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Assessing Rental Price Dynamics in Two Gentrified Neighbourhoods in Cologne by Means of a Dwelling Panel

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The study of neighbourhood change over time is a major focus of urban research. We argue that a dwelling panel, i.e., a panel in which dwellings are the sample unit, is the most appropriate method to study such changes, e.g., the process of gentrification or rental price dynamics. In this paper, we contextualize recent rent trends in urban neighbourhoods in Germany within both the theoretical context of gentrification processes and the legal framework of the German rental market. Then, we compare several methods for assessing rent price dynamics and introduce the dwelling panel as a method for studying rent trends in neighbourhoods. In the analyses, we particularly focus on the comparison between the increases in the costs of existing rental contracts and those of rents for new leases in two neighbourhoods that were in different phases of the gentrification process at the beginning of the observation period in 2010. We use face-to-face interview data from the Cologne Dwelling Panel (Friedrichs & Blasius 2015, 2020) with five waves conducted between 2010 and 2022, and sample sizes between 483 and 1009 dwellings. Applying fixed-effects regressions with the dwellings as units of analysis enables us to control for unobserved heterogeneity in the dwellings' features, while the effects of tenant changes, changes in household composition, and rental trends over time can be differentiated.

Keywords: dwelling panel; fixed-effects; rental prices; gentrification

1 Introduction

The shortage of affordable housing and the dynamics of rental prices have been major topics of discussion in German cities for many years. Housing-related expenditures are one of the main expenditures, if not the largest, for tenant households in Germany. Households in the lowest income quintile had to spend about 40% or more of monthly net household income on rent and other ancillary housing costs such as heating, garbage disposal, and water supply in the 2010s (Dustmann et al., 2018; Kohl et al., 2019). In particular, inner-city areas are subject to substantial rent increases and the transformation of rental apartments to condominiums, which can ultimately lead to the displacement of residents who cannot afford to live there anymore (Atkinson, 2012; Friedrichs & Blasius, 2020; Glatter & Mießner, 2022).

The problem of highly increasing rents in German cities has been widely discussed in German politics and the media for many years. High rents and a shortage of living space in cities have had consequences on policy (be they successful or not), such as rent control (the German Mietpreisbremse), which prohibits rents from increasing beyond a certain level above the average local rent. However, instruments such as rent control are not universally applicable (Kholodilin et al., 2018) and lead to further questions regarding, among other things, valid assessment methods for the average local rent (Kauermann et al., 2020). Despite the inarguable relevance of the topic, it is surprisingly difficult to obtain a clear and differentiated picture of the dynamics of rental prices in specific neighbourhoods. On the one hand, even large national panels such as the German Socio-Economic Panel Study SOEP (Schröder et al., 2020) do not allow for calculations on the level of urban districts, as there are too few cases in specific neighbourhoods. On the other hand, local indicators such as the rent price index are aggregated statistics where individual dwellings' trajectories, e.g., rent increases due to modernization measures or tenant change, cannot be assessed. Since price increases in existing rental contracts are limited by law, sharp price growth is only possible under two conditions: firstly, in the case of new leases, and secondly, in the case of extensive modernizations. As there is only very limited legal control over rent increases for new leases, the principle of supply and demand applies here—and the latter can be very high, especially in gentrified areas in major cities. Modernizations that lead to an improvement in housing conditions, e.g., the installation of more energy-efficient heating systems, can be passed on to the tenants at a rate of up to 11% of the costs (8% in regions with particularly competitive housing markets). In the

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case of formerly inexpensive apartments, such measures can almost double the rent.

In this paper, we illustrate a new way of distinguishing between the effects of annual increases and new rental contracts on rental price dynamics. For this purpose, we use data from a dwelling panel in two residential neighbourhoods in Cologne between 2010 and 2022 (Friedrichs & Blasius, 2015, 2020). Unlike a "conventional" panel that follows individuals or households over time, in a dwelling panel the units of investigation are the dwellings themselves. In the dwelling panel the tenants (or owners) act as the "spokespersons" of the dwellings (Friedrichs & Blasius, 2020). Conducting fixed-effects regressions with the dwellings as units of analysis and rent per square meter as the dependent variable allows us to control for unobserved heterogeneity in the dwellings' features, while the effects of tenant changes, changes in household composition, and time-related rental development can be differentiated.

After a short overview of gentrification processes in urban residential areas and some specific aspects of the German rental market, we discuss several methods for assessing the dynamics of rental prices and compare these to the dwelling panel. In the following analyses, we first compare mean rent change for dwellings with and without tenant change between panel waves. In the second step, we calculate fixed-effects regressions to show how rent per square metre has evolved. Here, we particularly focus on the comparison of rental dynamics in two neighbourhoods in Cologne (Germany), Deutz and Mülheim, that started out in different phases of the gentrification process.

2 Background

2.1 The process of gentrification

Since the mid-1960s, the revaluation of residential areas close to the centres of large cities has been termed "gentrification" (Glass, 1964; Lees et al., 2015). Gentrification describes an increase in the proportion of (upper) middle-class residents in former working-class residential areas located in the inner-city areas of major conurbations. Because these areas were subject to intensive non-residential urban expansion until the 1970s, little investment was made in the residential real estate; these were residential areas intended for the working classes, immigrants, and other low-income households. Households that could afford it moved to suburban areas to live in their own houses with their own garden. These developments began to change with increases in digitalization, the inner city becoming less important for the administration of companies and ceasing to expand further. Since the dwellings in the buildings in these areas were relatively large—often spacious apartments from the Wilhelmine period, with high ceilings and uniformly sized rooms—they were particularly attractive to well-earning, mostly childless residents who wanted to enjoy the advantages of the inner city. In line with this new demand, there was extensive modernization of apartments and houses. This process and the associated increase in rents can also lead to the—direct or indirect—displacement of tenants (Beran & Nuissl, 2019; Marcuse, 1986). In addition, gentrification is accompanied by infrastructural changes such as the opening of new shops, restaurants, and cultural venues, as well as a concomitant change in the image of the neighbourhood in question (Carpenter & Lees, 1995; Zukin, 2009).

