Socio-Economic Aspects of Urban Development

Unit 8: Rising Rent

Prof. Melanie Krause, Ph.D.

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Overview of Unit 8

- How is the rent of an apartment determined?
  - The hedonic pricing model
  - The importance of particular amenities
  - The vertical price gradient
- Trends of rising rent in big cities
- Regulatory instruments to cap rent
  - Discussion of various instruments, their effectiveness, and (sometimes unintended) consequences

Determinants of Rental Prices

- In the real estate literature, the **hedonic price model** is often used to analyze the determinants of the rental price (alternatively, the sales price) of an apartment
- Hedonic utility: Decomposition of the property into its value/benefit-generating characteristics. Often an additive model of the K X-characteristics is used, resulting in a linear model for the price of property i at time t:

$$Price_{it} = \alpha + \beta_1 \cdot X_{1,it} + \beta_2 \cdot X_{2,it} + ... + \beta_K \cdot X_{K,it} + \epsilon_{it} \quad (1)$$

- What determines the housing price $p \cdot q$ in the Alonso-Muth-Mills model?
  - (Only) distance from the city center
- In reality, apartments differ in many other characteristics. Which ones should be taken into account?

Hedonic Regression: The Characteristics

- Sopranezzi (2010) classifies the price-forming characteristics of an apartment into three main groups:
  1. **Structural characteristics** of the apartment
     - ★ e.g. size, number of rooms, bathrooms, age of the property (new/old building), renovation requirements, cellar, balcony/garden
  2. **Characteristics of the neighborhood**
     - ★ e.g. average income, unemployment, crime rate, pollution
  3. **Location** within the city
     - ★ e.g. distance to the city center, shopping facilities, proximity to metro stations, restaurants, geographic amenities (river/ocean view) and cultural amenities (museums, schools)
- Also: With data from different years, take into account the timing. If it is sales data, consider the characteristics of the transaction (e.g. broker fee)

Hedonic Regression: Interpretation of Results

- Equation (1) is typically estimated by Ordinary Least Squares (OLS). Minimizing the squared residuals

$$\sum_{i=1}^{N}(y_i - \beta_0 - \beta_1 x_{i1} - \beta_2 x_{i2} - ... - \beta_K x_{iK})^2 \quad (2)$$

  leads to the OLS estimator of the regression coefficients $\beta_1, \beta_2, ...\beta_K$.

- Econometric inference:
  - The null hypothesis is that the variable x_j is statistically insignificant, hence the characteristic does not contribute towards explaining the apartment price. Can we reject the null hypothesis in favor of the alternative hypothesis? $H_0 : \beta_j = 0$; $H_1 : \beta_j \neq 0$
  - The t-statistic $\frac{\hat{\beta}_j}{se(\hat{\beta}_j)}$ follows a t-distribution with $n - K - 1$ degrees of freedom. If the p-value of the t-statistic is smaller than, say $\alpha = 0.05$, we can reject the null hypothesis that x_j is statistically insignificant at the 95% confidence level. In other words: x_j is statistically significant at the 95% confidence level.

Hedonic Regression: Interpretation of Results

- $\hat{\beta}_j$ expresses the expected change in y resulting from a **ceteris paribus change** in x_j:

$$\Delta\hat{y} = \hat{\beta}_j \cdot \Delta x_j \tag{3}$$

  - y is the apartment rent in euros per square meter, x is distance to the city center in km and $\hat{\beta}_j = -0.9$: Moving further away from the city center by 1 km decreases apartment rent by 0.90 euros per square meter.

- **Binary variables**, or dummy variables, can only take two values. Example: Dummy variable indicating if the apartment has a garden
  - Variable x_j has the value of 1 if apartment i has a garden, and value of 0 if apartment i does not have a garden
  - $\hat{\beta}_j$ captures the expected change in y when the dummy jumps from 0 (no garden) to 1 (garden), e.g. $\hat{\beta}_j = 1.3$, if apartments with a garden have a rental price of 1.30 euros per square meters more than those without a garden

Hedonic Regression: Interpretation of Results

- Nonlinear effects of certain x-variables can be captured by **quadratic terms** or **interaction terms**:

$$Price = \beta_0 + \beta_1 \cdot area + \beta_2 \cdot area^2 + \beta_3 \cdot balcony + \beta_4 \cdot balcony \cdot ocean + ... + u \quad (4)$$

