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房租管制政策對租金之影響-以德國租屋市場為例

Estimating the Impact of Rent Control on Rents: Germany's Rental Housing Market as an Example

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Abstract

Five years after the first cities in Germany implemented rent controls, this thesis estimates the effect of the policy on the changes in rents with a difference-in-difference (DiD) approach comparing city-level rents for newly-let apartments. For this purpose, panel data for 110 German cities for the 60 quarters between 2005 and 2019 is used. Because the panel data inhibits unit roots and is therefore non-stationary, the first difference (FD) of the logarithmized time-series for rents as well as quarter-on-quarter changes for socioeconomic time-series are used. In order to overcome that city-level data in Germany is only available on a yearly basis, quarterly data will be derived with the Denton method for smoothing or disaggregation. Results of the analysis suggest that contrary to public opinion, rent control had a statistically significant dampening effect on the development of rents in the first group of cities that implemented the policy. Nevertheless, a lack of new rental supply due to slow building activity vis-à-vis strong in-migration to larger cities remains the main factor for increasing rents. For policy implication, the lack of residential supply will have to be addressed and building activity in larger and more popular cities will have to be increased, if a lasting solution to rising rents wants to be found.

Key Words: Rent control, German rental market, Difference-in-Difference (DiD), Denton method, Akaike information criterion (AIC)

DOI:10.6814/NCCU202001764

Table of Contents

DOI:10.6814/NCCU202001764

List of Tables

DOI:10.6814/NCCU202001764

List of Figures

DOI:10.6814/NCCU202001764

Chapter 1: Introduction

The private rental housing market in Germany has experienced turbulent times in recent years. Rents for newly-let apartments in larger cities have increased drastically and continuously, while new arrivals struggle to find a living space altogether due to low vacancy rates approaching near-zero levels in some cities (Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019). In Munich, the average residential rent increased by more than 50% between 2010 and 2019, and in Berlin, although at a lower absolute level, rents rose by 70% in the same time period (Empirica regio, 2020).

In Germany, affordable rents on the private rental market are especially important, because around 45% of households live in privately rented dwellings. This is due to a relatively small social housing sector and a low home-ownership rate compared to other European and Western countries, making Germany the country with the highest share of low-income-households living in the private rental sector among all Western countries (Dewilde, 2018).

In order to curb the strong increases in rents, the government introduced rent control measures in form of the so-called "Rent Brake" ("Mietpreisbremse") since 2015 in many major cities across the country, limiting the legal increase in rents of newly-let rental units in affected cities to 10% above a local reference rent level. In general, the policy has been attested to have had no effect whatsoever in the press and in public opinion, with rents seemingly continuing to increase unhalted or even more strongly (cf. The Economist, 2018 & Oechsner, 2018). Most recently, the city of Berlin launched a lone new maneuver to tackle high rents by introducing an immediate rent stop since 2020, freezing all rents for the duration of five years (Frehner, 2020).

Meanwhile, much-needed new supply of rental units has increased over recent years, but is only slowly catching up with increasing demand, so that in a majority of German cities building

DOI:10.6814/NCCU202001764

activity is still only a fraction of what would be needed to accommodate future populations (Henger & Voigtländer, 2019).

Given the public attention and general uncertainty as to the effects of the German rent control policy, research into the topic is valuable both for concrete policy evaluation and understanding of the workings of rent controls in general. This thesis will therefore estimate the impact of the German Rent Brake since 2015 by using a Difference-in-Difference (DiD) approach. It will be shown that a statistically significant dampening effect on rents exists for the first cohort of cities in the dataset that implemented the policy.

There has been literature on the effects of rent controls both in a general sense and on a smaller scale for the German case since 2015, but to my best knowledge I have not seen an empirical approach of measuring the effect of the German policy with the Difference-in-Difference method using city-level rents. The dataset used for this project consists of quarterly rents between the first quarter of 2005 and the fourth quarter of 2019 for 110 cities in Germany. The remainder of the thesis is structured as followed:

Chapter 2 will introduce existing literature on the German housing market and the German rental market before explaining the rent control policy that was implemented since 2015. Existing literature on rent controls in general is plentiful and some of the findings will be introduced here, before introducing studies with reference to the German rent control policy specifically. The issue of new supply of rental space (i.e. new constructions and repurposed spaces) will be discussed and the lack thereof identified as a major problem.

Chapter 3 introduces the data and the Difference-in-Difference (DiD) approach. Unit-root tests will be performed to test for non-stationarity and data will be transformed into first-differences and quarter-on-quarter/year-on-year change rates. Quarterly city-level data will be derived from yearly values with the help of the Denton method of data smoothing/disaggregation. Last but not least the Akaike information criterion (AIC) will be applied to select the best regression model.

DOI:10.6814/NCCU202001764

Chapter 4 shows the regression results and gives interpretations of the estimates. Section 5 will conclude with the policy advice, that although rent control might have had an effect in some cities, only new supply of rental spaces will suffice to combat increasing rents in the medium and long run.

Chapter 2: Literature Review

2.1 Germany's Housing Market

2.1.1 A Short Historical Overview of the German Housing Market

First and foremost, before laying out the methodology and empirical framework that will be used to measure the effects of the rent controls that were introduced in many German cities since 2015, an understanding of the underlying market should first be established. Therefore, the following sections will first introduce recent conditions of the German housing and rental markets.

German cities have a relatively old housing stock with many buildings, especially larger apartment complexes, built around the turn from the 19th to the 20th century and in the years following the devastation of the Second World War. In the late 19th and early 20th century before the First World War, larger German cities were shaped by Industrialization, and densely spaced tenement complexes were created to house the growing worker population. Despite the two World Wars, many of these so-called "Gründerzeit" buildings survived and define German cities until today (Kohl, 2016). After World War 2, accommodation was desperately needed in a short time for a displaced population returning to the cities. Many cities had lost a large share of their building stock and new construction had to quickly make up for the losses. Building activity was strongest in the years following the war and architecture from that time is now equally dominating many towns and cities. Especially, many multi-storey apartment buildings for rental apartments date back to these two time periods (Zeitler, 2018). In the following decades that were defined by strong economic growth, cities were growing back to old sizes at a fast pace, but the phase of re-growth was soon to be followed by a phase of stagnation in terms of city-population which was instead

DOI:10.6814/NCCU202001764

dominated by suburbanization and the boom of the family-home (Dewilde, 2018). The trend towards single-family homes continued over decades and peaked in 1999, when in the course of one year, around 180.000 new single-family units were added to the building stock (Bischoff & Maennig, 2011).

During this period in the 1990s, however, while in most European countries housing prices began to roar, Germany's house prices remained relatively flat due to conservative lending-practices to potential home-owners and a debt-adverse tax system. This is rather remarkable given the immense increase in property prices and housing wealth in neighbouring countries at the time. It was not until 2010 that prices in Germany began to increase significantly and strongly (Schneider & Wagner, 2016). During the housing and financial crisis that unfolded around 2008, other European countries' housing markets struggled and housing bubbles burst, but Germany weathered the storm relatively well due to decades of stable and lower price growth (Wijburg & Aalbers, 2017).

After the financial crisis, an upward trend in housing prices emerged. As opposed to the previously conservative credit lending policy, the market was now confronted with an expansionary monetary policy by the European Central Bank that tried to rejuvenate damaged economies across Europe with a continuously low interest rate. According to Hiller & Schultewolter (2014), this led to much easier and cheaper access to credit for future home owners. Moreover, the low interest rate led investors to anticipate future inflation which turned them towards the stock market and finally to the German housing market, in order to safely store their wealth and prevent any potential loss of value. At the same time, the supply of new homes was not sufficient to cover the suddenly increased demand, which further drove up prices (Hiller & Schultewolter, 2014). As for the rental housing market in particular, this thesis will show that new rental supply was also in no way able to keep up with demand to suppress rent growth.

Szumilo et al. (2018) who contrasted investment in real estate with investment in stock markets over time found that the two forms of investment were negatively correlated. This reveals people began investing into real estate when they stopped trusting the stock market. According to

DOI:10.6814/NCCU202001764

the authors this was especially true in Germany for the period after financial crisis around 2008. Since then, investment in the property market has increased significantly. The authors also stressed the increased attention that the German housing sector now began to receive by foreign investors who began to value this channel of investment as a means to lower risk vis-à-vis stock investment, while maintaining growth potential (Szumilo et al., 2018).

Similarly, Bienert (2018) points out that European investors became increasingly weary of the risks they faced when investing in real estate across the world and started to turn to Germany because of the generally stable and good condition of the market. The author accredits this perceived stability not only to the abovementioned historical conservative credit-giving by banks, but also to the more stable overall economic performance and relatively high transparency on the housing market in recent decades (Bienert, 2018). In terms of investment in real estate, Germany has regularly been described as a "safe-haven" in recent years (e.g. Wilkes, 2017), in which investors willingly accept a lower capitalization rate on their investment for a lower risk.

There is another crucial factor for the increased investment activity on the German housing market. After decades of suburbanization and the dominance of the single-family home, Germany's larger cities recently started to experience a new strong population boom. As a consequence, there is hope among investors, that Germany will remain a lucrative market for housing investment as well as investment in office and retail space. In central Berlin, prime office capitalization rates in 2017 were at a record low of 3.25%, but despite low returns investors were nevertheless willing to buy into the market due to a perceived guarantee that future demand would not decline (Grant & Patnaude, 2017). With low and decreasing vacancy rates in the larger prospering cities in recent years (while no exact data for this exists, it is estimated to be as low or below 2% in the largest cities) there is no reason why investors should assume that steady cashflows through rents should become harder to realize anytime soon. (Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019) At the same time, increased migration to larger and more popular cities

DOI:10.6814/NCCU202001764

in Germany not only put pressures on the housing and retail property markets, but also on cities' rental markets, which will be discussed in detail in the following section.

2.1.2 Germany's Rental Housing Market: Why Rents Matter

In recent years, we can observe not only house prices but also residential rents in German cities to have increased drastically, which brings us to the main focus of this thesis, the German rental housing market. Between 2012 and 2017 rents throughout Germany for "affordable apartments" alone rose by 20% (Wilkes, 2017). Furthermore, the trend was much stronger in larger cities. In Munich, average residential rent increased by more than 50% from 2010 to 2019, and in Berlin, although at a lower level, even by 70% in the same time period (Empirica regio, 2020). Germany has therefore not been an exception to the common phenomenon of rising rents among many western countries. In fact, rising rents have gone hand in hand with rising prices for owner-occupied housing (Edmiston, 2016).

The reason why the German rental market matters especially is its high share of households that rent. According to Eurostat data, Germany's homeownership of 51.9% in 2015 was the second-lowest in Europe after Switzerland's, while homeownership in countries like the US (in 2019) at 65.3%, the UK at 63.6%, Sweden at 70.6% or Spain at 78.2% (all in 2015) was significantly higher. It is noteworthy that this is not just a recent phenomenon, but that Germany's homeownership rate has been traditionally lower for decades. (Kohl, 2016) In the 1950s, the rate of renters was still as high as 73%. This number decreased to 60% in the 1980s as German banks more actively engaged in mortgage lending and homeownership was boosted. In 2013, the number of households that rented instead of owned was still almost half of all households at 47%, a relatively high share compared to other Western countries. The homeownership rate is lower in larger cities and lowest in Berlin, where more than 80% of people live in rented dwellings (Wijburg & Aalbers, 2017).

A high share of renters as opposed to owner-occupiers does not have to be a concern per se. Schneider & Wagner (2016) point out that Germany's strong private rental housing sector and a

DOI:10.6814/NCCU202001764

low home-ownership rate were crucial factors for stable house prices in the mid-1990s in Germany and Austria, while prices increased rapidly in other European countries that had actively boosted homeownership (Schneider & Wagner, 2016). However, a large share of renters implies that a higher share of the population inevitably depends on affordable rents. In Germany this is especially the case, because the country does not have a strong social housing sector that provides below-market rents for low-income households. The rate of public social housing as percentage of total housing has been below 5% during the last decade, decreasing from 5% in 2009 to 4.6% in 2012 (Ronald, 2013) and to around 4.3% in 2019. To put this into perspective, public social rental as percentage of total housing in 2012 was around 18% in Sweden and the UK, 23% in Austria, and as high as 32% in the Netherlands (Ronald, 2013). In such countries with a larger social housing sector, high rent prices in the Private Rental Sector (PRS) would trouble households with higher income than the lowest income group, as those will be more likely to live in social housing. In Germany, however, rent levels will directly matter for lowest income renters (Dewilde, 2018).

The low share of social housing in Germany is the result of an active dissolution of the public rental sector and a wave of privatization between the 1990s and 2000s in which private equity firms and hedge funds took over large portions of the country's social housing stock (Wijburg & Aalbers, 2017). As a result, there was a 21.8%-point decrease in social housing in Germany between 1995 and 2007. In the same time period private rental stock increased by 14.4%-points (Dewilde, 2018).

Social Housing became common throughout Western Europe since as early as the late-nineteenth century to prevent the development of slums due to rapid industrialization and urbanization. Around a century later, during the 1980s, social housing reached its peak across Europe with shares between 20% to 39% of all housing in Germany, Austria, France, Denmark, Sweden, The Netherlands and the UK. Although the drop in public housing in Germany described above was more extreme than in neighbouring countries, it was not the only European country in which the social housing sector shrank. In much of Europe of the 1990s, privatization came along

DOI:10.6814/NCCU202001764

with neo-liberalization, such as in the UK where owner occupancy rose from 56.4% in 1981 to 69.2% in 2000 in line with the countries "right-to-buy" campaign (Ronald, 2013).

However, while the focus in the UK and several other countries was laid on owner occupancy through a shift from social housing towards housing allowances or "rights to buy" for current occupants, in Germany much of the social housing stock was taken over by private investors who then continued to rent out the dwellings for profit (Dewilde, 2018). The dissolution of the social housing sector is seen critically by some researchers. Ronald (2013) points out the importance of public housing for the overall equity and stability of the housing market. As a positive example he names the Netherlands, who have a stable and equitable housing market with a high social housing rate of over 30% (Ronald, 2013).

As a result of the dissolution of social housing in Germany, around 45% of households lived in the private rental sector (PRS), both in 2007 and 2013. More critically, the number of low-income households in the PRS has increased steeply. In 2013, around 62% of all German low-income households lived in privately rented apartments, an increase from around 58% in 2007 and around 41% in 1995. As a consequence, the share of low-income households relying on cheap market rents in the private rental market in Germany has become the highest in all of Western Europe (Dewilde, 2018). The increasing rents across Germany that are seen in recent years will continue to especially strain these less well-off households.

Another societal group that is affected heavily by the development of rents are young people. In a study about young individuals in Scotland, Hoolachan et al. (2017) describe a "Generation Rent" that is struggling in the private rental sector, because it cannot attain spaces in the social rental sector. At the same time, due to a more and more flexible work environment, they are also not able or willing to afford their own homes (Hoolachan et al., 2017). While their research is limited to the UK, there are still parallels with the situation of young people in Germany who struggle to find cheap apartments in reasonable quality. Wilkes (2017) points out that due to the low overall availability of rental units and high and increasing rent levels, tenants are involuntarily forced to

DOI:10.6814/NCCU202001764

live in housing of lower quality than they would have otherwise wished to live in. (Wilkes, 2017) As a result, competition for smaller and lower quality flats intensifies and unavailability for living space intensifies, in extreme cases even increasing homelessness (Kroell & Farhauer, 2016).