Gentrification processes are frequently described using stage models (Berry, 1985; Friedrichs & Blasius, 2020; Kerstein, 1990). In the first stage, often called "infiltration", "pioneers"—young people with a high educational level, but low income, often students or artists—are attracted by low rental prices and gradually move into the area. The neighbourhood is still characterized by its long-established, predominantly lower social status population, often working-class people, older tenants, and immigrants. The second stage, "invasion", is characterized by an increasing influx of pioneers and some early "gentrifiers"—more well-off residents, e.g. so-called "dinkies" (double income, no kids), who respond to the incipient revaluation of the neighbourhood. At this stage, the demand for apartments, as well as land values and rental prices, starts to increase, and an increasing number of dwellings become modernized. In addition, new shops and restaurants open to cater to the demands of the new residents, and attention is drawn to changes in the area by local media. Investors start to show an interest in real estate in the neighbourhood. This is followed by the third stage, "gentrification": due to ever-rising rents and land values, long-term residents, as well as some pioneers, are displaced. Simultaneously, more gentrifiers move in, and pioneers become gentrifiers by definition after finishing their studies and entering the job market. Further, an increasing number of rental dwellings are converted into owner-occupied condominiums. The last stage of the process is referred to as "dominance": the area is remodelled according to the demands of high-status groups, with new restaurants, boutiques, and retailers; long established bars and shops, but also the non-commercial projects of early gentrifiers, begin to close down. Modern dwellings and commercial sites in the area are advertised on an international scale and often managed by international investors. The area becomes widely known as a tourist destination.

When comparing the gentrification processes in German cities with those in British, Canadian, or U.S. cities, one must consider that German law stipulates that rental contracts for non-commercial use be unlimited in duration, as well as ensuring relatively strong tenant protection in lease agreements (see below). Thus, the process of gentrification is slower than in most other countries, often barely visible within time periods shorter than three or four years (Üblacker, 2018).

Nevertheless, gentrification processes and the associated increases in rents and land values in—formerly—less affluent neighbourhoods contribute to the fraught housing situation in German cities (Baldenius et al., 2020). Even moderate increases in rent may pose substantial problems for low-income households, and due to the general trend of re-urbanisation, there are few alternatives for affordable housing which are not far away from the urban centre in large cities.

2.2 Regulations of the German rental market

In comparison to other countries, Germany has a high proportion of rental dwellers (53% in 2018) relative to homeowners (Statistisches Bundesamt, 2020); in cities, more than 70% of residents are tenants (Kohl et al., 2019). Existing rental contracts are strongly regulated by law; they are contingent on a local standard rate that is often determined with reference to a rent price index (the so-called Mietspiegel). This index indicates which rent prices have been agreed upon in the area in question within the last six years for apartments comparable in size and furnishing. Further, landlords are not allowed to increase the rent by more than 20% (15% in many cities) within three years, which is referred to as the Kappungsgrenze (rent cap). However, rents can be substantially increased when modernizations are undertaken, such as the improvement of thermal insulation, the installation of solar panels, or the replacement of (functioning) radiators on the walls with underfloor heating[1]. Up to 11% (8% in areas with the most competitive housing markets) of the costs for these measures can be recouped through the annual rent. Therefore, it is possible for formerly cheap rents to double due to modernization measures, thus facilitating the displacement of tenants who cannot afford the new rent. However, since it is almost impossible for poorer households to find a new, similarly sized and well-equipped apartment in the same area for a similar price, especially in residential areas close to the city centre, many households decide to pay the new rent and cut expenses elsewhere, e.g., forego holidays or try to spend less money on domestic appliances, clothes, and food (Blasius, 1993; Friedrichs & Blasius, 2020).

The private housing sector in Germany is characterized almost exclusively by tenancy agreements of unlimited duration, which can only be terminated by the landlord in the event of demonstrable misdemeanours on the part of the tenants (failure to pay rent over a longer period of time, destruction of in-house facilities, etc.) or when the owner or members of their family want to use the dwelling personally. In the event of a change of ownership, existing contracts are protected for at least seven years. In other words, it is not permissible to buy an apartment and terminate the existing tenant's contract only some months later by claiming personal use. When conversions of rental apartments to condominiums take place, it is almost exclusively after a tenant has moved out. On the real estate market, vacant apartments are therefore significantly more expensive than rented ones.

Since 2015, German cities have been able to introduce a cap on rent prices (Mietpreisbremse) in areas with a competitive housing market. According to this law, landlords may not demand a rent price more than 10% above the comparable local rent (often defined by rent indices) when a new rental contract for a dwelling is agreed on. However, the Mietpreisbremse is only effective in areas where there were previously very high increases in rents for new contracts (Kholodilin et al., 2018). In addition, it is almost impossible to enforce if new tenants themselves are willing to pay a price that is higher than the legal limit. Despite these attempts at market regulation, it is ultimately a question of supply and demand, and particularly in gentrified areas, there is high demand and low supply. Consequently, the gap between average rents and rents in new lease agreements significantly increased in the 2010s, particularly in large cities (Dustmann et al., 2018, p. 37).

We derive two hypotheses from the evidence to date and from the existing conditions for rented dwellings in Germany:

1. The rent increases in new leases are significantly higher than rent increase over time in existing rental contracts.

2. In an area that is in a more advanced stage of gentrification, rent increases both in new leases and in existing rental contracts are higher compared to an area in an earlier stage of gentrification.

2.3 Assessing rent price dynamics

There are several possible approaches to calculating the developing trends in rents. First, many cities and towns regularly publish rent price indices that are meant to serve as a reference for the pricing of (new) rental agreements. However, the quality of these indices varies widely—while some are based on surveys of tenants, landlords, or both, using different sampling and estimation methods (Kauermann et al., 2020), others merely consist of figures that are determined in discussions between local tenant and landlord associations (Sebastian & Memis, 2020; Voigtländer, 2016). Thus, rent price indices may reflect trends on a local level, but do not allow for in-depth analyses (e.g., rent burden of households, increase in rental price for new leases and for existing leases). In addition, data are often not published on the level of districts or postal codes, and certainly not on the level of neighbourhoods; they often consist merely of aggregate statistics

[1] If a non-functioning radiator is replaced by a new one, this is renovation and not modernization and cannot be passed on to the rent.

for residential areas rated as "relatively poor", "average" or "very good".