- **Concave** function for apartment size: Decreasing marginal effect of an additional square meter in apartments that are already large, $\hat{\beta}_1 > 0$, $\hat{\beta}_2 < 0$. The effect of apartment size on price reaches its maximum at:

$$max = -\frac{\hat{\beta}_1}{2\hat{\beta}_2} \quad (5)$$

- Interaction term: Does a balcony have a particularly large effect, if the apartment also has an ocean view? The partial effect of the balcony on the price is then
  - $\hat{\beta}_3$ for apartments without an ocean view
  - $\hat{\beta}_3 + \hat{\beta}_4$ for apartments with an ocean view

Hedonic Regression: Sopranezzi (2010)

- Let us start with an American example: In his well-known article, Sopranezzi (2010) runs a hedonic regression on data from 7088 real estate sales in Houston, Texas. The sales prices of houses range from USD 18000 and USD 385000.
- Some variables enter the hedonic regression with squared terms because a concave relation to price can be assumed:
  - Size of the living area (*feet*), size of the whole lot (*lot*), number of rooms (*bed*), age of the house (*age*)
- The results table gives the coefficient estimates and their t-statistics. If the t-statistics exceeds 1.98 in absolute values, it is statistically significant at the 95% confidence level.
- The signs of many coefficient estimates are as expected (e.g. number of baths, presence of a pool). What about the positive coefficient of distance to the city center (*cbd*)? Are you surprised?
- 84% of the variation of the real estate prices can be explained by the given characteristics.

Hedonic Regression: Sopranezzi (2010)

	OLS sale	
	Coefficient	T-stat
FT	0.94591	10.33
SQFT	−8.65E-04	−15.35
Age	−3035.3	−20.71
SQAGE	59.356	10.25
Lot	1.7881	10.01
SQLOT	−1.62E-05	−3.59
Bed	42,839	11.40
SQBED	−6207.4	−12.35
Bath 2	6305.7	2.11
Bath 3	4199.3	5.82
Bath 4	15,936	17.26
Bath 5	16,196	6.26
Pool	11,447	16.85
Foreclose	−10,025	−9.03
Asis	−11,932	−6.21
Defect	−383.98	−0.28
CBD	267.98	4.12
New	3004.3	1.60
Summer	1260.8	2.81
Constant	−17,355	−2.78
R2	84.3%	

Hedonic Regression in Leipzig: Liebelt et al.(2018)

- Liebelt, Bartke, and Schwarz (2018) focus on one particular characteristic of an apartment: Proximity to **green spaces** as an amenity
  - *Urban Green Space:* Parks, urban forests, meadows, cemeteries
- Hedonic regression including proximity to green spaces: Data from **Leipzig**

