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Urban House Prices: A Tale of 48 Cities

Konstantin A. Kholodilin and Dirk Ulbricht

Abstract
In this paper, the authors construct a unique data set of Internet offer prices for flats in 48 large European cities from 24 countries. The data are collected between January and May 2012 from 33 websites, where the advertisements of flats for sale are placed. Using the resulting sample of 750,000 announcements the authors compute the average city-specific house prices. Based on this information they investigate the determinants of the apartment prices. Four factors are found to be relevant for the flats' price level: income per capita, population density, unemployment rate, and income inequality. The results are robust both to excluding variables and to applying two alternative estimation techniques: OLS and quantile regression. Based on their estimation results the authors are able to identify the cities, where the prices are overvalued. This is a useful indication of a build-up of house price bubbles.

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Keywords Internet ads; flats' prices; large European cities; fundamental prices

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1 Introduction

Though the housing market affects the life of virtually every person, statistical data on flat prices are scarce. Statistical agencies typically report time series of housing markets only on a national level and in form of indices.[1] However, it is questionable if housing data aggregated on a national level make sense, at all. Housing markets are very heterogeneous, for instance, urban and rural areas or economically striving and ailing regions can hardly be described by a common indicator. Moreover, information on the price level would allow for international or intercity comparisons, allowing to exploit between country variability.

House prices can be decomposed in two elements—one reflecting the fundamental value, determined by future rental income and another that is related to potentially speculative motives. Bubbles are phases in which asset prices are excessively higher than their fundamental values would imply. However, there are only few studies in this context, that use urban prices in levels. Still, they only cover data of one country, thus, not making use of international heterogeneity. The most prominently cited work is that of Kajuth et al. (2013), who regress house prices on market fundamentals. Using data collected by a private company for more than 400 regions in Germany in the period from 2004 through 2012, they capture the entire spatial variation of the German housing market. They find a substantial overvaluation of up to 25% in some metropolitan areas.

We construct a data set of offer prices for flats in 48 large European cities. The data stem from the various Internet sites. Using these data as proxy for the flats' prices and some macroeconomic and demographic variables as regressors we investigate the determinants of the flats' prices. Income per capita, population density, and Gini index have a strong positive effect on prices. Employing the estimated model, we figure out the fundamental prices in all cities and determine whether the actual price is above or below the expected one. When the actual price exceeds the expected price, it can be interpreted as a sign of the overvaluation in the market of flats for sale in the respective city.

[1] As a result, there are few if any studies on the determinants of the home price levels. By contrast, there are many papers dealing with the determinants of the price dynamics. See, e.g., Abraham and Hendershott (1996), Blackley and Follain (1991), Borowiecki (2009), Clapp and Giaccotto (1994), Ebru and Eban (2011), Egert and Mihaljek (2007), Follain and Velz (1995), Glindro et al. (2011), Hlaváček and Komárek (2009), Hort (1998), Hua and Craig (2011), Iacoviello (2002), Lee (2009), Mahalik and Mallick (2011), Ozanne and Thibodeau (1983), Özsoy and Şahin (2009), Poterba (1991), Stepanyan et al. (2010), and Sutton (2002)

The paper is structured as follows: Section 2 describes the data used in the study. In section 3, the methodology of computing the flat rent/price indices is explained and results are discussed. Finally, section 5 concludes.

2 Flats' price data

In order to construct the estimates of prices for flats in 48 large European cities, the advertisements offering flats for sale on different Internet sites were downloaded. The list of the corresponding sites can be found in Table 2. The choice of Internet sites, from which to download the data, was dictated by three criteria: 1) the size of the site — ideally, the site should contain the largest number of ads compared to its competitors; 2) the availability of data on both price and area; 3) the possibility to download data.

The codes for data downloading are written in the free software environment for statistical computing and graphics **R**[2]. The data were downloaded at a monthly frequency in the period stretching from January until May 2012.

We consider the price per square meter and not the total value in order to take account of differences in size. Some outliers for three key characteristics (price, area, and number of rooms) are removed.[3]

In some countries the offer prices include transaction costs. For example, in France the price is expressed as *FAI* (*frais d'agence inclus*), that is, including the realtor's fee. We corrected the French and Dutch prices by subtracting from them the corresponding fees: 7.5% from French prices and 7.5% from Dutch k.k. prices and 3% from Dutch v.o.n. prices.

To account for outdated and inactive ads, some of them, that were placed prior to July 2011 have been removed. All prices in foreign currencies are converted to euros using the average exchange rate from January to April 2012.

The Internet offer prices for flats in 48 European cities are shown in Figure 1. For each city a boxplot of the offer prices for flats is displayed. The width of the boxplot is proportional to the number of ads. The notches represent an estimated confidence interval for each median estimate. The total number of downloaded and processed ads in all 35

[2] `http://www.r-project.org/`, see also R Development Core Team (2009).

[3] If an observation is higher (lower) than the median by 1.5 time interquartile range, the most widely used criterium to identify outliers in statistics, it dropped.

webpages exceeds 750,000. The biggest number of ads is available for Warsaw (more than 114,000), whilst the fewest ads are available for Oslo (805).

To the best of our knowledge, this is a unique database of prices for flats in cities. The only comparable one is the database of the Eurostat "City statistics — Urban Audit". However, it is published with a time lag of several years.

3 Determinants of housing prices

The literature suggests a wide range of the determinants of flat prices. Table 1 contains a list of the determinants with corresponding signs in regressions ("+" or "–"), which are grouped in broad categories. This list is far from being exhaustive and is based on the results of 18 papers in this area.[4] It shows both the total number of uses of a determinant (columns 2 through 4) and the proportion of the uses (columns 5 through 7). The most frequently used determinants are income variables (15.4%, exerting predominantly positive effect), demographic variables (13.2%, exerting predominantly positive effect), and interest rates (13.2%, exerting exclusively negative effect). Other groups of determinants ordered according to the frequency of their use include: 1) Credit (6.6%) and Housing supply (6.6%), 2) Labor market (6.6%), 3) Land supply (6.6%), 4) Overall prices (4.4%), and 5) Institutions (4.4%). In addition, equity prices and construction cost are frequently used, as well.

Guided by the literature and common sense we examine the following determinants of flat prices:

- Per-capita income is a measure of welfare of a particular city and thus a good indicator of the demand for housing. It is expected that income has a positive effect on the price level. As a proxy for income we take the city-level GDP per capita. In some cases, where such information is not available for the city, per-capita GDP for the respective region is taken.

- Housing is a very expensive good. Therefore, in the majority of cases, its purchase implies borrowing money. Hence, the variables of the credit market are of utmost

[4] Abraham and Hendershott (1996), Blackley and Follain (1991), Borowiecki (2009), Clapp and Giaccotto (1994), Egert and Mihaljek (2007), Follain and Velz (1995), Glindro et al. (2011), Hlaváček and Komárek (2009), Hort (1998), Hua and Craig (2011), Iacoviello (2002), Lee (2009), Mahalik and Mallick (2011), Ozanne and Thibodeau (1983), Özsoy and Şahin (2009), Poterba (1991), Stepanyan et al. (2010), and Sutton (2002)

importance to explain the variations in housing prices. Here, we employ the amount of mortgage loans per capita to capture the effect. The indicator refers to 2010 and stems from the European Mortgage Federation and gives the national average. This variable reflects both the demand for housing credit and the restrictions on the supply side of the credit market. It is expected to have a positive impact upon the flats' price.

- Population is a measure of size of the city reflecting demand pressure on the housing market.

- Population density is at the same time a measure of demand pressure and an indirect measure of supply shortage. When the population density is high, it may imply that the land endowment is very limited and thus the possibilities to increase the supply of housing are restrained. This should lead to higher real-estate prices.

- Unemployment rate is an indicator of income stability as a higher unemployment rate indicates lower job security. Therefore, a higher unemployment rate should imply lower housing prices.

- Income inequality can be an important determinant of the property prices. However, the sign of the income inequality measure is rather unclear. On the one hand, if per-capita income is high, high inequality means only few people can afford housing. On the other hand, the existence of a handful of very rich people can imply that these people will be looking for investment opportunities and thus invest part of their excessive capital into the property. We use the Gini index as an income inequality measure.

- Homeownership rate (HOR) indicates the propensity to buy a house. It should have a positive influence on prices. However, even in homeownership-friendly countries, high property prices can deter people from buying a dwelling. Therefore, there is a certain endogeneity problem in case of the HOR. Hence, we take past HOR values to avoid endogeneity.

- Finally, a dummy for the Euro area (EA) is included to account for the fact that the EA countries have a common monetary policy. In addition, for each explanatory

variable an interaction term with the EA dummy is created, which is denoted by the suffix "_EA".

The data sources and definitions are reported in Tables 4 through 9.

