental payments made up an average of 17–18 percent of income in Germany, while families with the lowest incomes (below 1,200 Marks a year) spent 20 percent of their budget on rent (Ascher 1917, p. 98). Given the predominance of tenants in the society[1] and an ongoing urbanization process, rents affected the well-being of a large and ever increasing portion of population. The 1910s, prior to the end of WWI, is historically important as a natural experiment. These were the last years of an unregulated housing market in Germany. The outbreak of WWI brought about large supply and demand shocks: massive mobilization, cessation of housing construction, inflow of defense industry workers to the cities, and increased family formation at the end of the war. The impact each event exerted on market rents is extremely interesting, given that it reflects reaction of market participants, who were not restrained by government regulations. It was not until 1919 that housing regulations were introduced, forever disfiguring the German housing market with consequences that persist even today. This conveys an additional historical relevance to the period as a determinant of the subsequent regulatory policy.

Unfortunately, housing rental data are not available for this period in Germany. Thus, the aim of the article is to construct and examine the evolution of a quality-adjusted rents index. It can address several important questions. First, it shows the change in affordability

[1] In the large German urban settlements, the share of rental dwellings in the overall housing stock reached 80–97 percent, meaning that the vast majority of city dwellers were tenants (Brander 1984, p. 81). For some, the rents were too high forcing them to share their dwellings or even beds with complete strangers.

of rental housing during WWI. Second, it gives a rough hint about the flexibility of housing rent in a free market, when hit by large supply and demand shocks. Third, it permits the examination of various segments of the rental market.

In order to fill the gap in the official statistics, the data are extracted from newspaper announcements of available rental dwellings in Berlin. However, starting from January 1918, the advertisements with information on rent virtually disappeared. This prevents the analysis of the exceptionally interesting period between 1918 and 1920, when the German housing market entered into crisis. Therefore, the analysis only focuses on the period between January 1909 and December 1917. Based on the dwelling-specific data, hedonic regressions are estimated, with the parameters used to construct quality-adjusted indices.

This article contributes in multiple ways to the existing literature.

First, this is the only study investigating the effects of WWI on housing rent. Although the impact of the war on rent is recognized by contemporaries (Kaeber 1921, p. 458), it is usually informally discussed without quantitative evidence.

Second, I take advantage of a unique data set never used before. Thus, this study contributes to the growing literature on the historical housing rents. The existing literature investigates the evolution of rents in several US and European cities. Rees (1961) is the first to employ data on rents collected from newspapers. The second study using historical offer rents from newspaper advertisements is Margo (1996). His data set contains approximately 1,000 observations and covers rental apartments in New York over 1830–1860. Margo estimates hedonic rent and investigate its determinants. More recently, the data were extended by Villarreal (2014). Likewise, Gray (2015) uses the newspaper announcements to extract housing rents for New York City in 1880–1910, geocode the observations, and compute a quality-adjusted rental index. There are also several studies on historical rents and house prices in European countries: Clark 2002, Carmona *et al.* (2014), Devaney (2009) and Drelichman and González Agudo (2014).

Third, using the collected archival evidence and employing the hedonic regression approach, I construct a quality-adjusted index of rents for Berlin from 1909 to 1917, bridging a gap in historical data. This index is compared with the available official indices of staple food prices. This permits the evaluation of the dynamics of real housing rents.

Fourth, I geocode the dwelling-specific data by finding geographical coordinates of each apartment using its address. Moreover, I approximate the accessibility of each dwelling by computing the isochrones, i.e., the equal-travel-time zones. To do this, I take advantage of the contemporary time schedules of the underground and city railways in Berlin.

Fifth, when running hedonic regression, I obtain the estimates of implicit values of the attributes of Berlin rental housing. By comparing them with the values estimated for other cities and periods, one can identify the specific preferences of Berlin citizens before and during WWI.

The main findings of the study are as follows. Starting in 1913, quality-adjusted rents substantially decreased. The decline lasted until the beginning of 1916 and was particularly pronounced for small apartments. In 1917, the tendency for the whole market reversed. However, in the segment of cheap apartments, rents continued to fall at least until the end of 1917. Compared with a much stronger overall price increase, the rent increase is very moderate: between July 1914 and December 1917, real rents fell by 50 percent. Hence, regulatory policy that followed the war was not a result of market failure but of the fear of rapid rent increases as a consequence of the construction freeze during WWI despite growing housing demand.

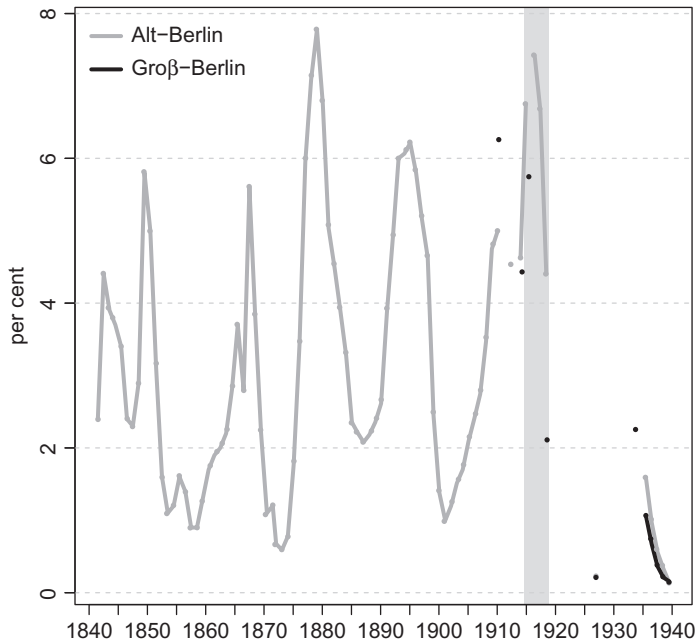

Figure 1. *Housing vacancy rate in Berlin, 1841–1939.*
Source: *1841–1871 Reich (1912); 1872–1939: statistical yearbooks of Alt- and Groβ–Berlin.*

2. Effects of Great War for housing market

Here, I use the case of Berlin to illustrate the evolution of the housing market during WWI in a large European city. At that time, Berlin was one of the biggest cities in the world. In 1910, its population was 3.7 million. It was quickly expanding as a result of the Industrial Revolution. Between 1816 and 1910, Berlin's population increased almost seventeen times. A chronic housing shortage resulted: the housing construction could not keep up with the population growth. Similar dwelling shortages, especially for poor, were observed in many other large European cities.[2] Before 1914, in German cities, including Berlin, the practice of subletting and bed-lodging (*Schlafgänger*) was quite common.[3] However, with the passage of time, the situation improved and the share of households with subtenants and lodgers decreased. In Berlin between 1905 and 1910, it declined from 33 to 18 percent, according to Brander (1984), p. 104, and my own calculations based on data from Statistisches Amt der Stadt Berlin (1913).

During WWI, the housing market experienced several violent demand and supply shocks, as illustrated in figure 1, which shows the housing vacancy rate in Alt-Berlin between 1841

[2] International Labour Office (1924, p. 9): "The phrases "housing crisis" and "housing shortage" were generally used before the war to convey the unsatisfactory quality of housing accommodation in towns and industrial districts, though even before the war there was in some countries an actual numerical shortage of small dwellings."

[3] The subletting and lodgers practice was so much developed that the Prussian 1918 Housing Act (*Wohnungsgesetz*. 28.03.1918, Preuß ische Gesetzsammlung 1918, p. 23–37) distinguished between fourteen different names to denote them: *Zimmermieter* (*Zimmerherren*), *Einlieger* (*Einlogierer*; *Miet-*, *Kost-*, and *Quartiergänger*), *Schlafgänger* (*Schläfer*, *Schlafleute*, *Schlafgäste*, *Schlafburschen* and *-mädchen*).

and 1939.[4] Initially, the market was characterized by an excess demand, as a relatively low vacancy rate in the 1900s shows. At the beginning of the war, a *negative demand shock* took place. This was related to the departure of men to the front.[5] During the war, almost 50 percent of German males aged between fifteen and sixty years were drafted for military service (Kocka 1988, p. 27). In Berlin, they accounted for 35 percent of the total population. Hence, 17.6 percent of all Berliners could, in principle, be called up. Other demand-reducing factors were the forced return of many wives to their parental households and departure of enemy aliens. The pressure in the housing market decreased, leading to an increase in the vacancy rate in 1914–1916, when it reached its peak.

Later came a *supply stagnation*, which was caused by the cessation of housing construction/renovation. The construction of dwellings in Berlin decelerated, starting during the first year of war, coming to almost a complete stop in 1916. While in 1913, a total of 4,519 new dwellings were completed, in 1916, this figure was only 53. However, at least until 1916, the effect appears to be much weaker than that of the decrease in demand.

Lastly, a *positive demand shock* occurred. Even while war was ongoing, new labor began to come into the cities, especially centers of the armament industry. An already strained situation deteriorated even more when the soldiers started to return home and the number of marriages suddenly increased.[6] As marriage statistics show, in the last two war years, the number of marriages in Alt-Berlin doubled compared to those in the first two years and was larger than in the pre-war period (figure 2). Consequently, the shortage of dwellings became acute, driving rents up.

Prior to WWI, the government avoided intervening in the housing sector other than some minimal regulations regarding the quality of rental housing (sunniness, dryness, and size).