The discussion above can help to understand why rents in Germany matter substantially for a large number of people and why the German government would want to maintain reasonable rent levels through the implementation of a rent control policy. Nevertheless, to present a more complete picture, it should also be pointed out that when discussing the German rental market in terms of overall welfare, one should also keep in mind that despite the large wave of privatization of social rental housing into the hands of large firms and hedge funds in recent decades, a majority of Germany's rental housing stock is still owned by private individuals, not by large corporations. Around 60% of all rental units throughout the country are owned privately and the market is generally organized "poly-centrically", which makes the discussion about fair rents and welfare much more complicated (Cajias & Freudenreich, 2018). If a large number of people uses investment in property as a steady source of income after retirement, the number of shareholders we should care about in the discussion about rising rents naturally increases.

2.1.3 Recent Developments in Rents and Rent Affordability Between Cities

In this section, a more detailed look into the rise of rents throughout German cities is necessary. In a comparison along all the cities in the dataset, the unweighted average nominal rent increased from EUR 5.69 in 2005 to EUR 8.01 in 2019, which is an increase of roughly 40% (Empirica regio, 2020). This 40% increase in rent prices already seems impressive at first sight. However, in terms of rent-affordability, we have to compare the nominal rent increase to the (nominal) increase in GDP per capita, roughly the average income of each individual.

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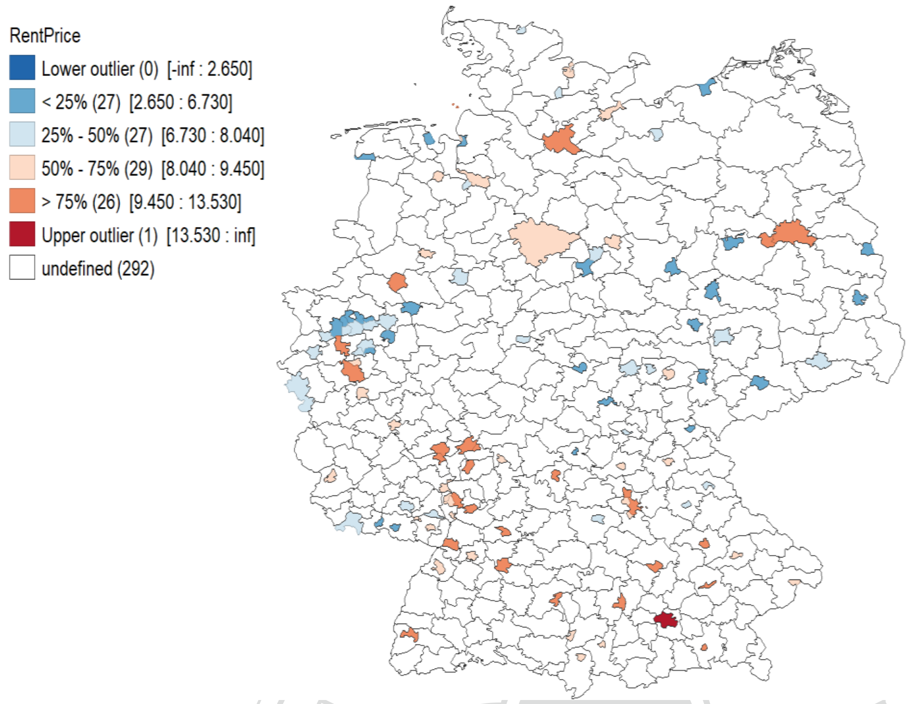

Figure 1: Percentile Map of Rent Levels for Newly-let Apartments in Q4 2019 (EUR/m^2)
Source: Own visualization based on data from Empirica regio

On first sight across all 110 cities there is actually no average decrease in affordability as GDP per capita also increased by roughly 40%, from EUR 36.204 to 50.80736 in the same time period (keep in mind that this is the unweighted average nominal GDP per capita in the 110 cities in the sample and not Germany's per capita GDP). However, rent affordability developed differently from city to city. To get an overview, Figure 1 gives a graphical overview of the rent prices for newly let apartments in the cities in the dataset in Q4 2019, while Figure 2 shows the increase in average rents between 2005 and 2019.

DOI:10.6814/NCCU202001764

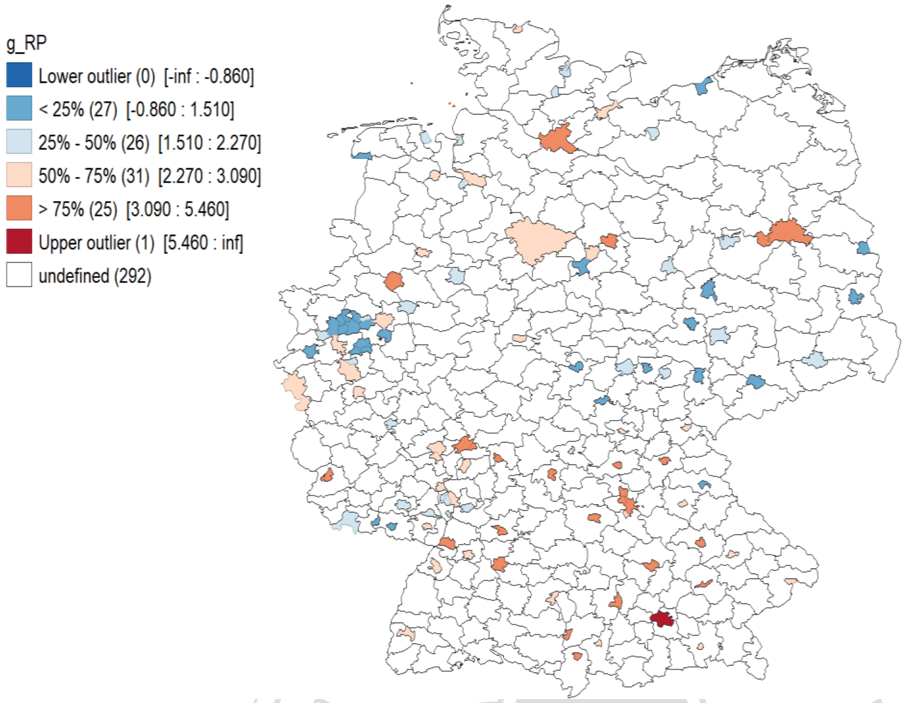

Figure 2: Percentile Map of Absolute Increases in Rents between Q1 2005 and Q4 2019 in EUR
Source: Own visualization based on data from Empirica regio

According to Micro-census data from 2018, renters in Hamburg spent approximately 30.4% of their average disposable income on rent. At the same time in the Chemnitz statistical region, it was only 21.5% (Statistisches Bundesamt, 2019). This is the case despite the fact that the average income per person in Hamburg is much higher than it is in the Chemnitz statistical region. Problems in housing affordability are defined as a threshold when housing costs exceed 30% of the available disposable household income (Dewilde, 2018). An average of 30.4% of disposable income spent on rent in cities like Hamburg therefore implies that a lot of people are above that threshold and have problems with affordability. Further keeping in mind that many households that rent instead of own have on average a lower income relative to owner-occupiers in the first place aggravates the problem further.

As we will see, rent affordability became an increasingly problematic issue over time in larger cities in particular. A look at how rent affordability has changed relative to other cities in

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recent years gives us more insight. If rent prices in a city are plotted against GDP per capita in a city at the same time period, we get a first visual overview of this relative rent affordability across cities. If a city lies left/above the trend in the graph, it has a lower than average rent affordability. If a city lies right/below the line, it has a generally higher rent affordability with lower rent price relative to income. This method is adapted from Edmiston (2016) who compared regionally varying trends in rent affordability between US cities (Edmiston, 2016).

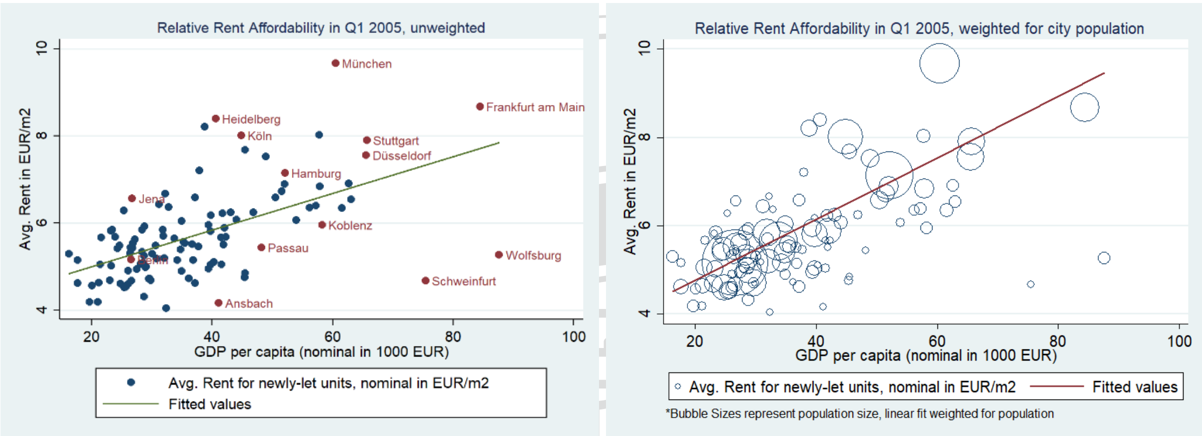

Figure 3: Relative Rent Affordability (Rent / GDP per Capita) in Q1 2005, Unweighted (Left) and Weighted for City Population Size (Right)

Source: Empirica regio & Statistische Ämter des Bundes und der Länder

A look at how relative rent affordability developed between 2005 (Figure 3) and 2017 (Figure 4) yields a first impression about what might have determined rent development in Germany. Figure 3 reveals that in the first quarter of 2005, GDP per capita unsurprisingly played a major role for rent levels in a city. The positive trend line reveals that rents for newly-let apartments were generally higher in cities with higher GDP per capita. Secondly, it is also visible that a city's population size might have mattered, as a few of the larger cities like Cologne, Munich, Hamburg, Stuttgart and Frankfurt seem to be the places with higher average rents and lower relative rent affordability. However, as can be seen in the right graph, which represents a city's population by bubble size and weighs the linear fitted line by population, relative rent affordability in many of the

DOI:10.6814/NCCU202001764

larger cities is mostly on trend and offset by higher GDP. Their rent affordability is in most cases not much lower than that of smaller cities.

To illustrate this, one could look at two example cities. In the first quarter of 2005, average rent prices in Frankfurt, one of Germany's "big-seven" cities, was EUR 8.67 per m^2, the second highest rent among all cities. However, since the GDP per capita in Frankfurt was more than twice as high as in most of the other cities at the time, relative rent affordability in the city was actually higher than – for example – in Jena, a smaller city where average rent was only EUR 6.56 /m^2 at the time.

Figure 4: Relative Rent Affordability (Rent / GDP per Capita) in Q4 2017, Unweighted (Left) and Weighted for City Population Size (Right)

Source: Empirica regio and Statistische Ämter des Bundes und der Länder

If we then jump ahead 12 years and take a look at Rent Affordability in Q4 of 2017, we see that GDP per capita is still correlated in the same way with rent levels in a city. Like in 2005, the linear fit shows that on average cities with higher levels of GDP per capita had higher average rents for newly-let apartments. However, compared to 2005, the two graphs reveal a drift between cities of different sizes. Specifically, cities of large population size seem to have significantly moved up towards lower relative rent affordability compared to 2005 while the major share of smaller cities seems to have moved either closer to the trend line or below it. This is the case even when the fitted trend line is weighted for population size in the bubble graph on the right side. Note that there is no

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such visible result when considering population densities at this stage. When building the empirical model later on, density will be considered.

As for the example cities above, Frankfurt with an average rent of EUR 12.36/m^2 in Q4 2017 had moved to a relative rent affordability well above the trend line, while Jena with an average rent of EUR 7.97/m^2 in Q4 2017 had moved down towards trend level of rent affordability (seen in the bulk of dots in the lower left corner).

Edmiston (2016) in her regional comparison of rent affordability in US cities uses an approach where she measures the change in rent affordability by comparing how a city's rents developed compared to its residents' income. In the German case it is an equally useful technique for getting an understanding of the current underlying developments on the rental markets and visualizes the problem that increasing rents in some areas, especially the larger cities, have not been tied to or caused by stronger increases in income.

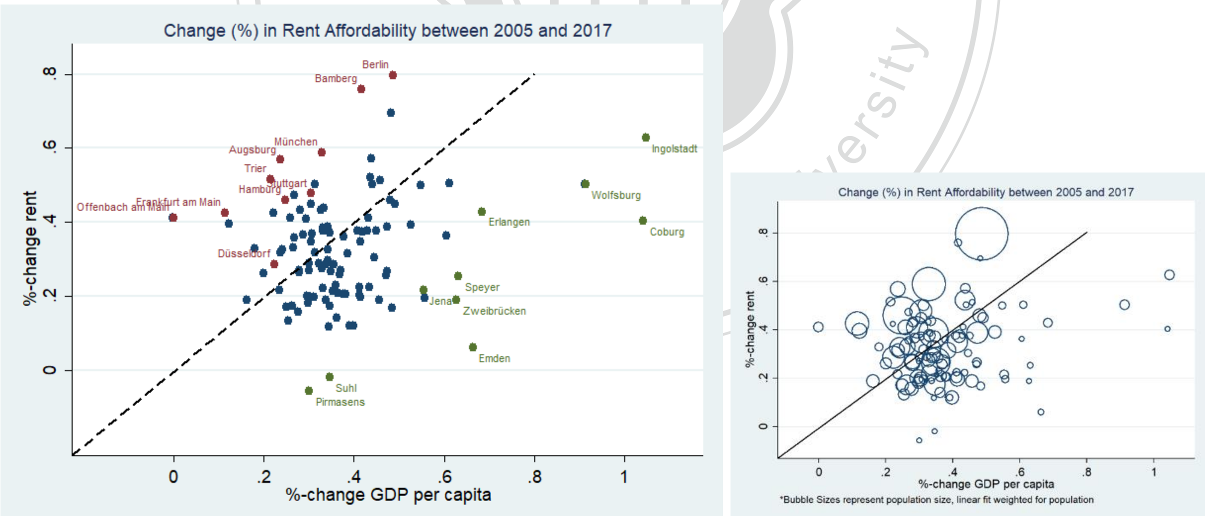

Figure 5: Changes in Rent Affordability between Q1 2005 and Q4 2017, Cities as Dots (Left) and as Bubbles Representing City Population Size (Right)

Source: Empirica regio and Statistische Ämter des Bundes und der Länder. Method adapted from Edmiston (2016)

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The method plots the percentage change in rents for newly-let apartments between Q1 2005 and Q4 2017 in each city against the percentage change in income (per capita GDP) in the same time period. If $\Delta Rent > \Delta Income$, then rent affordability has declined in the time period. In the graph, a 45-degree reference line is plotted for visualization purposes. If a city lies left of or above the line, then $\Delta Rent > \Delta Income$ and rent affordability decreased during the time period. If it lies right of or below the line, then $\Delta Rent < \Delta Income$ and rent affordability increased in the time period. Of course, the graphs do not reveal information about the absolute rent levels in any city, but in combination with Figure 3 and Figure 4, we can conclude that increasing rents, both on an absolute and in a relative level were an increasing concern in larger cities. This is the case despite generally higher income, as the comparison showed.

This diverging trend between cities of different sizes is due to the fact that there has been a change in migration pattern within Germany. While suburbanization and shrinking city-populations were predominant during the latter part of the 20th century, cities have started to increase in population size again recently (Statistische Ämter des Bundes und der Länder, 2019), especially due to internal in-migration of younger adults. Schaefer and Just (2018) were able to show that young adults today are drawn to cities that are attractive and provide amenities, and are not simply places to work. This importance for a city's attractiveness has increased over time. The authors found a statistically significant effect of cities' "tourism-attractiveness" on young adult in-migration. (Schaefer & Just, 2018). This change in internal migration patterns as well as the recent external in-migration of refugees has affected rental markets, especially in larger and popular cities, and put unexpected pressure on supply. Net migration to Germany reached a peak of 1.14 million people in 2015 and remained at high levels that continue to pressure rental markets since (Wilkes, 2017)**.** In this light, the issue of supply of new rental units will be discussed in Chapter 2.3. Before that, however, a look at the German rent control measures since 2015 with the purpose to curb increasing rents in affected cities will be taken.