As the GDP data represent city-level values, they are not reported as frequently as national GDP data. In many cases, the GDP and unemployment rate data refer to 2008 or even earlier periods. We extrapolated the GDP data and unemployment rates up to 2010. In some cases, the growth rates of these variables at the national level were used for extrapolation. In other cases, we utilized the growth rates of the variables at the higher regional level. For example, for Paris the growth rate of per-capita GDP in Île-de-France, whereas for Rome that in Lazio was used. For Russia and Spain the regional GDP data are available up to 2010, while for Germany and Ukraine they are available up to 2009. For Germany, Russia, and Ukraine the unemployment rate data are now available up to 2010.

In Russia, the homeownership rate is approximated by the proportion of the area of the dwellings belonging to the private persons in the total area of housing, see Table 9.

4 Estimation results

The relationship between the flats' prices and their potential determinants can be described as:

$$y_i = X_i'\beta + \varepsilon_i \tag{1}$$

where y_i is the average offer square meter price of housing in city i; X_i is the vector of city-specific house price determinants; and ε_i is the disturbance term.

The relationship can be estimated using a simple ordinary least squares (OLS) regression. In addition, for the sake of robustness the model is estimated using the quantile regression for median quantile, $\tau = 0.5$, see Koenker and Hallock (2001). A big advantage of the quantile regression over OLS is that it is insensitive to outliers.

Two versions of each model are presented: a large and a small one. The large models include all the potential determinants mentioned above. The small model and keeps only those explanatory variables that turned out to be significant at least at the 5% level. For the sake of objectivity the deletion of insignificant variables was carried out using the automatic

econometric model selection program PcGets[5].

The estimation results are reported in Table 10. It contains the coefficient estimates, standard errors, and p-values of four models: large and small OLS models and large and small quantile models. According to the OLS model, four variables are relevant for determining the price level: per-capita GDP, population density, unemployment rate, Gini index, and mortgage loans per capita. Moreover, the interaction of population as well as mortgage per capita with the Euro Area dummy are significant. As expected, the per-capita GDP and mortgage loans have a positive sign. Higher population density is associated with higher flats' prices. Higher unemployment leads to the lower prices for flats. Income inequality appears to positively affect the flats' prices. The goodness of fit is relatively high — in the small OLS model the adjusted R^2 is 0.777. According to the small quantile regression, in which the standard errors and p-values were bootstrapped, only four variables are statistically significant, namely: density of population, unemployment rate, Gini coefficient, and the interaction terms of EA dummy variable with population is kept in the parsimonious specification of the model. The signs and magnitudes of the regression coefficients in the OLS and quantile models are similar.

Several robustness checks are conducted. Figure 4 shows the changes in parameter estimates and coefficient of determination of the small OLS model after excluding one of the cities. The dotted line and the dashed lines show the coefficient estimate and the confidence bands of the model including all the cities. The bold blue line shows the parameter estimates when one of the cities is excluded. The excluded city is indicated at the horizontal axis. It can be seen that the parameter estimates remain quite stable. The R^2 varies between 0.75 and 0.81. Inclusion in the regression of Copenhagen and Rome leads to the largest deterioration of its explanatory power.

Figure 5 displays parameter estimates for the sequence of quantile regressions with $\tau = 0.1, 0.2, \ldots, 0.9$. The bold blue line shows the point parameter estimates, while the cyan area represents the corresponding confidence intervals. The red solid and dashed lines depict the coefficient estimate and the confidence bands of the OLS regression. Again, the parameter estimates are relatively stable and significant for all variables, except population, HOR, and interaction terms with unemployment rate and HOR.

[5]See Hendry and Krolzig (2001).

Figure 7 and 8 compare the actual Internet prices to the fitted prices obtained in the above regressions. The latter approximate the fundamental prices that one would expect, given the values of the price determinants. The cities where the offer prices are overvalued —the actual price is higher than the fitted one— are denoted by blue color. The cities with undervalued flats are denoted by red color. When an observation is lying on the dashed 45^0-degree line, the fitted price is exactly equal to the actual price. In addition, the numeric values of the fitted prices as well as absolute and percentage deviations of the fitted values from actual prices for both estimation techniques are reported in Table 11. The results of the OLS and quantile regressions produce in most cases qualitatively similar picture. It should be noticed that the fitted price can vary depending on the specification of the regression model. Therefore, it gives just a rough approximation of the possible over- or undervaluation of flats' prices in the cities examined in this paper. More attention should probably be paid to the sign of the relative difference between actual and fitted price. Moreover, small deviations between the actual and fitted price can be purely random. Thus, the fact that a relative difference between these prices is very small implies that the actual and fitted price are, in fact, identical.

Figure 9 shows the distribution of the relative percentage differences between the actual and fitted prices obtained by excluding one city, or one variable variable, or one city and one variable from the small OLS and quantile regressions. The total number of cities-variables combinations for each city is $2 \times (K \times (N-1) + K + N - 1) = 766$, where $K = 7$ is the number of regressors without intercept and $N = 48$ is the number of cities. To a certain extent, this distribution allows determining the significance of price deviations from zero. Istanbul, Sofia, Bucharest, Tallinn, Brussels, Düsseldorf, Stuttgart, and Köln are the cities, where the fitted price is in at least 95% of cases smaller than the actual price. By contrast, London, Rome, Stockholm, Vienna, Paris, München, Ekaterinburg, and St. Petersburg are the cities, where in vast majority of cases the fitted price exceeds the actual price.

The most overvalued city is London, where the actual average price for flats per m^2 by 45-52% exceeds the fitted one. The most undervalued cities in relative terms are Istanbul, Copenhagen, and Sofia, where the actual prices are almost 82-91% lower than the expected ones.

The flats in Paris are overvalued by 19-25% and this overvaluation is significant.

The flats in the largest and most affluent Russian city Moscow appear to be correctly priced, while those in St. Petersburg are by 4-12% larger than the prices that could be expected, given its fundamental factors.

Berlin housing seems to be correctly valued. The relative deviations between the actual and the fitted prices in both OLS and quantile regressions are close to zero. In addition, according to Figure 9, the 95% of distribution of the relative price deviations include both positive and negative values. Therefore, the recent property price increases in German capital —observed, for instance, in Kholodilin and Mense (2012)— can be considered as an overshoot that followed the adjustment from historically low values towards a fundamental price.

The housing prices in Spanish cities (except Seville) are undervalued by 11-30%. The undervaluation is especially pronounced in Madrid. This definitely reflects the economic crisis through which Spain has been going in the preceding months[6].

In the Italian capital the actual prices are substantially higher than the fitted values. This overvaluation appears to be significant. In other large Italian cities included in the study, the situation is diverse. Thus, in Milano and Napoli, the prices are close to the equilibrium levels, whereas in Torino they are lower than the fitted ones.

The flats' prices in Riga and especially in Tallinn are undervalued. As in case of Spain, this is a consequence of a deep recession that struck Baltic countries in 2008-2009. By contrast, in Vilnius they are overvalued, although this overvaluation cannot be considered significant, as Figure 9 testifies.

5 Conclusion

In this paper, we construct a data set of Internet offer prices for flats in 48 large European cities located in 24 different countries. For this purpose the prices as well as the most important characteristics of the flats contained in the Internet ads were downloaded from 33 webpages between January and May 2012.

[6]Spanish websites contain even a special field showing the changes in the offer prices. Usually, these changes are negative, meaning that the persons who place ads reduce their prices being unable to find buyers. In January-May 2012, the price have been reduced on average by about 14 euros per m^2 in Madrid and 20 euros in Barcelona. This amounts to a price decline of 0.5% and 0.6%, respectively. Similar process can be observed in Lisbon, where the average price change is approximately -8 euros per m^2, or -0.3%.

Using the Internet data we investigated the determinants of the prices for flats. Several robustness checks including quantile regression were implemented. The income per capita, population density, and Gini index exert strong positive impact upon the flats' prices, which is also robust. The coefficient of the unemployment rate is negative. However, it is significant only in the OLS regression.

Comparison of the actual prices to the fitted ones, which were obtained from the OLS and quantile regressions, allows detecting cities where flats are overvalued and where they are undervalued. This can be taken as a first indication of a build-up of a bubble in the housing market of the largest European cities.