Another possibility is to calculate rent developments using data from online platforms; most prominent here is the German market leader for online property, immoscout24.de, which had an estimated market share of 70% in 2016 (Bundeskartellamt, 2016). While the data allow for in-depth analyses at the municipality level (Boelmann & Schaffner, 2018), the initial prices online are not necessarily identical to the final agreement between landlord and tenant. In general, the calculation of rent price developments using online platform data is biased, both because only new lettings are included and because, even in this sector, prices may be overestimated as a substantial share of flats is not advertised, but simply "passed on" privately to friends and acquaintances, usually with less increase in rent than on the free market (Kauermann et al., 2016).

A different approach lies in the use of national survey and/or census data. Regular, large-scale household surveys such as the Income and Expenditure Survey (Einkommens- und Verbrauchsstichprobe, EVS), or the German Socio-Economic Panel (SOEP) provide data on household income and expenditures for housing costs (see e.g., Alcántara & Romeu Gordo, 2020; Backhaus et al., 2015; Dustmann et al., 2018). Though some of these data sources can be analysed down to the level of individual postal codes, comparable neighbourhoods must be aggregated to reach an adequate number of cases for analyses (see e.g., Drever, 2004; Kress et al., 2020). Further, postal code areas often consist of several neighbourhoods that are heterogeneous in terms of the social composition of residents, building structure, and rent level. Thus, national survey data are suitable for following general trends in rental price development, but cannot be used to study changes in specific neighbourhoods.

Another important data source is the German Mikrozensus, a random sample of 1% of the population, which has clusters of apartments as sampling units and therefore enables the study of rental prices down to the level of districts and—theoretically—even neighbourhoods. Participation in the study is mandatory, the selected households are interviewed up to four times on family and household characteristics, labor market and employment, occupation, education and migration. Articus et al. (2020, p. 20), however, applied model-based small-area estimation techniques in the City of Cologne and conclude that "the data is not suitable for evaluations at this very fine resolution level". The German 2022 census also collected data on dwellings and rent prices, which provides a wide database that offers analytical possibilities at the level of neighbourhoods. Both Mikrozensus and census data are cross-sectional[2]—rent prices can be analysed in conjunction with the duration of residence of the current household, but the rent before the in-move of the current household is not known.

In contrast, a dwelling panel where dwellings are the units of analysis allows for detailed investigations on the level of neighbourhoods. By design, it comprises information both on residents who stay in the neighbourhood and, in addition, information regarding new residents moving into the neighbourhood, replacing those moving out. Therefore, the dwelling panel allows us to obtain detailed information about the changes in the composition of social groups, their attitudes, their socio-demographic characteristics, and it includes information on the dwellings such as rents, size, number of rooms, and the rental status. In contrast to other data sources, the dwelling panel provides unbiased information about the rent price of a specific dwelling before and after a tenant change. As the basis of the dwelling panel is a random sample of the area under study, dwellings are included irrespective of their status on the housing market. Therefore, the dwelling panel offers a unique data base for the assessment of rent prices in a neighbourhood and the calculation of the net effect of tenant changes on rent.

To give an example comparing repeated cross-sectional surveys, person/household panels, and dwelling panels: In a repeated cross-sectional survey, changes in age in a specific neighbourhood can only be interpreted at the aggregate level. In a person/household panel, the average age in the first wave is $\overline{x}$, in the second wave it is $\overline{x}+t$, with t being time between two waves. By definition, the age of each remaining resident increases by t; since younger individuals change dwellings more often than older ones, the staying residents are no longer representative of the neighbourhood after a short time. For the dwelling panel, the average age in the first wave is $\overline{x}$, like in the conventional panel; in the second wave it is $\overline{x}+t$ only for stayers. Since those moving in and out are included in the calculation, changes in age in the neighbourhood can be calculated, and the new age distribution remains representative over time (Friedrichs & Blasius, 2015, 2020, for more details on the dwelling panel).

2.4 The composition of rent prices

In Germany, gross rent is composed of net rent (Kaltmiete, literally "cold rent") and ancillary costs for utilities such as heating, water supply, wastewater, garbage disposal, and shared facilities such as elevators, electricity in the stairwells, and a share of the relevant property taxes. The total amount of rent that the tenants must pay is referred to as Warmmiete ('warm rent', i.e. the "cold" price plus ancillary rental costs). Laws such as the rent cap, however, only pertain to net rent, as the influence landlords can have on most of these ancillary costs is rather limited. Here, other factors such as individual heating behaviour, but also general trends, such

[2]The Mikrozensus has a panel component, too, but information on dwellings and rent prices is only asked every four years and thus not part of the panel module.

as the (temporary) sharp increase in energy costs following Russia's invasion of Ukraine in February 2022, play an important role. As such, differences in ancillary rental costs are not directly associated with neighbourhood effects such as gentrification and affect both tenants and homeowners. On the one hand, the specific energy provider has a strong effect. In the energy crisis in 2022, exacerbated by the interruption of gas supplies from Russia, prices from private suppliers rose by up to 300% and even more, according to media reports, while some municipal suppliers completely refrained from price increases. On the other hand, the entire sum of ancillary rental costs is not a valid indicator for individual consumption, as parts of these costs are incurred for the whole building and allocated to the tenants proportionally (based on the size of the flat and the number of persons residing there). The regulations for the calculation of these costs can be read in the 808 pages of the Handbuch der Mietnebenkosten (Handbook of Ancillary Rental Costs) (Schmid, 2016). That the calculation of these costs very often leads to disputes between tenants and landlords is unsurprising; according to Kimmeskamp (2018), every second calculation of ancillary costs is wrong.

For these reasons, theoretically it would be desirable to be able to differentiate between trends in the net rent and ancillary rental costs. However, our experience in the collection of data is that most respondents are not able to report exact numbers for net rent, heating, and other costs. They know—if at all—the amount they pay to the landlord each month, which is the gross rent (Warmmiete). This problem is partly compensated, however, by the use of dwelling panel data. As we are assessing rent prices in the same dwellings over time, gross rent can—theoretically—be decomposed into dwelling-specific ancillary costs (costs for elevators, property tax etc.), energy costs, and cold rent. Individual differences in energy costs (related to heating behaviour, water usage etc.) are not likely to be systematically related to tenant change, our main variable of interest, while an increase in dwelling-specific ancillary costs affects tenants just as an increase in net rent would. Since parts of ancillary costs are often calculated dependent on the number of people in the household, we use this number as a control variable. In summary, when we talk about "rent" in the following, we refer to gross rent, as this is the amount tenants have in mind when asked about how much rent they pay.