DOI:10.6814/NCCU202001764

2.2 Rent Control

2.2.1 Germany's Introduction of the Rent Brake ("Mietpreisbremse")

As a means to tackle increasing rents in German cities, the newly-elected German coalition government in 2013 of Conservatives (CDU) and Social Democrats (SPD) allowed federal states to implement a rent control policy, publicly known as the "Mietpreisbremse" ("Rent Brake") in cities with "tense" rental housing markets, which forbade landlords to charge new tenants monthly rents exceeding the local reference rent levels ("Mietspiegel") by more than 10% (Thomschke, 2019a).

Each local reference rent is defined by the respective city itself or in negotiations by stakeholders from local tenant and landlord organizations. Until 2020, the reference rent was officially based on rent levels of the last four years. In 2020 the law was updated to include the last six years into consideration instead, to further limit the increase in rents in cities with significant and fast increases (Frehner, 2020).

Furthermore, in order not to prevent investment into construction and refurbishment, newly constructed units as well as newly renovated buildings were completely exempted from the law (Deschermeier et al., 2016). Existing contracts before policy implementation are also not affected and landlords can continue to charge a rent beyond the legal limit, if that same level of rent was already paid by the previous tenant.

The law was first introduced in a number of German cities in June 2015 and over the course of two years was introduced in a large share of the major cities throughout the country. While the law was passed by the national government, each state decides independently which cities will implement the policy based on the factors population growth, vacancy rates, rent development and how heavily cost-burdened renters in a city are relative to income (Frehner, 2020).

Originally intended as a temporary short-term policy to bridge the time until new housing supply would catch up with migration, the law was renewed to stay in place for another five years until 2025 as recent as April 2020 (Frehner, 2020).

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2.2.2 Rent Controls: A General Literature Review

Before turning to evaluations of the German Rent Brake since 2015 in particular, a more general review of existing literature on rent controls should be undertaken. Although a new phenomenon in the recent German context, rent controls in some form or another have been applied in many places around the world before, so that a number of analyses and studies exist.

The United States and several European countries implemented rent freezes (as opposed to rent brakes) during WWII, forbidding all increases in rents above the current level, to ensure that workers essential for the war economy could move where they were most needed without having to fear being taken advantage of by profit-seeking landlords. In much of Europe, where these immediate rent stops were kept in place for years even after the war ended, the rent-controlled housing stock often deteriorated, while new investment was mostly made into the uncontrolled building stock outside of the historical city centres. This strict form of rent controls was later termed the "first generation" of rent control and was unanimously judged by researchers to have done more harm than good to housing markets in the rent-controlled cities due to the deterrence of investment in new supply and maintenance (Arnott, 1995). In many European countries like the UK, France, Spain or the Netherlands, some form of such strict first-generation rent controls that effectively froze rents at a level far below market level lasted for decades before they were abandoned or updated (Deschermeier et al., 2016).

The negative experience with these "rent stops" or "rent freezes" as the first-generation rent control measures are commonly termed led to a bad reputation of any type of rent controls for a long time in both research and politics. The most common critique about such policies is that taking away the prospects for profit from landlords will prevent investment into the housing stock. Alston et al. (1992) in a survey among leading economists as late as 1992 found rent controls to be the least contested issue among all economic topics, with more than 90% of surveyed economists agreeing that rent controls will in all cases reduce both the quantity and quality of rental housing available (Alston et al., 1992).

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Furthermore, Turner & Malpezzi (2003) showed that strict rent regulations will directly incentivise landlords to sell their property to potential homeowners in order to maximize their income, rather than renting it out at a below-market rate (Turner & Malpezzi, 2003). This is identified as one of the reasons why the homeownership rate in Germany, where no rent freezes were implemented from the 1960s to 1980s, remained relatively low over time compared to other European countries with such policies such as France, Spain or the UK (Deschermeier et al., 2016).

Since then, however, a so-called "second generation" of rent controls has been discussed much more controversially. The discussion was famously set off by Arnott in 1995 in his paper "Time for Revisionism on Rent Control?" in which he argues that the benefits of "well-designed" and soft rent control mechanisms can outweigh the harms. While economic theory would suggest purely negative effects in perfect markets by disincentivising investment in quality and quantity of the rental housing stock, Arnott argues that in imperfect markets, controls can prevent inefficient strong fluctuations in rent levels and consequently increase welfare (Arnott, 1995).

Nevertheless, despite this revival of the discussion about rent controls, there are further concerns related to all sorts of such policy instruments. Fallis and Smith (1984) showed that when part of the rental stock within a city is affected by rent control measures and part is not, as is the case with the German Rent Brake, that the rents for unaffected rental units would actually increase (Fallis & Smith, 1984). In the case of the German Rent Brake, this would mean that within a city, older dwellings might become relatively cheaper, while newly constructed dwellings would experience an increase in rents through the policy.

Moreover, Thomschke (2019) describes that rent controls will lead to inefficient distribution of rental units, as high- and low-income earners will now compete for the same apartments and no selection process due to sorting based on the prospective tenants' willingness to pay can take place (Thomschke, 2019a).

Furthermore, in an empirical study tracking migration of tenants in San Francisco, Diamond et al. (2018) showed that landlords affected by rent controls reduced their rental unit supply by

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around 15%, which in turn lead to rent increases, not a dampening of rent levels. What's more, the author identified that rent controls strongly decreased tenant mobility, as households lucky enough to already live in a rent-controlled apartment were around one fifth less willing to move, further limiting the chances of new potential renters to find a suitable place (Diamond et al., 2018).

2.2.3 Evaluations of the German Rent Brake

The German rent control policy since 2015 falls into the category of the so-called "second-generation" rent control mechanisms due to two reasons. Firstly, it still permits rent increases up to a level of 10% above the local reference rent, which – combined with an increase of the local reference rents over time – leaves room for future rent increases within a reasonable range and therefore stable income for landlords. As the name shows, it only "brakes" the increase in rents, while it does not aim to "freeze" rents altogether. Secondly, as mentioned above, it also excludes all new constructions and renovations and should therefore have a smaller impact on new supply of rental housing.

Nevertheless, around five years after its implementation, the German Rent Brake has mostly received limited praise at best. In the general public's opinion and press, the policy is mostly perceived to have had no effect (Oechsner, 2018), or to even have increased prices in the largest cities (The Economist, 2018). Besides the fact that the policy belongs to the softer versions of rent controls, it was also criticised by researchers who pointed out that it will not help to fight the underlying problem of undersupply of rental units (Deschermeier et al., 2016).

One other main argument for the perceived failure of the policy is that landlords do not have to fear legal consequences if they break the regulation and demand rents more than 10% above the local reference rent. Only if a tenant accuses the landlord of overstepping the legal limit for the rent, will the rent have to be adjusted, while the landlord will face no punitive measures (Frehner, 2020). Because of the contested rental housing markets with low vacancy rates in the larger and more popular cities, many potential tenants would not want to jeopardise their chances for an apartment

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and will choose to accept rents above the legal limit even despite the knowledge that they are legally being overcharged. An evaluation of the German Rent Brake by the German Institute for Economic Research Berlin (DIW Berlin) compared several studies by researchers, all identifying that in many larger cities the share of listed rentals on rental websites that exceeded the legal limit was still as high as 50-75% in some cases and as high as 95% in the city of Frankfurt (DIW Berlin, 2018).

Furthermore, Deschermeier et al. (2016) point out that the effectiveness of the rent control policy will by design be linked to the effectiveness of the local reference rents. Only in a few cities like Berlin and Munich, the representative rent is set by experts with the help of objective measurement. In most cities the reference rent is negotiated by tenant and landlord organisations and does not necessarily represent realistic numbers. Tying the legal upper limits of rents to inconsequential numbers might render the law arbitrary, as the rules would be much more restrictive in some cities and ineffectual altogether in other cities, depending on whether the local reference rent is set unrealistically high or low (Deschermeier et al., 2016).

In the debate about the effect of the German Rent Brake on investment in construction and renovation of rental units, the aspect of quality should be mentioned. Even if newly constructed buildings and renovations are entirely exempt from the law for now, it is unclear how it will affect quality of rental dwellings over time, as the law does not differentiate between high-end luxury apartments and student lofts. While the policy is proclaimed to be only a temporary measure which will not interfere with supply of new rental units, it is reasonable to suspect that if the law was to be extended further over a longer period of time, landlords would think twice about investing into apartments of higher quality and might instead prefer cost-saving measures when constructing new rental units.

Despite the doubts and reservations regarding the law, however, a few recent studies have in fact shown small but significant dampening effects on the rent levels for newly-let apartments. Kholodilin et al. (2018), in a study on the effects of the German Rent Brake, find evidence that the policy has had a dampening effect on the development of rents in areas where there had previously

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been a relatively large increase in rents. The authors calculate that the policy can by design only begin to show some effect in areas with a yearly increase in rents of roughly 3.9%, and a significant effect in areas with a yearly increase of above 4.8%, as the law permits rent increases within the limit of 10% above the periodically updated local reference level. The authors claim that only if rents increased fast enough in the first place, could the legal limit be reached by a relevant number of rental units, before the local reference was adjusted. The authors underscore their theoretical argument with evidence that the law did in fact halt the increase in rents in the cities of Berlin, Munich, Stuttgart and Bielefeld, where especially fast increases were present in prior years (Kholodilin et al., 2018).

Deschermeier et al. (2017) analyse the development of rents for more than 100,000 geo-referenced rental units in Berlin between 2015 and 2016 based on micro-characteristics, location, and whether they were affected by the rent control policy. The authors employ a Difference-in-Difference approach like the one used in this project, but instead of focusing on city rent averages they compare individual units that were affected by the policy (treatment group) with units that were unaffected by the policy (control group consisting out of newly constructed or renovated rental units). The authors come to the conclusion that the Rent Brake significantly decreased new rents of affected units in the City by around 2.7% relative to unaffected units (Deschermeier et al., 2017).

Last but not least, Thomschke (2019) follows a similar idea and methodology when applying the Difference-in-Difference approach to micro-data of rental units in a number of major German cities. For each city, the author compares rent-controlled units (treatment group) with exempted units (control group). His findings are in line with the abovementioned findings by Kholodilin et al. (2018) and Deschermeier et al. (2019) as he attests relatively strong dampening effects on rents for the city of Munich, followed by Hamburg and Berlin, but finds no effect on the rent levels in Cologne or Düsseldorf, where initial rent growth was not as extreme in recent years (Thomschke, 2019b).

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2.2.4 A New Attempt: The "Rent Freeze" in Berlin Since 2020

Last but not least, when talking about rent control in Germany, one most recent development demands attention. On February 23rd 2020, a law for an immediate rent freeze ("Mietendeckel", i.e. "rent cap") in Germany's capital Berlin came into effect. The policy was independently passed by the Berlin State Senate led by Social Democrats, Green Party and The Left, making the city the only place with such a law in all of Germany. The law goes far beyond the purpose of the nationwide Rent Brake ("Mietpreisbremse"). Instead of limiting increases in rents to 10% above the local level, the new rent stop immediately freezes all rents retroactively for the duration of five years at the level from June 18th 2019, the day the law was first proposed in the state senate. (Frehner, 2020) At the moment it is still more than uncertain whether the law will be able to hold before the Federal Constitutional Court due to its drastic nature, but the policy is already showing an immediate impact. While rents in the other "big-seven" cities in Germany rose between 1.2% and 3.7% from Q4 2019 to Q1 2020, rents in Berlin dropped by 1.3% in the same period, completely reversing a trend of constantly increasing rent levels in the last decade (Zacharakis, 2020)

With its wide-reaching effects, the law, unlike the nationwide Rent Brake policy, falls closer into the category of first-generation rent controls that were discussed above and has met heavy criticism by opposition parties, housing associations and researchers alike. Even before the law took effect the German national housing association claimed that 50,000 less rental units would be built as a direct effect over the next five years by its member companies alone (The Economist, 2019). Supporters of the law can claim that new building supply will not be directly affected, as newly constructed rental spaces completed since the year 2014 are excluded from the law (Zacharakis, 2020). But unlike the national Rent Brake policy that fully excludes newly renovated apartments as well, in Berlin every redo or refurbishment that would raise rents by more than 50 Cents per m^2 will now need official approval (The Economist, 2019).

Furthermore, as much of the city's rental stock is controlled by large corporations such as Deutsche Wohnen SE owning around 115,000 rental spaces in Berlin alone, critics fear that

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investment will be hemmed and foreign investors scared away. The company experienced an initial 17% decrease in their stock after the policy implementation (Goncalves Raposo, 2019). In April and May of 2020, the number of rental units posted for lease online decreased by a remarkable 40% compared to January of the same year, which according to Immowelt AG, one of the largest German rental websites, was due to landlords offering up their property for sale instead of rent due to decreased rentability. While part of the decrease in listings during these two months can certainly be attributed to travel and contact restrictions due to the spread of SARS-Cov-2, the drop in listings was significantly smaller in all other cities, which makes it more likely that much of the decrease was a consequence of the new law (Zacharakis, 2020).

For the following analysis of the German Rent Brake policy since 2015, however, the new law in Berlin does not have any impact and does not influence the results, as the dataset in use here only includes rents until 2019 before the new policy in Berlin came into effect. Nevertheless, it will be highly interesting to see how the policy plays out in terms of rent price development, supply of new rental space, as well as public and political approval towards the policy.

2.3 The Role of New Rental Supply

As discussed above, one of the major concerns when discussing rent control mechanisms is the effect such a policy can have on the supply of rental space. At this point it’s important to discuss the current lack of supply of rental spaces in Germany, which is a major concern in its own right, especially in larger cities with high internal and external in-migration.

The problem that the supply of new rental units in German cities is struggling to keep up with increasing demand is a much-discussed issue in research (e.g. Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019, Henger & Voigtländer, 2019 & Schwarz, 2019). Although the amount of completed floor space for residential rental use has increased steadily since the financial crisis in 2009 (see Figure 6) it is only slowly picking up and is still short of what would be needed to meet increasing demand in larger cities.

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Henger & Voigtlaender (2019), in a study for the Cologne Institute for Economic Research, estimate the yearly required amounts of rental units for each city based on population predictions of each city for the time between 2016 and 2020. They then compare this estimation for yearly demand with the actually completed rental units between 2016 and 2018 and derive the quotient of yearly supply over yearly demand as an indicator whether there has been enough building activity. The average quota among the 110 cities of the dataset in use in this thesis is around 0.87, indicating that on average only 87% of the rental units that were needed were built in this period. This means that on average (1.0 / 0.87) – 1 ≈ 15% more rental spaces would have had to be constructed in the 110 cities of this sample to meet the expected demand. However, further amplifying the problem, there are significant regional differences, with the quota being as high as 3.57 in the city of Hof in Bavaria (meaning that more than three times the amount of required rental spaces was completed per year in the period between 2016 and 2018) and as low as 0.21 in the city of Speyer in Rhineland-Palatinate (Henger & Voigtländer, 2019). In total, the supply of rental spaces was not enough (i.e. the quotient was < 1) to cover expected demand for as much as 70% of the 110 cities in the dataset. Therefore, the problem cannot simply be described by regional differences and the problem of a few major cities, but as a systemic problem.

There are several reasons for this. Firstly, it is normal for supply to lag behind demand by up to a few years, as planning, permissions and constructions take time (Wilkes, 2017)**.** Construction time alone was measured to average around 20 months for an average home in 2018 and 25 months for the average multi-story apartment building, both numbers that increased from 18 and 22 months respectively since 2014 (Henger & Voigtländer, 2019). Naturally, planning and decision-making take similar times.

