

# Online Appendix for the paper “Location, Location, Location! -A quality-adjusted rent index for the Oslo office market”<sup>\*</sup>

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April 30, 2021

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<sup>\*</sup>This paper combines two previous working papers: Anundsen and Hagen (2020) and Bjørland and Hagen (2019). This paper should not be reported as representing the views of Norges Bank. The views expressed are those of the authors and do not necessarily reflect those of Norges Bank. We thank Henrik Borchgrevink, Francesco Furlanetto, Karsten Gerdrup, Torbjørn Hægeland, Christian Lorange, Nina Larsson Midtehjell, Erling Røed Larsen, Ella Getz Wold, Sigmund Aas and an anonymous referee from the Norges Bank Working Paper series for helpful comments. This paper was presented at various seminars in Norges Bank and at a workshop in the Nordic-Baltic Forum in 2019. We are thankful to the participants at these seminars for useful comments.

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# A Appendix

Figure A.1: Number of observations by year

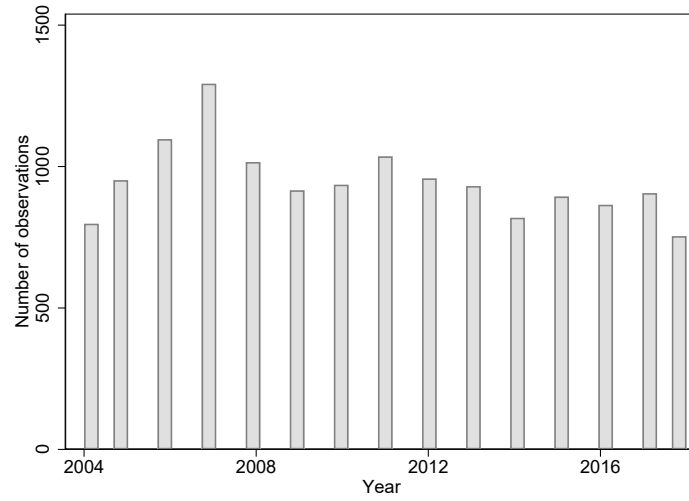
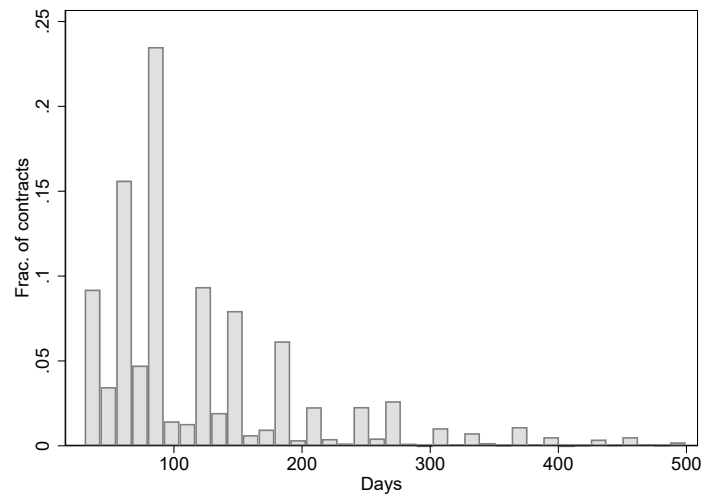


Figure A.2: Lag between signature date and start date. Number of days



**Notes:** The figure displays only contracts where the number of days between signature and contract start date is 500 days or less (excludes three percent of the observations).