2.5 The areas of investigation

The areas under study are two neighbourhoods in Cologne, Germany; one is located in the district Deutz and the other one in the district of Mülheim (see images in Friedrichs & Blasius, 2016, pp. 18–19). Both districts are located on the eastern side of the river Rhine and both are very well connected to the city centre by public transport. Deutz is a former working-class district that has, since the early 1980s, been experiencing an increased influx of white-collar workers. The whole district has roughly 15,000 inhabitants. The proportion of people with a migration background increased from 28% in 2010 to 33.7% in 2021, which is below the average of Cologne (40.5% in 2021). The proportion of households who received benefits under SGBII (basic state security scheme for jobseekers) decreased from 8.9% in 2010 to 6.7% in 2021, which is also below the average of 10.6% in Cologne in 2021 (Stadt Köln, 2022a).

With over 42,000 inhabitants, Mülheim is Cologne's most populous district, a traditional working-class neighbourhood with a heterogeneous population composition; in 2010, in the entire district 49% of the residents had a migration background, whereas in 2021 it was 55%. In Mülheim, 21.1% of households received SGBII benefits in 2010, 20.3% in 2021 (Stadt Köln, 2022a).

While these numbers give an overview of the districts as a whole, in the following we report calculations from two neighbourhoods within the districts that were selected as natural areas (see Friedrichs & Blasius, 2015). Consequently, the characteristics of the neighbourhoods differ in some respects from those of the entire districts. For example, in the municipal statistics of Cologne (Stadt Köln, 2022b), average flat size in Deutz and Mülheim is denoted as about 65 square meters, whereas in our sample the average flat size is higher, particularly in the neighbourhood in Deutz (76 sqm; Mülheim 72.3 sqm; see also table A1 in the appendix). This difference can be attributed to our deliberate selection of readily distinguishable, pre-existing areas in the two districts: while neighbourhoods with a substantial share of houses from the Wilhelmine period (and relatively large apartments) were deemed particularly susceptible to gentrification processes and therefore selected for the dwelling panel sample, areas with a high share of tower blocks, in contrast, are not part of our sample.

The data collected in the dwelling panel support the assumption that both areas are affected by gentrification, but at a rather slow pace (see Friedrichs & Blasius, 2020) In Mülheim, the process of gentrification started later than in Deutz. At the time of the first study period, from 2010–2014, the selected neighbourhood in Mülheim could be classified as being in the "invasion" stage, whereas the selected neighbourhood in Deutz was already in the "gentrification" stage (Friedrichs & Blasius, 2016). In the last decade, the gentrification process in Mülheim notably accelerated; the part of the district we selected was classified as possibly subject to a revaluation of buildings and infrastructure and displacement of tenants in 2021 (ALP—Institut für Wohnen und Stadtentwicklung, 2021)—a sign that (parts of) the area are now entering the "gentrification" stage. In reaction, the Cologne city council resolved the application of a preservation statute that protects tenants by a stronger control of building and modernization activities (Soziale Erhaltungssatzung). This

preservation statute is part of the German Building Code and authorizes municipalities to define areas in which demolition, alteration, or changes of use—which also include the conversion of rental apartments into owner-occupied apartments and modernization measures—are subject to approval. Approval can be denied if the composition of the residential population is to be preserved (Franke et al., 2017; Stein, 1990).

3 Data and methods

The Cologne Dwelling Panel currently consists of five waves that were conducted between 2010 and 2022 using face-to-face interviews (Blasius, 2020)[3]. Extensive walkthroughs and expert interviews were conducted prior to the first panel wave in 2010 to define the demarcations of the chosen neighbourhoods (Friedrichs & Blasius, 2016). The gross sample of the first wave of the Cologne dwelling panel was drawn as a random person sample in the designated research areas by the Cologne Office of Statistics and Population (N = 2372). Respondents were sent an invitation letter and subsequently visited by interviewers, resulting in 1009 completed interviews. In fact, the first wave of our dwelling panel is identical to a panel study of persons or households. The only difference is that the exact positions of the flats within the apartment buildings were recorded after successful interviews. In practice, this was done using the doorbell board at the main entrance[4], with residents' names on the doorbells (Friedrichs & Blasius, 2015). The 1009 dwellings that were successfully interviewed in the first wave became the gross sample for subsequent waves. Before each new wave, there was a cross-check of the names on the bell boards so that personal invitation letters could be sent to the old and new panel members. "Staying" tenants were interviewed again, whereas respondents who had moved out between waves were replaced by a person from the new household that had moved into the respective apartments. Whenever a household left the dwelling, the dwelling itself remained in the sample; it did not change its location, it only received a new "spokesperson". The only permanent loss of units of observation is due to buildings being demolished (which is rare) or dwellings being converted to office or other commercial space.

While the first four waves were conducted in short succession, from 2010 to 2014, there is a gap of eight years between wave four and wave five (2022). In between two waves, a substantial number of tenants (between 11 and 16% between each of the first four waves, about 50% between wave four and five) were replaced. Furthermore, there was a change in spokesperson when the former respondent moved out of a joint household but at least one other member of the household remained in the dwelling, e.g., in the case of divorce or when a grown-up child moved out. In these events, an attempt was made to interview a person aged 18 years and older from the new household; for pragmatic reasons and to reduce the number of possible refusals, this usually was the person with whom the interviewer had the first face-to-face contact. Table 1 shows samples and numbers of completed interviews in all five waves.

In the second and following waves, table 1 differentiates between staying residents and new residents, i.e., in-movers. In the second wave, 784 out of 892 persons (88%) of all stayers could be convinced to participate a second time. Of those, 28 interviews were conducted with new target persons, as the household itself had not moved, but the person who had been interviewed in wave 1 had moved out in the meantime. Of the 117 new target persons in wave 2, the in-movers, 94 were eligible and willing to be interviewed (80%). Regardless of whether the spokespersons of the apartments moved out, refused, or were not available, the 1009 apartments remained as sample units in all four waves.