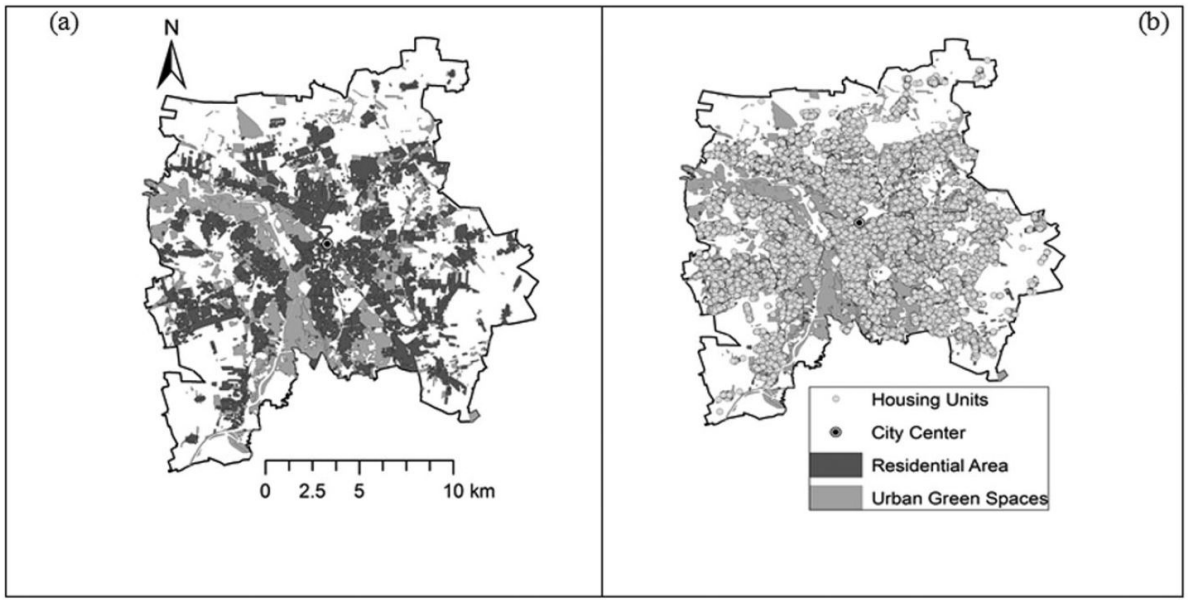


Figure 2. Location of (a) UGS and residential area overlaid with (b) real estate data in the case study area. Sources: Own representation, data from ATKIS (2010) and Immobilien Scout GmbH. The white sections on the maps indicate other types of land uses (e.g. agricultural land and water).

Hedonic Regression in Leipzig: Liebelt et al.(2018)

- Data from ImmobilienScout from 2007-2013: 261,827 rental apartments, 19,465 apartments for sale, 907 rental houses, 8360 houses for sale
- Spatial data of the topographic-cartological information system to calculate the size of the green area and the percentage of green area around the apartment
- The usual structural, neighborhood and location characteristics are taken into account. Distance to the city center clearly has a negative coefficient
- The influence of green areas on the property price is small compared to other characteristics (such as apartment size, own garden, etc).
  - Increasing the proportion of green space within a 300m radius by 1%, increases the sales price per square meter of apartments by 1.52 euros and that of houses by 1.15 euros
- Smaller effects of green space on rental apartments than on those for sale

Vertical Rent Gradient: Danton and Himbert (2018)

- Danton and Himbert (2018) work with rental prices from Switzerland: More than 200,000 apartments
  - Geocoded data on the location and building characteristics of all residential buildings in Switzerland in the period 2004-2014 (x-variables)
  - Geocoded rental price data for the same observation period (y-variable)
- In particular, they consider the location of an apartment in the building and how it affects the rental price
  - Ground floor? Top floor? Anything in between?
  - What are advantages/disadvantages of living on the respective floor? How do you expect the floor to influence the rental price?

Vertical Rent Gradient: Danton and Himbert (2018)

$$\ln P_{ibgmt} = \beta_1 GF_i + \beta_2 GF_i \times BH_b + \gamma_1 \ln FL_i + \gamma \ln FL_i \times \mathbf{X}_b + \theta_1 TF_i + \theta_2 TF_i \times BH_b + \mu Z_i + \delta_b + \delta_{gt} + \delta_{mt} + u_{ibgmt},$$

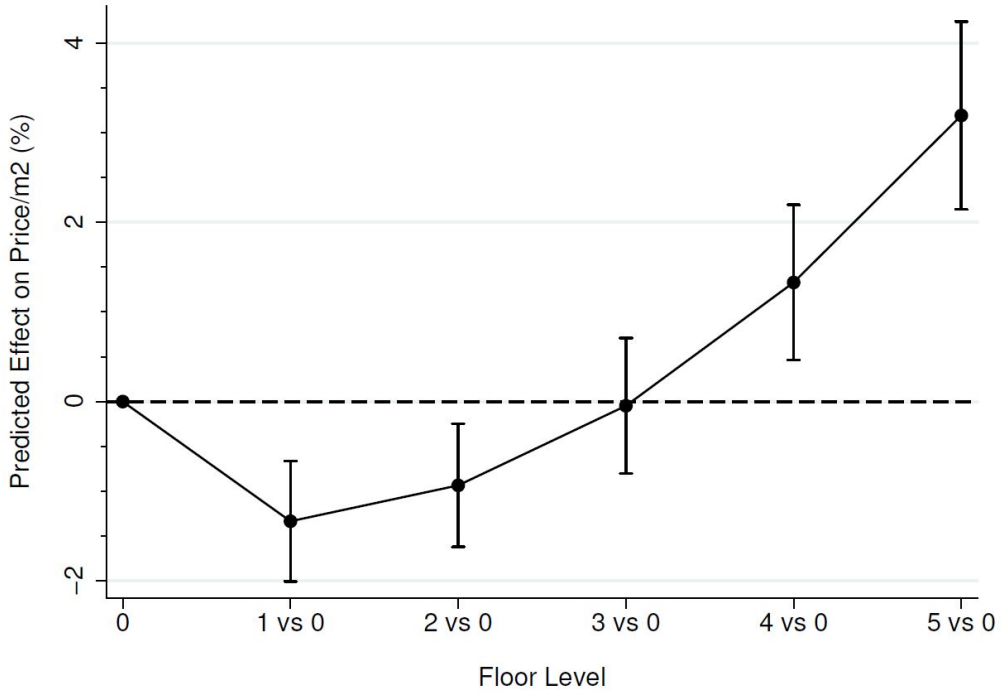
- Regress the log rental price of apartment *i* in building *b* in grid cell *g* in municipality *m* at time *t* on...
  - a ground floor dummy variable *GF*, also interacted with the building height *BH*
  - the (log) floor the apartment is on (*FL*), also interacted with other explanatory variables *X* of the location
  - a top floor dummy variable *TF*, also interacted with the building height *BH*
  - a vector of apartment-specific characteristics (size, balcony...) Z_i
  - fixed effects of the building, grid cell, municipality