Figure A.3: Map of Oslo divided into different city districts

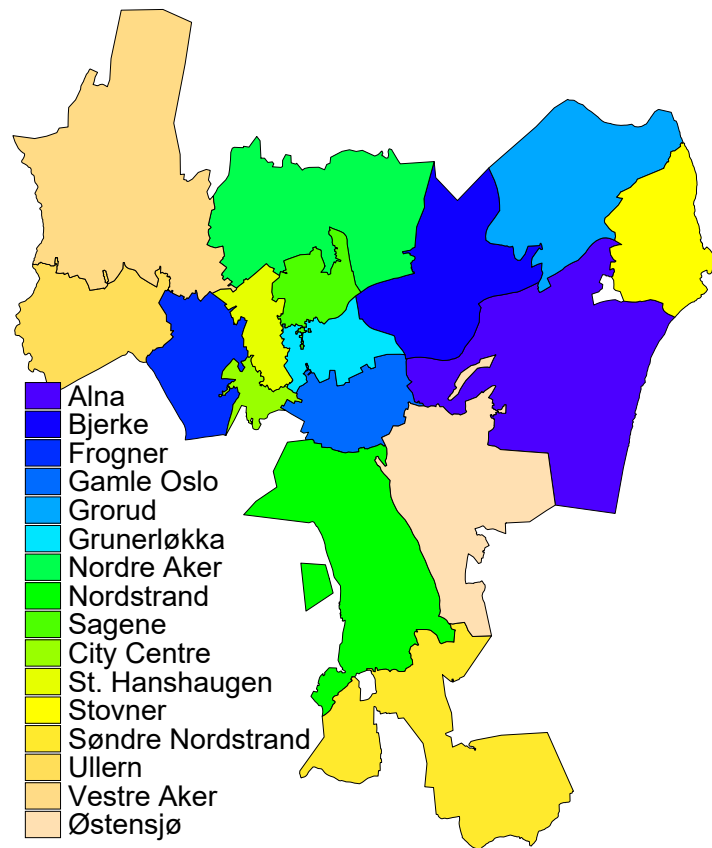