The on-site inspection of dwellings before wave 5 showed that the dwelling panel sample was reduced by 53 cases due to demolished buildings and dwellings that had been converted to office or other commercially used space. In order to account for losses and an expected decline in response rates, in wave 5 a refreshment sample was drawn, consisting of a "twin dwelling" for each panel dwelling. For this purpose, an immediately neighbouring dwelling (a flat in the same building, ideally on the same floor or one floor up or down; in the rare cases of individual houses, the house next door) were included in the sample. In addition, apartments in newly erected buildings were sampled.

All panel studies suffer from the problem of attrition—if units of analysis become unavailable or refuse in the course of the panel study, the sample loses both statistical power, and, in the case of systematic attrition, representativeness (Lepkowski & Couper, 2002; Uhrig, 2008). In the case of the dwelling panel, the hazard of permanent attrition is low, as the loss of dwellings due to changing contact details (i.e., address) is an unlikely case, and dwellings whose current spokespersons were unavailable or refused to participate in a certain wave can be re-contacted in the next one. In the case of a change of residents, the new residents' willingness to give an interview should be seen as independent from their predecessors. However, there might be bias due to selective non-response. From table 1, it becomes apparent that in the case of yearly interviews, the response rate

[3]The data and questionnaires of the first four waves are accessible via the self-archiving Datorium at GESIS (https://doi.org/10.7802/2523, version 1.0; an updated version 1.1. will soon be published under https://doi.org/10.7802/2523). The cumulated data set including data of the fifth wave will be published via GESIS after the end of the current DFG funding period in spring 2024.

[4]In Germany, almost all apartments and houses have a doorbell board at the front door; this helps visitors and delivery services to quickly find the household they are looking for.

Table 1

Samples and obtained interviews

	Total		Staying residents		New residents	
	N	%	N	%	N	%
Wave 1, Main field period 6/2010–10/2010						
Gross sample	2372	100				
Neutral failures						
Moved out	120	5	-	-	-	-
Permanent not available	43	2	-	-	-	-
Net sample	2209	100	-	-	-	-
Not available	408	18	-	-	-	-
Refusals	792	36	-	-	-	-
Interviews	1009	46	-	-	-	-
Wave 2, Main field period 09/2011–12/2011						
Sample	1009	100	892	100	117	100
Not available	68	7	56	6	12	11
Refusals	63	6	52	6	11	9
Interviews	878	87	784	88	94	80
(of those new target persons)			(28)			
Wave 3, Main field 3/2013–06/2013						
Sample	1009	100	843	100	166	100
Not available	84	8	50	6	34	21
Refusals	115	11	104	12	11	7
Interviews	810	81	689	82	121	73
(of those new target persons)			(12)			
Wave 4, Main field period 0 09/2014-12/2014						
Sample	1009	100	848	100	161	100
Not available	118	12	64	8	54	34
Refusals	144	14	125	15	19	12
Interviews	747	74	659	78	88	55
(of those new target persons)			(22)			
Wave 5, Main field period 06/2022–12/2022						
Panel sample	953	100	460	100	493	100
Not available	223	23	99	22	124	25
Refusals	247	26	127	28	120	24
Interviews	483	51	234	51	249	51
(of those new target persons)			(24)			

	Overall		Twin flats		New Buildings	
	N	%	N	%	N	%
Refreshment sample of "twin flats" and new buildings						
Sample	1030	100	965	100	65	100
Not available	305	30	282	29	23	35
Refusals	293	28	283	29	10	15
Interviews	432	42	400	42	32	49

of experienced panellists was higher compared to in-movers who participated for the first time. Therefore, dwellings with long-term residents might be over-represented in the data. In this respect, the results of wave five are a good sign: in the dwelling sample, there is no difference in the response rate between staying and new residents. In the refreshment sample, the overall response rate is almost 10 percentage points lower compared to the panel sample, but regarding duration of rental contract, the numbers match those of the original panel: there are also about 50% of respondents who have been living in their dwelling before 2015, and 50% who moved in after the data collection of the fourth wave was finished. Therefore, we are confident that our data are not biased regarding this important aspect.

In all waves, information on both the dwellings' and the respondents' characteristics, as well as those of other household members, was collected. In addition, respondents were asked about their attitudes towards the neighbourhood and several lifestyle preferences. For the analysis at hand, the main variable is the total monthly rent, including ancillary costs (Warmmiete).

We first show how the average total monthly rent, as well as the average rent per square metre, evolved between 2010 and 2022 in the two neighbourhoods. Then, we calculate average change scores in rent between two waves conditional on the tenant status (moved or not) using Welch's t-tests (due to unequal variances between the groups). In the final step, we conduct fixed-effects regressions with rent per square metre as the dependent variable. In the fixed-effects model, the time mean is subtracted from each variable. This "within transformation" serves to eliminate unobserved time-invariant unit-specific—that is, dwelling-specific—heterogeneity. We do this because it is reasonable to assume that there is a multitude of time-invariant unobserved dwelling characteristics (e.g., the presence of a balcony, the amount of street noise, year of construction) that influence the rent price and may also be correlated with the number of tenant changes. In the fixed-effects model, the net effects of time and tenant change on rent can be estimated with a—relative—minimum of bias[5]. As a modified Wald test (Greene, 2000, p. 598) indicates the presence of heteroscedasticity, robust standard errors are used.

In the first model, only wave (year) is used as explanatory variable, whereas in the second model the event of tenant change[6] and the number of persons in the household is added. Using this stepwise approach, we are able to separate the variance in the development of rents into regular yearly increase and increase due to new rental contracts. We first analyse the development during the years 2010 to 2014 and then add the data for the 2022 wave in order to separate different stages of rent development.

