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Article

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Online-Appendix

„Exploring Discrepancies in Energy Performance Certificates: Analyzing Energy Efficiency Premiums for Buildings Based on Theoretical Energy Requirements Versus Actual Energy Consumption“

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Appendix

Appendix 1 - Regulation regarding the use of allowed EPC types in Germany

Type of building	Legal norm	Allowed EPC type
New building	§ 80 (1) GEG	Requirement certificate
Refurbished building	§ 80 (2) GEG	Requirement certificate
Existing building - With missing consumption data for the last 36 months	§ 82 (4) GEG	Requirement certificate
Existing building - with planning application before 1 st November 1977 - consists of < 5 apartments - not fulfilling the Ordinance on Thermal Insulation (11.08.1977; BGBl. I S. 1554)	§ 80 (3) GEG	Requirement certificate
Existing building - with planning application before 1 st November 1977 - consists of < 5 apartments - fulfilling the Ordinance on Thermal Insulation (11.08.1977; BGBl. I S. 1554) - consumption data for the last 36 months	§ 80 (3) GEG	Requirement certificate Consumption certificate
Existing building - with planning application on or after 1 st November 1977 - consumption data for the last 36 months	§ 80 (3) GEG	Requirement certificate Consumption certificate
Existing building - consists of ≥ 5 apartments - consumption data for the last 36 months	§ 80 (3) GEG	Requirement certificate Consumption certificate

Appendix 2 - OLS model assumptions and respective tests

Assumption	Explanation	Test used
Linearity	The estimated coefficients are of a linear nature.	Visual test using plots of model residuals
No multicollinearity	Independent variables must not be linearly dependent. If two independent variables were dependent, one could easily omit one.	Generalized Variance Inflation Factor (GVIF)
Homoscedasticity	The residuals exhibit constant variance. It is also assumed that residuals are normally distributed.	White Test; visual test using plots of residuals
No autocorrelation	There is no correlation between the i th and j th residual terms.	Durbin-Watson (DW) statistic
Exogeneity	The expected value of the residual vector, given X , is 0 ($E(\varepsilon X) = 0$). For technical reasons, this is true for the sample model. However, this does not address the problem of omitted variable bias.	/

Appendix 3 - Hedonic characteristics of buildings and their description

Attribute	Description of the attribute
Cold rent	Numeric variable indicating the cold rent of the observation in EURO.
Warm rent	Numeric variable indicating the warm rent (cold rent plus operational costs) of the observation in EURO.
Sales price	Numeric variable indicating the sales price of the observation in EURO.
Number of rooms	Numeric variable indicating the number of rooms of the observation.
Living area	Numeric variable indicating the overall living area of the observation in m ² .
EPC type	Nominal variable indicating whether the observation has a requirement certificate or consumption certificate as EPC.

Energy consumption value	Numeric variable indicating the end energy consumption in kWh / (m ² * a).
Construction year	Numeric variable indicating the year the observation was constructed.
Address	Nominal five-digit postal code indicating the location of the observation.
Elevator	Nominal (binary) variable indicating whether the observation is equipped with an elevator.
Landmarked building	Nominal (binary) variable indicating whether the observation is or is part of a landmarked building.
First occupancy	Nominal (binary) variable indicating whether someone has lived in the building before.
Refurbished	Nominal (binary) variable indicating whether a refurbishment of the observation has taken place since the original construction date.
Parking space	Nominal (binary) variable indicating whether a parking space comes with the observation.
Rent status	Nominal (binary) variable indicating whether there exists an active lease agreement for the observation.
Object type	Nominal variable indicating the building type of the observation (e.g., penthouse, multi-family, single-family).
Commission	Nominal (binary) variable indicating whether a commission must be paid.
Furnished	Nominal (binary) variable indicating whether the observation is a building that is furnished or not.
Day of publication	Nominal variable indicating the day the observation was first listed on the market.