The 1900 German Civil code provided for a complete freedom of contractual relations in the housing market. This implied that the relations between the tenants and landlords were regulated exclusively by the contracts they concluded without interference of a third party.

Before WWI, in contrast to the landlords who had their established associations, tenants were poorly organized. This allowed landlords to impose their will. Despite the contractual freedom declared in the 1900 German Civil Code, model contracts that were compiled by landlords and their associations, which primarily protected the landlord's interests, were used (Kholodilin and Meerovich 2016). However, by causing a large housing shortage, the war led to a dramatic change in the attitude of the state toward market regulation. Attempting to avoid social turmoil, German authorities actively intervened in the housing market. The first measure taken, even while war was ongoing, was to introduce the protection of tenants from eviction.[7] After the war was over, rent controls were introduced.

[4] The data are from Silbergleit (1913) and Silbergleit (1920). They refer to the so-called Alt-Berlin, which was about thirteen times smaller than the modern Berlin in terms of territory and about two times smaller in terms of population. Berlin's current boundaries were established following the administrative reform of April 27, 1920, when Alt-Berlin was merged with many neighboring communities to form the so-called Groß-Berlin. The 1913 and 1915 figures for Groß-Berlin are approximations obtained for the six (Alt-Berlin, Charlottenburg, Neukölln, Schöneberg, Wilmersdorf, and Steglitz) and eight (plus Lichtenberg and Spandau), respectively, largest districts that accounted for more than 85 percent of total housing stock in Groß-Berlin.

[5] Across the whole German Reich, the ratio of persons mobilized during the war to the total population in 1914 was about 20 percent: 13.3 out of 67.8 million persons. Own calculations are based on the data from Statistisches Jahrbuch für das Deutsche Reich, 1923, pp. 2 and 24.

[6] For a comprehensive analysis of the housing problem during and after WWI, see International Labour Office (1924).

[7] *Bekanntmachung zum Schutze der Mieter*. 26.07.1917, Reichsgesetzblatt (RGBl), 659. and *Bekanntmachung zum Schutze der Mieter*. 23.09.1918, RGBl, 1140.

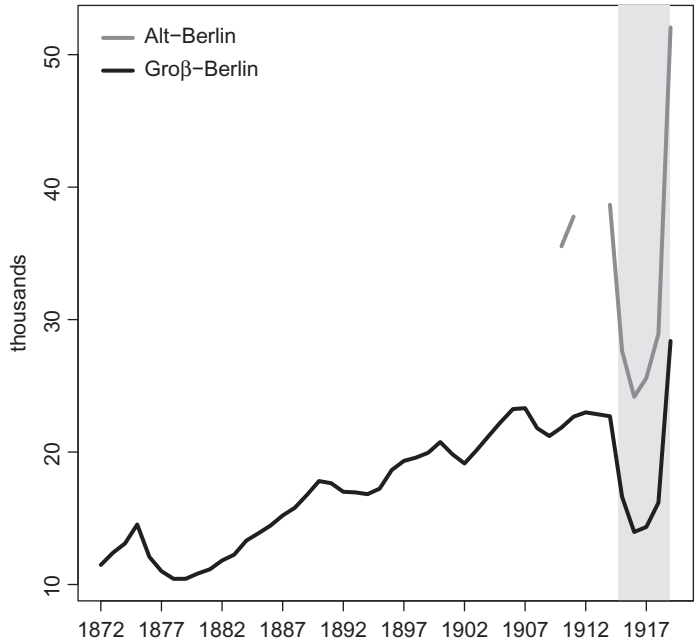

Figure 2. *Marriages in Berlin, 1872–1919.*
Source: *Statistisches Amt der Stadt Berlin, 1913, 1916, 1917, 1918, 1919, 1920.*

Prussia was one of the first federal states to implement rent controls, when it froze rents in December 1919.[8] In 1922, this measure was introduced nationally.[9]

Thus, WWI introduced dramatic changes in terms of housing policy. Since then, the rental housing market has been constantly regulated by the state.[10] Hence, the period studied in this article covers the last years of "liberal" housing markets in Germany prior to strengthening of tenant's rights. Using the data presented here, we can learn about market behavior in war times, something that the post-1918 data would potentially be problematic for.

3. Data

The data on rents in Germany and in Berlin before WWI are poor,[11] with three separate time series spanning distinct time periods, including only two historical time series of rents in Berlin. The first is the annual series for 1841–1895 in Reich (1912), which is based on rental tax (*Mietsteuer*) data. The second is that in Ascher (1917), covering 1880–1910 with five-year frequency. For 1911–1919, no time series of housing rents is available.[12] The third

[8] *Anordnung des Ministers für Volkswohlfahrt, betreffend Einführung einer Höchstgrenze für Mietzinssteigerungen.* 9.12.1919, Preussische Gesetzsammlung 187.
[9] *Reichsmietengesetz*. 24.03.1922, RGBl, 273.
[10] Kholodilin (2015).
[11] Bernhardt (1998, pp. 157).
[12] Deutsche Bundesbank (1976) reports yearly values of CPI between 1876 and 1974. However, they refer to the national level and do not provide a breakdown by expenditure categories.

series, an official rents index for Germany, started in 1920 and is a monthly subindex of a consumer price index.[13] Although 1913/1914 is used as a reference period, no intermediate values for the war years were computed. To fill this gap in the data, I constructed my own time series of quality-adjusted housing rents for Berlin. For this I took advantage of the rental housing announcements placed in Berlin's two most popular advertising papers: *Berliner Tageblatt und Handels-Zeitung* (BTB) and *Berliner Lokalanzeiger* (BLA).[14] The advertisements include information about rents and the various housing characteristics (figure 3).

The sample covers January 1909 through December 1917 and includes about 14,000 observations. The data are collected from four issues of each of both newspapers per month. Similar to Amsterdam (Eichholtz *et al.* 2012) and New York (Margo 1996), there were two common moving periods in Berlin, April and October, when most moves took place.[15] Still, useful information can be extracted from the announcements published between these periods.

Rent depends both on the structural (size and quality) and locational characteristics of the dwellings. The descriptive statistics are reported in the online appendix. At that time, information on the square meters of apartments was not included in newspaper announcements, thus the size of an apartment could only be measured by the number of rooms.

Most announcements contain the street name and the house number (98.7 percent of all dwellings). This information was used to assign geographical coordinates to each dwelling. Many street names in Berlin are used multiple times in different districts,[16] but the district names are mentioned just in few announcements. Therefore, to find house coordinates, I used an additional geographical information contained in the announcements (e.g., "close to the Zoo" or "5 minutes walk from Bellevue station").

The resulting coordinates were used to assign dwellings to districts. In the twentieth century, the number and names of Berlin's districts underwent several major changes. Here, I use the administrative divisions corresponding to the 1920 Groß-Berlin reform, which delineated 20 districts.

An important rent determinant is the transport connection to the central business district (CBD). Typically, it is measured as a direct distance to the CBD. However, this approach does not account for the real accessibility depending on the transportation network. I measure it using travel times,[17] which are computed using the coordinates of the stations of underground, city, and suburban railways[18] as well as travel times between each pair of adjacent stations computed from the time schedules. The travel times for city and suburban railways were taken from Königliche Eisenbahndirektion Berlin (1912), which contains

[13] Statistisches Reichsamt (1920).

[14] The BTB was founded in 1871/1872 by Rudolf Mosse and had a daily circulation of 230,000 copies on the eve of WWI. The BLA, founded in 1883 by August Scherl, had a daily circulation of 300,000 copies in 1910; Dussel (2011, p. 87) and Stöber (2014, p. 257), respectively.

[15] *"Sporadisch erfolgen in der Weltstadt Umzüge an jedem einzelnen Tage des Jahres fast. Zweimal aber steigern sich in wenigen Wochen die Umzüge zu Hochfluten, die um die Quartalsende des Frühjahres und Herbstes ihren Gipfelpunkt erreichen"*. BTB, 14 September, 1913, p. 68. English translation: "The moves happen in the metropolis sporadically almost every single day of the year. But twice in a year within a few weeks, the number of moves turns into floods that reach their peak at the end of the spring's and fall's quarter".

[16] For example, there were twenty-eight Bahnhofstrasse and twenty-five Berliner Strasse in Groß-Berlin.

[17] A similar indicator is used in Ahlfeldt and Wendland (2011).

[18] In 1914, the underground, city, and suburban railways in Berlin accounted for one-fourth of the 955 million persons who were conveyed by public transportation, as calculated from Silbergleit (1920, p. 505). The majority of trips within the city was made by trams and buses. However, no information on geographical location of their stops and travel times between them is available.

(a)

Es sind zu vermieten: 1. eine Wohnung in dem im Walde liegenden Wärterwohnhaus Nr. 4 (1. Geschoß) in km 19.4 der Eisenbahnstrecke Berlin—Potsdam, bestehend aus 1 Stube, 1 Kammer, Küche und Zubehör zum 1. April 1912; 2. eine Wohnung im Beamtenwohnhause in Potsdam, Alte Luisenstraße 88 (2. Geschoß) bestehend aus 1 Stube und 1 Küche zum 1. März 1912. Die Besichtigungen der Wohnungen vermittelt: im Wärterwohnhaus Nr. 4 die 74. Bahnmeisterei in Zehlendorf-Mitte und in Potsdam die 79. Bahnmeisterei in Wildpark. Bedingungsgemäße Angebote sind bis zum 21. Februar 1912, vormittags 11 Uhr, an das unterzeichnete Betriebsamt einzusenden. Bedingungen sind daselbst einzusehen und für 50 Pfennig verkäuflich.
Berlin, im Februar 1912. [4660a*
Königl. Eisenbahnbetriebsamt 7.