Moreover, Figure 6 shows that there is a significant and large gap between governmental permissions for the construction of rental units vis-à-vis actually completed constructions. As mentioned above, one of the reasons for this is the natural lag through long construction times. Another complication is a current persisting shortage of skilled construction workers and resulting

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high construction costs, which amplify the problems of the building industry. Even if a will to build exists, worker shortages and high costs can result in the abandonment of existing plans (Goncalves Raposo, 2019).

Furthermore, since the German housing market evolved as a lucrative market for investors in recent years, significant hoarding behaviour can be observed, in which investors purchase a piece of land in anticipation of future value increases, but do not carry out their intended building project after acquiring a permission to build. Selling the land with a bundled building permit will then greatly increase value, as application times are long and represent an investment hurdle for many investors. For the time being, however, the permit will be wasted for potential would-be-tenants and no construction activity will take place (Goncalves Raposo, 2019).

Last but not least, complicated regulations make construction in Germany a tedious affair and even having obtained an official permit, developers will more often than not find themselves confronted with incidents of "NIMBYism" ("not in my backyard"), where local residents would protest and take legal actions to prevent further property development in their neighbourhoods (Henger & Voigtländer, 2019). One most recent example are the large-scale demonstrations against "gentrification", "displacement" and the recent removal-by-force of squatters occupying a building in the city of Leipzig in early September 2020. After violent protesters fired pyrotechnics on police personnel and onto the balconies of newly constructed residential buildings, the mayor of Leipzig pointed out the major setback for the future development of affordable rental space and noted that "one doesn't create living space by attacking the police and lighting barricades" (Tagesschau, 2020).

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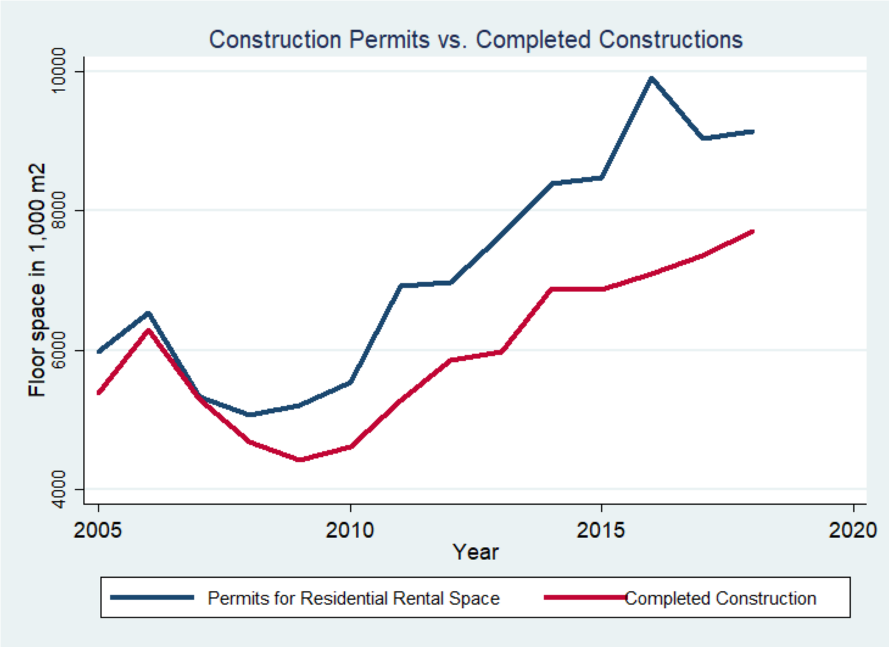

Figure 6: Constructions Only Slowly Catching Up with Increasing Number of Permits: Sum of Yearly Rental Space Permits (Blue) and Completed Rental Space Constructions (Red) in the 110 Cities of the Dataset

Source: Statistische Ämter des Bundes und der Länder

Nevertheless, it can be assumed that constructions of buildings will continue to increase in coming years. Afterall, middle-class housing continues to be in high demand as immigration, especially to big cities, increased in recent years (Wilkes, 2017)**.** With low and decreasing vacancy rates in recent years, estimated to lie below 2% in some of the larger prospering cities, there is no reason why investors should assume that steady income through rents should become harder to realize anytime soon (Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019).

On the other hand, it is expected that supply insufficiencies will persist even if the situation improves to some degree. (Goncalves Raposo, 2019) To underscore this it is noteworthy to mention that although 320,000 housing units were built throughout Germany in 2016 alone, which is the highest number since 1999, supply is still not keeping up fast enough and Henger estimates that around 100,000 more housing units per year would be needed to meet demand (Wilkes, 2017)**.**

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Chapter 3: Data & Methodology

3.1 Data Sources

After having established a general understanding of the German rental market and the German Rent Brake since 2015, the following chapter will introduce the data and methodology used in this thesis. The main complication when working econometrically with rent prices in German cities is the limited availability of data. Some data is simply not available, the rest has to be derived from different sources and is often not available quarterly but only yearly. Other authors have pointed out the issue of a lack of detailed data before when discussing why it is difficult to evaluate the real effects of Germany's rent control policy (Thomschke, 2019a). In the following it will be explained what data from which sources is used and what data might be missing due to unavailability.

i) Rent Prices

First and foremost, data for quarterly rents for rental dwellings on a city-level was kindly provided for this project by empirica regio ag (Empirica regio, 2020). The data is available quarterly from Q1 2005 until Q4 2019. Please note that if not stated otherwise, when referring to rents or rent prices, city-level average nominal monthly rents for newly let apartments in a given quarter in EUR / m^2 are implied.

ii) City-level GDP

Data for city-level GDP is retrieved from the National Accounts of the Federal States ("Volkswirtschaftliche Gesamtrechnung der Länder") in the Regional Database Germany ("Regionaldatenbank Deutschland") (Statistische Ämter des Bundes und der Länder, 2019). However, while rent prices are available on city-level on a quarterly basis, GDP on city-level is only available yearly. Furthermore, calculation is slow, so the numbers are only available until 2017 up to the point of writing. This issue will be addressed later in this chapter.

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iii) National-level GDP

Data for GDP on a national level is retrieved from the German National Accounts ("Volkswirtschaftliche Gesamtrechnung des Bundes") from the website of the Federal Statistical Office of Germany (Statistisches Bundesamt, 2020).[1] On the plus side, this data is available quarterly until Q4 2019, on a down side, the national data is naturally the same for all cities in the sample and will help to explain variation in rent price over time, but not between cities. Both of the GDP variables (yearly until 2017 on city-level, and quarterly until Q4 2019 on national level) have to be taken into consideration for now to see which one has better explanatory value to the variation of rent prices. This will be discussed in detail later on.

iv) Population

Population data for each city is retrieved from the Regional Database Germany ("Regionaldatenbank Deutschland") (Statistische Ämter des Bundes und der Länder, 2020). Once again, this data is only available yearly, more specifically it is available for the 31st December for each year between 2005 and 2018.

v) Consumer Price Index (CPI)

Because we are working with nominal rent prices, we also have to take into consideration inflation. This paper includes a consumer price index (CPI) (2005 = 100). The CPI is only available on the national level, so it is also the same for all cities, but can still help to explain variation in rents over time.

vi) New Rental Supply

Data for completed constructions of new residential rental space in each city as well as construction permits (measured in 1000 m^2) is retrieved from the Regional Database Germany

[1] The data for quarterly national German GDP is, like most other data used in this project, retrieved from the official website of the Federal Statistical Office of Germany ("Bundesamt für Statistik (Destatis)") and is already seasonally adjusted by the X13 method in JDemetra+ and BV4.1 ("Berliner Verfahren") which is why values might on first look deviate from other values for German GDP found elsewhere. For more information on the method see (Linz, Fries, & Völker, 2018) What matters for this project are not the absolute values but the fluctuation of GDP over time, so that this difference can be ignored.

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(Regionaldatenbank Deutschland"), but is once again only available yearly until 2018. Especially the data for newly completed rental spaces will be implemented into the model. To make the data for completed construction comparable among cities, the constructed floor space will be divided by the city's population.

vii) Medical Doctors Coverage

Data for the number of medical doctors (all fields, per 100,000 population) as a proxy for general quality of healthcare as a major pull-factor of cities is retrieved from the "Gesundheitsdaten" database of the German National Association of Statutory Health Insurance Physicians (KBV) (Kassenärztliche Bundesvereinigung, 2019). Data is available only yearly since 2014, so an average of the numbers between 2014 and 2019 is taken and taken as a constant value for each city. There are large discrepancies for access of health care that have generally been classified as an urban-rural gap with rural areas struggling to maintain health service coverage and larger cities having relatively ample supply of doctors. Whereas the number of doctors per 100,000 population is lowest among cities in the data set in Duisburg with only 141.6, the number in Freiburg im Breisgau is highest with around 386.4 doctors per 100.000 population. In rural areas outside of the dataset used here there is an even bigger lack of doctors. The massive shortage of doctors in some areas is a much-discussed issue in literature as well as politics (e.g. Kaduszkiewicz et al., 2018). The German government introduced financial incentives to doctors for choosing to remain in more rural areas as early as 2011 (Tuffs, 2011). Interestingly, in this dataset of cities, the number of doctors is not correlated with population size or density of a city and relatively weakly correlated with the per-capita GDP in a city, so this variable seems to incorporate some other form of city attractiveness in it. Ono et al. (2014) identified the attractiveness of places to live and work in as a major factor for location choice for physicians unrelated to earning opportunities (Ono et al., 2014), a factor that is impossible to measure but equally important for many would-be residents, especially young professionals. For example, Schaefer & Just (2018) found out that a city's tourism attractiveness

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had a direct effect on the number of people that migrated to the city (Schaefer & Just, 2018). The variable could therefore also be interpreted as a measure for a city's appeal to would-be citizens.

viii) University Student Population

Data for the number of university students as a share of total city population is taken from the Federal Statistical Office of Germany, which lists the number of enrolled students at each university in Germany in the Winter Semester of 2019/20. For this study, the numbers were added up "by hand" to estimate the approximate student share among each city's population. As is not uncommon in European countries there are cities in Germany with large university student populations, e.g. as high as above 25% of total population in cities like Darmstadt or Würzburg (Statistisches Bundesamt, 2020). Whereas in other countries many university students will live in cheaply provided student accommodation, only 9.6% of German university students live in student dormitories, while around 68% live in privately rented apartments and will be relying on a strong and cheap rental market (Deutsches Studentenwerk, 2018). It could therefore be suspected that the strongly contested rental markets in student cities are subject to higher rent prices.

ix) Rent Control

Information on the exact timings of the implementation of rent control in the respective cities in the dataset has been retrieved from the Kommunalwiki of the "Heinrich Böll Foudation". It lists in detail, which cities implemented rent control on exactly which day.

x) Missing Variables

In any empirical model one wants to include as many independent variables to explain as much of the variation in the dependent variable (rent prices) as possible, and to see whether they have a statistically significant effect. Unfortunately, there are certain variables that cannot be incorporated into this empirical analysis because the data simply doesn't exist or is not easily and freely accessible for the public. As such, this project has to make do without data on construction cost, which was found to be a significant driver of housing prices by Case and Shiller in 1990 (Case & Shiller, 1990). Furthermore, in Germany there is no accurate longitudinal data for vacancy rates on

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district level but only very rough estimates (Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019). Last but not least, it would have been preferable to check rent levels vis-à-vis house prices, but these are not publicly available either.

The data availability problem is clearly a major limitation of this study and might also explain why there is relatively little quantitative research on the effects of the German rent control policy up until today.

The combined dataset contains 110 cities in Germany, specifically all of the 107 district-free cities ("Kreisfreie Städte", also called "independent cities"), as well as the city regions of Aachen, Hanover and Saarbrücken which function as cities in all but name. The dataset therefore contains all major cities and most of the larger and medium sized cities of the country. The largest city in the dataset by population size is Berlin with an estimated population of around 3.65 million at the end of 2018 and the city with the lowest population in 2017 was Zweibrücken in the state of Rhineland-Palatinate with around 34,200 inhabitants at the end of 2018.

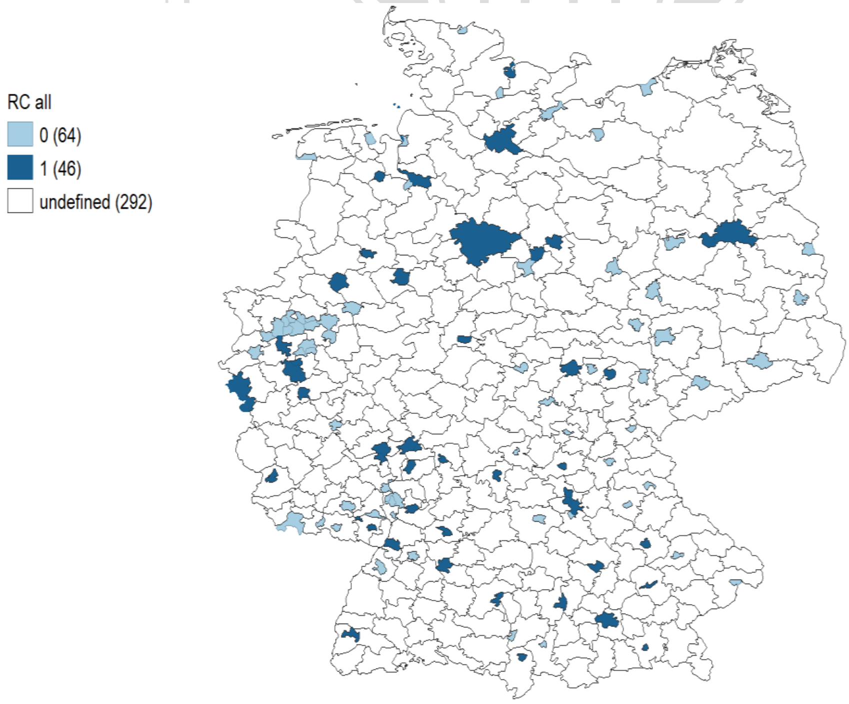

Figure 7: District-free Cities in Germany (Rent-controlled in Dark Blue)
Source: Own visualization based on Heinrich-Böll-Stiftung

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Figure 7 shows all the 110 district-free cities in the dataset in blue. The regional boundaries correspond to the EU's hierarchical NUTS-3 level ("Nomenclature des unités territoriales statistiques"). All district-free cities are their own entity on this hierarchical level. A disadvantage of using these larger independent cities is that a number of smaller or medium-sized cities that are not independent but part of a larger regional districts ("Landkreise") could not be included into the dataset, but on the plus side this method ensures that all cities remain comparable due to identical criteria in terms of how their territory and administration is defined. In the map, cities that implemented rent control measures in recent years were marked dark blue, while cities that did not implement any rent control measures are marked in light blue.

3.2 The Difference-in-Difference (DiD) approach

When quantitatively analysing the effect of the German Rent Brake, we cannot simply compare the rent levels in rent-controlled cities before and after implementation of the policy. In that case we would quickly come to the conclusion that rents continued to increase after policy implementation and the Rent Brake must thereby have failed. Instead, we have to find a best-possible way to compare rent levels in rent-controlled cities (treatment group) to the rent levels that would have been if rent control had not been implemented, i.e. the "unobserved counterfactual outcome". In order to do so, one can make use of the knowledge of how rents evolved in cities that were not rent-controlled (control group). If rents in cities that were not rent-controlled continued to increase – for example – at the same rate as before, while rents in cities that were rent-controlled kept increasing but at a slower pace relative to all other cities after the policy implementation, this difference in the difference represents the treatment effect that the implementation of rent control had. The method that makes it possible to isolate such a treatment effect is the suitably-named "Difference-in-Difference" (DiD) method (Columbia University Mailman School of Public Health).