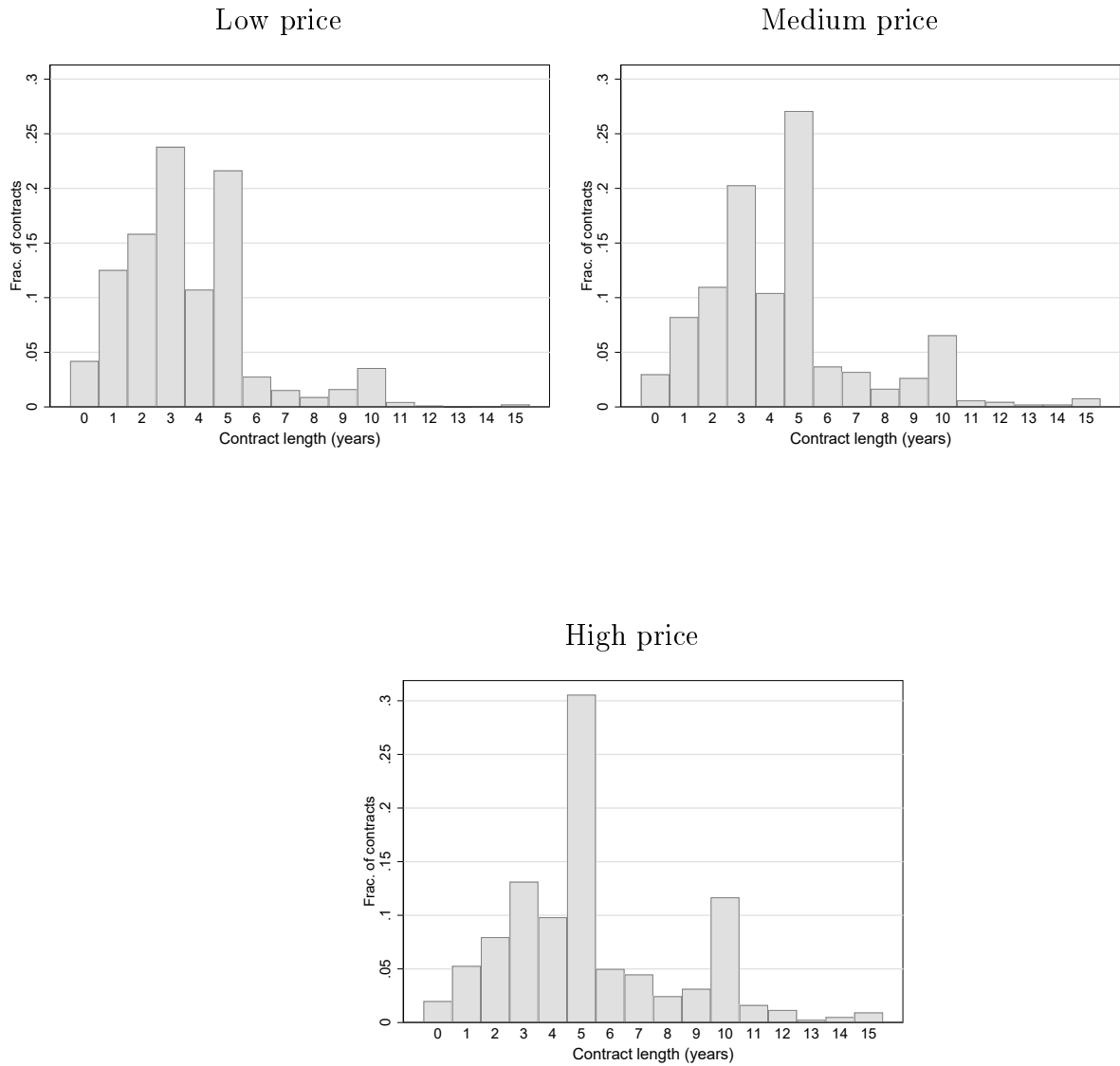
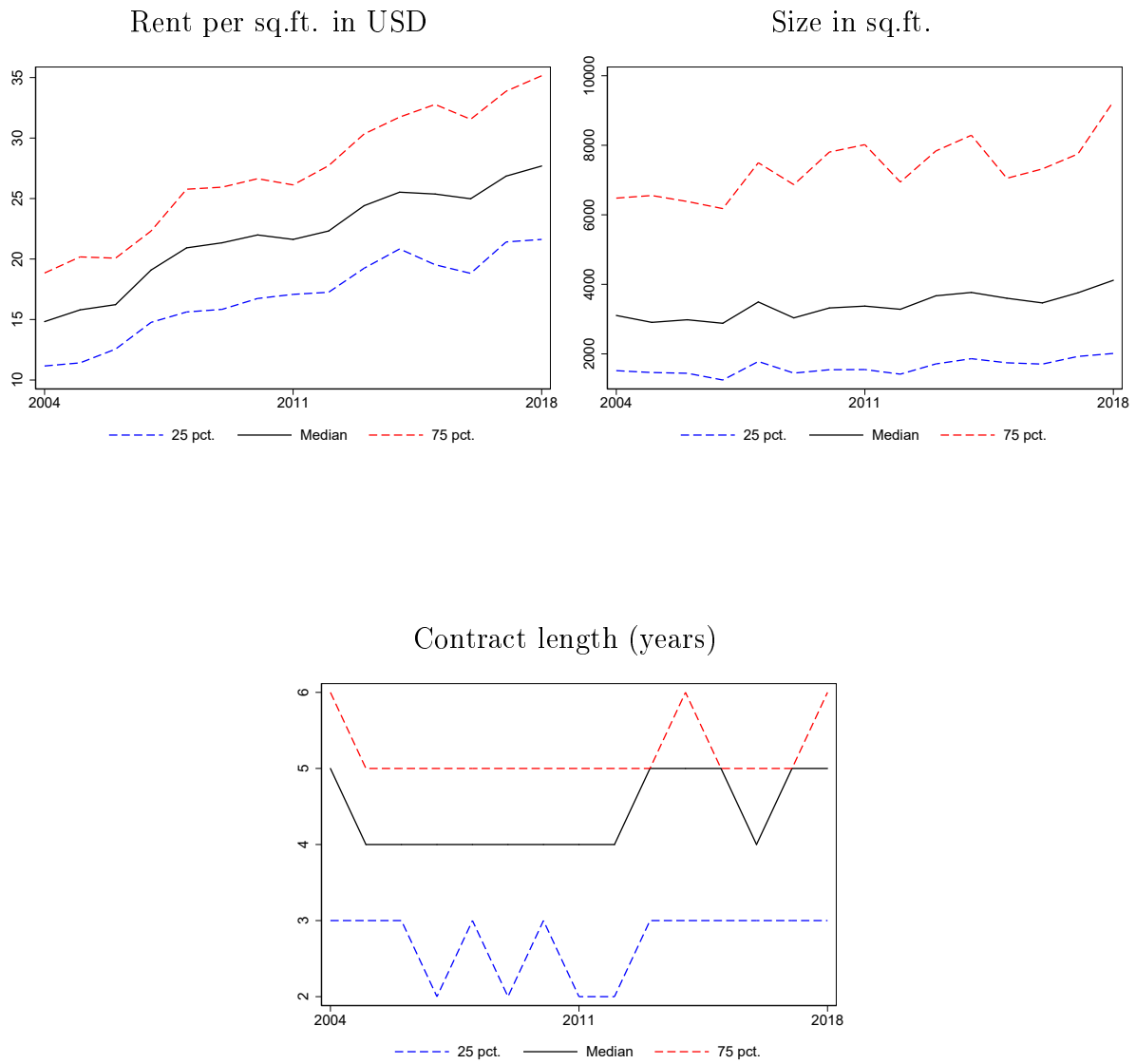