Sofort 4 Zimmer, Bad, April miete-frei. **Scharnhorststr. 8.** [U 354

Joachimsthaler Strasse 15.
Gartenhs. I., 4-Zim.-Wohnung, 1. April 12. [D 459

Landwohnung, 3 Zimmer mit Zubehör, großem Obstgarten sofort zu verm. 30 M. **Rädeke,** Wensickendorf. [15775

Waldemarstr. 51 [E 37*
4 Zimmer, Bad u. Zubehör, Parkaussicht, z. 1. 4. zu verm. Preis 825 M.

Alexander-Ufer 5
(Lehrter Bahnhof) per 1. 4. herrschaftl. Wohnung, 7 Zimmer, Zubeh., elektr. Licht, Oefen, Warmwasserv., M. 2700.— z. verm. [12910

Linienstr. 57, III. Et., 3 Zimmer u. Zub. Mark 500.— per 1. 4.*

Parterre-Wohnung mit Erker, Vorgart. 3 Zimmer, Zubeh., Kamm. Elisabethufer 46, daselbst Kellerw. [F 305

Belle-Allianceastr. 71a, III. Etage, 4 Zimmer 775 M., desgl. IV. Et. 600 M. [G 423

6-Zimmer-Wohnung
I. Etage, Heiz., Warmwass., Fahrst., sof. od. spät. z. verm. Charlottbg., Mommsenstr. 21. [T 428

Invalidenstr. 149, III., a. Pappelplatz, i. neuem Hause, sehr schöne 3-Zimmer-Wohnung, viel Nebengel., Balk., i. Schlafzimm. Wasseranschl., per 1. April od. früher zu verm. 940.— **Bartsch.** [13793*

Schmargendorf, Grunewald,
Cramaspl. 7. Hochherrsch. 3-Zim.-W., Warmwasserheiz. u. -versorg. bill. sofort od. April zu vermiet. Verbindung: Grunewald-Ring 8, A und B und Stadtbahn. [12935*

(b)

Wohnungen

6 und mehr Zimmer

Am Joachimsthalschen Park!
Vornehme 8-Zimmer-Wohnung
mit grösstem modernen Komfort, 7 Vorderzimmer
sehr preiswert
Kaiserallee 14, Ecke Hohenzollerndamm! **Untergrundbahn.**
Auskunft daselbst. Tel. Uhland 4550.

Zum Abvermieten vorzügl. Gegend. Bülowstr. 6, Verkehrsseite, Nollendorfpl. **8 Zimmer 1600 Mk.** III. Etage, Kriegspreis*

Sechs- und Dreizimmerwohnung, Warmw., Fahrstuhl, elektr. Licht etc., möbliert oder unmöbliert, sofort zu vermieten.
Hardenbergstr. 39 am Knie.*

Augsburgerstr. 38,
neben Ecke Joachimsthalerstr., 8 Zimmer, Warmwasserversorgung, III. Etag., vollst. neudecor. pr. 1. 4. M. 2500.*

Bamberger Str. 14
an der Motzstr.
6 Zimmer m. groß. Diele, I. Etage, Warmwasser und elektr. Licht (per sofort). Glänzende Fahrverbindung, auch Untergrundbahn.

Figure 3. *Historical newspaper advertisements. (a) Berliner Lokalanzeiger, February 11th, 1912. (b) Berliner Tageblatt, March 28th, 1915.*

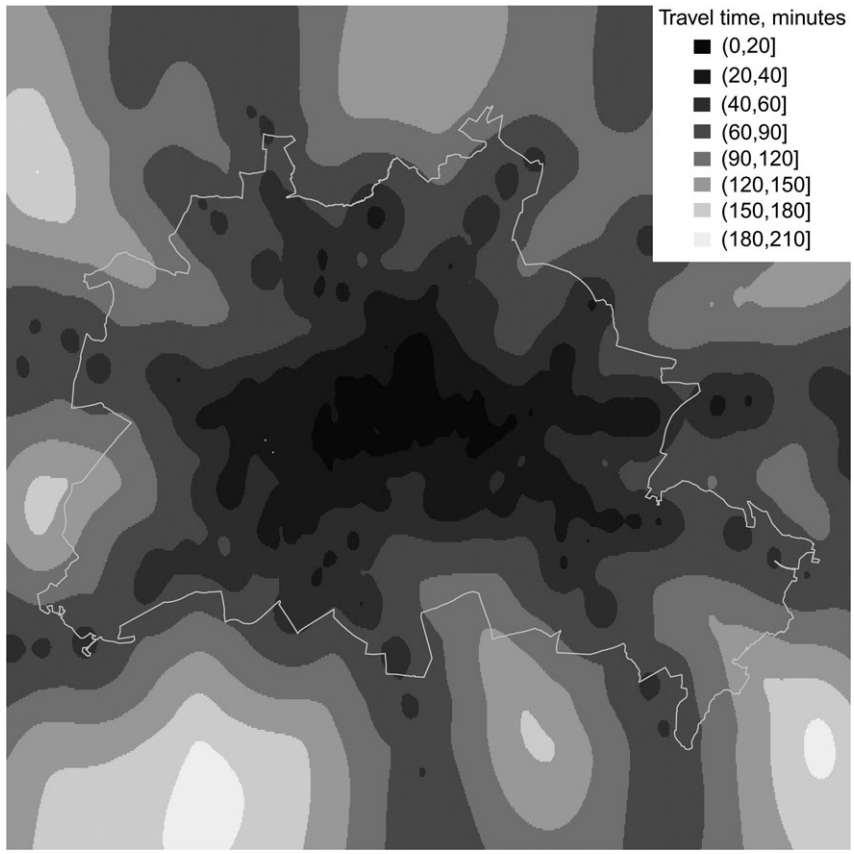

Figure 4. *Isochrones of underground, city, and suburban railways for Alexanderplatz, 1912–1914.*

information on 176 stations and the 23 lines connecting them. I use only travel times that were valid during the working days. The travel times between the forty-six underground stations are borrowed from a 1914 subway map. Using the **R** package *igraph*, the shortest travel times to Alexanderplatz are computed.[19] A grid of 900 points is constructed. From each point, a walking time in minutes to each station is computed as the great circle distance multiplied by sixty minutes and divided by the walking speed of 4 km/hour. This speed is assumed in Leyden (1933, p. 121). Then, from each point, the shortest travel time (walking and riding the railways) to Alexanderplatz is calculated. Afterwards, the travel times are spatially interpolated for 227,474 points using ordinary kriging with a spherical semivariogram model as implemented in **R** package *gstat*.[20] Figure 4 depicts the resulting isochrones, i.e., the lines of equal travel time. It can be seen that they are very far from resembling the concentric circles that would result from employing a mere great circle distance to the CBD as a proxy for accessibility. This difference is caused by the radial lines of the suburban railways.

[19] http://igraph.org/r/.
[20] http://www.gstat.org/.

A few caveats concerning the quality and availability of the data should be made.

Cheap apartments are underrepresented.[21] First, newspaper announcements were mainly addressing higher income persons. This is especially the case of *Berliner Tageblatt*.[22] Second, poorer people must have searched for information about housing from sources other than newspapers. It was most probably related rather to the cost of purchasing newspaper than to their ability to read; as by the 1910s, the literacy rate was extremely high in Germany.[23] To get an impression of how affordable the newspaper housing announcements were, let us consider a couple of figures. In 1913, the prevailing local daily wage (*ortsüblicher Tagelohn*) in Berlin was 3.6 Marks, while purchasing the advertising supplement of the BTB or BLA cost 0.5 or 0.4 Marks at the newsstand, respectively. Thus, even a low-qualified worker could afford to buy the newspaper with announcements once or twice a year. Moreover, Stöber (2014) indicates that the costs of buying a newspaper could be shared. In pre-WWI Germany, there were numerous reader clubs that jointly subscribed to newspapers.

According to Ascher (1917), the average annual rent in Alt-Berlin in 1910 was 474, 1,657, and 592 marks per apartment without commercial space, with commercial space, and overall (including both these categories), respectively. In my data set, the average annual rent for Alt-Berlin 1910 is about 1,014 marks. Not accounting for the structural misalignment of my data set can lead to exaggerated average rent estimates. However, if I account for the underrepresentation of smaller apartments and compute a corrected rent using the actual distribution of housing stock by habitable rooms,[24] I arrive at 526 marks for 1910, which is close to Ascher's average figure for overall dwellings. The underrepresentativeness of cheap dwellings should not pose problems when estimating regression, because all size classes of apartments are present in my sample.

Some districts are underrepresented. This can be related to the previously mentioned challenge, for among the underrepresented districts are mainly those with a large share of cheap apartments. The overrepresented districts (Schöneberg, Wilmersdorf, and Charlottenburg) were centers of building activity in the pre-war period and therefore possessed many new dwellings to be let out.

4. Empirical approach

4.1 Model specification

Here, I estimate the quality-adjusted rents in Berlin in 1909–1917. The quality adjustment is conducted using hedonic regression. This approach is commonly used in housing economics (Malpezzi 2003; Ahlfeldt and Wendland 2011; Mense and Kholodilin 2014).