4 Results

4.1 Mean changes in rent, rent per square metre and rent per square meter per year/wave

Table 2 shows the development of mean rental price and mean rent per square meter over the five panel waves in the two neighbourhoods in Cologne-Deutz and Cologne-Mülheim. Of all panel respondents, about 20% are owner-occupiers, who are not included in the following analyses as they do not pay rent. In the 2010s, in Deutz the average rent is about €50–€65 higher compared to Mülheim, and the difference in rent per square meter between the two neighbourhoods amounts to approximately €0.40–€0.60. In 2022, there is almost no difference between the two areas anymore, which suggests a steeper gradient of rent increase in the neighbourhood in Mülheim[7]. This is also reflected in the proportional increase in gross rent per square meter: from 2010 to 2022, it is about 30% in Deutz, but almost 40% in Mülheim. For comparison: for the entire city, an increase in offered rents (i.e., new leases) of about 40% between 2011 and 2019 is estimated (Stadt Köln, 2021)[8].

To demonstrate the increase in rent due to new rental contracts, we analyse the differences in rent and rent per square metre between old and new residents. For this purpose, we compute the mean average change score Δ between two waves (the amount of rent in wave i minus the amount of rent in $i-1$) and compare the mean change in rent for dwellings with and without tenant change between the waves (table 3). Between waves 1 and 2, 2 and 3, and 3 and 4, respectively, there are about 20% of tenants reporting no change in rent price (between waves 4 and 5, there are only four dwellings with no reported change). In the case of no change in rent price, the respective Δ value is zero, but these cases are also included to prevent a biased estimation of change. As the two groups have unequal variances, the significance of the mean difference is assessed by Welch's approximation. Cohen's d for unequal variances is reported as a measure of effect size.

Both change in total rent and rent per square meter differ significantly depending on the dwelling's tenant status.

[5] A significant Hausman test also indicates that a fixed-effects model is preferable over random effects.

[6] Households who moved into their flat within the year before the first panel wave, that is, after June 2009, are counted as tenant change in wave one.

[7] In both areas, rent and rent per square meter are approximately normally distributed in each wave, with some outliers towards the right (i.e. very expensive rents).

[8] We would have liked to relate our results to the developments reported in a qualified rent index—however, the city of Cologne only has a simple rent index that is not based on the collection of primary data and can therefore not be considered as a valid source of information. Further, it only differentiates between three categories of residential areas (relatively poor, standard, and good area), without taking specific city areas or districts into account.

Table 2

Statistics of mean rent and mean rent per square meter in Deutz and Mülheim, 2010–2014, 2022

	Rent			Rent per square meter					
	Mean	Std.Dev.	Median	Mean	Std.Dev.	Median	Min	Max	N
W1, Deutz	693	250	650	9.7	2.0	9.7	4.5	18.0	478
W1, Mülheim	632	235	598	9.3	1.8	9.3	4.7	17.8	313
W2, Deutz	731	257	690	10.0	2.2	10.0	4.5	17.0	424
W2, Mülheim	681	277	608	9.6	1.9	9.5	5.5	17.8	259
W3, Deutz	752	271	700	10.4	2.3	10.2	5.3	18.5	401
W3, Mülheim	701	277	630	9.8	1.8	9.8	5.6	17.8	230
W4, Deutz	767	276	700	10.5	2.3	10.5	5.8	17.4	332
W4, Mülheim	698	267	627	10.0	1.9	10.0	5.2	17.8	224
W5, Deutz[a]	930	358	850	12.5	3.4	12.1	4.0	26.1	223
W5, Mülheim[a]	922	378	850	12.4	2.9	12.5	6.2	22.2	148
W5, Deutz[b]	941	367	850	12.7	3.3	12.8	4.0	26.1	432
W5, Mülheim[b]	927	379	850	13.0	3.3	12.7	6.21	24.4	298

[a] Panel dwellings only [b] Panel dwellings, "twin dwellings" and dwellings in new buildings

Table 3

Mean average change in rent and rent per square meter by tenant status[a] (panel dwellings only), Welch's T-test

		Rent		Rent per sq. meter	
	N	Δ	Std. Dev.	Δ	Std. Dev.
Wave 1 to 2					
Tenant change	75	44.5	94.0	0.61	1.14
No tenant change	567	22.3	62.0	0.33	0.86
Welch's T		1.99		2.06*	
Cohen's d		0.33		0.31	
Wave 2 to 3					
tenant change	80	56.1	118.7	0.83	1.47
No tenant change	469	22.2	57.9	0.31	0.81
Welch's T		2.51*		3.09**	
Cohen's d		0.48		0.56	
Wave 3 to 4					
Tenant change	41	63.7	117.0	0.87	1.41
No tenant change	418	13.4	56.5	0.19	0.79
Welch's T		2.72**		3.04**	
Cohen's d		0.79		0.79	
Wave 4 to 5					
Tenant change	138	243	242	2.96	2.50
No tenant change	124	117	142	1.54	1.68
Welch's T		5.21***		5.44***	
Cohen's d		0.63		0.66	

[a] Cases where rent/square meter decreased more than 1.5 €/m² between two waves were not taken into account.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

While the average increase in rent between waves one and two is €22.3 for staying tenants, a new rental contract means an average increase of €44.5. Across waves one to four, there is a widening gap between old and new rental contracts and an increase in the effect size of the mean difference in rent and rent per square meter. The differences between waves 4 and 5, comprising eight years (2014 to 2022), shows an increase that is comparable to the difference between waves 3 and 4 in the dwellings without tenant change (€117 or €1.54 per square meter during eight years; on average €15 or €0.19 per square meter per year). The difference between waves 4 and 5 in the event of a tenant change is relatively high: €243 or €2.96 per square meter. However, these numbers should be interpreted with caution, as due to the research design, there may have been additional unobserved tenant changes between 2014 and 2022.

The results support our first hypothesis—across the waves, rent increase in new leases, both in total rent and rent per square meter, is significantly higher than time-related rent increase in existing rental contracts. Furthermore, the variances in both total rent and rent per square meter are significantly higher for dwellings with a new rental contract compared to staying tenants. This indicates that there is considerable variation in the amount of rent increase in case of a new rental contract: while for some dwellings, the rent almost stayed the same, other tenants experienced a considerable increase in rent.