Figure A.4: Histogram of contract length for different price segments.



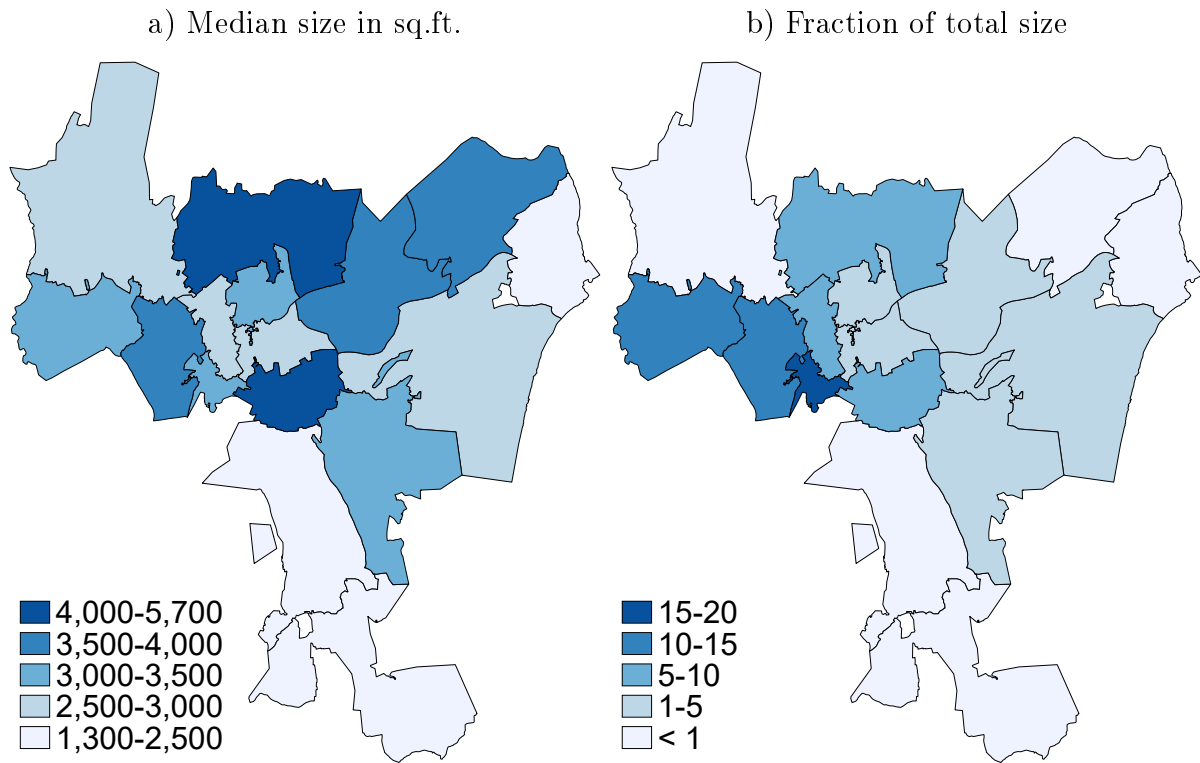
**Notes:** The figure shows histograms of contract length over the full sample. We distinguish between three different rent categories; the low-priced contracts (below the 25<sup>th</sup> percentile) are shown in the upper left panel, the medium-priced contracts (between the 25<sup>th</sup> and the 75<sup>th</sup> percentiles) are shown in the upper right panel, and the high-priced contracts (above the 75<sup>th</sup> percentile) are shown in the lower panel. All classifications into price categories are made based on annual distributions.