[21] In what follows, I use the terms "cheap" and "small" interchangeably. The same applies also to the large and medium dwellings that are synonyms to expensive and middle-priced ones. During the period under inspection they were regarded as synonyms. Small dwellings (*Kleinwohnungen*) were known as dwellings for poor both in common language and in the legal acts.

[22] *"Berliner Tageblatt... hat allein in Groß-Berlin über 115 000 feste Abonnenten, die meist den gutsituierten Kreisen angehören"*, BTB, 7 June, 1914, p. 60. English translation: "Alone in Big Berlin, Berliner Tageblatt has over 115,000 permanent subscribers who mostly belong to the well-off circles".

[23] In 1912, the literacy rate in Germany was virtually 100 percent (Eisenberg 1983, p. 13).

[24] The distribution of Alt-Berlin's housing stock by size was taken from Silbergleit (1920, p. 11) reporting the results of the 1918 housing survey.

The hedonic regression has the following form:

$$log(p_i) = \alpha + X'_i\,\beta + \sum_{j=1}^{\mathfrak{J}} \gamma_j I_{ji}^{D} + \sum_{k=1}^{K} \delta_k I_{ki}^{TT} + \sum_{t=1}^{T} \theta_t I_{ti}^{P} + u_i \tag{1}$$

where p_i is the annual rent for ith apartment in Marks; X_i are the structural characteristics of the housing; I_j^D are the district dummies; I_k^{TT} are the travel time dummies; I_t^P are the time dummies, α, β, γs, θs, and δs are the parameters; and u_i is the error term. The time dummies are defined as year and month. So, a time dummy for August 1914 is defined as:

$$I_t^{1914:08} = \begin{cases} 1 & \text{if } t = \text{August } 1914 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

The model has a log-linear functional form, the dependent variable being in logarithms. Although the choice of functional form for a hedonic regression has no strong theoretical foundation, it is found that the log-linear form has several advantages over the linear form (Malpezzi 2003). In particular, the former allows the value added of each characteristic to vary proportionally with the size and quality of the dwelling. Moreover, the log-linear form alleviates the heteroskedasticity problem.

The regression is estimated by the *ordinary least squares* (OLS). The estimation results are in column (1) of table 1.

To test the rent dynamics of different market segments (cheap vs. expensive apartments), I apply a *quantile regression* (QR) using **R** package *quantreg*.[25] Under this technique, the quantiles of the conditional distribution of the dependent variable are expressed as functions of explanatory variables. The QR is formulated as:

$$Q_\tau(p_i|X'_i, I_j^D, I_k^{TT}, I_t^P) = X'_i\,\beta_\tau + \sum_{j=1}^{\mathfrak{J}} \gamma_{\tau,j} I_{ji}^{D} + \sum_{k=1}^{K} \theta_{\tau,k} I_{ki}^{TT} + \sum_{t=1}^{T} \delta_{\tau,t} I_{ti}^{P} \tag{3}$$

where Q_τ is a τth quantile of p_i conditional on the explanatory variables, with $0<\tau<1$. Thus, the QR allows estimating the effect of explanatory variables for the whole distribution, i.e., at each quantile of dependent variable, p_i. In addition, QR is robust to the outliers and imposes no assumptions on the exact distribution form of the error term.

4.2 Estimation results

The model specification is determined using an automatic model selection approach.[26] The idea is to generate all possible model specifications. The fitness of each model is characterized by a corresponding information criterion (IC) value. The model with the lowest IC is treated as the "best model." An exhaustive fitting may be prohibitive, given a large sample size and a relatively big number of potential explanatory variables. The number of all possible combinations is 2^n, where n is the number of covariates. In my case, there are $n = 22$ potential explanatory variables and so the candidate set should contain 4,194,304 models. Hence, the exhaustive search would be too time consuming. Therefore, a genetic algorithm that allows finding the best model without fitting all possible models is applied. The optimal model was obtained by running five independent genetic algorithms and finding their consensus. Thus, I end up with thirteen explanatory variables chosen from the twenty-two covariates.

[25] Koenker (2012).
[26] The model selection was done using **R** package *glmulti* (Calcagno and de Mazancourt 2010).

Table 1. *Estimation results of OLS and QRs*

	Dependent variable: LRent			
	OLS		Quantile regression	
	Estimated coefficients (1)	Percent effect on rent from one unit change (2)	Estimated coefficients (3)	Percent effect on rent from one unit change (4)
Constant	5.295*** (0.024)		5.269*** (0.025)	
Room	0.439*** (0.009)	43.900	0.456*** (0.007)	45.600
Room_sq	−0.017*** (0.001)	−1.700	−0.019*** (0.001)	−1.900
Bay window	0.034*** (0.010)	3.459	0.038*** (0.012)	3.856
Maid room	0.019** (0.008)	1.912	0.019*** (0.007)	1.938
Vestibule	0.036** (0.016)	3.706	0.019 (0.020)	1.926
Floor: 1	0.081*** (0.007)	8.395	0.079*** (0.006)	8.242
Floor: 2	0.051*** (0.008)	5.257	0.047*** (0.008)	4.766
Floor: 3	0.003 (0.008)	0.339	−0.006 (0.007)	−0.583
Floor: 4	−0.023** (0.011)	−2.269	−0.010 (0.011)	−1.018
Floor: hochparterre	0.093*** (0.012)	9.771	0.083*** (0.009)	8.631
Floor: parterre	0.036*** (0.013)	3.645	0.027** (0.013)	2.733
Corridor	−0.039*** (0.013)	−3.831	−0.059*** (0.016)	−5.76
Garden	0.023 (0.015)	2.349	−0.011 (0.011)	−1.136
Lift	0.075*** (0.013)	7.791	0.086*** (0.013)	8.961
Furnished	0.459*** (0.019)	58.233	0.478*** (0.019)	61.208
Electric light	0.037*** (0.008)	3.795	0.034*** (0.007)	3.414
Heating: central	0.090*** (0.013)	9.389	0.121*** (0.011)	12.883
Heating: vapor	0.270*** (0.060)	30.956	0.255*** (0.090)	28.985
Heating: warm water	0.109*** (0.011)	11.542	0.120*** (0.011)	12.706
Warm water	0.081*** (0.007)	8.456	0.084*** (0.007)	8.72
Isochrone: (20,40]	−0.019*** (0.007)	−1.869	−0.025*** (0.006)	−2.452
Isochrone: (40,60]	−0.021 (0.018)	−2.112	−0.036** (0.015)	−3.503
Isochrone: (60,90]	−0.190*** (0.048)	−17.329	−0.286*** (0.068)	−24.845
Source: Berliner Tageblatt und Handels-Zeitung	0.041*** (0.006)	4.136	0.032*** (0.005)	3.232
Districts	Yes		Yes	
Year/month dummies	Yes		Yes	
Observations	11,257			

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

The estimation results of OLS and QRs are reported in table 1. In columns (1) and (3), coefficient estimates are presented, while in columns (2) and (3), the percentage effects resulting from one-unit change in the explanatory variables are presented. For dummy variables the effects are computed using Halvorsen and Palmquist (1980) approximation: $100 \times \exp(\hat{a}) - 100$, where $\hat{a}$ is the estimated coefficient of a dummy variable.

For OLS, the heteroskedasticity and autocorrelation-consistent standard errors were computed using the Newey–West robust covariance matrix. For QR, the standard errors were obtained using bootstrap. Default bootstrap settings of the **R** package *quantreg* are

used: *xy*-pair method and 200 bootstrap replications. OLS has a high explanatory power with $R^2_{adj.} = 0.89$.

The number of rooms and its square are significant in all models. While the coefficients of the former are positive, those of the latter are negative. The magnitude of coefficients is similar in both OLS and QR. Adding one more room to an apartment will lead to an average increase in its annual rent by 42–44 percent. This coefficient falls into the estimate range of the other studies. It is almost two times smaller than the value estimated in Margo (1996): 75–77 percent. By contrast, my estimate is three times larger than what Marks (1984) obtained for uncontrolled apartments from the City of Vancouver in 1978 (15 percent rent increase for an additional bedroom); four times larger than what Fallis and Smith (1985) obtained for uncontrolled dwellings in Toronto in 1982 (10 percent); and seven times larger than what Tsoodle and Turner (2008) found using American Housing Survey data (6 percent). One possible reason might be that with the growing density of population, people become used to crowding and value additional space less. Other factors, like space standards and household size have also changed a lot over time and vary substantially between cities. Thus, between 1956 and 2010, in West Germany the average per-capita floor space increased from 18.4 to 39.2 m². In Berlin, household size fell from 3.8 persons (1905, Alt-Berlin) to 3.3 (1919, Groß-Berlin), and to 1.8 (2013, Groß-Berlin). Note that with the passage of time, the room coefficient becomes smaller: the largest Margo's estimates refer to the period by sixty years preceding that in my study, while the much smaller coefficients in other studies are obtained for the period seventy years later. This can be explained by improved space standards. The presence of a statistically significant negative quadratic term makes the effect of room number on the rent dependent on the "starting point." Given the estimated OLS coefficients, $\beta_{\text{room}} \approx 0.439$ and $\beta_{\text{room}^2} \approx -0.017$, the marginal effect of one more room can be computed as: $\exp(\beta_{\text{room}}(x+1) + \beta_{\text{room}^2}(x+1)^2) - \exp(\beta_{\text{room}}x + \beta_{\text{room}^2}x^2)$, where x is the number of rooms. It increases up to seven rooms and then declines. For any reasonable range of room number, the effect remains positive.