Vertical Rent Gradient: Danton and Himbert (2017)

Dependent variable:	Log Rental Price Per Square Meter					
	(1)	(2)	(3)	(4)	(5)	(6)
Ground Floor	0.023***	0.027***	0.017***	0.015***	0.015***	0.011**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Ground Floor × Building Height	-0.003***	-0.003***	-0.002**	-0.002*	-0.001*	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Top Floor	-0.021**	-0.023**	-0.021**	-0.019*	-0.019*	-0.017*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Top Floor × Building Height	0.009***	0.009***	0.008***	0.008***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log Floor	0.013***	0.027***	0.045***	0.046***	0.044***	0.041***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)
Log Floor × Building Height	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Log Floor × Building with View		0.006***	0.008***	0.009***	0.008***	0.008***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log Floor × Building Age Period		-0.002***	-0.004***	-0.004***	-0.004***	-0.004***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log Floor × Commute Distance from CBD (km)			-0.003***	-0.003***	-0.003***	-0.003***
			(0.000)	(0.000)	(0.000)	(0.000)
Log Floor × Neighborhood Density (in 10 buildings)				-0.003***	-0.002**	-0.003***
				(0.001)	(0.001)	(0.001)
Log Floor × Neighborhood Density (in 100 units)				0.003**	0.003***	0.004***
				(0.001)	(0.001)	(0.001)
Log Floor × Internal Building Density (# of Apartments)				-0.000**	-0.000**	-0.000**
				(0.000)	(0.000)	(0.000)
Log Floor × Altitude (in 100m)					-0.001	-0.001
					(0.001)	(0.001)
Log Floor × Slope of Terrain					0.002***	0.002***
					(0.000)	(0.000)
Log Floor × Building Higher than Average in Neighborhood						0.006***
						(0.002)
Buildings	37,382	37,382	37,382	37,382	37,382	37,382
Observations	265,089	265,089	265,089	265,089	265,089	265,089

Vertical Rent Gradient: Danton and Himbert (2017)

Figure 3: The Vertical Rent Gradient*



- Apartments on the first and second floor less expensive than
  - those on the ground floor $\Longrightarrow$ Ground floor premium
  - those on higher floors $\Longrightarrow$ Vertical rent gradient