The method was famously applied by Card & Krueger in 1994, who estimated the effects of a rise in the minimum wage for fast food workers in the state of New Jersey in 1992. After the raise in

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the minimum wage, the number of people employed in the sector in New Jersey increased by around 2.8%. The authors, however, did not stop there but compared the increase to a drop in employees in the fast-food sector in neighbouring Pennsylvania in the same time period, which except for the raise in minimum wage has similar features to the sector in New Jersey. Keeping in mind that employment in Pennsylvania at the time actually fell by more than 9% despite having similar preconditions, they argued that the real treatment effect of the minimum wage hike in New Jersey was actually more likely to be a more than 10% increase in employment in the sector. (Card & Krueger, 1994) Their paper is until today a typical text book example for an application of the Difference-in-Difference approach.

For the case of rent prices in 110 German cities, the 46 cities in the dataset that implemented rent control measures will be assigned to different treatment groups depending on their implementation date of the policy. It then compares the variation in rent prices in the treatment groups before and after policy implementation with the variation in all other cities without such policy at the time. If there is a difference in trend, we can better understand the causal effect of the policy on rent prices. To implement the DiD method in this regression framework, one can estimate the regression

$$Y = \beta_0 + \beta_1*(RC) + \beta_2*(Post) + \beta_3*(DiD) + \beta_4*(covariates) + \varepsilon$$

- Where Y is the dependent variable rent price (or more specifically first difference of logarithm of rent price, as will be explained later).
- Where (RC) is a dummy variable for the treatment group of rent-controlled cities. If a city is part of the treatment group (i.e. is rent-controlled), (RC) takes the value of 1 in all observed time periods, even before policy implementation. For all cities without the policy, (RC) equals 0 for all time periods. In this case there will be three different treatment groups

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(sub-groups RC1, RC3 and RC5) for three cohorts of cities that implemented rent control at different time periods. Each sub group will be tested individually with an own model.

- Where (Post) is a dummy variable separating pre- and post-treatment periods. (Post) will take the value of 1 for all cities if the given time period is any time period after the implementation of rent control in the treatment group. As there will be three different treatment groups, there will also be three different post periods (Post1, Post3 and Post5).
- Where (DiD) = (RC)*(Post). (DiD) will only take the value 1 if observation is in a rent-controlled city after the implementation of rent control. This is the variable of interest, the estimator for β_3 will show if there is a significant “difference in difference”.
- Where (covariates) represents all other variables, such as GDP- or population-related variables, etc.

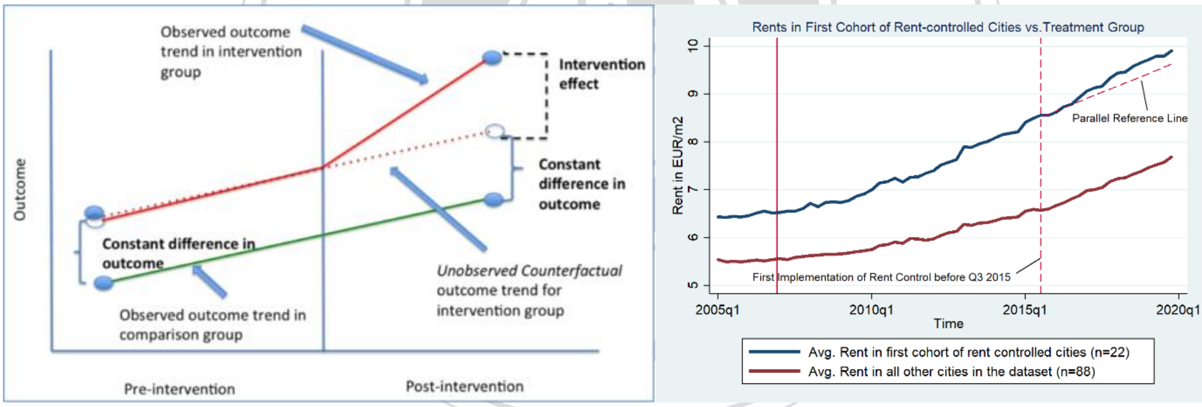

Figure 8: Conceptual Visualization of the Difference-in-Difference Approach (Left), Exemplary Visualization of Rents in Rent-controlled Cities of the First Cohort (RC1) vs. Cities in Control Group (right)

Source: Columbia University Mailman School of Public Health & Empirica regio

This way, the actual treatment effect will be isolated from the initial differences in outcome between treatment and control group as well as the time trend that would have led to a change in outcome even under the absence of the treatment. Figure 8 (left) visualizes the idea behind the Difference-in-Difference approach. The difference of interest is the gap between the observed

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outcome in the treated cities post intervention and the unobserved counterfactual outcome. As such, the following parameters are estimated:

- $\hat{\beta}_1$, the estimated coefficient for (RC), predicts the difference in outcome between treatment group and control group that is constant throughout all time periods, i.e. the gap between the two lines for rent-controlled cities and not rent-controlled cities on the Y-axis. It is possible and likely that the cities that were later rent-controlled had an initially higher rent than cities in the treatment group in the first place, a circumstance that has nothing to do with the policy.
- $\hat{\beta}_2$, the estimated coefficient for the (Post) dummy variable, predicts the time trend affecting all cities equally. A positive $\hat{\beta}_2$ indicates that rent prices were higher on average in all cities after the policy implementation time period.
- $\hat{\beta}_3$, the coefficient we estimate for (DiD), therefore estimates the isolated "treatment effect" or "intervention effect". It represents the difference between the observed outcome in the treatment group and the unobserved counterfactual outcome had rent control not been implemented. Only if $\hat{\beta}_3$ is statistically significantly different from zero in the model, there is a difference in trend ("difference in difference") between treated cities and control group, and only then it can be judged whether rent control had any effect on the development of rents in treated cities. If β_3 takes a significant negative value for example, it suggests that rent control has had a dampening effect on rent prices (Columbia University Mailman School of Public Health).

As Thomschke (2019) points out, the most important assumption that has to be fulfilled for the application of the Difference-in-difference model is the parallel trend assumption. We can only assume the counterfactual unobserved outcome (with which to compare the actual observed rents in treated cities) to be predicted accurately, if we can assume that rents in treated cities would have

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followed the same trend as untreated cities if rent control had not been introduced (Thomschke, 2019a).

In Figure 8 (right), which shows the average rents in treated cities (RC1) in blue and average rents in the control group in red, we can see that both treatment and control group do seem to follow at least a similar trend and experience the same quarterly shocks at the same time. However, we can also see a widening of the gap, already before the implementation of the policy in Q3 2015. To combat this possible violation of the same-trend assumption, the panel data will have to be de-trended and instead of analysing *absolute* rents, changes in the logarithmized time-series of rents will be used. Before this will be described in section 3.3, however, a look at the treatment groups should be taken.

In the 110 district-free cities in the data set, the Rent Brake has been introduced in a total of 46 cities, while 64 of them did not implement the policy. Figure 7 indicates all district-free cities that implemented rent control in dark blue. Besides the cities in the dataset, rent control has also been introduced in a number of smaller towns that belong to larger districts ("Landkreise"), especially in the metropolitan hinterland around cities like Berlin or Munich, but these places are not included in the data set. If data were available it would also be highly relevant and interesting to make neighbourhood comparisons within larger cities or to even use micro-data with house characteristics. However, this type of data was impossible to acquire for this project. Here, the focus lies on a country-wide inter-city comparison between all major cities.

Conveniently for any comparison between average rent prices, any district-free city that introduced the Rent Brake always did so for the entire city area and not just certain neighbourhoods. Furthermore, the 46 cities that have introduced the policy have not all introduced these measures at the same time. In a difference-in-difference method approach we can therefore treat different sets of cities as different treatment groups and see if results are consistent among them. Table 1 shows a list of all district-free cities that introduced rent control measures, sorted into five cohorts by their respective implementation dates.

DOI:10.6814/NCCU202001764

Table 1: Five Cohorts of Rent Control Implementation

RC1 (First Cohort)	RC2	RC3	RC4	RC5
München Aschaffenburg Augsburg Bamberg Erlangen Fürth Ingolstadt Kempten Landshut Nürnberg Regensburg Rosenheim Würzburg Berlin *(June 2015)* ______________ Hamburg Aachen Bielefeld Köln Bonn Leverkusen Düsseldorf Münster *(July 2015)*	Mainz Trier Landau *(September 2015)*	Freiburg Heidelberg Heilbronn Karlsruhe Ulm Stuttgart Bremen Darmstadt Frankfurt Kassel Offenbach Wiesbaden *(November 2015)* ______________ Kiel *(December 2015)* ______________ Potsdam *(January 2016)*	Erfurt Jena *(March 2016)*	Braunschweig Hannover Oldenburg Osnabrück Wolfsburg *(December 2016)*
➔ **Post1=1 from Q3 2015**	➔ **Post2=1 from Q4 2015**	➔ **Post3=1 from Q1 2016**	➔ **Post4=1 from Q2 2016**	➔ **Post5=1 from Q1 2017**

Source: Heinrich-Böll-Stiftung

Because the data for average city rents is available quarterly, not the month but the first quarter in which rent control is first active has to be defined, in this case the first *complete* quarter after the introduction of the Rent Brake in a city is defined as the starting quarter. For example, if a city introduced the measure in December 2015, the first quarter in which rent control is considered active for analysis (Post=1) would be Q1 2016. If a city introduced rent control on any day later than January 1st 2016, the first rent control quarter would be Q2 2016.

This way, we can isolate five separate cohorts of cities that introduced rent control that can be seen in Table 1. 22 cities introduced rent control before or at the beginning (January 1st) of the third quarter of 2015, including Munich, Berlin, Cologne and Hamburg. Three cities in the western

DOI:10.6814/NCCU202001764

state of Rhineland-Palatinate followed suit before the fourth quarter of 2015. 14 cities, among them Stuttgart and Frankfurt introduced measures before the first quarter of 2016, while Erfurt and Jena in Thuringia did the same before the second quarter of 2016. Last but not least five cities in Lower Saxony were last to introduce rent control measures before the first quarter of 2017. In order to have enough data points available, this thesis will focus on cohorts one (RC1), three (RC3) and five (RC5) as three separate treatment groups for analysing the effects of the rent control measures (Heinrich-Böll-Stiftung, 2020). Sub-groups two (RC2) and four (RC4) will be neglected here, because two or three cities are not enough to draw a conclusion from any analysis.

3.3 Unit Roots and Non-Stationarity: Moving from Absolutes to First Differences and Change Rates

Ideally, one could just run an OLS multiple regression of the absolute values of GDP, population etc. on rent prices and use the absolute values for all time-series. However, in this case this will not be sufficient, because the time-series for rents, GDP, population and new supply all inhibit autoregressive unit roots and are non-stationary.

A stationary variable would be one in which time series data evolve around a constant mean, which means that instead of increasing or decreasing, values would in the long run return to that mean. A stationary time series does not exhibit an increasing or decreasing time trend. If a time series does not evolve around a constant mean, but current values attach directly to the previous period's value, then it is non-stationary. An example for a stationary time series vs. a non-stationary time series can be seen in Figure 9, the graphs on the left and middle show a non-stationary time series with a clear trend over time, while the right graph shows the de-trended stationary time series that evolves around a constant mean. To see whether a unit root exists, one can imagine the following time series data defined as:

$$y_t = d_t + u_t$$

$$u_t = \alpha * u_{t-1} + v_t,$$

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where d_t stands for a deterministic component and u_t is defined by $\alpha * u_{t-1} + v_t$. u_{t-1} is the value of u in the previous time period and v_t is an error term with mean zero. If α equals 1, a unit root exists and the whole time series is non-stationary, as current values will directly depend on the previous value (Elliott et al., 1996). Granger & Newbold (1974) famously called such regressions containing unit-roots "spurious", as the statistical model is autoregressive (AR) and OLS estimators can be incorrect (Granger & Newbold, 1974). Furthermore, it is likely that in this specific example of rents in 110 German cities, the different trends in different cities break the same-trend assumption of the Difference-in-Difference approach. We therefore will have to de-trend the panel data and make it stationary if we find the presence of unit roots.

If unit roots exist and non-stationarity is the case, the panel data will have to be converted to stationary data through either taking first differences, which are simply given by the difference between a period's observation and the previous periods observation

$$fd\_y_t = Y_t - Y_{t-1},$$

or by taking the quarterly (QoQ) or yearly (YoY) change rates given by

$$QoQ = ((Y_t - Y_{t-1})/Y_{t-1}) * 100 \quad \text{and}$$

$$YoY = ((Y_t - Y_{t-4}) / Y_{t-4}) * 100,$$

assuming that quarterly data is used and each t stands for a quarter.

In order to find out whether unit roots exist and whether the time series are non-stationary, a fisher-type panel unit root test with Augmented Dickey-Fuller test (ADF) specification was performed in STATA. The test combines the results of individual ADF tests on every time-series in a panel for a given variable and is advertised as being the best and most straightforward test for testing for unit roots in panel data (Maddala & Wu, 1999). Each ADF test is applied to the model:

$$\Delta Yt = \alpha + \beta t + \gamma Y_{t-1} + \delta_1 \Delta Y_{t-1} + \ldots + \delta_{p-1} \Delta Y_{t-p+1},$$

where the values for Y are the time-series values of one city for a variable (rents, gdp, etc.) within the panel, α is a constant, βt resembles a time trend and p is the autoregressive process' lag order.

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As time-series without unit-roots evolve around a constant mean, we expect current change rates to be negatively correlated with the previous time period's value and γ should be smaller than 0. Consequently, if $\gamma = 0$ a unit root exists and we know that future values of Y depend directly on previous values of Y. For each time-series the ADF test tests the null-hypothesis H_0: $\gamma = 0$ vs. the alternate hypothesis $\gamma < 0$. The Dickey-Fuller test statistic is given by

$$\mathrm{DF}\tau = \frac{\hat{\gamma}}{SE\ (\hat{\gamma})}\ ,$$

where SE($\hat{\gamma}$) denotes the standard error of the sample. If DFτ is lower (i.e. more negative) than a critical value, the null-hypothesis can be rejected and no unit root exists. For the data set used in this project, the test results indicate that all panel data for rents, GDP, population data and new supply of rental space inhibits unit roots and is therefore non-stationary.

In a next step, in order to de-trend the time series and to eliminate the unit roots, we therefore have to take first differences of the time series, quarter-on-quarter (QoQ) or year-on-year (YoY) changes of the series as described above. For the independent variable rent price, the first difference of the logarithm will be used. For GDP and population data, QoQ and YoY changes will be compared to see which have better explanatory value.

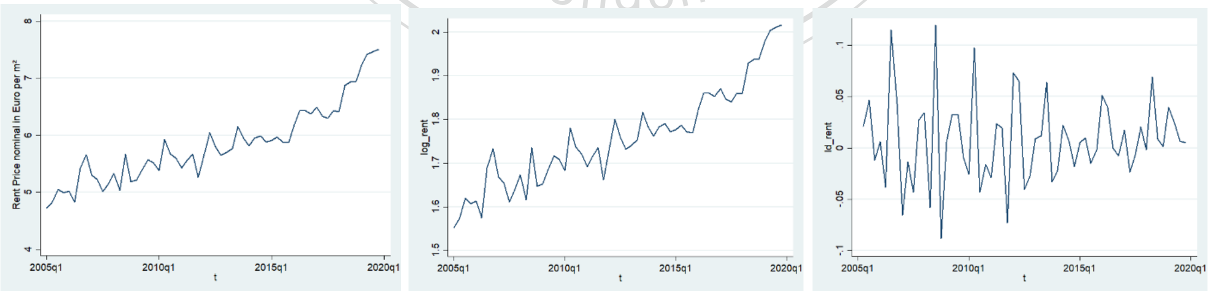

Figure 9: Rents (Left) Absolute, Logarithm of Rent (Mid), First Difference of Logarithm (Right). Exemplary Visualization for Rents in the City of Amberg (Bavaria)

Source: Empirica regio

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Figure 9 visualizes the concept of using first differences, in this case representatively for the rent price in the small Bavarian city Amberg. On the left, we can see the rent price in absolute terms with a clearly visible trend. In the centre, we can see the time series converted to logarithmic function, however the same trend is still visible as before. On the right side we see the first difference of the logarithm function, which clearly visibly has no trend and varies around a constant mean.