The coefficients of bay window, maid's room, and vestibule are positive in both models. While bay window and maid's room are significant in both models, vestibule is significant only in the OLS. Having a bay window increases the rent by 3.5–4.0 percent, whereas the availability of maid's room makes the rent almost 2 percent higher. Corridor has a negative and significant effect, which varies between −3.8 and −5.8 percent in the OLS and QR, respectively.

The effects of the floor, in which the dwelling is located, are reasonable: the most expensive floors are Hochparterre (raised ground floor) and the first floor. The cheapest dwellings were located in the cellar or in the highest, fourth, floor, immediately below the roof. This corresponds to the findings of the contemporary literature: the most expensive dwellings located on the first floor,[27] the moderately priced ones were in the parterre as well as in the second and third floors, while the cheapest ones were in the fourth floor (Eberstadt 1920, p. 200). Apart from the lack of accessibility to the upper floors, since most buildings had no lifts, the uppermost floor suffered from stuffiness and heat in the summer. There were no dwellings higher than in the fourth floor, for in 1887–1925 it was prohibited to lodge people higher than the fifth and fourth floor in Alt-Berlin and its neighbor communities, respectively (Piechottka 1979, p. 25; Willert 1975).

[27] In Germany, the ground floor is floor 0, and the first floor is up one floor.

The availability of a garden has no significant effect on the annual rent. If a tenant lives higher than the ground floor, then his ability to take advantage of the garden should be rather limited. Moreover, in some cases, the word "garden" may refer to a couple of bushes. The availability of a lift has significant positive impact on the rent: it is rewarded with a rent markup between 7.8 and 9.0 percent. The lifts were rather rare during that period, and the hierarchy of floors had not yet been inverted (Bernard 2006). The lift coefficient is 2.5 smaller than that obtained by Büchel and Hoesli (1995) for unsubsidized apartments in Geneva in 1992: 21 percent.

Furnished dwellings are rented with a 58–61 percent premium. This is very close to the estimate of Marks (1984), which is 50 percent rent increase if furniture is included.

The availability of electricity and warm water contributes positively to the asking rent. The rent effects of different types of heating vary a lot, with vapor heating being the highest valued (the default value is unknown type of heating, which includes in many cases the non-availability of heating).

The location of dwellings has a strong effect on their rent. The district coefficients are omitted to save space. Their impact can be appreciated in figure 5 depicting the distribution of quality-adjusted rents by districts. The district-specific rent is obtained as a weighted average of OLS quality-adjusted rents for the district and size classes (1, 3.5, 6, and 9 rooms) as of July 1914. As weights, the structure of housing stock for respective district was used. The Alt-Berlin contours are highlighted by a black continuous line. In the center of each district, the quality-adjusted rent and the observations number are indicated. The highest rents are observed in the west, especially in Wilmersdorf and Zehlendorf, which were districts

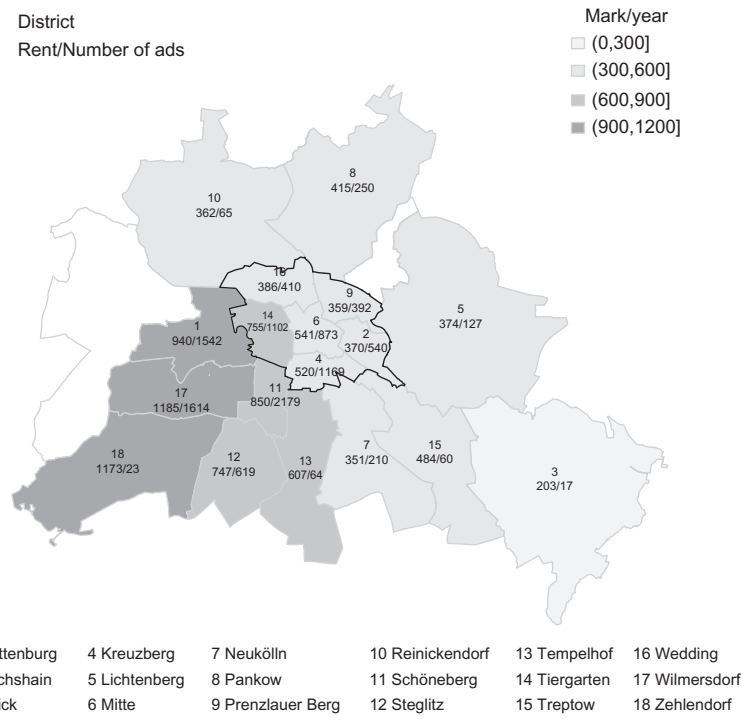

Figure 5. *Geographical distribution of quality-adjusted rent in Berlin, July 1914.*

inhabited by the affluent. The lowest rents are observed in the outskirts of the city.[28] In Alt-Berlin, the low rents were found in Gesundbrunnen, Wedding, Prenzlauer Berg, and Friedrichshain districts with high concentration of factories and industrial workers.

The isochrone coefficients provide estimates of the price of accessibility. A greater travel time is associated with significantly lower rent. The rent discount is especially high, when the travel time exceeds one hour. A referee pointed out that the isochrone boundaries are rather arbitrary and suggested to use a degree polynomial in travel time. However, I find that using dummies instead of a continuous travel-time variable allows for more flexibility by capturing the nonlinear effects. Additional five minutes might hardly have any effect on the rent, if the dwelling is located at one-hour travel time from the CBD. Moreover, the humans tend to count the travel time at discrete steps of five or ten minutes.

The source coefficient is positive and significant, implying that the BTB was addressing more affluent social classes and tended to advertise more expensive apartments.

5. Evolution of Berlin's rent before and during WWI

The evolution of the quality-adjusted rents is shown in figure 6. The continuous thin gray line represents the raw hedonic rent resulting from the OLS regression:

$$\hat{p}_{it} = \hat{F}_G exp\left(\hat{\alpha} + \tilde{X'}_i\hat{\beta} + \hat{\gamma}_j I_{ji}^{D} + \hat{\delta}_k I_{ki}^{TT} + \hat{\theta}_t I_{ti}^{P}\right) \tag{4}$$

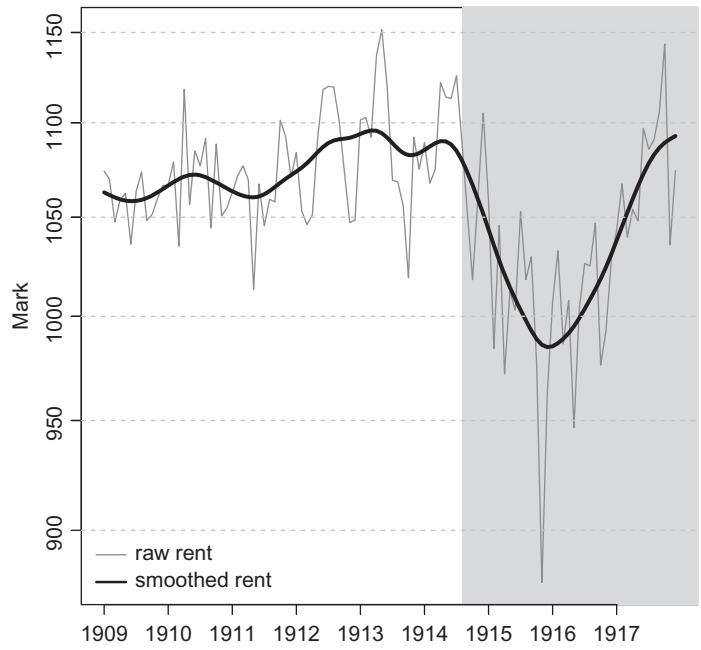

Figure 6. *Quality-adjusted housing rent in Berlin, 1909–1917.*

[28] Leyden (1933, pp. 148–154) and Bernhardt (1998, pp. 19–20).

where $\hat{p}_{it}$ is the fitted annual rent in period t; $\tilde{X}$ are the structural characteristics of a typical apartment of the sample (four rooms, second floor, electric light, hot water heating, and hot water provision) located in district j = *Schöneberg*; within travel-time category k = (20,40] minutes; $\hat{F}_G$ is the adjustment factor of Goldberger (1968) defined as:

$$\hat{F}_G = \exp\left(\frac{\hat{\sigma}^2}{2}(1 - m^{11})\right) \tag{5}$$

where $\hat{\sigma}^2$ is the residual variance and m^{11} is the (1,1) element of the inverse of the regressors variance–covariance matrix. The adjustment factor is needed to obtain an unbiased estimate of the conditional mean of rent. Under the semilog specification the antilog of the predicted logarithm of rent does not give an unbiased estimate of predicted rent (Malpezzi 2003).