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Appendix

Table 1: Home price determinants in the literature

Determinants	Number of uses of determinant			Share of uses of determinant, %		
	total	+	−	total	+	−
Income						
GDP per capita	2	2	0	2.2	2.2	0.0
income	3	2	1	3.3	2.2	1.1
income per capita	2	2	0	2.2	2.2	0.0
real GDP	4	3	1	4.4	3.3	1.1
GNP growth	0	1	0	0.0	1.1	0.0
economic activity	1	0	1	1.1	0.0	1.1
real wage	1	1	0	1.1	1.1	0.0
average monthly wage	1	1	0	1.1	1.1	0.0
Total Income	14	12	3	15.4	13.2	3.3
Interest rate						
real interest rate	7	0	7	7.7	0.0	7.7
mortgage rate	3	1	2	3.3	1.1	2.2
real mortgage rate	1	0	1	1.1	0.0	1.1
discount rate	1	0	1	1.1	0.0	1.1
Total Interest rate	12	1	11	13.2	1.1	12.1
Demography						
population	4	3	1	4.4	3.3	1.1
proportion of the population ≤ 15	1	1	0	1.1	1.1	0.0
net migration	1	1	0	1.1	1.1	0.0
marriage rate	1	1	0	1.1	1.1	0.0
divorces	1	1	0	1.1	1.1	0.0
number of households	1	0	1	1.1	0.0	1.1
proportion of non-elderly singles	1	1	0	1.1	1.1	0.0
number of black or hispanic	1	1	0	1.1	1.1	0.0
demographic demand	1	1	0	1.1	1.1	0.0
Total Demography	12	10	2	13.2	11.0	2.2
Credit						
domestic credit	2	2	0	2.2	2.2	0.0
housing credit	1	1	0	1.1	1.1	0.0
trend of mortgage/GDP ratio	1	0	1	1.1	0.0	1.1
loans	1	0	1	1.1	0.0	1.1
real non-food credit	1	0	1	1.1	0.0	1.1
Total Credit	6	3	3	6.6	3.3	3.3
Labor market						
unemployment	4	0	4	4.4	0.0	4.4
employment	1	1	0	1.1	1.1	0.0
vacancies/labour force	1	1	0	1.1	1.1	0.0
Total Labor market	6	2	4	6.6	2.2	4.4
Land supply						
land supply index	1	1	0	1.1	1.1	0.0
land supply	1	0	1	1.1	0.0	1.1
land prices	1	1	0	1.1	1.1	0.0
agricultural land prices	3	3	0	3.3	3.3	0.0
Total Land supply	6	5	1	6.6	5.5	1.1
Housing supply						
completed apartments	1	1	0	1.1	1.1	0.0
number of apartments per 1000 inhabitants	1	1	0	1.1	1.1	0.0
supply of dwellings	1	0	1	1.1	0.0	1.1
log of the number of dwellings per person	1	1	0	1.1	1.1	0.0
improvements in quality of new constructed or modified dwellings	1	1	0	1.1	1.1	0.0
number of home sales	1	0	1	1.1	0.0	1.1
Total Housing supply	6	4	2	6.6	4.4	2.2
Overall prices						
inflation	1	1	0	1.1	1.1	0.0
expected inflation	1	0	1	1.1	0.0	1.1
unexpected inflation	1	1	0	1.1	1.1	0.0
non-housing price	1	0	1	1.1	0.0	1.1
Total Overall prices	4	2	2	4.4	2.2	2.2
Institutions						
development of housing markets and housing financial institutions	1	1	0	1.1	1.1	0.0
institutional factor	1	1	0	1.1	1.1	0.0
municipalities / 100,000 households	2	0	2	2.2	0.0	2.2
Total Institutions	4	2	2	4.4	2.2	2.2
Miscellanea						
construction cost	6	6	0	6.6	6.6	0.0
real construction cost	2	2	0	2.2	2.2	0.0
real effective exchange rate	1	1	0	1.1	1.1	0.0
equity price	5	3	2	5.5	3.3	2.2
rent per month	1	1	0	1.1	1.1	0.0
composite index of taxes, wages, and utilities	1	1	0	1.1	1.1	0.0
turnover rate	1	0	1	1.1	0.0	1.1
risk premium	1	1	0	1.1	1.1	0.0
remittances	1	1	0	1.1	1.1	0.0
foreign inflows	1	1	0	1.1	1.1	0.0
FDI-to-GDP ratio	1	1	0	1.1	1.1	0.0
GRAND TOTAL	91	59	33	100.0	64.8	36.3

Table 2: Sources of flats' price data

City original language	City English	City short	Country	Website	Number of ads	Price, euros per m^2		Total area, m^2		Number of rooms	
						median	average	median	average	median	average
Amsterdam	Amsterdam	AMS	Netherlands	funda.nl	7308	3395.3	3405.1	72.0	75.9	3.0	2.8
Athina	Athens	ATH	Greece	spiti24.gr	9865	2075.3	2106.1	76.0	77.1	3.0	2.9
Barcelona	Barcelona	BCN	Spain	pisos.com	4448	3231.5	3356.6	77.0	80.8	3.0	2.8
Berlin	Berlin	BER	Germany	immobilienscout24.de	11202	2142.2	2295.9	75.0	82.5	2.5	2.6
Bruxelles	Brussels	BRU	Belgium	immoweb.be	4505	2343.8	2413.8	88.0	90.9	3.0	2.7
Bucuresti	Bucharest	BUH	Romania	imopedia.ro	11272	1019.2	1049.8	60.0	61.8	2.0	2.4
Budapest	Budapest	BUD	Hungary	maganingatlan.hu	1236	896.7	936.9	54.0	56.3	2.0	2.2
Dnepropetrovsk	Dnepropetrovsk	DNK	Ukraine	est.ua/dp	2113	725.3	784.9	56.0	58.2	2.0	2.3
Dublin	Dublin	DUB	Ireland	myhome.ie	499	3026.7	3134.3	65.0	64.3	3.0	2.7
Düsseldorf	Dusseldorf	DUS	Germany	immobilienscout24.de	1337	1956.8	2168.6	74.0	79.4	3.0	2.6
Ekaterinburg	Yekaterinburg	EKA	Russia	upn.ru	7473	1611.5	1629.5	49.0	53.8	2.0	2.2
Frankfurt am Main	Frankfurt	FRF	Germany	immobilienscout24.de	1652	2910.9	2953.3	84.0	91.0	3.0	3.0
Hamburg	Hamburg	HAM	Germany	immobilienscout24.de	1876	3072.6	3199.5	84.4	89.4	3.0	3.0
Istanbul	Istanbul	IST	Turkey	emlak.net	37866	486.6	517.2	100.0	110.0	3.0	3.4
Kazan	Kazan	KZN	Russia	kazan.mlsn.ru	5194	1268.1	1276.9	53.4	57.4	2.0	1.9
Kharkov	Kharkov	HRK	Ukraine	gorod.kharkov.com	6071	641.0	646.8	52.0	55.0	2.0	2.1
Kiev	Kiev	KIV	Ukraine	address.ua	53136	1331.7	1453.3	61.0	65.9	2.0	2.2
København	Copenhagen	CPH	Denmark	dba.dk	3541	2874.0	3039.0	74.0	78.0	3.0	2.6
Köln	Cologne	CGN	Germany	immobilienscout24.de	2130	1905.3	2081.8	75.0	75.6	3.0	2.7
Lisboa	Lisbon	LIS	Portugal	casa.trovit.pt	11261	2292.7	2392.3	100.0	109.6	3.0	3.4
London	London	LDN	UK	foxtons.co.uk	3944	6677.6	7362.7	63.0	64.8	3.0	2.8
Lyon	Lyon	LYN	France	seloger.fr	4267	3106.3	3185.2	74.0	77.2	2.0	2.2
Madrid	Madrid	MAD	Spain	pisos.com	13363	2787.5	2987.4	75.0	82.6	3.0	2.5
Marseille	Marseille	MRS	France	seloger.fr	8244	2507.4	2575.4	65.0	66.6	2.0	2.1
Milano	Milan	MLN	Italy	casa.it	17043	3518.5	3829.4	80.0	83.8	2.0	2.5
Moskva	Moscow	MSK	Russia	egsnk.ru	16161	3966.8	4145.1	55.0	60.4	2.0	2.1
München	Munich	MUC	Germany	immobilienscout24.de	3497	4067.5	4213.9	80.0	82.3	3.0	2.7
Napoli	Naples	NAP	Italy	casa.it	3117	3550.0	3721.2	90.0	90.7	3.0	3.2
Nij. Novgorod	Nizhniy Novgorod	NNG	Russia	gipernn.ru	5871	1262.8	1283.6	48.0	51.5	2.0	2.1
Odessa	Odessa	ODS	Ukraine	alians.com.ua	6761	922.7	972.6	64.0	68.1	2.0	2.2
Oslo	Oslo	OSL	Norway	finn.no/eiendom	805	5187.6	5186.8	64.0	64.0	3.0	2.7
Paris	Paris	PAR	France	seloger.fr	16989	8586.8	8864.1	55.0	61.6	2.0	1.9
Praha	Prague	PRG	Czech Republic	bytyvpraze.cz	7763	1953.4	2026.3	66.0	67.3	2.0	2.4
Riga	Riga	RIG	Latvia	ss.lv	11871	700.0	839.8	56.0	59.6	2.0	2.3
Roma	Rome	ROM	Italy	casa.it	20593	4375.0	4556.9	90.0	91.7	3.0	3.2
Rostov/Don	Rostov-on-Don	RND	Russia	rostov.life-realty.ru	67835	1312.0	1325.2	50.0	52.0	2.0	1.9
S.-Peterburg	St. Petersburg	SPB	Russia	restate.ru	12336	2165.0	2170.1	50.0	57.3	2.0	2.0
Samara	Samara	SAM	Russia	dom63.ru	9690	1233.8	1245.1	50.0	52.6	2.0	2.0
Sevilla	Seville	SEV	Spain	pisos.com	1383	1942.9	2123.8	85.0	87.9	3.0	2.7
Sofia	Sofia	SOF	Bulgaria	imoti.net	8822	750.0	773.0	80.0	83.9	2.0	2.4
Stockholm	Stockholm	STO	Sweden	bovision.se	4305	5245.9	5122.4	63.0	64.9	2.0	2.5
Stuttgart	Stuttgart	STU	Germany	immobilienscout24.de	1655	2187.5	2333.2	74.0	80.0	3.0	3.0
Tallinn	Tallinn	TAL	Estonia	ekspresskinnisvara.ee	5649	1065.2	1067.7	54.0	54.9	2.0	2.3
Torino	Turin	TUR	Italy	casa.it	6075	2225.0	2318.0	75.0	81.3	3.0	3.1
Valencia	Valencia	VAL	Spain	pisos.com	12127	1773.3	1883.1	93.0	96.5	3.0	2.8
Vilnius	Vilnius	VIL	Lithuania	reals.lt	2597	1262.0	1311.6	59.0	59.7	2.0	2.3
Warszawa	Warsaw	WAW	Poland	oferty.net	114189	1938.8	1982.7	54.0	56.7	2.0	2.4
Wien	Vienna	VIE	Austria	immobilien.net	7871	3636.4	3715.5	90.0	95.6	3.0	3.0