Performing another fisher-type unit root test on the first difference of the logarithm of rent prices as well as the year-on-year and quarterly changes of GDP, population data and new constructions show that no more unit roots exist. All time-series are now stationary and no second difference etc. have to be taken.

A further importance of detrending the data has to do with the difference-in-difference approach that will be applied here. As mentioned in the chapter on the DiD approach above, one important assumption is the "same trend assumption". As could be shown in the chapter on the regionally different development of rent affordability this is not necessarily the case for the rent development in the 110 cities in the dataset and on average it is likely that cities with faster-rising rents were selected to be targets of the new policy in the first place. De-trending all time-series by taking the stationary series of first differences of the logarithm of rent prices has the positive effect to overcome this problem.

3.4 Smoothing of Yearly Data to Quarterly Data with the Denton Method

One of the main obstacles that remains is that the panel data for city-level GDP, city population and new rental supply/construction is not available on a quarterly basis, but only yearly. When working with quarterly rents, it is not preferrable to assume the same yearly value for all four quarters in the same year, but have to find a way to smooth or disaggregate the yearly data into realistic quarterly data. Fortunately, there are ways to do this. In this project, the Denton method

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(1971) for converting yearly to quarterly data with the help of an indicator or benchmark variable is used for GDP and population variables. (Denton, 1971).

The method is advertised both by the IMF (Baum & Hristakeva, 2001) and in a statistical handbook by the European Commission (CROS, 2014) and is used by statistical offices worldwide for the purpose of disaggregating or smoothing data, and therefore appears to be reliable enough and proven method for this purpose (Di Fonzo & Marini, 2012).

Its goal is to derive higher-frequency time-series data (e.g. quarterly data) from lower-frequency time-series data (e.g. yearly data) with the help of a correlated indicator variable that is available in a higher frequency and that can tell us about quarterly fluctuations in the original variable. As a most important restriction of the Denton method, the yearly sums of the derived quarterly data have to strictly add up to the original annual data. Within this restriction the lower-frequency data is disaggregated and distributed so that the higher-frequency variation is moving as close as possible to the higher-frequency variation of the benchmark time series. More specifically, the Proportional First Differences (PFD), in this case the proportional quarter-on-quarter changes, have to be as close as possible to the PFD of the indicator variable (Di Fonzo & Marini, 2012).

For this project, a STATA module created by Baum & Hristakeva in 2001 was used to create the smoothed time series data for GDP per capita and city population for each of the 110 cities using the Denton method. (Baum & Hristakeva, 2001) The following example can help to illustrate the advantage of the Denton method vis-a-bis no smoothing and linear smoothing with a simple visualization. For this, the annualized per-capita GDP of Berlin will be taken as a representative example of what happens with time series when smoothing linearly or with the Denton method.

Figure 10 shows the absolute annualized values (left) and first differences (right) of per-capita GDP in Berlin over time without smoothing. As we can see, the absolute values on the left side fail to take into account that GDP increases and decreases quarterly, but suggest the same level for all four quarters within a year. Note that in this project, annualized GDP is used as it enables a

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more intuitive understanding of the value, even when talking about quarterly changes. An annualized GDP per capita of 30,000 EUR is easier to process than a quarterly per-capita GDP of 7,500, even though quarterly GDP is implied. Mathematically. It does not make a difference which version is used. Either way, when using the first differences without smoothing the data beforehand, it will lead to the nonsensical outcome that the first difference in every first quarter of a given year is the entire difference between the two year's observations, while the first difference for all other time periods equals 0.

Figure 10: Berlin per Capita GDP 2005-2017 Without Smoothing, Absolute (Left) and First Differences (Right)

Source: Statistische Ämter des Bundes und der Länder

A significant improvement on this is to smooth the data linearly through interpolation. Technically this method just draws a straight line between two observations and fills in missing values accordingly. If the observed variable consists of yearly averages or sums (as is the case for GDP and new constructions/supply), it is common to "delete" observations from Q1, Q3 and Q4 and keep the value of Q2 (i.e. the value at the end of June), which represents the value at the year's half point, and then to interpolate the data points in between.

The intuition behind linear smoothing is simple. If the yearly sum of GDP in year 1 is EUR 30,000, in year 2 is EUR 32,000 and in year 3 is EUR 34,000, then it is unlikely that the quarterly

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GDP in year 2 is strictly the same in each of the four quarters, but it is likely that the quarterly GDP progresses somehow over time from 30,000 in the last year to 34,000 in the next year. As we are talking about annual sums, it makes the most sense to assume the middle point (32,000 EUR in the example) to be in the middle of the year (at the end of Q2).

For city population data in this dataset the situation is different, as we know the yearly value represents the city population at the end of the year (December 31st of each year). We therefore have to delete the first three quarters of the year and interpolate between fourth quarters of each year.

Figure 11 illustrates the example of linear smoothing for Berlin's GDP over time. Now we can see that the line is smoothed and more logical first differences are yielded for each time period. However, as the right graph shows, the first differences between each quarter within a section between two Q2s is the same for all four quarters. Mathematically this would have a similar effect as simply using the year-on-year increase/decrease of the yearly values as it is exactly that divided by the four quarters.

The advantage of this linear smoothing method is that it is easy to implement, the problem is that we can still not at all represent the actual quarterly fluctuations, but have to assume the quarterly change was the same and constant in all four quarters.

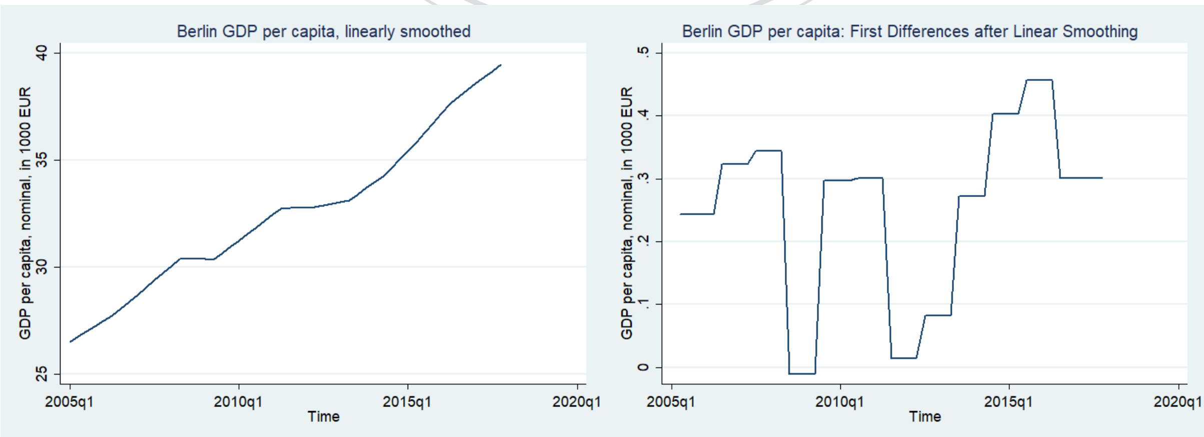

Figure 11: Berlin per Capita GDP 2005-2017 after Linear Smoothing, Absolute (Left) and First Differences (Right)

Source: Statistische Ämter des Bundes und der Länder

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This is why this project will make use of the denton method that was described above. As mentioned, it makes use of an “indicator” variable to predict how city-level data might have fluctuated in the four quarters. The largest obstacle with the Denton method is finding such a suitable benchmmark variable to use. Fortunately, in the case of GDP and population, this is easy to find. While city-level GDP and population data is only available yearly, German national GDP and population data is available quarterly. Naturally, it makes sense that city-level GDP and population are highly correlated with the national level population and GDP (afterall the population of cities in the dataset represents around a third of Germany’s population in the first place) so that we can use the national quarterly values as the respective indicator variable. For example it makes sense that city-level GDP in Berlin took a strong hit in the same quarter in 2009 as national GDP did and not – for example – two quarters later.

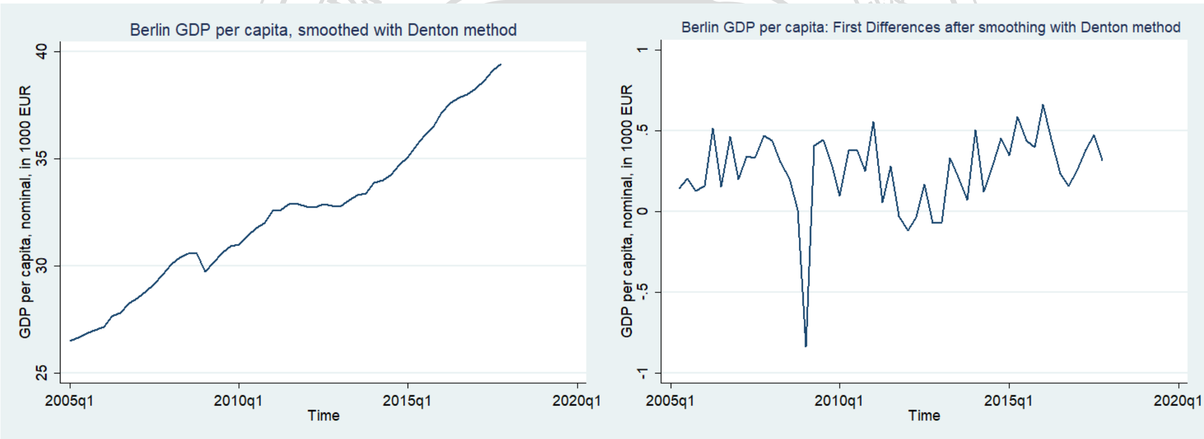

Figure 12: Berlin per Capita GDP 2005-2017 after Smoothing with Denton Method, Absolute (Left) and First Differences (right)

Source: Statistische Ämter des Bundes und der Länder

Of course this is not to say that city-level GDP and population do not have their own fluctuations unrelated to national factors, but this is still a reasonable approach to approximate the quarterly variations on a city-level. Furthermore, as mentioned above the method does not change the yearly trend of the city-level data, only lets fluctuation in the indicator variable influence

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quarterly fluctuation of the smoothed variable. This maintains the dominance and integrity of each city's individual growth path.

Figure 13 shows Germany's national GDP growth over time (left) as well as first differences (right). When comparing with Figure 11 and Figure 12, it becomes visible that smoothing with the Denton method does not change a city's growth trend, but helps to estimate quarterly differences that are more sensical than through linear smoothing.

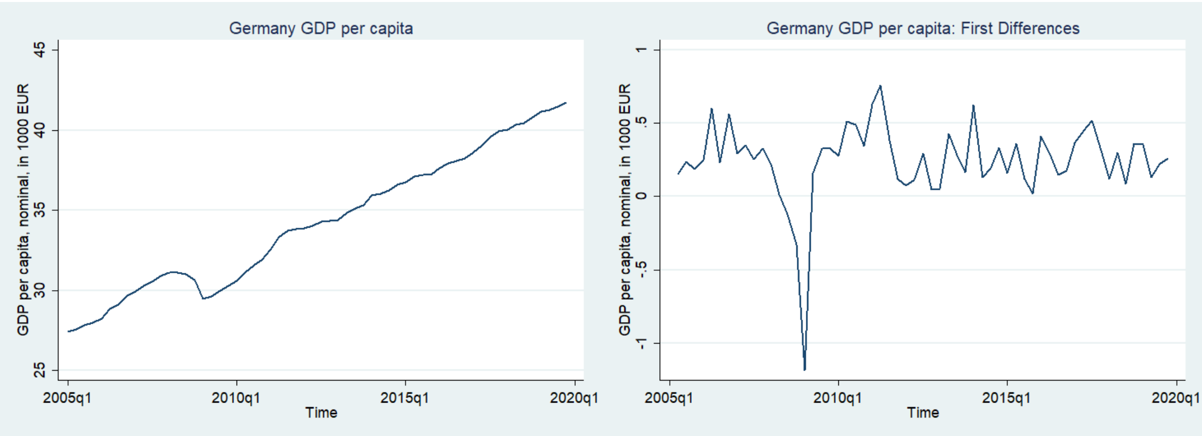

Figure 13: Germany Quarterly Nominal GDP per Capita 2005-2019 Serving as Benchmark Variable for Denton Method, Absolute (Left) and First Differences (Right)
Source: Statistisches Bundesamt

While it makes sense to smooth city-level GDP and population data with the help of quarterly national data, the same cannot be said for the supply of residential rental space. The construction activity varies too much not only from city to city but is somewhat random from year to year as well, making a systematic connection to aggregated national levels meaningless. This is why for new rental building supply the linear smoothing method is used.

3.5 Model Selection and Introduction of Lags

Last but not least a decision has to be made which variables will be implemented into the econometrical model. In Chapter 3.1, the data sources for certain variables have been introduced,

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but there was still no discussion of how these variables can best explain variation in growth of rents. First of all, since the dependent variable is now the first difference of the logarithmized time-series of rents and unit roots have been identified in the panel data for GDP, population data and constructions, differences or change rates instead of absolute levels will have to be used for those independent time-series variables as well. Specifically, it will have to be tested whether quarter-on-quarter (QoQ) changes or year-on-year (YoY) changes will have more explanatory power.

Furthermore, a decision will have to be made whether city-level GDP or national level GDP should be used in this analysis. The trade-off has been described above: Of course, it would be preferable to use city-level GDP to describe different developments in the individual cities, but as mentioned above such data is only available yearly and only until 2017, while national data is available quarterly until 2019. It will have to be tested, which of them will have a higher explanatory value. Unfortunately, it is not possible to use both variables at the same time, because of the high correlation between the two of them (0.5347 for QoQ changes and 0.4204 for YoY changes) and because the national data was used in Denton's smoothing process that was described above.

Last but not least, it is likely that changes in the independent variables will have a lagged effect on rents instead of an immediate impact. For example, it is possible to imagine that landlords raise their expectations of what rents they can charge only after they learn by how much wages or prices have increased in the last quarter or in the last year, not in the very moment that this increase happens. Especially for data on city level, it can take years for official data to be released. Lags for the explanatory variables will therefore have to be introduced and suitability of the different resulting models will have to be compared.

For this purpose, the common goodness-of-fit parameter Adjusted R-squared (R^2_{adj}) will be used as well as the Akaike information criterion (AIC). R^2 is a common parameter that describes the simple "goodness of fit" of a model by stating exactly how much of the variation in the dependent variable can be explained by the variation of the independent variables. Mathematically speaking it is derived by deducting from 1 (i.e. the case in which 100% of the variation would be

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explained in the model) the quotient of Sum of Squares of Residuals (SSR, the difference between actual observations and predicted values squared, i.e. the "unexplained" part) over the Total Sum of Squares (TSS, i.e. the total variation in the data, or the sum of each difference between an observation and the mean of observations squared), so that:

$R^2 = 1 - \frac{SSR}{TSS}$,

where $SSR = \sum(Yi - \hat{Y}\, i)^2$

and $TSS = \sum(Yi - \bar{Y})^2$.

The maximum that R^2 can take is 1, with the entire variation in Y explained by the variation in the independent variables and the minimum would be 0, with none of the variation in Y explained by the variation of the explanatory variables. (Angrist & Pischke, 2014).