The resulting rent is too volatile. So, it is smoothed using a spline function, represented by the continuous bold black line.[29] A gray polygon denotes the war period. The rents started to fall in June 1913. This is related to the crisis that struck Berlin's real-estate market in 1912 (Bernhardt 1998). In addition, 1912 and especially 1913 saw a substantial increase in the peacetime army size, which should have exerted a negative effect on the housing demand.[30]

The outbreak of the war accelerated the rent decrease. Between July 1914 and December 1915, rents fell by 9 percent. This can be attributed to a massive mobilization.[31] This might have triggered two effects: First, the demand for housing dropped. Second, the overcrowding that existed before WWI receded.[32] The latter effect may have alleviated to some extent the rent decrease, since a part of the decreased demand may have been reflected in endogenously reduced supply rather than putting downward pressure on rents. Following December 1915, rents started to climb slowly. In December 1917, asking rents reached prewar levels. What could have caused the rent increase? During the war, Groß-Berlin's population stagnated and started to rise only in the aftermath of WWI. However, the last two war years saw increased household formation through a surge in the number of marriages. Together with declined housing stock, this should have triggered the rent increase.

In addition, the rent increase could have been caused by expansionary monetary and fiscal policy. Money supply increased rapidly: in 1918, available money volume was eight times that of 1913.[33] Likewise, in 1918, government debt was twenty-one times larger than in 1913.

Nevertheless, the rent growth that started in the late 1915 is dwarfed when compared to that of the prices for staple foods. Average wholesale food prices in the German Reich increased by 74 percent from 1914 to 1917. Over the same period, in Berlin, the retail prices for food increased between 16 percent (wheat flour) and 289 percent (eggs). For rents, demand went

[29] Given that I deal with asking rather than transaction rents, the actual evolution of the latter can be somewhat different. They can be lower during excess supply periods and higher during excess demand phases. However, the difference should not be large as shown in the comparison conducted in Section 3.

[30] For more details, see the online appendix.

[31] In August 1914–September 1915, the actual size of German army (in the field and occupation) increased rapidly and then stabilized around seven million persons. Presumably the outflow of called-up males from Berlin followed the same pattern.

[32] The overcrowding of dwellings for poor was a serious issue before 1914. However, Ascher (1917, pp. 16–17) shows that between 1900 and 1910, housing crowding (number of inhabitants per dwelling) in Berlin had been gradually decreasing. Overall crowding decreased from 3.82 to 3.56. In small dwellings, this was also the case: in 1-room dwellings it reduced from 3.4 to 3.2.

[33] See various issues of the Statistisches Jahrbuch für das Deutsche Reich.

down, but the lack of supply due to absent construction workers was probably not felt very severely in the short run. For food, however, soldiers were still demanding nutrition, but production workers were absent. In addition, Britain was running a rather efficient naval blockade of Germany, stopping the supplies of raw materials and foodstuffs (Cox 2015).

The rent increase also is very moderate compared to the national inflation rate (Deutsche Bundesbank 1976, pp. 6–7). Thus, the real rents in Berlin actually went down (figure 7). While consumer prices more than doubled between 1914 and 1917, Berlin's nominal rents stagnated. By the end 1917, the rents lost more than half of their 1913 value.

Given the importance of housing rents in the family budgets of most city dwellers, it would interesting to compare the quality-adjusted rents to the income dynamics. In the absence of income data, they can be approximated by wages. Kocka (1988, pp. 29–30) presents female and male wage indices (March 1914 = 100) between March 1914 and September 1918 for eight industries: four armament and four non-armament ones. Between March 1914 and September 1917, the overall wages increased from 100 to 175 percent for males and 188 percent for females. Over the same period, the wages in armament (non-armament) industries went up to 213 percent (142 percent). Thus, during the war, dwellings became more affordable to the working class. The purchasing power gains varied depending on the industry, gender, and skills. As shown in Agthe (1921), between 1914 and 1920 in Berlin, the wages of high- (low-) skilled workers increased in the metalworking industry by 575 percent (600 percent), while in construction by 503 percent (669 percent). The civil servants, having sticky salaries, have experienced much smaller, if any, increases in affordability of rental housing. However, due to unavailability of the data on their salaries, only tentative conclusions can be drawn about their real incomes.

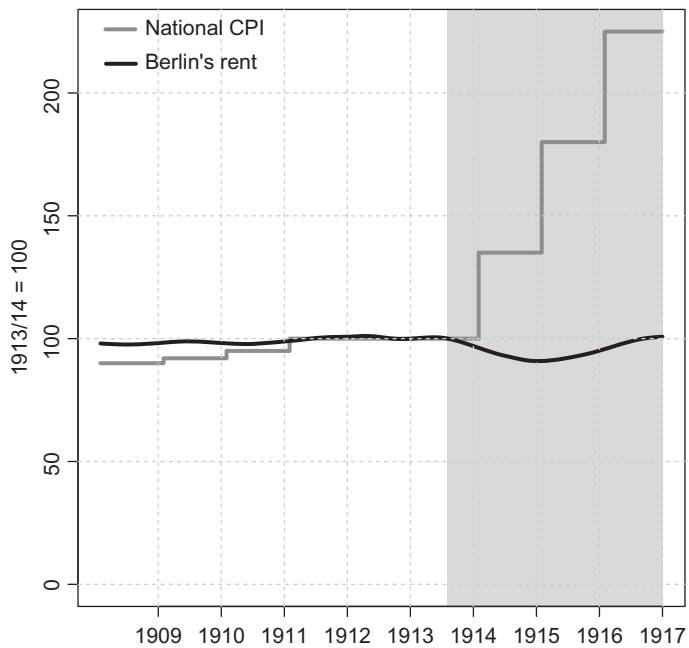

Figure 7. *Berlin's rent versus overall price increase in Deutsches Reich, 1909–1917.*
Source: *(1) CPI = Deutsches Geld- und Bankwesen in Zahlen 1876–1975; (2) rent = own calculations.*

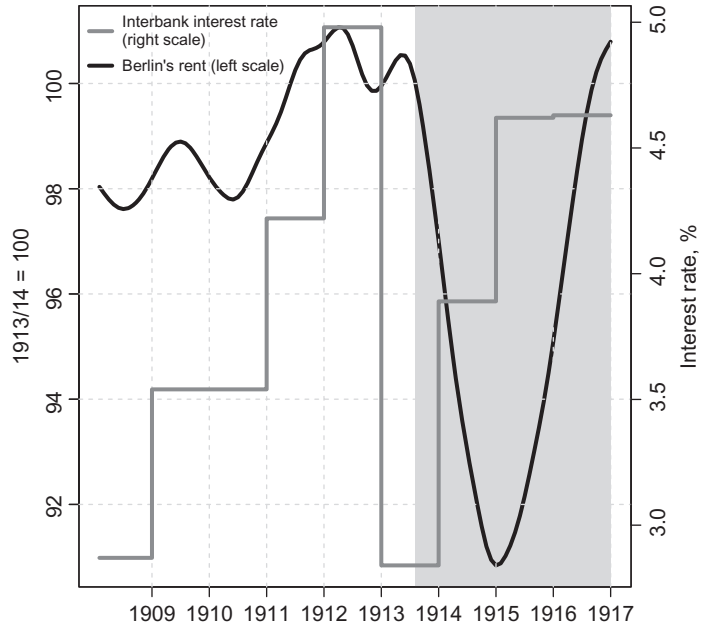

Figure 8. *Quality adjusted Berlin's rent versus interbank interest rate in German Reich.* Source: *(1) interest rate = Deutsches Geld- und Bankwesen in Zahlen 1876–1975; (2) rent = own calculations.*

The wage increases were accompanied by a relatively low unemployment. An initially sharp rise in the unemployment related to the outbreak of the war was followed by a noticeable decline to just 1 percent (Pierenkemper 1987, p. 59). The called-up men were quickly replaced with women (Kocka 1988). As a result, the purchasing power of the working classes was swiftly restored and even increased.

Figure 8 compares Berlin's rent with the interbank interest rate in German Reich. There appears to exist a positive correlation between the rent and the interest rate, the latter leading the former by about one year. Given a large indebtedness of the landlords, whose own capital as a rule was just 10–20 percent,[34] such a relationship is not surprising. Higher interest rates mean large expenses that are transmitted to the tenants in form of a higher rent. Very similar rent dynamics could be observed during the same period in Swiss cities, for which official data on housing rentals are available (ILO 1924). Interestingly, during WWI, the German house prices followed the same pattern as quality-adjusted rents in Berlin (Knoll *et al.* 2014). The reason might be that most dwellings at that time were let and their value strongly depended on the expected rent returns. This result, based on completely different data sources, corroborates my finding.

6. Housing market segmentation

Different market segments can have different dynamics. According to the literature, the largest housing shortage was in the small (less than three rooms) apartments segment.[35] These

[34] Kämper (1930, p. 239).
[35] Führer (1995, p. 23).

are the dwellings occupied by low-income households. To identify the segment-specific dynamics of rents, I use QR.

Nine different QRs ($\tau = 0.1,0.2,\ldots,0.9$) are estimated to obtain segment-specific rents: from the least expensive (first decile) to the most expensive (ninth decile) dwellings.

The homoskedasticity Wald-type test leads to a rejection of a joint null hypothesis that all of the conditional quantile functions have the same slope parameters at 1 percent significance level. When conducted for each slope parameter separately, the test allows rejecting the null for the most dwelling characteristics. This implies that the elasticity of rents with respect to these characteristics depends upon the total rent level. For the time dummies, the null can only be rejected in 8.4 percent (24.3 percent) of the periods at 1 percent (10 percent) significance. The null hypothesis is mainly rejected for the latter periods, especially for 1917. This implies that during the first half of the war, all segments evolved in the same direction, while toward the end of WWI, they started to diverge. In particular, cheap dwellings ($\tau = 0.1$ and $\tau = 0.2$) strongly deviated from the rest of the rental market.