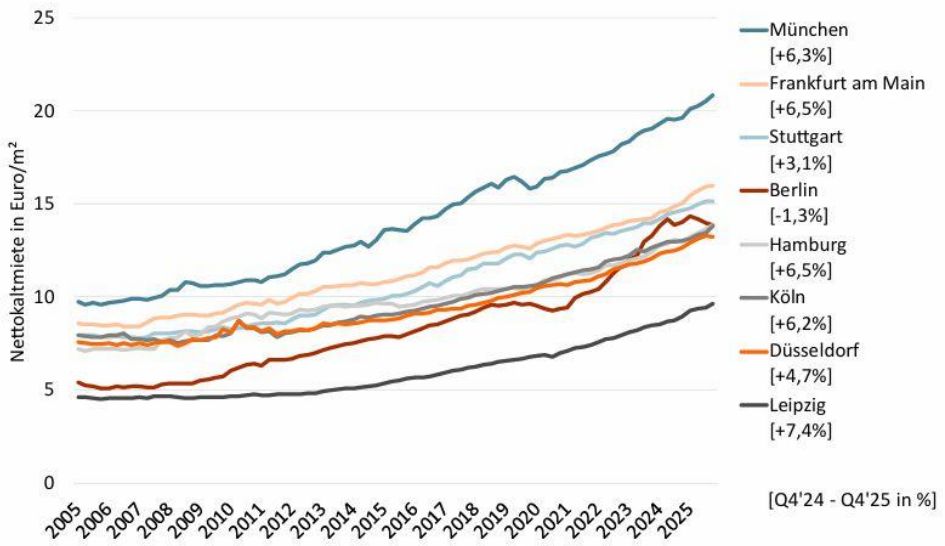
Vertical Rent Gradient: Danton and Himbert (2018)

- The key results of Danton and Himbert on the vertical rent gradient are:
  - The ground floor premium ranges between 1.5% and 3%.
    - ★ This is the same order of magnitude as the ground floor premium in office buildings (Liu, Rosenthal, and Strange, 2015).
  - A ground floor apartment costs as much as a more upper-floor apartment approx. 250 to 450 meters closer to the city center.
  - The ground floor premium is driven by upper floor access costs (stairs) rather than ground floor amenities (e.g. a garden). A building without a lift has a considerably larger ground floor premium.
  - The vertical rent gradient is convex, i.e. in high buildings, upper floors command higher prices per square meter. Amenities (e.g. views) may compensate consumers for the lack of easy access to the street (**access vs amenities tradeoff**).
  - The vertical rent price gradient is steeper for higher buildings, those with a view, those close to the city center, and those that are higher than average in the neighborhood.

Rent Increase in Big German Cities

In big German cities, there has been a significant increase of rental prices in recent years, driven by strong demand and limited supply. $\Longrightarrow$ Political debate, calls for intervention

Abbildung 23: Angebotsmieten für Bestandswohnungen zur Wiedervermietung in den Top-8 Städte Q1/2005 – Q4/2025



Referenzwohnung: 60–80 m², gute Ausstattung, Baujahr bis drei Jahre vor Vermarktungszeitraum
Quelle: empirica regio (VALUE Marktdaten / bis 2011: IDN ImmoDaten GmbH) **empirica**

Mietsteigerungen

bei im Internet inserierten Wohnungen* in den 14 größten kreisfreien Städten Deutschlands

	2014	2023	Jährl. Veränderung in %
Berlin	8,10 €	16,35 €	8,1 %
Leipzig	5,51	8,68	5,2
Dortmund	5,98	8,92	4,5
München	13,86	20,59	4,5
Köln	9,26	13,44	4,2
Stuttgart	10,35	14,89	4,1
Bremen	6,94	9,90	4,0
Düsseldorf	8,73	12,24	3,8
Essen	5,88	8,26	3,8
Nürnberg	7,88	11,07	3,8
Duisburg	5,33	7,31	3,6
Frankfurt/M.	10,81	14,57	3,4
Hamburg	9,94	13,26	3,3
Dresden	6,65	8,23	2,4

* Erst- u. Wiedervermietung, unmöblierte Wohnflächen von 40 bis 100 m² mit mittlerer Wohnungsausstattung in mittlerer bis guter Wohnlage