R^2 is a good parameter for its easy interpretation and application, however it will usually increase by adding new variables to the model, regardless of whether the added variables make sense or have any real explanatory power at all. To accommodate for this, Adjusted R-squared or R^2_{adj} can be used. It is defined as

$R^2_{adj} = 1 - (1 - R^2)\,\frac{n-1}{n-p-1}$,

where n is the number of observations in the model and p is the number of explanatory variables. It therefore assigns a penalty for needlessly adding explanatory variables to the model. For the same model, R^2_{adj} is therefore always smaller than R^2. However, the difference between R^2_{adj} and R^2 becomes smaller the higher n. With up to 6600 observations in the dataset and an already relatively low R^2, which is normal for regressions using the first differences, the absolute difference between R^2_{adj} and R^2 is rather small.

The goodness-of-fit-indicator R^2_{adj}will therefore not be the only parameter for the model selection here, but the Akaike information criterion (AIC) will be used as well. The Akaike information criterion (AIC) uses the concept of goodness-of-fit in a similar fashion, but includes a

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stronger penalty for over-explanation of variables. If a variable does not make sense, but suggests to help with the goodness of fit, AIC will assign a relatively strong penalty. AIC is defined as the following:

$$\text{AIC} = 2k - 2\ln(\hat{L}),$$

where k is the number of parameters that are estimated. The higher the number of parameters k, the higher the "penalty" will be, and the more positive the value of AIC will be. $\hat{L}$ is the maximum value for the likelihood function of the model. It represents the goodness of fit of a statistical model for the given estimated parameters, Relative to other estimated models, the goodness of fit is higher the higher the estimated L. Therefore, the smaller or more negative in absolute terms the AIC of a model, the better the model relative to the other estimated models. However, the absolute value of AIC never carries any direct information about the model and is only interpretable relative to the AIC of alternative models.

In the following, it will be tested how different models compare in terms of R^2_{adj} and AIC. Owing to the circumstance that models with QoQ-change-rates have to be compared with models with YoY-change rates, the use of national level GDP vs. city level GDP will have to be put under inspection, and that there is technically an unlimited combination of lags that can be implemented for the variables GDP, population density, new supply and CPI, a more tactical approach is needed.

In a first step, it will therefore first be tested which combination of the variables for GDP (City GDP YoY, City GDP QoQ, German GDP YoY or German GDP QoQ) and population (Density YoY or density QoQ) should be included in the model, without the implementation of any lags (inclusion of variable is labelled as "L0" indicating that no lags are present, while "-" indicates variable was not added). The only exception for this is the first difference of CPI, which is included into the first set of models with a two-period lag. The models were compared using the DiD estimators for treatment group 1, the first cohort of 22 cities that implemented rent control, because it was both the first and the largest group of cities to implement the policy and includes many of the

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country's major cities. For a more detailed explanation of the variables in question and covariates please turn to chapter 4.1 below.

Table 2 lists the R^2_{adj} and AIC for the different combinations of the variables described above. As can be seen in the table, R^2_{adj} is still the highest when including all four possible explanatory GDP-variables (quarterly as well as yearly change rates for city and national level), because the maximization of goodness-of-fit is stronger than the assigned penalty for over-explanation. AIC is likewise higher (indicating a worse model) due to the over-fitting that was described above. This example visualized the necessity of considering AIC in the model selection process as well besides R^2. Testing for all combinations yields the result that using quarter-on-quarter (QoQ) changes for national GDP in combination with quarter-on-quarter (QoQ) changes in city population density have the highest explanatory power. After finding the right amounts of lags in the following parts, it will be double-checked if this finding still holds (see Table 3).

Table 2: Model Selection with $\boldsymbol{R^2_{adj}}$ and AIC (Part 1)

Dependent Variable: ΔFD Log_Rent (First difference of logarithmized rent prices)

Other Covariates: New rental supply (ΔFD), CPI (ΔFD, 2-period lag), time, students, doctors, east, RC1, Post1, DiD1 (For a list with explanations for each variable, please turn to Ch. 4.1)

City GDP *YoY*	City GDP *QoQ*	GER GDP *YoY*	GER GDP *QoQ*	Density *YoY*	Density *QoQ*	R^2_{adj}	AIC
L0	L0	L0*	L0	L0*	L0*	**0.0298**	-25784.18
L0	-	-	L0	L0*	-	0.0213	-25744.15
L0	-	-	L0	-	L0*	0.0222	-25748.72
-	-	-	L0	L0*	-	0.0200	-28146.61
-	-	-	L0	-	L0*	0.0216	**-28683.44**
-	-	L0	-	L0*	-	0.0201	-28147.07
-	-	L0	-	-	L0*	0.0205	-28149.12
-	L0	-	-	L0*	-	0.0213	-25745.92
-	L0	-	-	-	L0*	0.0236	-26286.9
L0	-	-	-	L0*	-	0.0212	-25745.64
L0	-	-	-	-	L0*	0.0222	-25750.59

Note: "L0" indicates zero lags, "-" indicates variable not included in model. "*" indicates variable statistically significant at least on the 10% significance level ($p < 0.1$)

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What this has shown so far, is that city-level GDP seems to be significantly worse at explaining the variation in rent growth than country-level GDP, even though in both cases the variable is insignificant, and that quarterly change rates seem to be significantly better at explaining growth in rents than yearly change rates. The former is probably mostly owing to the unfortunate circumstance that city-level GDP is only available yearly and information is lost by not knowing the exact quarterly fluctuations. It is, however, not unreasonable to assume that landlords actively follow the overall national economic situation on the news and adjust their rent expectations accordingly, while data for regional GDP is not only harder to access, but will also not get published until around two years later. Either way, national level GDP will have to be used in the further analysis and quarterly change rates for both GDP and population density will be used.

With that knowledge, in a second step, it will have to be seen if introducing lags to the explanatory variables will help to improve the model. Table 3 gives an overview of different models and corresponding values for R^2_{adj} and Akaike information criterion. In the table, the process of finding the right time lags is documented. AIC suggests that a two-period lag for GDP, a three-period lag for density and a two-period lag for inflation yields the best model (marked in green). However, the selection process also shows that neither new constructions of rental spaces (change in rental supply), nor the variables for the share of university student population or the dummy variable for the "big-seven" cities was statistically significant in any of the combinations. All three variables will have to be dropped from the model. While the share of student population and whether a city belongs to the so-called "big seven" is an important factor for the *absolute* level of rents in a city, it is enlightening to see that both variables did not have any further effect on the *increase* of rents in recent years. That also means the increase in rents in the largest seven cities was not statistically significantly higher than that in other cities when keeping in mind the underlying factors like GDP, stronger increase in population density, etc.

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Table 3: Model Selection with R^2_{adj} and AIC (Part 2)

Dependent Variable: ΔFD Log_Rent (First difference of logarithmized rent prices)

Other Covariates: Time, RC1, Post1, DiD1 (For a variables list with more explanation, please turn to Ch. 4.1)

GER GDP *QoQ*	Density *QoQ*	Supply *ΔFD*	CPI *ΔFD*	Students	Doctors	"Big 7"	East	R^2_{adj}	AIC
L0	L0*	L0	L0	Yes	Yes	Yes	Yes	0.0215	-29313.76
-	L0*	-	-	-	Yes*	-	-	0.0206	-29320.05
L1*	L1*	L1	L1	Yes	Yes	Yes	Yes*	0.0190	-29745.59
L2*	L2*	L2	L2*	Yes	Yes	Yes	Yes*	**0.0253**	-29925.07
L3	L3*	L3	L3*	Yes	Yes	Yes	Yes*	0.0201	-29981.32
L4	L4	L4	L4	Yes	Yes	Yes	Yes*	0.0165	-30057.95
L1	L1*	-	L2*	-	Yes*	Yes	Yes*	0.0227	-29292.4
L2*	L1*	-	L2*	-	Yes*	Yes	Yes*	0.0234	-29296.29
L1	L2*	-	L2*	-	Yes*	Yes	Yes*	0.0244	-29923.14
L1	L3*	-	L2*	-	Yes*	Yes	Yes*	0.0208	-29989.14
L2*	L3*	-	L2*	-	Yes*	Yes	Yes*	0.0216	**-29994.12**
L1	L1*	-	L3*	-	Yes*	Yes	Yes*	0.0219	-28760.18
L2	L1*	-	L3*	-	Yes*	Yes	Yes*	0.0216	-28758.37
L1*	L2*	-	L3*	-	Yes*	Yes	Yes*	0.0236	-29391.42
L2	L2*	-	L3*	-	Yes*	Yes	Yes*	0.0233	-29389.63
L1*	L3*	-	L3*	-	Yes*	Yes	Yes*	0.0205	-29987.76
L2	L3*	-	L3*	-	Yes*	Yes	Yes*	0.0202	-29985.7
L2*	L2*	-	L2*	-	Yes*	-	Yes*	0.0251	-29929.59
-	L2*	-	L2*	-	Yes*	-	Yes*	0.0239	-29924.00
-	L2*	-	L3*	-	Yes*	-	Yes*	0.0229	-29391.00
-	L3*	-	L2*	-	Yes*	-	Yes*	0.0203	-29990.5
-	L3*	-	L3*	-	Yes*	-	Yes*	0.0199	-29987.73
L2*	L3*	-	L2*	-	Yes*	-	Yes*	0.0214	**-29994.92**

Note: "L0" indicates zero lags, "L1" = 1 lag, etc. "-" indicates variable not included in model. "*" indicates variable statistically significant at least on the 10% significance level ($p < 0.1$)

In a last step it will have to be double-checked if the results change if city-level GDP or yearly change rates are used, to make sure that it was not just a coincidence that quarterly change rates and national level GDP yielded the best results in Table 2. Table 4 lists the values for R^2_{adj} and AIC for such models and reconfirms the previous findings.

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Table 4: Model Selection with $\boldsymbol{R^2_{adj}}$ and AIC (Part 3)

Dependent Variable: ΔFD Log_Rent (First difference of logarithmized rent prices)

Other Covariates: CPI (ΔFD, 2-period lag), time, doctors, east, RC1, Post1, DiD1

City GDP *YoY*	City GDP *QoQ*	GER GDP *YoY*	GER GDP *QoQ*	Density *YoY*	Density *QoQ*	R^2_{adj}	AIC
-	-	-	L2*	-	L3*	0.0214	**-29994.92**
-	-		L2*	L3*	-	0.0185	-28571.48
-	-	L2*	-	-	L3*	0.0251	-28993.85
-	-	L2	-	L3	-	0.0213	-28587.75
-	L2	-	-	-	L3*	0.0210	-26941.00
-	L2	-	-	L3	-	0.0182	-25505.31
L2	-	-	-	-	L3*	0.0223	-25921.02
L2	-	-	-	L3	-	0.0182	-25505.65

Note: "L0" indicates zero lags, "-" indicates variable not included in model. "*" indicates variable statistically significant at least on the 10% significance level ($p < 0.1$)

To sum up, this section has helped to build and finalize the best model for further analysis. New supply of rental space proved to be insignificant for rent changes, as well as the share of student population of a city and whether the city belongs to the group of "big-seven". Furthermore, the use of the Akaike information criterion (AIC) revealed that the number of lags for the panel data variables that can best explain changes in rents are two lags for the quarterly change of national GDP, three lags for the quarterly change of the city's population density and two lags for national inflation. Last but not least, after identifying the ideal model to estimate the effects of rent control on the development of local rent levels, an autoregressive term, i.e. the last period's change in rents will be added to complete the regression, which will improve R^2 and AIC further. The results of the final regression will be discussed in the next section.

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Chapter 4: Empirical Results

4.1 Final List of Variables

Table 5: List of Variables Implemented in the Final Regression

Dependent Variable:	
ΔFD Log_Rent (First difference of logarithm)	Nominal monthly rental price for newly let apartments in a given quarter in EUR / m^2. City-level averages, quarterly data between Q1 2005 and Q4 2019. Model uses first difference of logarithm function as the dependent variable
Independent Variables:	
Δ% GDP per capita (QoQ change rate (%) of real per-capita national GDP) *2-quarter lag*	National-level real GDP per capita in 1000 EUR. Available quarterly between Q1 2005 and Q4 2019. Model uses quarter-on-quarter change rate.
Δ% Population density (QoQ change rate (%) of city population density) *3-quarter lag*	City population per km^2. Quarterly estimates derived from yearly population data between 2005 and 2018 with Denton method. Model uses quarter-on-quarter change rate.
ΔFD New supply * (First difference)	New Supply (new construction and repurposed buildings) of rental spaces in $1000m^2$ per capita. Yearly data 2005-2018 smoothed to quarterly with linear smoothing. Model uses first differences. (*excluded from final model as proven insignificant during model selection process)
ΔFD Inflation (First difference) *2-quarter lag*	Consumer Price Index. Model uses first difference.
Time	60 quarters from Q1 2005 (=1) until Q4 2019 (=60)
Student population *	Share of university students as a share of total population. (*excluded from final model as proven insignificant during model selection process)
Doctors/Physicians	Number of medical doctors (of all fields) per 100.000 population
"Big seven" *	Dummy variable for Berlin, Hamburg, Munich, Cologne, Frankfurt, Dusseldorf, Stuttgart. These Cities attract more people and have significantly higher rents that cannot be explained alone by economic performance or population densities. (*excluded from final model as proven insignificant during model selection process)
Former GDR (east Germany)	Dummy variables for Cities in the former GDR ("Neue Länder") These Cities have significantly lower rents that cannot be explained alone by economic performance or population densities
RC (Rent-Controlled)	Dummy variable for "Diff-in-Diff." method for treatment group. In all "treated" cities RC =1. Model looks at three treatment sub-groups: First cohort of cities RC1, third cohort of cities RC3, fifth cohort of cities RC5.
Post (Post-Treatment)	Dummy variable for "Diff-in-Diff." method for time periods after rent control is implemented. In all time periods after implementation = 1 for all cities. Different implementation times for different treatment sub-groups (Post1, Post3, Post5)
DiD (Treatment effect)	Dummy Diff-in-diff. estimator takes the value of 1 for all treated cities (RC=1) after policy implementation (Post=1). This shows the real treatment effect (or "intervention effect")
Lagged ΔFD Rent Price (first difference of log) *1-quarter lag*	Autoregressive (AR) term: First difference of logarithm of Rent Price from previous quarter. Because first-difference time series is stationary, it will return to a constant mean and previous change level should be negatively correlated to current change level

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In the previous chapter, the empirical framework has been constructed step by step and it was tested which variables should be included in the final model. Table 5 shows a list of the variables in detail. Note that the variables for new rental supply, university student population as a share of total city population, as well as the dummy variable for "big-7" cities had to be dropped from the model, as they proved statistically insignificant in the model selection process.

4.2 Econometrical Model and Estimated Effect of Covariates

Table 6 shows the output of the three statistical models for each of the three treatment groups of interest (i.e. the first group of cities "RC1" that implemented rent control before Q3 2015, the third group of cities "RC3" that implemented rent control before Q1 2016, and the fifth group of cities "RC5" that implemented rent control before Q1 2017). The models are estimated according to the description in Chapter 3.2. with the treatment group dummy variable RC taking the value 1 for cities in group RC1 in Column 1, the value 1 for cities in group RC3 in Model 2, and the value 1 for cities in group RC5 in Model 3 respectively. For all other cities, including rent-controlled cities in other cohorts that are not part of the particular treated sub-group, RC equals 0. The post-treatment dummy variable Post is 1 for all observations (in rent-controlled as well as untreated cities) starting from the respective first complete quarter of policy implementation, i.e. from Q3 2015 (in model 1), Q1 2016 (in 2) and Q1 2017 (in 3). The DID estimator is given by the multiplication of RC and Post for each respective model (i.e. RC1*Post1 in column 1, RC3*Post3 in column 2 and by RC5*Post5 in column 3) and therefore only takes the value 1 for observations in treated cities after the policy implementation. This way the treatment effect of rent control can be isolated separately from constant differences between treatment and control group (RC) and common time trends between the two groups (Post).