Figure A.5: Time developments in rent, size and contract length



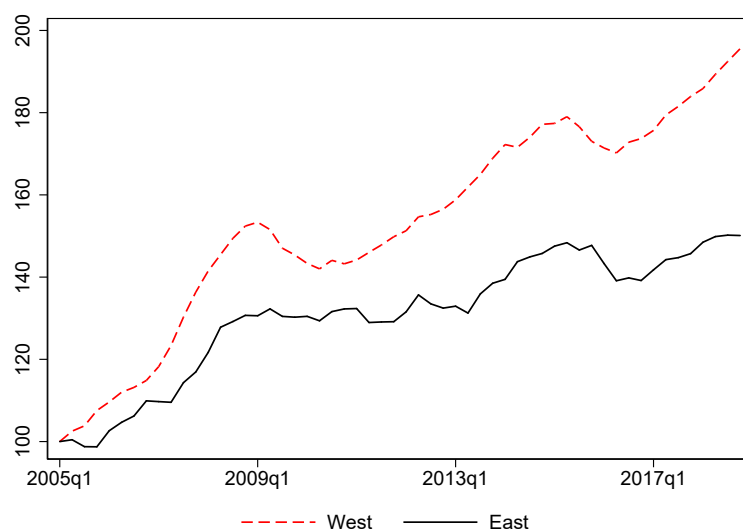
**Notes:** The figure shows the time series developments of different parts of the rent (upper left), size (upper right) and contract length (lower panel) distributions.

Figure A.6: Local differences in size of office space



**Notes:** The left panel shows variations in median size of contracts within different parts of Oslo. The right panel shows the fraction of total office space rented out in different parts of the city. See Figure A.3 in Appendix for a map that includes the name of each city district.

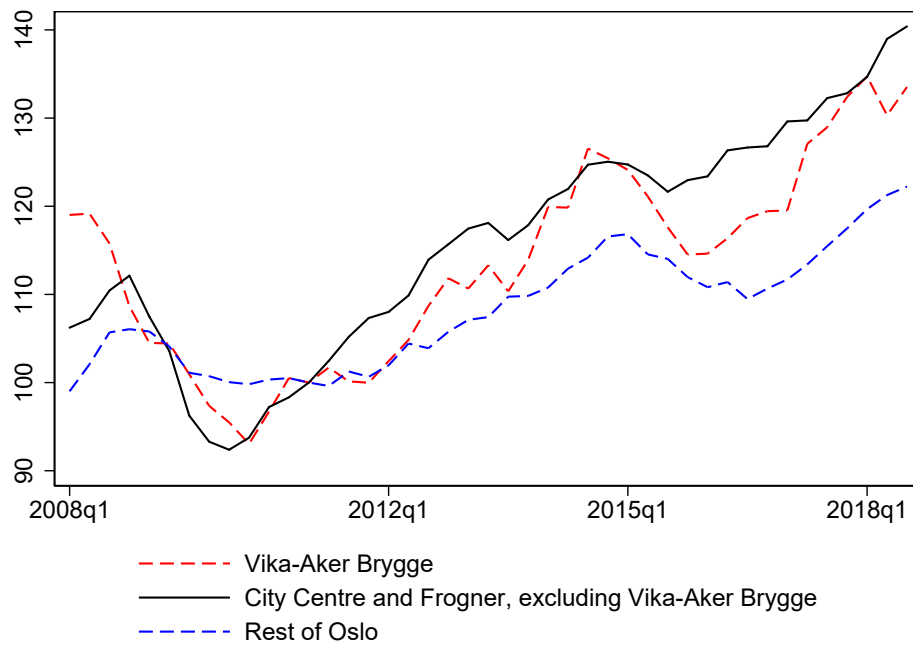
Figure A.7: Hedonic rent indices for eastern and western Oslo



**Notes:** The figure compares developments in rent indices for western and eastern Oslo. The indices are estimated as a four-quarter moving average. Both indices are normalized to 100 in 2005 Q1. The western part consists of Frogner, Gamle Oslo, Grünerløkka, Nordre Aker, Sagene, City Centre, St. Hanshaugen, Ullern and Vestre Aker, while the eastern part consists of the rest of the city districts.



Figure A.8: Hedonic rent indices based on signature date for Vika-Aker Brygge versus Frogner and City Centre versus the rest of Oslo



**Notes:** The figure compares developments in hedonic indices based on signature date across different parts of Oslo. The indices are estimated as a four-quarter moving average. All indices are normalized to 100 in 2011 Q1.

## Figure A.9: Actual rents and estimated long-run equilibrium

**Notes:** The figure compares developments in actual rents with their estimated long-run equilibrium. Indices are normalized to 100 in 2010 Q1.