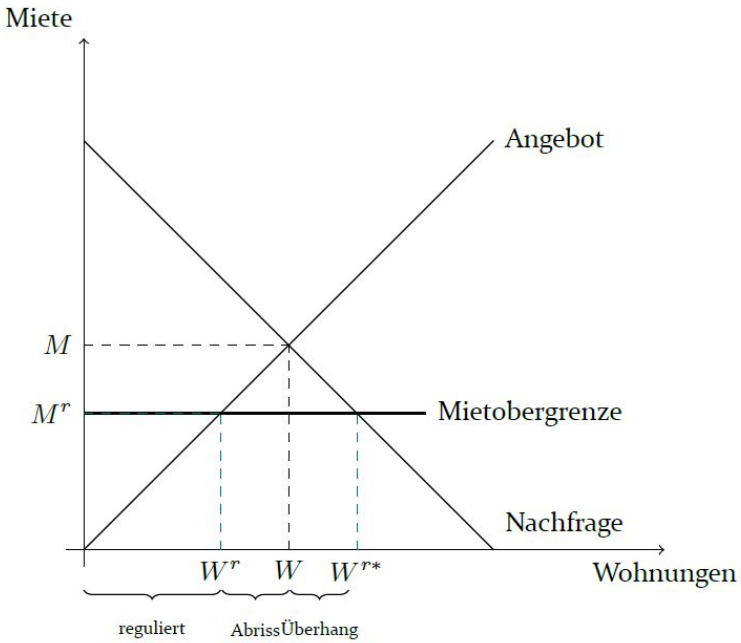
dpa•108116 Quelle: Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen

Instruments of Rent Regulation: The Case of Germany

Two examples of regulatory instruments for intervention in the rental market:

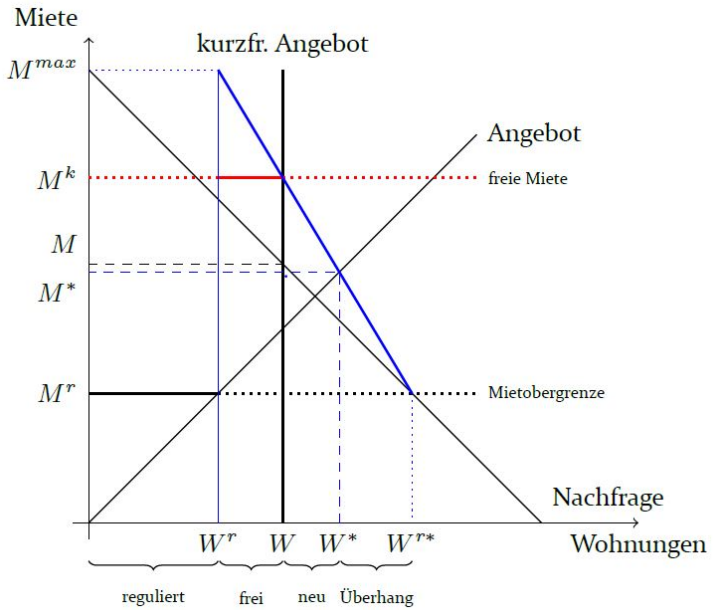
- ***Mietpreisbremse*** ('Rental Price Brake'): § 556d(2) BGB (German Civil Code) has included a provision since 2015: German Bundesländer can decide that in 'tight rental markets', the price for new rental must not exceed the local comparable rent by more than 10%.
  - Introduced in several major German cities, e.g., Berlin, Hamburg, Munich, and also medium-sized cities; since 2022 in Leipzig. Exemptions for new buildings (built after 2014) and after extensive refurbishments.
- ***Berliner Mietendeckel*** ('Berlin Rent Cap'): Passed by the Berlin House of Representatives and in force in 2020 before overturned by the Federal Constitutional Court in 2021 for lack of legislative authority. $\rightarrow$ Rents fozen at 2019 levels, rent caps set for 12 categories of apartments, even rent reductions at tenants' request under certain circumstances
  - 80% of all rental apartments in Berlin affected, exemptions for new buildings

Economic Mechanisms: Rent Regulation without Exemptions for New Construction



Mense et al (2017): A crude rent cap at M^r below the intersection of housing supply and housing demand (W, M). Only W^r apartments are supplied at rental rate cap M^r, there is a shortfall of $W^{r*} - W^r$.

Economic Mechanisms: Rent Regulation with Exemptions for New Construction



Mense et al (2017): Short-run housing supply is fixed (vertical line at W), short-run equilibrium (W, M) would be at higher prices than long-run equilibrium.
Rental price cap M^r is introduced only for existing apartments, holds for W^{r*} apartments.
Demand for unregulated apartments is the steep blue curve, intersecting the short-run supply at high-price (W, M^k). In the long-run, new construction - unaffected by regulation - is supposed to bring the unregulated price segment down to (W^*, M^*).