4.2 Fixed-effects regression

In the final step of our analysis, we conduct, separately for the two neighbourhoods, fixed-effects regressions with rent per square metre as the dependent variable. We first consider the period from 2010–2014, as the two areas demonstrably were in different phases of gentrification, and both rent development and tenant change were continuously measured by yearly panel waves. In the first step (model 1), only the year is used as independent variable; in the second step (model 2), tenant changes in the observation period are added. In addition, we control for changes in the number of household members as a proxy for possible changes in heating and water utilisation behaviour that might impact ancillary costs. Table 4 shows the solutions for the two selected neighbourhoods, with the (unstandardized) regressions coefficients and their standard deviations in the upper part of the tables.

In both neighbourhoods, model 1 shows that there is a highly significant yearly increase in rent per square meter of €0.22 in Mülheim and €0.29 in Deutz[9]. In Mülheim, the R-square for model 1 indicates that 11% of the time-related variance in rent per square meter can be explained by the panel wave. In Deutz, this amount is higher (16%).

With respect to the regression coefficient for tenant change in model 2, the estimation shows that in Mülheim, the average rent per square metre increases by about €0.47 in the event of one tenant change and by €0.53 when the dwelling's tenant(s) change(s) more than once. In Deutz, rent increases in case of tenant changes are higher: €0.84 with one tenant change, and €0.97 for two or three tenant changes. In addition, the yearly effect of rent increase diminishes to €0.18 and €0.22 , respectively, when the variable tenant change is added to the model. Thus, the increase due to new rental contracts clearly exceeds average yearly rent increase. In the observation period from 2010 to 2014, the estimated rent increase for a dwelling with no tenant change in Deutz is $0.22 \cdot 3 = 0.66$ Euro. If this dwelling changes its tenant twice or more, the estimated rent increase adds up to $0.66 + 0.97 = 1.33$ Euro per square meter. Changes in the number of household members are not significant in both neighbourhoods, indicating that changing ancillary costs due to changes in household composition are not a relevant explanatory factor for rent developments. In model 2, the R-square rises to 0.127 in Mülheim and to 0.205 in Deutz, showing that the independent variables capture up to 20% of the time-related variance within individual dwellings.

These results partly confirm the second hypothesis concerning rent increases in areas in different stages of the gentrification process. While the yearly increase in rents in Deutz—which was in a later stage of the gentrification process than Mülheim in the 2010s—is only marginally higher, the influence of tenant change on rent is considerably stronger in Deutz between 2010 and 2014. This indicates that in an area which was in a more advanced stage of gentrification, new rental contracts contribute particularly strongly to rental price dynamics.

Finally, we add the data for the 2022 wave to the model to see how the trend has developed in the last decade. Table 5 shows that, from 2010 to 2022, the linear increase of rent per year is, on average, similar (about €0.25 per year) in the two neighbourhoods. In relation to the model covering four years only (table 4), the explained variance of the year (R-square within) in the twelve-year period quadrupled in the neighbourhood in Mülheim (from 11 to 45%), while in Deutz it doubled (from 16 to 35%). This result suggests that, despite similar yearly figures, the overall impact of rent increases after 2014 is stronger in Mülheim than in Deutz. As the neighbourhood in Mülheim was on a lower rent level at the beginning of the observation period, the result supports the assumption that the gentrification process has accelerated in Mülheim compared to Deutz.

Again, in model 2 we add tenant change(s) and number of household members. In the neighbourhood in Mülheim, the average rent per square metre increases by about €0.69 and

[9] In order to control for possible non-linear changes in the observation period, we also ran a model with year dummies as a robustness check (see table A2 in the appendix). This specification shows that there are small deviations from linearity in the yearly increase, but overall, results are robust.

Table 4

Fixed-effects regressions on rent per square meter, Cologne-Mülheim and Cologne-Deutz, 2010-2014

	Cologne-Mülheim				Cologne-Deutz			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Year	0.22***	0.03	0.18***	0.03	0.29***	0.03	0.22***	0.05
One tenant change	-	-	0.47*	0.19	-	-	0.84***	0.16
Two or three tenant changes	-	-	0.53*	0.25	-	-	0.97***	0.27
Number household members	-	-	0.15	0.09	-	-	0.04	0.09
Constant	9.14***	0.07	8.76***	0.21	9.41***	0.06	9.25***	0.20
R-square (within)	0.107		0.127		0.159		0.205	
N (dwelling-years)	1018		1018		1628		1628	
N (dwellings)	335		335		497		497	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 5

Fixed-effects regressions on rent per square meter, Cologne-Mülheim and Cologne-Deutz, 2010-2022

	Cologne-Mülheim				Cologne-Deutz			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Year	0.27***	0.02	0.23***	0.02	0.25***	0.02	0.20***	0.02
One tenant change	-	-	0.69***	0.19	-	-	1.17***	0.18
Two tenant change	-	-	0.89**	0.27	-	-	1.39***	0.28
Three or four tenant changes	-	-	2.02***	0.56	-	-	2.06***	0.53
Number household members	-	-	0.20*	0.08	-	-	0.06	0.09
Constant	9.04***	0.06	8.47***	0.18	9.49***	0.06	9.15***	0.20
R-square (within)	0.447		0.483		0.353		0.400	
N (dwelling-years)	1165		1165		1851		1851	
N (dwellings)	347		347		511		511	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

€0.89 in the event of one or two tenant changes and by €2.02 when the flat changed its tenant three or four times within the observation period. In Deutz, rent increases on average by €1.17 with one new rental contract, €1.39 with two, and €2.06 with three or four tenant changes. Thus, in both neighbourhoods there seems to be a number of dwellings with high tenant turnover where rent increases are exceptionally high. Changes in the number of household members have a significant effect on rent level only in Mülheim, suggesting a slight effect of changing ancillary costs.

In total, the analysis demonstrates that gentrification processes are dynamic and move at different speeds. Comparing the models in tables 4 and 5 shows that in the analyses that cover four years (2010 to 2014), the effects in Deutz are larger than in Mülheim (see especially the year coefficients and R-square), whereas in the models including data from 2022, effects in both neighbourhoods are similar and the explained variance in the panel regression is considerably higher in Mülheim.