Figure 9 depicts the segment-specific rents. These were computed for typical dwellings located in the Schöneberg district, between twenty and forty travel minutes from Alexanderplatz. The number of rooms in a dwelling belonging to each segment was determined based on the corresponding quantiles. Thus, the number of rooms in small dwellings is two, while in the large ones it is six. The upper panel shows the segment-specific rents in Marks. The lower panel reports the segment-specific rent indices, obtained by dividing the rents in Marks through their July 1914 levels. It can be seen that the quality-adjusted rents

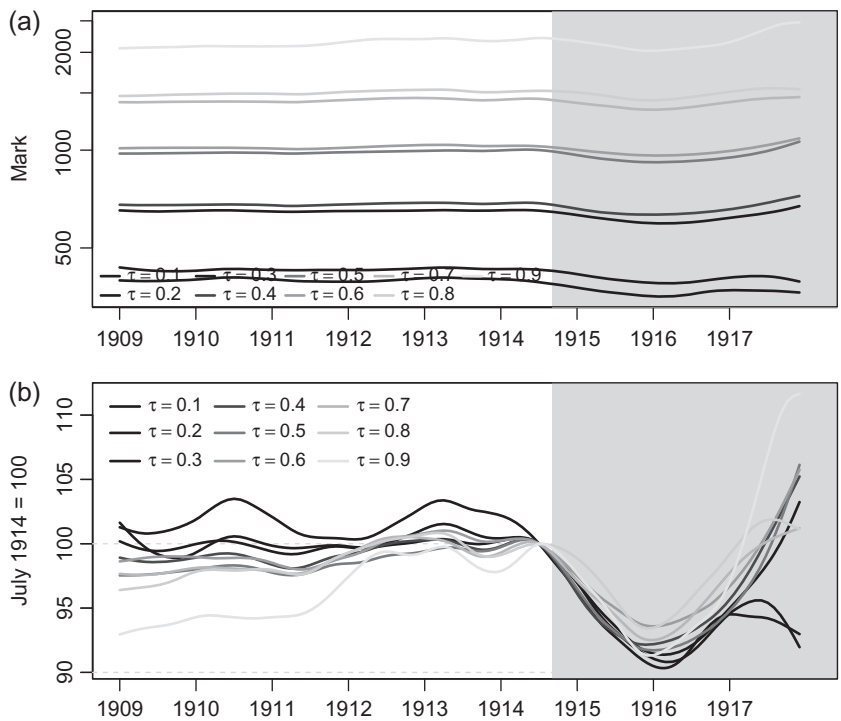

Figure 9. *Dynamics of smoothed quality-adjusted housing rent in Berlin by segments, 1909–1917. (a) Rent in Marks. (b) Rents in percentage.*

experienced a substantial decrease. It had started on April 1913 for most market segments. For all segments, the decline lasted until December 1915 to March 1916 and was particularly pronounced for small apartments. While the rents for expensive apartments fell by 7.5–8 percent, those for cheap dwellings declined by almost 10 percent. In the middle of the war, the tendency for the whole market was reversed. The dynamics were different for different market segments. In December 1917, rents for the largest dwellings went up by 12 percent over their pre-war level, while those for the middle and large apartments increased by 5–6 percent. Finally, the rents for cheap apartments after having followed the general upward trend for about a year, started to decrease in July 1917, ultimately falling to 92 percent of the pre-war level by December 1917.

However, in the segment of cheap apartments, the rents continued to fall at least till the end of 1917. A possible explanation could be a *filtering down effect*. It means that the maintenance of housing was neglected and new construction inhibited. In June 1917, the building and maintenance of dwellings were even prohibited by the military authorities (Schmidthuysen 1928, p. 163, and Kaeber 1921, p. 469). Thus, the supply of expensive dwellings decreased, while that of cheap dwellings went up. Another tendency that may have contributed to this phenomenon was an increase in the incomes of the employees of the armament industry, whose wages were raised by the state in order to stimulate the war production.[36] As a result, they may have moved into larger apartments. This is corroborated by Noack (1922), who noted that even in the early 1920s, workers did not want to stay in tiny apartments but rather wished to live in bigger ones, given their improved social and economic situation. Korff-Petersen (2013, p. 183) also indicates that in the end of the war, the number of inhabitants of small dwellings went down, while the demand for middle and large apartments increased substantially.

The volatility of cheap rents was much greater than that of the rents for more expensive apartments. One explanation can be found in Reich (1912), p. 7. According to her, the lower income persons are more exposed to the business cycle fluctuations. Therefore, by making decision on creating a family or migrating factors that directly affect housing demand, they are more responsive to overall economic fluctuations.

7. Conclusion

This article presents new evidence on housing rents in Berlin in 1909–1917. The data are extracted from newspaper announcements and georeferenced. This enables the construction of quality-adjusted rents.

The rent index facilitates the examination of how rents in Berlin evolved shortly before and during WWI. Starting in 1913, a substantial decrease of the quality-adjusted rents in Berlin is found. The decline lasted until the beginning of 1916 and was particularly pronounced for small apartments. Afterwards, driven by a strong demand increase, the tendency for the whole market was reversed. However, in the segment of cheap apartments, rents continued to fall at least until the end of 1917.

Compared with a much stronger overall price increase, especially that of staple foods, the rent increase appears to be very moderate. In fact, during the war, when neither rent regulations nor tenants' protection were in place, real rents fell. This suggests a high degree of downward and a low degree of upward flexibility of the housing rents in the absence of

[36] Wiel (1939, p. 621).

regulations. However, in the early 1920s, faced with a strong post-war housing shortage and striving to establish social justice, authorities put an end to market freedom, thus destroying the signaling function of the rents. Therefore, regulatory policy did not emerge as a result of dramatic failures in rental housing markets but rather due to the fear of rapid rent increases as a consequence of the decrease in construction during WWI that caused a supply stagnation in the face of growing housing demand.

The quality-adjusted rent index suggested here sheds more light on the evolution of the cost of living in a big German city during WWI. It permits bridging a large gap in the historical data and substantially improving our understanding of the functioning of the market economy during war. In particular, it can be concluded that inflation was contained due to the collapse of housing prices in big cities during the first half of the war. Even during the last half of the war, a relatively slow rent increases alleviated the overall price increase. Moreover, distinguishing between market segments allows obtaining a more realistic picture of the living cost of the working classes. Given their stronger wage increases and decline in the small dwellings rents, their real income losses during WWI were more moderate than the estimates not accounting for rent could suggest.

Supplementary material

Supplementary material is available at *EREH* online.

Acknowledgements

I thank Claus Michelsen and Dirk Ulbricht for their helpful comments; Dmitry Chervyakov and Niklas Dornbusch for their great research assistance; Gabriele Knopf for her kind help in collecting the historical statistical data, and Adam Lederer for his fruitful suggestions. I also thank the participants at the internal macroseminar of the Deutsches Institut für Wirtschaftsforschung, Germany, and at the Symposium on Business and Economic History 2015, in Lisbon, Portugal. The standard disclaimer applies.

References

Agthe, A. (1921). Lohnsteigerung 1913 bis 1920. *Wirtschaft und Statistik* (2), pp. 81–84.

Ahlfeldt, G.M. and Wendland, N. (2011). Fifty years of urban accessibility: the impact of the urban railway network on the land gradient in Berlin 1890–1936. *Regional Science and Urban Economics* **41**(2), pp. 77–88.

Ascher, S. (1917). *Die Wohnungsmieten in Berlin von 1880–1910*. Erlangen: Carl Heymanns Verlag.

Bernard, A. (2006). *Die Geschichte des Fahrstuhls: Über einen beweglichen Ort der Moderne*. Frankfurt am Main: Fischer Taschenbuch

Bernhardt, C. (1998). *Bauplatz Groß-Berlin. Wohnungsmärkte, Terraingewerbe und Kommunalpolitik im Städtewachstum der Hochindustrialisierung (1871–1918)*. Berlin, New York: Walter de Gruyter.

Brander, S. (1984). *Wohnungspolitik als Sozialpolitik. Theoretische Konzepte und praktische Ansätze in Deutschland bis zum Ersten Weltkrieg*. Berlin: Duncker & Humblot.

Büchel, S. and Hoesli, M. (1995). A hedonic analysis of rent and rental revenue in the subsidised and unsubsidised housing sectors in Geneva. *Urban Studies* **32**(7), pp. 1199–213.

Calcagno, V. and de Mazancourt, C. (2010). glmulti: an R package for easy automated model selection with (generalized) linear models. *Journal of Statistical Software* **34**(112), pp. 1–29.

Carmona, J., Lampe, M. and Rosés, J.R. (2014). Housing affordability during the urban transition in Spain. Working Papers in Economic History wp14-05, Universidad Carlos III, Instituto Figuerola de Historia y Ciencias Sociales.

Clark, G. (2002). Shelter from the storm: housing and the industrial revolution, 1550–1909. *The Journal of Economic History* **62**(2), pp. 489–511.

Cox, M.E. (2015). Hunger games: or how the allied blockade in the first World War deprived German children of nutrition, and allied food aid subsequently saved them. *The Economic History Review* **68**(2), pp. 600–31.

Deutsche Bundesbank. (1976). *Deutsches Geld- und Bankwesen in Zahlen 1876–1975: Statistischer Beiband zur Bundesbank Festschrift, Währung und Wirtschaft 1876–1975*. Deutsche Bundesbank.