Table A.1: Estimating hedonic models year-by-year

Year	Adjusted $R^2$	Corr(Year-by-Year,Full sample)
2004	0.647	0.829
2005	0.593	0.871
2006	0.569	0.862
2007	0.673	0.922
2008	0.677	0.911
2009	0.671	0.864
2010	0.703	0.894
2011	0.682	0.890
2012	0.731	0.886
2013	0.762	0.919
2014	0.791	0.914
2015	0.783	0.917
2016	0.758	0.900
2017	0.739	0.881
2018	0.776	0.901
All years	0.705	0.919

*Notes:* The table shows results from estimating the hedonic model year-by-year, thereby allowing all parameters to change every year. The estimates are based on the specification in Column (V) in Table 2. Adjusted  $R^2$  achieved by estimating the hedonic model year-by-year is reported in the second column. The last row in the second column shows the adjusted  $R^2$  based on estimating the model on the full sample. The third column shows the correlation coefficient between the predicted rents from the hedonic model estimated year-by-year and predicted rents from the hedonic model estimated on the full sample. These correlation coefficients are shown for each of the years covered by our sample. The final row shows this correlation coefficient for the full sample.

Table A.2: Hedonic models with different granularity in location-fixed effects

	(I)	(II)	(III)
Observations	12,121	12,121	12,121
$R^2$	0.376	0.448	0.541
Year-by-quarter fixed effects	✓	✓	✓
2-digit ZIP codes fixed effects	✓		
3-digit ZIP codes fixed effects		✓	
4-digit ZIP codes fixed effects			✓

*Notes:* The table shows estimation results for alternative hedonic models for rents. We consider both two-digit ZIP codes, three-digit ZIP codes and four-digit ZIP codes. As more digits are added, the granularity increases. The sample period covers 2004 Q1 - 2018 Q3.

Table A.3: Estimating hedonic models for full sample, private tenants only and public tenants only

	(I)	(II)	(III)
log(Size (sq.ft.))	0.017*** (0.00)	0.016*** (0.00)	0.026** (0.01)
Private renter	-0.031*** (0.01)		
Contract length (years)	0.015*** (0.00)	0.016*** (0.00)	0.011*** (0.00)
Renegotiation	-0.013** (0.01)	-0.013** (0.01)	-0.021 (0.03)
Observations	12,121	11,440	681
$R^2$	0.705	0.711	0.660
Full sample	✓		
Private tenants		✓	
Public tenants			✓
Time fixed effects	✓	✓	✓
Building fixed effects	✓	✓	✓

*Notes:* The estimates are based on the specification in Column (V) in Table 2. The model is estimated on: the full sample, private tenants and public tenants. The sample period covers 2004 Q1 - 2018 Q3.

Table A.4: Alternative hedonic models based on contract signature date

	(I)	(II)	(III)	(IV)	V
log(Size (sq.ft.))			0.049*** (0.00)	0.047*** (0.00)	0.017*** (0.00)
Private renter			-0.058*** (0.02)	-0.057*** (0.02)	-0.068*** (0.01)
Contract length (years)			0.017*** (0.00)	0.017*** (0.00)	0.014*** (0.00)
Renegotiation			-0.032*** (0.01)	-0.030*** (0.01)	-0.016** (0.01)
Dist. to closest metro. (miles)				-0.163*** (0.02)	
Observations	5,991	5,991	5,991	5,991	5,991
$R^2$	0.0863	0.507	0.557	0.563	0.698
Time fixed effects	✓	✓	✓	✓	✓
ZIP code fixed effects		✓	✓	✓	
Building fixed effects					✓

*Notes:* The table shows estimation results for alternative hedonic models for rents when signature dates are used. The sample period covers 2007 Q1–2018 Q3. Standard errors are reported in parenthesis below the point estimates. The asterisks denote significance levels: \* = 10%, \*\* = 5% and \*\*\* = 1%.

Table A.5: Error correction model. Data sources

Variable	About the series
Employment Oslo	The series is break-adjusted for the change in age-limit in 2005 and the use of a new data source in 2015. Quarterly numbers are constructed by cubic interpolation of the annual data. Source: Statistics Norway.
Quality-adjusted rent index Oslo office market	Based on lease signing date. Connected from 2006 with office rents based on lease inception date.
Stock of offices Oslo	Estimate of stock of offices in 2014. Time series constructed by adjusting for completed office space each quarter. Sources: Akershus Eiendom and Statistics Norway
Office vacancy rate Oslo	Semi-annual data. Quarterly data constructed by linear interpolation. Source: DNB Næringsmegling

## References

Anundsen, A. K. and M. Hagen (2020). Location, location, location! A quality-adjusted rent index for the Oslo office market. Working Paper 2, Norges Bank.

Bjørland, C. and M. Hagen (2019). What drives office rents? Staff memo 19, Norges Bank.