Evaluation of the German Rental Price Brake by DIW (2018)

- In their official report, researchers from DIW (2018) summarize the findings of various empirical studies that investigate the effects of the German *Mietpreisbremse* ('Rental Price Brake') in the first years since introduction.
  - The rental price brake has led to a deceleration of the rental price increases in the regulated market segments.
  - There has been a slight increase in building permits in regions with the price brake compared to those without the price brake. $\Longrightarrow$ Exemptions for new buildings credible, expected to remain in place, also expecting higher prices in the unregulated segment $\Longrightarrow$ Importance to keep this exemption
  - Little data yet on any effect of more/less investment in refurbishment

Evaluation of short-lived 'Berlin Rent Cap'

- Hahn et al. (2024) analyze the short time period (Feb 2020 - April 2021) during which the stringent Berlin rent cap was in place:
  - **Asking rents in advertisements for regulated apartments fell** by 7–11% relative to unregulated apartments
  - **But rental supply also fell strongly:** The number of newly advertised rental apartments declined substantially (weekly listings roughly halved)
  - **Spillovers to surrounding areas:** Asking rents increased more rapidly in Potsdam and other municipalities just outside Berlin
  - Because the constitutionality of the law was uncertain, some landlords included a higher "shadow rent" into the rental agreement that would apply if the law was overturned
- $\Longrightarrow$ Effects consistent with the standard price-ceiling mechanism: Lower rents for tenants who obtained a regulated apartment, but reduced availability and displacement to unregulated market segments

Long-Run Effects of Rent Regulation: Diamond et al.(2019)

- International empirical results in the literature vary with the type of rent regulation considered. General agreement on who the **short-term winners (existing tenants) and losers (landlords)** are, but some studies tend to find negative impacts on **quality** and **quantity** of housing.
- An active field of research is concerned with **long-term consequences** and broader effects of rent control.
- Example of the **long-term effects of San Francisco's rent control** in 1994: Diamond, McQuade, and Qian (2019) observe the city and affected tenants in the subsequent decades
  - Rent control reduced mobility of affected tenants by 20%.
  - New construction went down by 15%.
  - Some landlords reconverted their rental apartments into (expensive) apartments for sale, drawing in rich buyers and making it harder for poor renters to find a place to live.
  - San Francisco's rent control thereby made an (unintended) contribution to gentrification.

Potential Consequences of Rent Regulation

- Relief for existing tenants
- Remedial action in case of market failure

- All landlords lose, including the small ones
- Quality of housing decreases if less investment is made (investment in energy efficiency, etc)
- Potentially fewer new buildings (depends on precise regulations and exemptions for new buildings, note the importance of credibility and planning (un)certainty)
- Insider-Outsider problem of existing tenants vs newcomers
- Less mobility and dynamism

The strength of these effects depends on the details of the rent regulation (exemptions, incentives).

How to Create More Residential Living Space?

- **How can housing supply in large cities be increased?** The 2021-2025 German government aimed for 400,000 new dwellings per year, but fell short of the target every year. What to do?
  - **Build faster and cheaper:** Simplify planning and building regulations, accelerate permitting and digitalize approval procedures ⇒ Germany's new "Housing Construction Turbo" (*Wohnungsbau-Turbo*, 2025)
  - **Build more densely:** Add floors to existing buildings, build on underused sites and close gaps
  - **Use the existing building stock more efficiently:** Reduce vacancies and convert suitable office and commercial buildings into housing
  - **Mobilize additional land:** Redevelop brownfield and previously commercial sites in attractive locations
  - **But supply is not only constrained by land and regulation:** High construction costs, financing costs and long construction times can make projects economically unviable

Wrap-Up of Unit 8

- In a **hedonic regression**, the rental price or sales price of an apartment is regressed on its structural characteristics (size, building age, balcony etc), neighorhood characteristics (average income, pollution, crime rate etc) and locational characteristics (distance to city center, distance to geographical and cultural amenities etc).
- Many large cities have seen strongly **rising rental rates**, driven by a combination of strong demand and limited supply.
- Instruments for **rent regulation** in metropolitan areas typically relieve the rent burden for existing tenants but not for newcomers. The careful design of the policy is important in order to consider the incentives for new construction and investment in renovations, otherwise quality and quantity of housing may be negatively affected in the long run. Providing affordable housing in growing metropolises is a challenging issue of the political debate.

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