Table 3: Definitions of flat in different countries and websites

Country	Site	Type	Currency
Austria	immobilien.net	Eigentumswohnung	euro
Belgium	immoweb.be	appartement, duplex, flat/studio, loft/entrepôt, penthouse, rez-de-chaussée, triplex	euro
Bulgaria	imoti.net	апартамент/apartament	euro (> 99% of ads), lev, and US dollar
Czech Republic	bytyvpraze.cz	byt	Czech crown
Denmark	dba.dk	ejerbolig	Danish crown
Estonia	ekspresskinnisvara.ee	korter	euro
France	seloger.fr	appartement, duplex, loft, studette, studio, triplex	euro
Germany	immobilienscout24.de	Dachgeschoss, Loft, Maisonette, Penthouse, Terrassenwohnung, Souterrain, Erdgeschoß, Etagenwohnung, Hochparterre, Sonstige	euro
Greece	spiti24.gr	$\delta\iota\alpha\mu\epsilon\rho\iota\sigma\mu\alpha$/diamerisma	euro
Hungary	maganingatlan.hu	lakás	forint
Ireland	myhome.ie	apartment, dormer, duplex, penthouse, studio	euro
Italy	casa.it	appartamento, attico, loft, mansarda, monolocale	euro
Latvia	ss.lv	квартира/kvartira or dzivoklis	euro (> 52% of ads) and lat
Lithuania	reals.lt	butas	Lithuanian litas
Netherlands	funda.nl	appartement	euro
Norway	finn.no/eiendom	bolig	Norwegian crown
Poland	oferty.net	mieszkanie	zloty
Romania	imopedia.ro	apartament, garsoniera	euro
Russia	upn.ru	квартира/kvartira	Russian ruble
Russia	kazan.mlsn.ru	квартира/kvartira	Russian ruble
Russia	egsnk.ru	квартира/kvartira	Russian ruble
Russia	gipernn.ru	квартира/kvartira	Russian ruble
Russia	rostov.life-realty.ru	гостинка/gostinka, квартира/kvartira	Russian ruble
Russia	restate.ru	квартира/kvartira	Russian ruble
Russia	dom63.ru	квартира/kvartira	Russian ruble
Spain	pisos.com	ático, apartamento, dúplex, estudio, loft, piso	euro
Sweden	bovision.se	bostadsraetter	Swedish crown
UK	foxtons.co.uk	apartment, flat, maisonette	British pound
Ukraine	est.ua/dp	квартира/kvartira	US dollar
Ukraine	gorod.kharkov.com	квартира/kvartira	US dollar (denoted as conditional units)
Ukraine	address.ua	квартира/kvartira	US dollar
Ukraine	alians.com.ua	квартира/kvartira	US dollar
Turkey	emlak.net	daire	Turkish lira (> 99% of ads), US dollar, and euro

Table 4: Prices for flats — official data: sources and definitions

Country	Administrative level	Year	Source	Database / Publication	Definition
Austria	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Belgium	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Bulgaria	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Czech Rep.	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Denmark	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Estonia	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
France	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Germany	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Greece	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Hungary	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Ireland	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Italy	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Latvia	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Lithuania	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Netherlands	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Norway	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Poland	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Romania	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Russia	Moscow, St. Petersburg, oblasts, and autonomous republic Tatarstan	2003-2009	Rosstat	Russian regions database	Average price for a dwelling per m^2 in secondary market
Spain	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Sweden	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Turkey	—	—	—	—	—
UK	city	2003-2009	Eurostat	CSUA	Average price for an apartment per m^2
Ukraine	—	—	—	—	—

Note: CSUA = City statistics — Urban Audit

Table 5: GDP per capita: sources of data

Country	Administrative level	Year	Source	Database / Publication	Currency
Austria	NUTS3	2008	Eurostat	Regional statistics	euros
Belgium	NUTS3	2010	BNB	BNB (2012)	euros
Bulgaria	NUTS3	2008	Eurostat	Regional statistics	euros
Czech Rep.	NUTS3	2008	Eurostat	Regional statistics	euros
Denmark	NUTS3	2008	Eurostat	Regional statistics	euros
Estonia	NUTS3	2008	Eurostat	Regional statistics	euros
France	NUTS3	2008	Eurostat	Regional statistics	euros
Germany	NUTS3	2009	Destatis	VGRdL	euros
Greece	NUTS3	2008	Eurostat	Regional statistics	euros
Hungary	NUTS3	2008	Eurostat	Regional statistics	euros
Ireland	NUTS3	2008	Eurostat	Regional statistics	euros
Italy	NUTS3	2008	Eurostat	Regional statistics	euros
Latvia	NUTS3	2008	Eurostat	Regional statistics	euros
Lithuania	NUTS3	2008	Eurostat	Regional statistics	euros
Netherlands	NUTS3	2008	Eurostat	Regional statistics	euros
Norway	NUTS3	2007	Statistics Norway		Norwegian crowns
Poland	NUTS3	2009	Statistical Office in Warsaw		zlotys
Romania	NUTS3	2008	Eurostat	Regional statistics	euros
Russia	Moscow, St. Petersburg, oblasts, and autonomous republic Tatarstan	2009	Rosstat	Russian regions database	Russian rubles
Spain	NUTS3	2008	Eurostat	Regional statistics	euros
Sweden	NUTS3	2008	Eurostat	Regional statistics	euros
Turkey	NUTS3	2008	Turkstat		Turkish liras
UK	NUTS3	2008	Eurostat	Regional statistics	euros
Ukraine	Kiev and oblasts	2009	Ukrstat	Ukrstat (2011a)	hryvnas

Notes: 1) CSUA = City statistics — Urban Audit. 2) VGRdL = Volskwirtschaftliche Gesamtrechnungen der Bundesländer (Regional accounts of Federal regions).

Table 6: Population: sources of data

Country	Administrative level	Year	Source	Database / Publication
Austria	city	2003-2006	Eurostat	CSUA
Belgium	city	2003-2006	Eurostat	CSUA
Bulgaria	city	2003-2006	Eurostat	CSUA
Czech Rep.	city	2003-2006	Eurostat	CSUA
Denmark	city	2003-2006	Eurostat	CSUA
Estonia	city	2003-2006	Eurostat	CSUA
France	city	2003-2006	Eurostat	CSUA
Germany	city	2003-2006	Eurostat	CSUA
Greece	city	2003-2006	Eurostat	CSUA
Hungary	city	2003-2006	Eurostat	CSUA
Italy	city	2003-2006	Eurostat	CSUA
Ireland	city	2003-2006	Eurostat	CSUA
Latvia	city	2003-2006	Eurostat	CSUA
Lithuania	city	2003-2006	Eurostat	CSUA
Netherlands	city	2003-2006	Eurostat	CSUA
Norway	city	2003-2006	Eurostat	CSUA
Poland	city	2003-2006	Eurostat	CSUA
Romania	city	2003-2006	Eurostat	CSUA
Russia	city	2009	Rosstat	Russian cities database
Spain	city	2003-2006	Eurostat	CSUA
Sweden	city	2003-2006	Eurostat	CSUA
Turkey	city	2007-2011	Turkstat	Turkey's Statistical Yearbook 2010
UK	city	2003-2006	Eurostat	CSUA
Ukraine	city	2010	Ukrstat	Ukrstat (2011b)

Notes: 1) CSUA = City statistics — Urban Audit. 2) Ukrstat = State Satistics Committee of Ukraine.