5 Discussion

In this paper, we argued that a dwelling panel provides unique possibilities for assessing rent dynamics on the level of neighbourhoods that exceed those in "conventional" panel data or other data sources. The main difference is that the dwellings are the sample units—the tenants are (only) their "spokespersons". Since relocations depend on the sociodemographic characteristics of the residents, after a short time the members of a "conventional" panel are no longer representative of the neighbourhood. We used data from the Cologne dwelling panel to depict rental price dynamics over time in the two selected neighbourhoods that were in differ-

ent stages of gentrification, and in doing so we subdivided between stayers and new residents. Over the entire time, the dwelling itself as sample unit remained constant. With the dwelling panel data, it was possible to assess intra-dwelling variance over time, which enabled us to differentiate between yearly rent increases and the effects of one or more tenant changes.

We argued that, due to regulations of the German rental market, the opportunities to increase rents in existing contracts are limited. However, especially in areas with a highly competitive housing market, rents are likely to be significantly increased when there is a tenant change in the dwelling. In our analyses, it becomes apparent that tenant change indeed leads to a significant increase in gross rent; on average, the increase in rent is more than twice as much with a new rental contract compared to sitting tenants. In the theoretical framework of gentrification processes, it is assumed that this is caused by an influx of affluent "gentrifiers" into the area who are willing to pay prices for a dwelling that often exceed the index-specified rent for that neighbourhood and the dwelling's features (ortsübliche Vergleichsmiete). We further hypothesized that in a neighbourhood that is in a more advanced stage of gentrification, both yearly and tenant change-related increases in rent are higher due to a stronger demand of (costly) living space.

With respect to differences between neighbourhoods in varying stages of gentrification, we distinguished two differential trends. In the first period of the study, between 2010 and 2014, the neighbourhood in Deutz was already in the third stage, "gentrification", whereas the neighbourhood in Mülheim was in the second stage, "invasion", according to Kerstein's classification (1990). In the neighbourhood where the gentrification process was more advanced, the average rent was higher from the beginning, but there was also a stronger dynamic of rising prices in the area. While the neighbourhood in Deutz remained in the third stage of gentrification up to 2022, the process gained momentum in Mülheim, which—at least in parts—has reached the "gentrification" stage in the meantime. Accordingly, rental price dynamics in the two areas seem to converge towards the end of the observation period. However, apart from a small share of dwellings with a high turnover in tenants, the effect of a tenant change on rent price is still higher in the neighbourhood which already was at the third stage at the beginning of the study.

The analyses demonstrate that rent price development is a dynamic process that varies by neighbourhood. Therefore, a rent price index (Mietspiegel) that only differentiates between poor, standard and good residential areas without taking the actual location into account is not a suitable instrument for a fine-tuned regularisation of the rental market. Area-specific real estate data can be gathered from commercial platforms such as immoscout24 or the VALUE market data archive, but these sources document only advertised rent prices, thus the magnitude of the difference between new rental contracts and existing rental contracts cannot be assessed. In contrast, with the dwelling panel data, this difference—and its development—can be calculated. This is important, as a widening gap between new and incumbent rental contracts may eventually produce a "lock-in effect", as long-term residents who are dissatisfied with their home are not capable of moving to another reasonably priced apartment in the neighbourhood (Gohl, 2019).

One limitation of the analysis at hand is the lack of differentiation between trends in net rent and ancillary costs, which is due to the impossibility of getting reliable figures for both in survey interviews. However, the longitudinal design that eliminates dwelling-specific heterogeneity can provide a—partial—solution to this problem. Further, it would be interesting to assess more indicators influencing the level of rents in dwellings, e.g., changes in the condition of the building, or features of the apartment, such as the installation of underfloor heating or expensive bathroom fittings. However, these variables were not part of the questionnaire in the first four waves. We added these and other indicators in the fifth wave (see appendix A3) which will allow further explanations of rent dynamics over time and facilitate comparisons of estimates from the dwelling panel with official rent indices and other data sources such as online rent marketplaces. Prospectively, dwelling panel data could, on the one hand, serve as an alternative method for calculating a Mietspiegel on the neighbourhood level, and on the other, be used to complement information on rent prices advertised on commercial platforms.

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Appendix
Tables

Table A1

Living space in the two neighbourhoods, tenants only

	Mean	Median	Min	Max	N
Mülheim, W1	68.6	67	22	180	313
Deutz, W1	73.0	70	15	172	477
Mülheim, W2	70.9	68	24	180	258
Deutz, W2	74.7	72	27	172	423
Mülheim, W3	71.1	68	22	180	229
Deutz, W3	74.2	70	27	172	401
Mülheim, W4	70.0	68	22	180	221
Deutz, W4	74.9	72	25	172	330
Mülheim, W5[a]	74.7	71	20	183	147
Deutz, W5[a]	75.9	72	27	174	223
Mülheim, W5[b]	72.2	70	20	183	298
Deutz, W5[b]	75.1	72	9	174	432

[a] Panel dwellings only [b] Panel dwellings, twin dwellings and new buildings

Table A2

Fixed-effects regressions on rent per square meter, wave dummies, Cologne-Mülheim and Cologne-Deutz, 2010-2022

	Cologne-Mülheim				Cologne-Deutz			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Wave 2, autumn 2011	0.30***	0.06	0.23***	0.07	0.39***	0.05	0.28***	0.05
Wave 3, spring 2013	0.55***	0.09	0.36***	0.09	0.76***	0.07	0.53***	0.07
Wave 4, autumn 2014	0.65***	0.09	0.41***	0.10	0.84***	0.08	0.54***	0.08
Wave 5, summer 2022	3.02***	0.20	2.46***	0.20	2.86***	0.19	2.26***	0.19
One tenant change	-	-	0.73***	0.19	-	-	0.99***	0.17
Two tenant changes	-	-	0.99**	0.28	-	-	1.26***	0.28
Three to four tenant changes	-	-	1.51**	0.63	-	-	1.79***	0.48
Number of household members	-	-	0.18*	0.08	-	-	0.07	0.09
Constant	9.33***	0.05	8.79***	0.18	9.64***	0.04	9.34***	0.20
R-square within	0.451		0.480		0.357		0.391	
N (dwelling-years)	1165		1165		1851		1851	
N (dwellings)	347		347		511		511	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table A3

Selected facilities of dwellings in wave 5 (2022)

	%
Balcony/loggia	68
Central hot water supply	46
Bathroom with shower and bathtub	23
Separate WC for guests	19
Terrace/roof terrace	15
Underfloor heating	9