As described in Chapter 3.2., the estimators for RC will isolate the initial difference in rent growth between the respective treated cities and cities in the respective control group across all time

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periods, so that these constant differences are not mistaken for results of the treatment. The estimators for the variable Post will isolate the common time-effect that is the same in all 110 cities (treated and untreated) that might otherwise be interpreted as an effect of the policy. By isolating the two factors of initial difference between treatment and control group (RC) and the common time trend (Post), the Difference-in-Difference method is able to predict the real treatment effect with the estimator DiD. Only DiD yields information about the effect that rent control had on each respective treatment sub-group. To conclude that a policy had such an intervention effect requires the DiD estimator to be statistically significant. In the case of rent control, only a statistically significant and negative estimator would indicate that the policy had a dampening effect on the development of rents. Meanwhile, for the analysis of the effect of the policy it is irrelevant whether RC or Post are statistically significant or not, or whether they are positive or negative.

The overall fit as described by R^2_{adj} lies between 0.0693 in models (2) and (3), and 0.0714 in model (1). This means that around 7% of the variation in the dependent variable in each model can be explained by the variation in the independent variables. Compared to the preliminary model with absolute values from section 3.3, this might seem small, but it is to be expected to get smaller values for R^2_{adj} with a model using first differences. In the three models, the values for AIC lie between -30310.21 in model (1) and -30296.54 in model (2). While the exact values for the Akaike information criteria (AIC) have no real meaning, we can still see that the models improved further by adding the autoregressive lag term after the model selection process.

To make sure the regression is valid, another fisher-type panel unit root test with Augmented Dickey-Fuller test specification, which was introduced in Chapter 3.3, is performed on the residuals of all three models. The results suggest that for all three models the null-hypothesis is rejected (p=0.0000) meaning that there is no unit root and the residuals are stationary.

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Table 6: Statistical Output Final Regression

	(1)	**(2)**	**(3)**
Dependent Variable: ∆FD Log_Rent	**Rent Control Cohort 1 (RC1)**	**Rent Control Cohort 3 (RC3)**	**Rent Control Cohort 5 (RC5)**
∆FD Log_Rent$_{t-1}$ (AR term)	-0.2244***	-0.2223***	-0.2223***
First difference of log from previous quarter (1 lag)	(0.0249)	(0.0249)	(0.0249)
∆% GDP	-0.0007**	-0.0007**	-0.0007**
QoQ %-change (2 lags)	(0.0003)	(0.0003)	(0.0003)
∆% Population density	0.0031***	0.0031***	0.0029***
QoQ %-change (3 lags)	(0.0006)	(0.0006)	(0.0006)
∆FD CPI	0.0038***	0.0037***	0.0037***
First difference (2 lags)	(0.0007)	(0.0006)	(0.0007)
Additional independent vars:			
Time (quarter)	0.0002***	0.0001***	0.0002***
	(0.0000)	(0.0000)	(0.0000)
Doctors per 1,000 pop.	0.0014**	0.0017***	0.0017***
	(0.0006)	(0.0006)	(0.0006)
East (Former GDR)	-0.0014**	-0.0017***	-0.0016***
	(0.0006)	(0.0006)	(0.0006)
DiD estimators:			
RC	0.0022***	-0.0003	0.0016
	(0.0008)	(0.0008)	(0.0015)
Post	-0.0021**	0.0015*	-0.0008
	(0.0009)	(0.0008)	(0.0008)
DiD	-0.0027**	-0.0013	-0.0011
	(0.0011)	(0.0009)	(0.0010)
Constant	-0.0445***	-0.0269***	-.0361***
	(0.0059)	(.0056)	(0.0052)
Obs. N =	6,050	6,050	6,050
Adjusted R^2	0.0714	0.0693	0.0693
AIC	-30310.21	-30296.54	-30297.04

Notes: The dependent variable in all three models is the first difference of the logarithm of nominal average Rent Price (in EUR/m^2). Robust standard errors in parentheses. The treatment group dummy variable RC takes the value of 1 for cities in group RC1 in Columns (1), the value 1 for cities in group RC3 in Model (2), and the value of 1 for cities in group RC5 in Model (3). The post-treatment dummy variable Post is 1 for all observation in treated as well as untreated cities starting from the first complete quarter of policy implementation, i.e. from Q3 2015 (in model 1), Q1 2016 (in 2) and Q1 2017 (in 3). The DID estimator is given by RC1*Post1 in column (1), by RC3*ost3 in column (2) and by RC5*Post5 in column (3).
*** p<0.01, ** p<0.05, * p<0.1

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First conclusions that can be drawn from the model are that an increase in population density seems to be a main driver of rent increases, while economic performance (i.e. the change in GDP) is not. The estimator for the effects of a quarter-on-quarter increase of population density of 1% with a three-period-lag is 0.0031 in model (1) and (2), and 0.0029 in model (3). All estimates are valid on the 1% level. The estimator for the effects of a GDP quarter-on-quarter increase of 1.00% with a two-period lag is -0.0007 in all three models. All estimates are significant on the 5% level. It is surprising that an increase in real GDP should have decreased average rents in a city, especially when keeping in mind that GDP is a good predictor of the *absolute* level of rent prices.

As should be expected, the autoregressive (AR) term, i.e. the change in rents in the last period (1 lag) is a good prediction for the current term's change in rent price. The coefficient is estimated to be -0.2244 in model (1) and -0.2223 in model (2) and (3), all significant at the 1%-level. This should be the case, because as described above, the de-trended stationary time-series will evolve around a constant mean to which it will return over time. If a period-on-period change (first difference) of rent prices was especially high in the last period, the change in this period can on average be expected to be especially low in order to counter out last period's change and to bring back the average towards the expected constant mean.

Furthermore, the first difference in the consumer price index (CPI) with a two-period lag has a significant effect on the change in rent prices at the 1%-level. The estimated coefficients are 0.0038 in model (1) and 0.0037 in model (2) and (3). This makes sense, because the data set uses nominal rent prices, so naturally rents will be correlated to inflation.

While Germany's student cities seem to have higher *absolute* rent levels, the regression results suggest no higher *increase* of rents over time in cities with high shares of university students. This was shown in the model selection process in Chapter 3.5, so the share of students was excluded from the final regression in this Chapter. Interestingly, however, the number of doctors as a proxy for the quality of healthcare in a city and possibly also an indicator of a city's attractiveness (Ono, Schoenstein, & Buchan, 2014), did have an effect on the change of rents in a city. In all three models

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(1), (2) and (3), the model estimated that rent prices increased stronger (coefficients from 0.0014 to 0.0017) in cities with more doctors per 1,000 population.

Meanwhile cities in the new Federal States of the former German Democratic Republic experienced not only lower absolute rent prices as shown before, but also a lower growth over time. Models (1) to (3) estimate coefficients between -0.0014 and -0.0017 at the 5% significance level.

4.3 The Estimated Treatment Effect of Rent Control

The Difference-in-Difference (DiD) estimator for the treatment effect of rent control is statistically significant for the first cohort of cities (RC1) at the 5% level with an estimated effect of -0.0027, i.e. reducing rent increases by around 0.3% per quarter, but not significant for the third and fifth cohorts of cities, although also suggesting a low negative impact of the policy on rent development (with estimated coefficients of -0-0013 and -0.0011 respectively). This is a relevant finding that is possibly surprising for some, as it goes against the mostly anecdotal and descriptive consensus in both public and media that the German Rent Brake had no effect on the development of residential rents at all, or that it even made things worse (The Economist, 2018) & (Oechsner, 2018). Instead, it further provides evidence for findings by Deschermeier et al. (2017), Kholodilin et al. (2018) and Thomschke (2019) that predicted small but significant effects of the German rent control policy for some cities, but not for all.

Meanwhile, the estimated coefficient for RC1 (indicating the first cohort of 22 cities that first implemented the policy) is statistically significant on the 1% level and stands at 0.0022, which means rent increases in these 22 cities were on average significantly higher than in the other 88 cities throughout all time periods. This is not surprising, as the first cohort of cities consisted of five out of the "big seven" cities which experienced the largest influx of population, as well as a number of student cities and well-off cities in wealthy Bavaria. While a significant and positive estimator for RC explains why these cities might have been chosen as the first cities to implement rent control, it still carries no meaning for the effect of the policy, which is solely predicted by the estimator for

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DiD. After the first initial group of cities with the tensest rental markets, the policy was also implemented in a number of cities with less extreme conditions, which explains why RC3 and RC5 are statistically insignificant, indicating that rent increases in these cities were not significantly higher or lower than in other cities.

The estimated coefficients for the Post variable lie between -0.0021 in model 1 and 0.0015 in model 3 and are partly statistically significant and partly not. As this variable is mostly included for the purpose of isolating the common time trend among all cities for the Difference-in-Difference approach, the results should not be overinterpreted. The key finding of the model remains what is represented by the estimator for DiD, i.e. that the German Rent Brake was able to dampen the increase in rents in the first group of cities that implemented the policy.

There are a few speculative explanations for why the policy had a dampening effect on the development of rents in the first group of cities that implemented the policy, but didn't have a statistically significant effect in the cities that followed later. Most intuitively, the first cohort of rent-controlled cities included many of those cities, such as Berlin, Hamburg, Munich, Cologne and Düsseldorf, that were struggling most with high and fast-increasing rents in which flats were more likely to reach a rent 10% above the official local rent level ("Mietspiegel") This would be in line with the finding of Kholodilin et al. (2018), who found that the policy only showed effect, when an increase of rents in cities was fast enough in the first place (Kholodilin, Mense, & Michelsen, 2018). Due to the significant in-migration in those cities the model would have predicted even higher rent increases under the absence of rent control.

Moreover, it is possible that it has to do with the longer running time of the policy in the first cohort of cities that introduced the policy and that the policy needs time to take effect. Rents are supposed not to exceed the 10% level of average local rent level. However, the local reference rent ("Mietspiegel") as defined by the city or local stakeholders is only updated occasionally and includes rent levels from the previous four years. The longer the running time, the more likely it is that the actual level of rents for new rentals hits the 10% level above the official reference level.

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Last but not least it is possible that there was an initial learning process before landlords realized that the new rent control measures would not lead to legal consequences in case of an exceeding of the legal limit (Frehner, 2020). It is reasonable to expect that after the initial introduction of the law in the first cohort of cities, there would have been a short-term impact on average rent prices in these cities, because landlords would have been cautious at first, before the relative ineffectiveness of the law became clear. By the time the third and fifth group of cities implemented the policy, the ineffectiveness of the policy would already have become obvious.

4.4 A Note on New Supply of Residential Rental Space

The model suggests that rent control policy did in fact have a small effect in some cities on limiting the increase in local rents. Meanwhile the supply of new rental dwellings didn't have a significant effect whatsoever. As discussed in Chapter 3.5 regarding the model selection process, new supply of rental space did not have any dampening effect on rents, neither when measuring the immediate effect of new supply, nor when looking at lagged effects, which is why it was excluded from the models that are shown in Table 6.

It could have been suspected that new supply might have an immediate positive effect on the quarterly rent for newly let apartments, both because the quality of new apartments should be higher than that of the average existing stock which makes tenants more willing to accept higher rents (Edmiston, 2016), and because new apartments are exempt from the law. As mentioned above, Fallis and Smith (1984) showed that assuming part of the rental stock within a city is affected by rent control measures and part is not, that the price for unaffected rental units would actually increase (Fallis & Smith, 1984). However, introducing at least a one-period lag should remove this immediate price-driving impact and measure the long-term effects of more supply of rental housing spaces. The fact that no effect by new supply can be observed over time confirms the general consensus in the literature that the new supply of rental spaces in German cities has just not been enough to have any dampening effect on rents and should be expanded in the future in order to meet

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demand (Henger & Voigtländer, 2019). As describe before, the argument that there is too little building activity is underscored by continuously low vacancy rates (Fed. Inst. for Research on Building, Urban Affairs and Spatial Development, 2019).

Therefore, in terms of which policy should have priority to better combat high and increasing rent prices, it has to be said that although the model proposes that rent control did actually have a small dampening effect on rents while new supply did not, it should be clear that the only viable policy measure in the long and medium run can only be new supply of rental spaces. If anything, the finding that new supply has been entirely insignificant further contributes to the serious concerns in the literature about the significant lack of rental space, especially in big cities. Limiting prices might give short-term ease to the symptoms, but will not fix the underlying problem of too few vacancies for too many people.

Last but not least, it should be noted here that there is an obvious complication when working with city averages of rents for all newly-let dwellings. Because the law exempts newly constructed apartments as well as renovated flats, but the average rent prices in the dataset for this project include all newly-rented dwellings including old and new flats, it is impossible to say how many of the apartments within each city have actually been exempted by the rent control measures and what proportion of the rent increase was carried by these exempted new apartments. It is likely that *within* a city, rent control actually had a stronger impact than the model predicts on those units which fall under the law, while exempted units contributed to a higher increase in rents.

Chapter 5: Conclusion and Policy Implications

This thesis contributes to the existing literature on the German Rent Brake since 2015 by offering a new econometrical approach to measuring the effects of the policy. There has been literature on the effects of rent control, but to my best knowledge I have not seen an empirical approach with the Difference-in-Difference method using city-level rents.

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For this project, data was collected from different sources. Quarterly values for city-level panel data was derived by smoothing with the help of the Denton method for disaggregation. Unit-root tests were performed to identify non-stationarity in the data for rent prices, GDP, city population data, and new rental space supply. Non-stationary data was then de-trended by deriving first differences of the logarithm of rents for the independent variable as well as the quarterly change rates (QoQ) for GDP and population data and first differences for CPI and new supply.

This made it possible to perform an estimation of the possible effects of the rent control policy by the use of the Difference-in-Difference (DiD) method, which isolates a treatment effect for each sub-group of treated cities. By doing so, it could be shown that there was after all a statistically significant dampening effect on the change of rents through the implementation of rent control, even if this could only be confirmed with certainty for the first group of cities that had implemented rent control until the third quarter of 2015.

The confirmation that rent controls had in fact a significant effect in some cities is a relevant finding as it goes contrary to much of public belief about the policy, and instead gives some support to scholarly arguments like that made by Arnott in 1995 that well-designed rent control mechanisms of the so-called "second generation" can have a positive effect and be a reasonable policy tool (Arnott, 1995). In this sense this project in theory agrees with the government's plan to use the Rent Brake as a temporary tool to help bridge the time until new rental supply catches up with demand.

In practice however, it has to be pointed out that although new construction of rental space has slowly begun to pick up in recent years, there is still a discrepancy between what will be needed and what is being built. It was shown that a main driver of rents was increasing population density in cities. Especially the larger cities experienced a large influx of internal and external migration in recent years which combined with low vacancy rates and low building-activity put supply under immense pressure.

The regression results revealed that new supply did not have any significant effect on the development of rent prices in the past, neither immediately nor over time through lagged effects,

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which indicates that building activity was on average still too low and insignificant to have any effect whatsoever. Traditional housing theory suggests that prices will always be defined by Demand vs. Supply. Leaving Supply out of the equation will not be enough in the long run. The government should find ways to increase building activity for affordable rental housing instead of solely focusing on the Rent Brake as the sole solution to increasing rents.

This conclusion is especially relevant in light of the new rent freeze policy introduced by the city of Berlin in 2020, which immediately freezes rents at the current level for the duration of five years and therefore more closely resembles those "first-generation" rent control mechanisms that are generally criticized to be doing more harm than good by disincentivising investment into the quantity and quality of rental housing supply. It will be interesting to see how the policy will play out in the long run and more research should and will be undertaken in this regard.

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