Table 7: Unemployment rate: sources of data

Country	Administrative level	Year	Source	Database / Publication
Austria	city	2003-2006	Eurostat	City statistics - Urban Audit
Belgium	city	2003-2006	Eurostat	CSUA
Bulgaria	city	2007-2009	Eurostat	CSUA
Czech Rep.	city	2003-2006	Eurostat	CSUA
Denmark	city	2003-2006	Eurostat	CSUA
Estonia	city	2007-2009	Eurostat	CSUA
France	city	2003-2006	Eurostat	CSUA
Germany	city	2007-2009	Eurostat	CSUA
Greece	city	2003-2006	Eurostat	CSUA
Hungary	city	2003-2006	Eurostat	CSUA
Ireland	city	2003-2006	Eurostat	CSUA
Italy	city	2003-2006	Eurostat	CSUA
Latvia	city	2003-2006	Eurostat	CSUA
Lithuania	city	2007-2009	Eurostat	CSUA
Netherlands	city	2007-2009	Eurostat	CSUA
Norway	city	2007-2009	Eurostat	CSUA
Poland	city	2010	Statistical Office in Warsaw	SOW (2011)
Romania	city	2003-2006	Eurostat	City statistics - Urban Audit
Russia	Moscow, St. Petersburg, oblasts, and autonomous republic Tatarstan	2010	Rosstat	Russian regions database
Spain	city	2007-2009	Eurostat	CSUA
Sweden	city	2007-2009	Eurostat	CSUA
Turkey	city	2010	Turkstat	Turkey's Statistical Yearbook 2010
UK	city	2007-2009	Eurostat	CSUA
Ukraine	city	2010	Main administration for statistics of the respective regions	

Notes: 1) CSUA = City statistics — Urban Audit. 2) IIS = Institute for Informatics and Statistics.

Table 8: Gini index: sources and definitions

Country	Administrative level	Year	Source	Database / Publication	Definition
Austria	whole country	2009	Eurostat	ILC	Total disposable household income
Belgium	Rgion de Bruxelles-Capitale	2008	Belgian Federal Government	Marché du travail et conditions de la vie	Fiscal data, income before taxation
Bulgaria	whole country	2009	Eurostat	ILC	Total disposable household income
Czech Rep.	whole country	2009	Eurostat	ILC	Total disposable household income
Denmark	whole country	2009	Eurostat	ILC	Total disposable household income
Estonia	whole country	2009	Eurostat	ILC	Total disposable household income
France	units urbaines	2009	INSEE	Revenus fiscaux localisés des ménages — Année 2009	
Germany	Bundeslaender	2009	Destatis		Net equivalence income of households
Greece	whole country	2009	Eurostat	ILC	Total disposable household income
Hungary	whole country	2009	Eurostat	ILC	Total disposable household income
Ireland	whole country	2009	Eurostat	ILC	Total disposable household income
Italy	regioni	2009	INS		Net family income excluding imputed rent
Latvia	whole country	2009	Eurostat	ILC	Total disposable household income
Lithuania	whole country	2009	Eurostat	ILC	Total disposable household income
Netherlands	whole country	2009	Eurostat	ILC	Total disposable household income
Norway	whole country	2009	Eurostat	ILC	Total disposable household income
Poland	Centralny region	2009	GUS	ILC	Equivalized disposable income before social transfers except old-age and survivors benefits (not clear)
Romania	whole country	2009	Eurostat	ILC	Total disposable household income
Russia	Moscow, St. Petersburg, oblasts, and autonomous republic Tatarstan	2009	Rosstat	Russian regions database	Per-capita monetary income (not clear)
Spain	comunidades autonomas	2006	INE	Encuesta de Estructura Salarial 2006	Annual salary
Sweden	whole country	2009	Eurostat	ILC	Total disposable household income
Turkey	city	2010	Turkstat		Equivalized household disposable income
UK	whole country	2009	Eurostat	ILC	Total disposable household income
Ukraine	whole country	2007	Ukrstat	Ukrstat (2010)	Money per-capita income in urban settlements

Notes: 1) ILC = Income and Living Conditions database. 2) Ukrstat = State Statistics Committee of Ukraine.

Table 9: Homeownership rate: sources and definitions

Country	Administrative level	Year	Source	Database / Publication	Definition
Austria	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Belgium	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Bulgaria	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Czech Rep.	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Denmark	city	2003-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Estonia	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
France	city	2003-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Germany	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Greece	city	2003-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Hungary	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Ireland	city	2003-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Italy	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Latvia	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Lithuania	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Netherlands	city	2007-2009	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Norway	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Poland	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Romania	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Russia	Moscow, St. Petersburg, oblasts, and autonomous republic Tatarstan	2009	Rosstat	Russian regions database	Proportion of area of dwellings owned by private persons, %
Spain	city	1999-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Sweden	city	1999-2002	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Turkey	city	2005	Turkstat		Proportion of households living in owned dwellings, %
UK	city	2003-2006	Eurostat	CSUA	Proportion of households living in owned dwellings, %
Ukraine	city	2010	Ukrstat	based on Ukrstat (2011c)	Proportion of households living in owned dwellings, %

Note: CSUA = City statistics — Urban Audit

Table 10: Estimation results of OLS and quantile regressions

Regressor	OLS regressions						Quantile regressions					
	Coeff.	St. error	p-value	Coeff.	St. error	p-value	Coeff.	St. error	p-value	Coeff.	St. error	p-value
Intercept	1.656	1.698	0.337	1.875	0.958	0.057	3.380	4.032	0.408	2.883	1.558	0.072
LGDP_PC	0.359	0.131	0.010	0.278	0.075	0.001	0.325	0.317	0.313	0.159	0.114	0.170
LPopulation	-0.040	0.105	0.710				-0.189	0.354	0.598			
LDensity	0.221	0.157	0.170	0.224	0.080	0.008	0.259	0.403	0.525	0.225	0.118	0.064
URate	-0.041	0.016	0.014	-0.032	0.009	0.001	-0.053	0.045	0.253	-0.038	0.014	0.010
Gini	0.031	0.011	0.006	0.032	0.008	0.000	0.044	0.017	0.012	0.036	0.011	0.002
HOR	0.003	0.004	0.480				0.003	0.013	0.796			
Euro_area	-2.056	3.262	0.533				-1.949	6.238	0.757			
LGDP_EA	-0.057	0.249	0.820				-0.126	0.497	0.802			
LPop_EA	0.246	0.168	0.153	0.041	0.012	0.002	0.242	0.411	0.560	0.050	0.020	0.018
LDensity_EA	-0.006	0.196	0.976				0.001	0.445	0.998			
URate_EA	0.021	0.023	0.386				0.019	0.052	0.710			
Gini_EA	-0.010	0.024	0.679				0.012	0.038	0.756			
HOR_EA	-0.002	0.006	0.718				-0.005	0.015	0.755			
Mortgage_PC2010	0.023	0.009	0.018	0.027	0.007	0.000	0.021	0.061	0.726	0.033	0.025	0.198
Mortgage_EA	-0.019	0.015	0.195	-0.024	0.010	0.018	-0.011	0.061	0.857	-0.027	0.026	0.305
R^2_{adj}	0.741			0.777			0.766			0.697		
Breusch-Pagan test	13.260		0.582	10.834		0.146						

Table 11: Actual vs. fitted prices

City	Actual price P	OLS regression			Quantile regression, $\tau = 0.5$		
		Fitted $\widehat{P}_{OLS}$	Absolute difference $P - \widehat{P}_{OLS}$	Relative difference, % $100\frac{P-\widehat{P}_{OLS}}{P}$	Fitted $\widehat{P}_{QR}$	Absolute difference $P - \widehat{P}_{QR}$	Relative difference, % $100\frac{P-\widehat{P}_{QR}}{P}$
Amsterdam	3415	3341	74	2	3415	0	0
Athina	2109	2237	-128	-6	2272	-163	-8
Barcelona	3298	3704	-406	-12	3819	-522	-16
Berlin	2300	2293	7	0	2300	0	0
Bruxelles	2426	3527	-1102	-45	3278	-853	-35
Bucuresti	1048	1451	-403	-38	1353	-305	-29
Budapest	936	1070	-134	-14	936	0	0
Dnepropetrovsk	768	665	103	13	744	24	3
Dublin	3106	2407	699	23	2272	834	27
Düsseldorf	2186	3082	-896	-41	2799	-613	-28
Ekaterinburg	1643	1333	310	19	1464	179	11
Frankfurt am Main	2958	3305	-347	-12	2986	-28	-1
Hamburg	3148	3199	-51	-2	3148	0	0
Istanbul	524	1000	-476	-91	952	-427	-82
Kazan	1306	1375	-69	-5	1503	-196	-15
Kharkov	654	695	-41	-6	800	-146	-22
Kiev	1495	1487	8	1	1621	-126	-8
København	3105	5748	-2643	-85	5755	-2650	-85
Köln	2084	2574	-490	-23	2491	-407	-20
Lisboa	2410	1996	414	17	1937	473	20
London	7437	4076	3361	45	3565	3872	52
Lyon	3189	2954	235	7	2937	252	8
Madrid	2967	3666	-699	-24	3853	-886	-30
Marseille	2589	2311	278	11	2294	295	11
Milano	3834	3778	56	1	3794	40	1
Moskva	4187	4016	171	4	4187	0	0
München	4181	3517	663	16	3394	786	19
Napoli	3731	3293	439	12	3668	63	2
Nij. Novgorod	1308	1174	134	10	1308	0	0
Odessa	978	758	220	23	883	95	10
Oslo	5174	5186	-11	0	5174	0	0
Paris	8869	7172	1697	19	6637	2232	25
Praha	2030	1390	640	32	1229	801	39
Riga	834	923	-89	-11	834	0	0
Roma	4564	2586	1978	43	2586	1979	43
Rostov/Don	1340	1109	231	17	1282	58	4
S.-Peterburg	2193	1922	272	12	2109	84	4
Samara	1260	1453	-194	-15	1660	-400	-32
Sevilla	2110	1651	459	22	1638	472	22
Sofia	768	1410	-642	-84	1445	-677	-88
Stockholm	5163	3417	1746	34	3244	1919	37
Stuttgart	2338	3068	-730	-31	2925	-587	-25
Tallinn	1065	1539	-474	-44	1664	-599	-56
Torino	2332	2731	-399	-17	2704	-372	-16
Valencia	1871	2082	-211	-11	2116	-245	-13
Vilnius	1299	932	367	28	872	427	33
Warszawa	1978	2085	-107	-5	1935	43	2
Wien	3685	2782	904	25	2655	1030	28