Appendix 4 - Rent data correlation matrix

Variable		Pearson's correlation coefficient*												
		i)	ii)	iii)	iv)	v)	vi)	vii)	viii)	ix)	x)	xi)	xii)	xiii)
i)	Cold rent	1.00												
ii)	Warm rent	0.99	1.00											
iii)	Energy consumption	-0.26	-0.26	1.00										
iv)	Living space	0.79	0.80	-0.16	1.00									
v)	Number of rooms	0.64	0.65	-0.07	0.87	1.00								
vi)	Construction year	0.21	0.23	-0.53	0.17	0.07	1.00							
vii)	EPC type	-0.18	-0.17	0.23	-0.10	-0.08	-0.23	1.00						
viii)	Furnished	0.01	0.01	0.01	-0.09	-0.10	0.00	0.02	1.00					
ix)	Refurbished	0.00	-0.01	0.20	-0.02	0.01	-0.27	0.13	0.02	1.00				
x)	First occupancy	0.19	0.18	-0.24	0.09	0.05	0.21	-0.23	-0.01	0.06	1.00			
xi)	Landmarked building	0.00	0.00	0.01	0.00	0.00	-0.05	0.00	0.00	0.00	-0.01	1.00		
xii)	Elevator	0.16	0.17	-0.31	-0.02	-0.10	0.32	-0.17	0.03	-0.10	0.16	0.01	1.00	
xiii)	Parking space	0.23	0.25	-0.25	0.28	0.21	0.42	-0.04	-0.02	-0.07	0.09	-0.01	0.13	1.00

*Pearson's correlation coefficient rounded to two digits behind the comma.

Appendix 5 - Sales data correlation matrix

Variable		Pearson's correlation coefficient*												
		i)	ii)	iii)	iv)	v)	vi)	vii)	viii)	ix)	x)	xi)	xii)	xiii)
i)	Sales price	1.00												
ii)	Energy consumption	-0.12	1.00											
iii)	Living space	0.59	0.09	1.00										
iv)	Number of rooms	0.49	0.19	0.91	1.00									
v)	Year of construction	0.10	-0.63	-0.10	-0.20	1.00								
vi)	EPC type	-0.14	-0.13	-0.15	-0.16	0.00	1.00							
vii)	Refurbished	0.01	0.08	0.01	0.02	-0.19	0.03	1.00						
viii)	First occupancy	0.08	-0.36	-0.06	-0.09	0.38	-0.28	-0.06	1.00					
ix)	Landmarked building	0.02	0.02	0.00	-0.01	-0.08	-0.01	0.05	0.00	1.00				
x)	Elevator	-0.08	-0.22	-0.28	-0.31	0.20	0.03	-0.02	0.19	0.01	1.00			
xi)	Parking space	0.03	-0.04	0.07	0.04	0.16	0.02	-0.02	0.05	-0.04	-0.02	1.00		
xii)	Existing lease	-0.10	0.03	-0.05	-0.03	-0.06	0.13	0.00	-0.11	0.02	0.07	-0.02	1.00	
xiii)	Commission free	0.04	-0.21	-0.05	-0.07	0.21	-0.13	0.04	0.33	0.04	0.08	0.03	-0.03	1.00

*Pearson's correlation coefficient rounded to two digits behind the comma.

Appendix 6 - Summary and description of model variables (taken from Deller, 2022, Appendix 1 and slightly adjusted)

Variable	Data codification & transformation	Description of variable
Dependent variables		
ln(cold_rent)	Quantitative; log-transformed	The natural logarithm of the cold rent of the building. Unit: EUR
ln(warm_rent)	Quantitative; log-transformed	The natural logarithm of the warm rent of the building. Unit: EUR
ln(sales_price)	Quantitative; log-transformed	The natural logarithm of the sales price of the building. Unit: EUR

Building-specific independent variables		
epc_level	Dummy	Indicating the German EPC level ranging from A+ to H. The reference value of the dummy is set to D. Overall, nine levels.
epc_type	Dummy	Indicating whether the building is issued a requirement certificate or a consumption certificate as an EPC. The reference value is the requirement certificate.
ln(living_space)	Quantitative; log-transformed	The natural logarithm of the living space of the building in m ²
living_space	Quantitative	The living space of the building in m ² .
no_rooms	Dummy	Indicating the number of rooms as a categorical feature of the building.
furnished	Dummy	Whether the building comes with ready to use furniture or not.
refurbished	Dummy	Whether the building has been refurbished since the original construction year.
first_occupancy	Dummy	Whether no one has lived in the building before or not.
landmarked_building	Dummy	Whether the building falls under the German “Denkmalschutz” or not.
elevator	Dummy	Whether an elevator is present in the building or not.
parking_space	Dummy	Whether a parking space is available or not.
building_type	Dummy	Controlling for the different building types: e.g., ground floor apartment, penthouse, multi-family.
construction_year	Dummy	Controlling for the different construction years with time intervals of 10 years.
rent_status	Dummy	Whether the building is currently let to a tenant or not.
Contract-specific independent variable		
commission_free	Dummy	Whether a commission is to be paid to a broker when buying the building or not.

Location-specific independent variable		
γ	Dummy	Controlling for the building location on a postal code level. This helps to control for population density, purchasing power and other factors.
Time-specific independent variable		
δ	Dummy	Controlling for the different upload dates on a quarterly level starting with Q1 2015 and ending with Q2 2023.