Devaney, S. (2009). Trends in office rents in the City of London: 1867–1959. *Explorations in Economic History* **47**(2), pp. 198–212.

Drelichman, M. and González Agudo, D. (2014). Housing and the cost of living in early modern Toledo. *Explorations in Economic History* **54**(C), pp. 27–47.

Dussel, K. (2011). *Deutsche Tagespresse im 19. und 20. Jahrhundert*. Berlin: LIT Verlag.

Eberstadt, R. (1920). *Handbuch des Wohnungswesens und der Wohnungsfrage*. Jena: Verlag von Gustav Fischer.

Eichholtz, P., Straetmans, S. and Theebe, M. (2012). The Amsterdam rent index: the housing market and the economy, 1550–1850. *Journal of Housing Economics* **21**(4), pp. 269–82.

Eisenberg, P. (1983). Arbeiterbildung und Alphabetisierung im 19. Jahrhundert. In H.W. Giese and B. Gläß (eds.), *Analfabetismus in der BRD. Osnabrücker Beiträge zur Sprachtheorie Band (OBST) Band 23*. Osnabrück: Verein zur Förderung der Sprachwissenschaft in Forschung und Ausbildung, pp. 13–32.

Fallis, G. and Smith, L.B. (1985). Price effects of rent control on controlled and uncontrolled rental housing in Toronto: a hedonic index approach. *The Canadian Journal of Economics Revue canadienne d'Economique* **18**(3), pp. 652–9.

Führer, K.C. (1995). *Mieter, Hausbesitzer, Staat und Wohnungsmarkt: Wohnungsmangel und Wohnungszwangswirtschaft in Deutschland 1914-1960 (Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte. Beihefte)*. Stuttgart: Franz Steiner Verlag.

Goldberger, A.S. (1968). The interpretation and estimation of Cobb-Douglas functions. *Econometrica* **36**(3/4), pp. 464–72.

Gray, R. (2015). Rents and welfare in the second industrial revolution: Evidence from New York City. eh.net/eha/wp-content/uploads/2015/05/gray.pdf

Halvorsen, R. and Palmquist, R. (1980). The interpretation of dummy variables in semilogarithmic equations. *The American Economic Review* **70**(3), pp. 474–5.

International Labour Office. (1924). *European Housing Problems since the War*. Geneva: Imprimeries réunies S.A.

Kaeber, E. (1921). *Berlin im Weltkriege. Fünf Jahre städtischer Kriegsarbeit*. Berlin: Trowitzsch und Sohn.

Kämper, O. (1930). Finanzierung des Wohnungsbaues. In G. Albrecht, A. Gut, W. Lübbert, E. Weber, O. Wölz and B. Schwan (eds.), *Handwörterbuch des Wohnungswesens*. Jena: Verlag von Gustav Fischer.

Kholodilin, K.A. (2015). Fifty shades of state: quantifying housing market regulations in Germany. DIW Berlin Discussion Paper No. 1530.

Kholodilin, K.A. and Meerovich, M.G. (2016). Housing policy in Soviet Russia and Germany between the two world wars: comparative analysis of two systems. *Journal of Urban History* (1391), forthcoming. http://juh.sagepub.com/content/early/2016/05/21/0096144216649951.full.pdf+html

Knoll, K., Schularick, M., and Steger, T. (2014). No price like home: global house prices, 1870–2012. Globalization and Monetary Policy Institute Working Paper 208, Federal Reserve Bank of Dallas.

Kocka, J. (1988). *Klassengesellschaft im Krieg*. Deutsche Sozialgeschichte 1914–1918. Frankfurt am Main: Fischer Verlag. https://cran.r-project.org/web/packages/quantreg/vignettes/rq.pdf

KOENKER, R.W. (2012). Quantile regression in R: A vignette.

KÖNIGLICHE EISENBAHNDIREKTION BERLIN. (1912). *Fahrplan für den Berliner Stadt-, Ring- und Vorortverkehr. Gültig vom 1. Oktober 1912*. Berlin: Druck von W. Bürgenstein.

KORFF-PETERSEN, A. (2013). Einfluß der Wohnungsbeschaffenheit auf die Gesundheit der einzelnen Bewohner. In A. GOTTSTEIN, A. SCHLOßMANN and L. TELEKY (eds.), Handbuch der Sozialen Hygiene und Gesundheitsfürsorge*:* Fünfter Band: Soziale Physiologie und Pathologie. Berlin, Heidelberg: Springer-Verlag, pp. 146–255.

LEYDEN, F. (1933). *Groß-Berlin. Geographie der Weltstadt*. Breslau: Ferdinand Hirt in Breslau.

MALPEZZI, S. (2003). Hedonic pricing models: a selective and applied review. In T.O. SULLIVAN and K. GIBBS (eds.), *Housing Economics: Essays in Honour of Duncan Maclennan*. Oxford: Blackwell.

MARGO, R.A. (1996). The rental price of housing in New York City, 1830–1860. *The Journal of Economic History* **56**(3), pp. 605–25.

MARKS, D. (1984). The effect of rent control on the price of rental housing: an hedonic approach. *Land Economics* **60**(1), pp. 81–94.

MENSE, A. and KHOLODILIN, K. (2014). Noise expectations and house prices: the reaction of property prices to an airport expansion. *The Annals of Regional Science* **52**(3), pp. 763–97.

NOACK, V. (1922). *Taschenbuch für Kommunalpolitiker*. Berlin, Stuttgart: Dietz Vorwärts.

PIECHOTTKA, O. (1979). *Dacharumnutzung Städtbauliches Planungsinstrument zur Erhaltung und Verbesserung der Stadtstruktur*. Berlin: Kommissionsverlag Kiepert KG.

PIERENKEMPER, T. (1987). The standard of living and employment in Germany, 1850–1980. An overview. *Journal of European Economic History* **16**, pp. 51–73.

REES, A. (1961). Real wages in manufacturing, 1890–1914. Princeton: Princeton University Press.

REICH, E. (1912). *Der Wohnungsmarkt in Berlin von 1840–1910*. Verlag von Duncker & Humblot.

SCHMIDTHUYSEN, F. (1928). Die Entwicklung der Wohnungsbauabgabe und des Geldentwertungsausgleichs bei bebauten Grundstücken (Hauszinssteuer) in Deutschland. *Finanzarchiv* **1**, pp. 162–255.

SILBERGLEIT, H. (ed.) (1913). *Statistisches Jahrbuch der Stadt Berlin. 32*. Jahrgang, enthaltend die Statistik der Jahre 1908 bis 1911 sowie Teile von 1912. Berlin: Verlag von P. Stankiewicz' Buchdruckerei GmbH.

SILBERGLEIT, H. (ed.) (1920). *Statistisches Jahrbuch der Stadt Berlin. 34*. Jahrgang, enthaltend die Statistik der Jahre 1915 bis 1919 sowie Teile von 1920. Berlin: Verlag von P. Stankiewicz' Buchdruckerei GmbH.

Statistisches Amt der Stadt Berlin. (1913). *Statistisches Jahrbuch der Stadt Berlin, 32*. Jahrgang, enthaltend die Statistik der Jahre 1908 bis 1911, sowie Teile von 1912. Berlin: Druck und Verlag von P. Stankiewicz' Buchdruckerei GmbH.

Statistisches Amt der Stadt Berlin. (1916). Groß Berlin Statistische Monatsberichte. Berlin: Verlag von Puttkammer & Mühlbrecht.

Statistisches Amt der Stadt Berlin. (1917). Groß Berlin Statistische Monatsberichte. Berlin: Verlag von Puttkammer & Mühlbrecht.

Statistisches Amt der Stadt Berlin. (1918). Groß Berlin Statistische Monatsberichte. Berlin: Verlag von Puttkammer & Mühlbrecht.

Statistisches Amt der Stadt Berlin. (1919). Groß Berlin Statistische Monatsberichte. Berlin: Verlag von Puttkammer & Mühlbrecht.

Statistisches Amt der Stadt Berlin. (1920). Groß Berlin Statistische Monatsberichte. Berlin: Verlag von Puttkammer & Mühlbrecht.

Statistisches Reichsamt. (1920). Die Teuerungsstatistik im Reich. *Vierteljahreshefte zur Statistik des Deutschen Reichs* **I**, pp. I.158–I.167.

STÖBER, R. (2014). *Deutsche Pressegeschichte*. Konstanz: UVK Verlagsgesellschaft.

TSOODLE, L.J. and TURNER, T. M. (2008). Property taxes and residential rents. *Real Estate Economics* **36**(1), pp. 63–80.

Villarreal, C. (2014). Where the other half lives: evidence on the origin and persistence of poor neighborhoods from New York City 1830–2012. https://sites.google.com/site/carlosrvillarreal/research

Wiel, P. (1939). Preis und Preispolitik im Kriege. *Zeitschrift für die gesamte Staatswissenschaft* **99**(4), pp. 614–50.

Willert, P.-F. (ed.) (1975). *Zusammenstellung der für die Anwendung des § 110 Abs. 1 BauO Bln wesentlichen früheren Bauordnungsvorschriften aus der Zeit vom 1. Juli 1853 bis zum 30. November 1925 / Im Auftrag des Senators für Bau- und Wohnungswesen*. Berlin: Senator für Bau- und Wohnungswesen.