Figure 1: Internet offer prices for flats in large European cities, January – May 2012

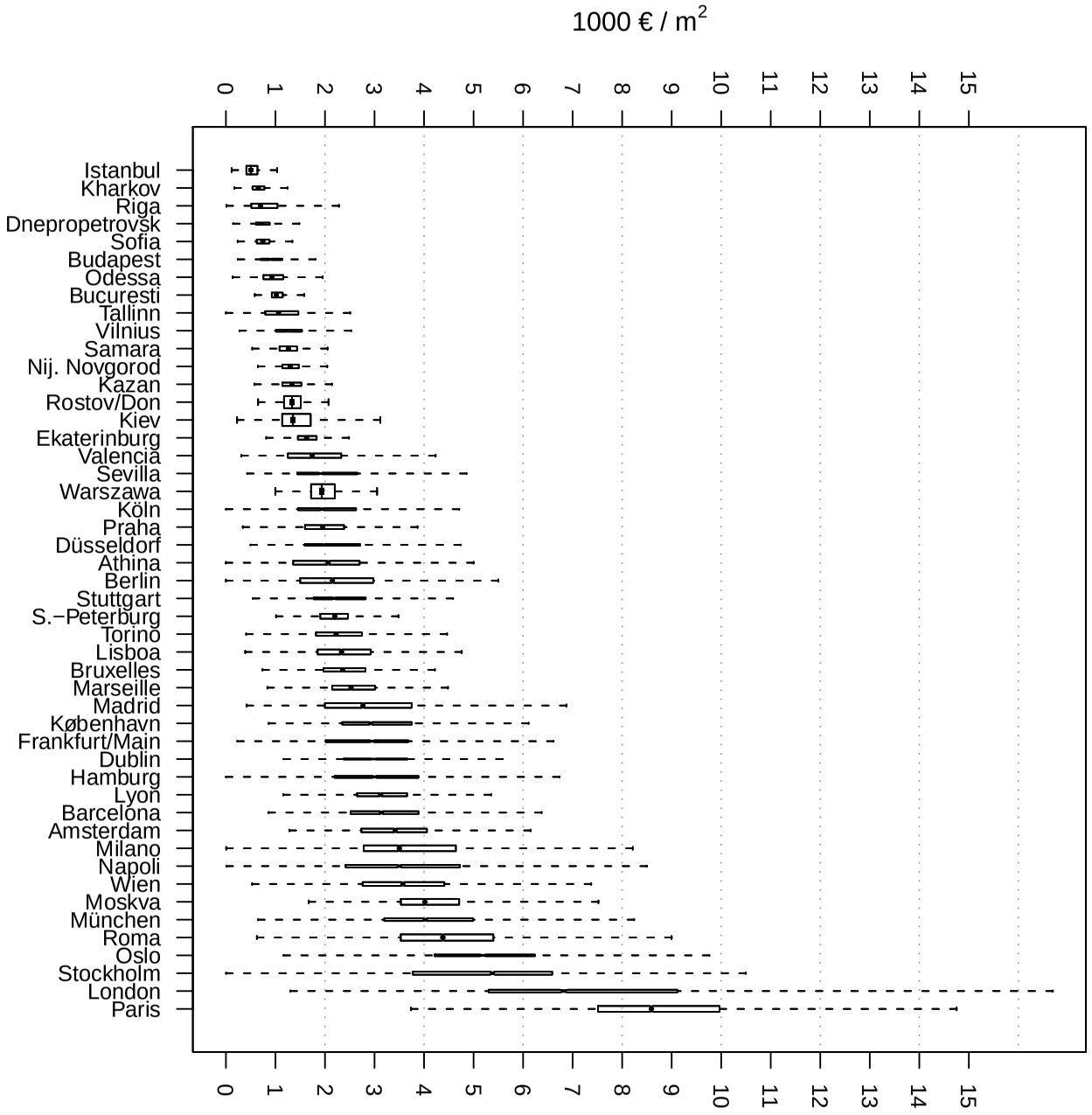
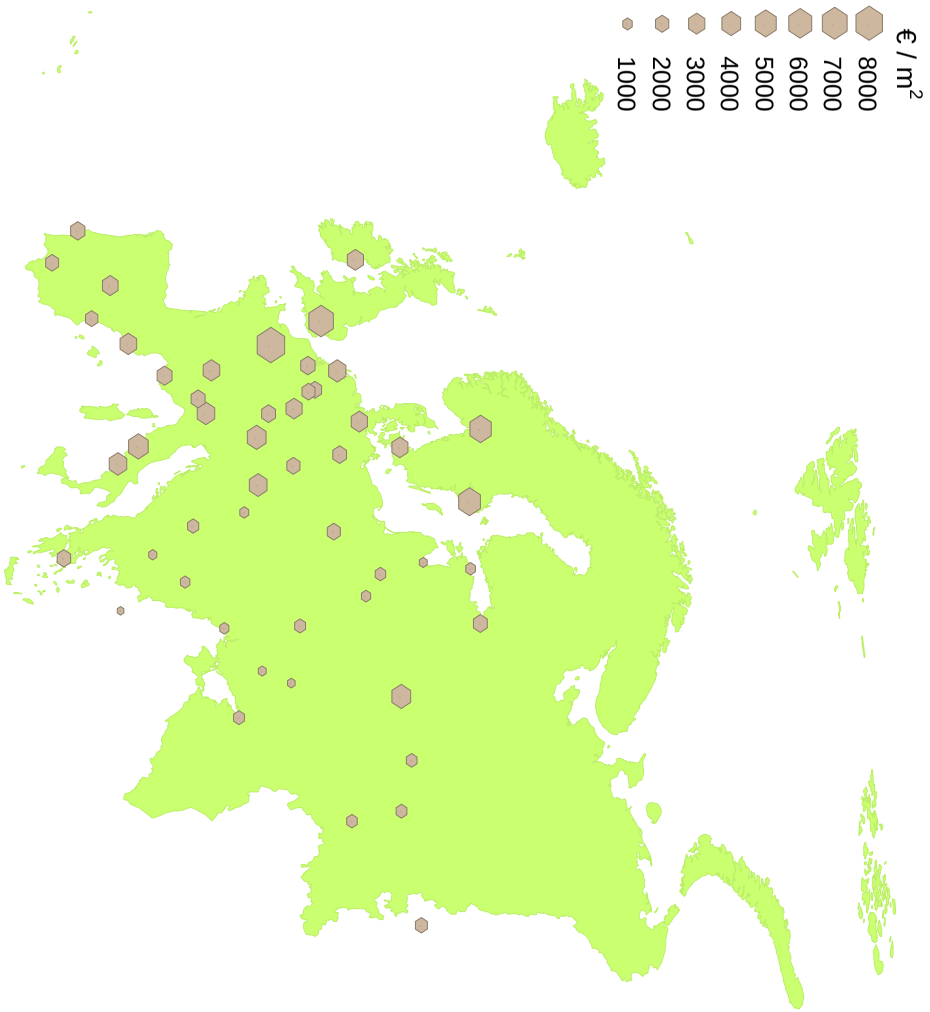


Figure 2: Geographical distribution of Internet offer prices for flats, January – May 2012



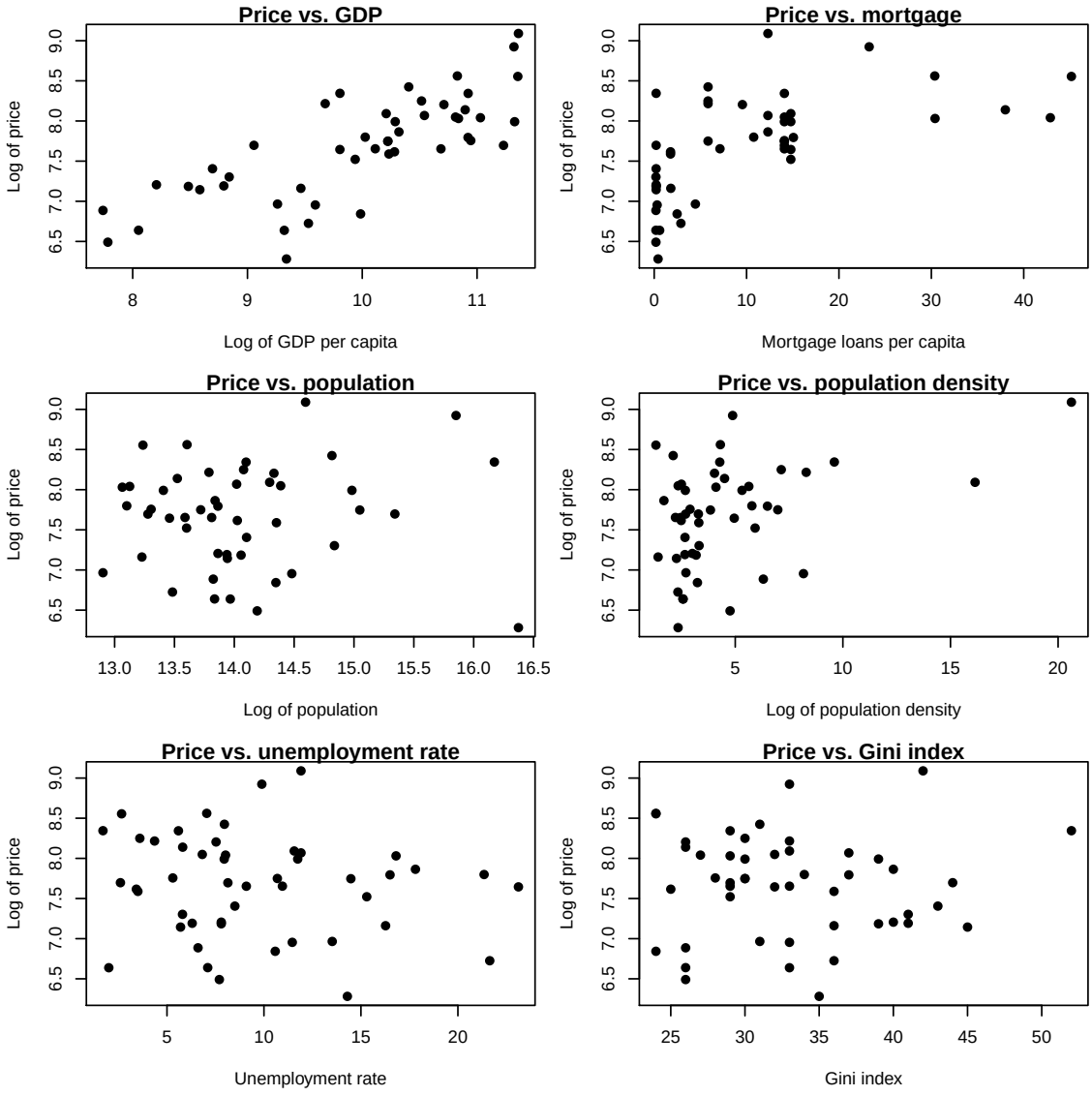


Figure 3: Potential determinants of the flats' prices

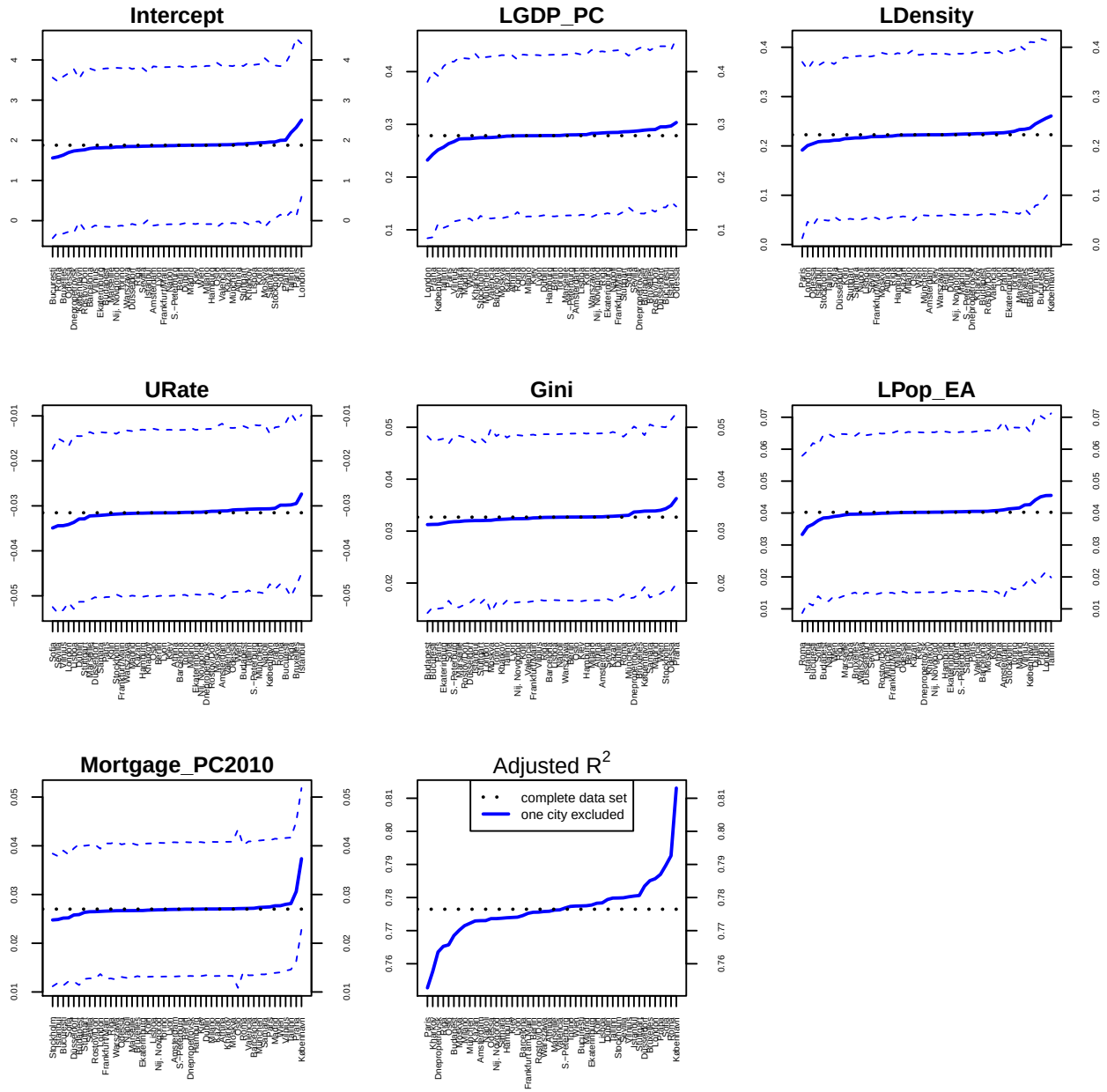


Figure 4: Coefficient estimates when one city is excluded from regression

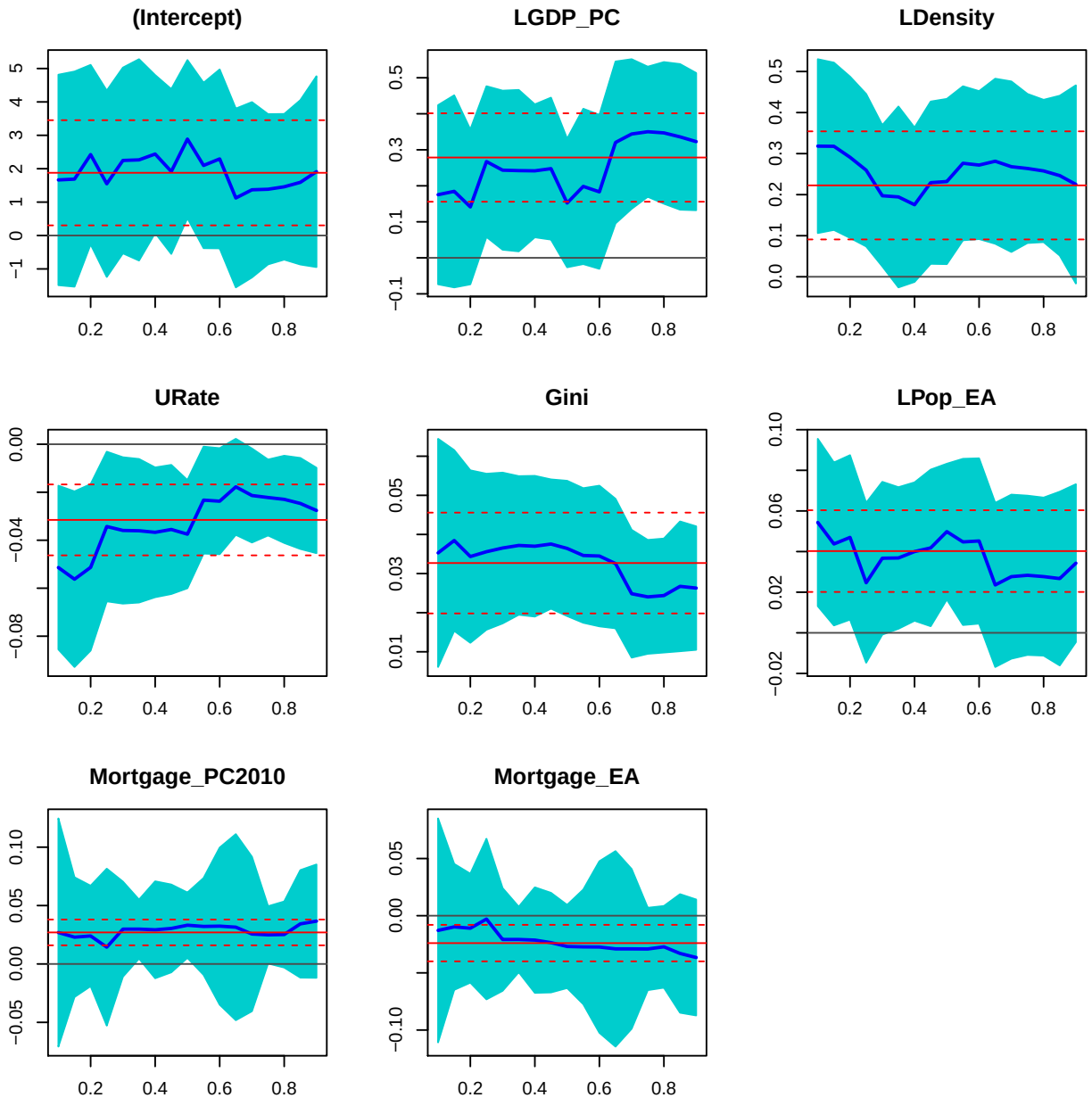


Figure 5: Quantile regression's coefficient estimates at different quantiles

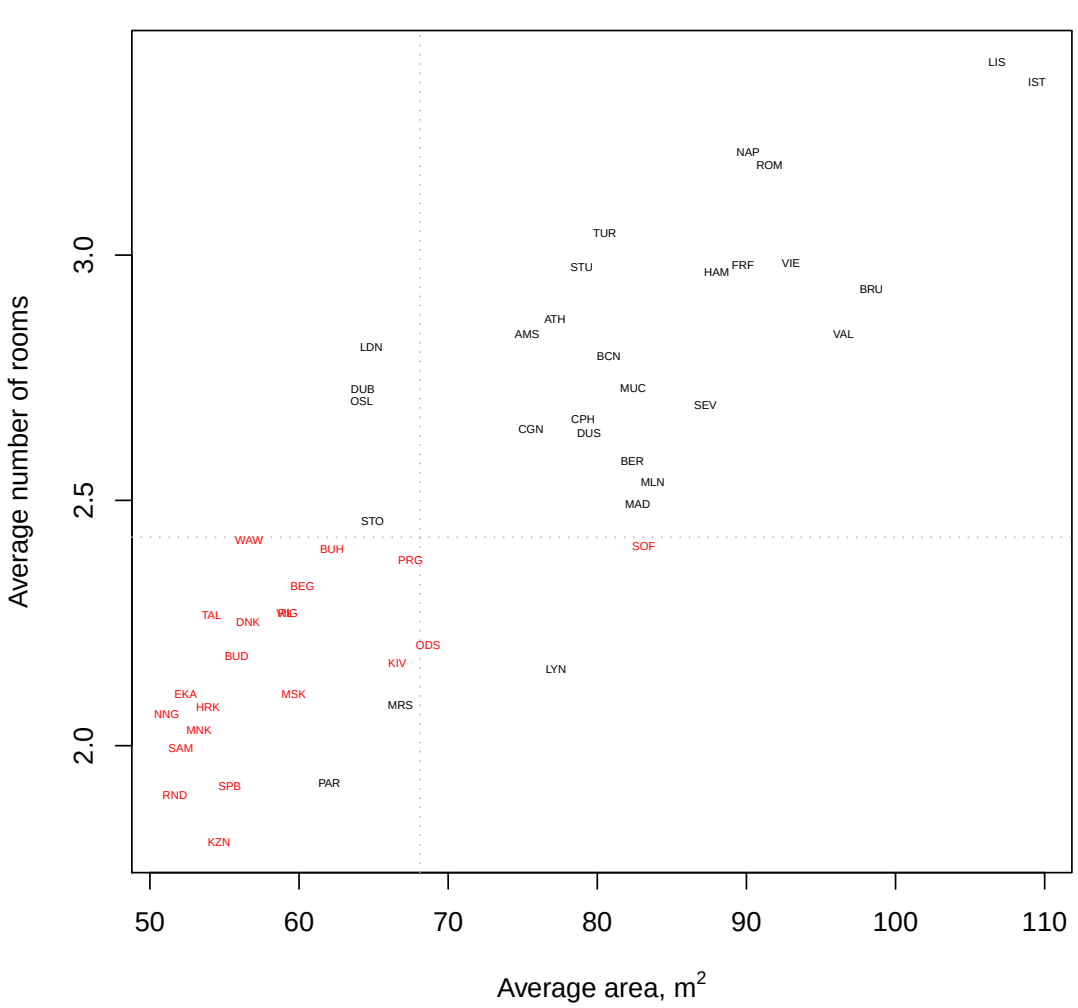


Figure 6: Size of flats in large European cities, January – May 2012

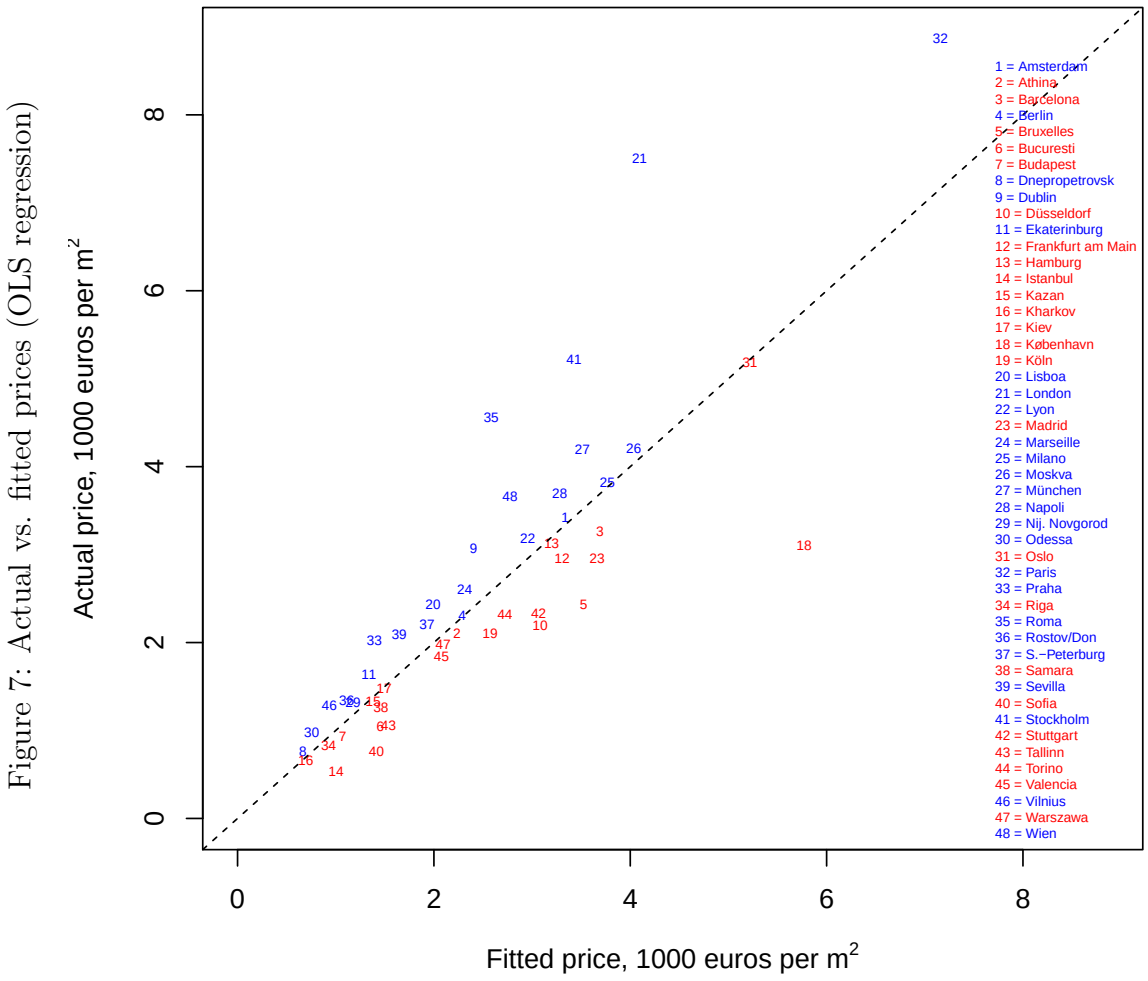


Figure 7: Actual vs. fitted prices (OLS regression)

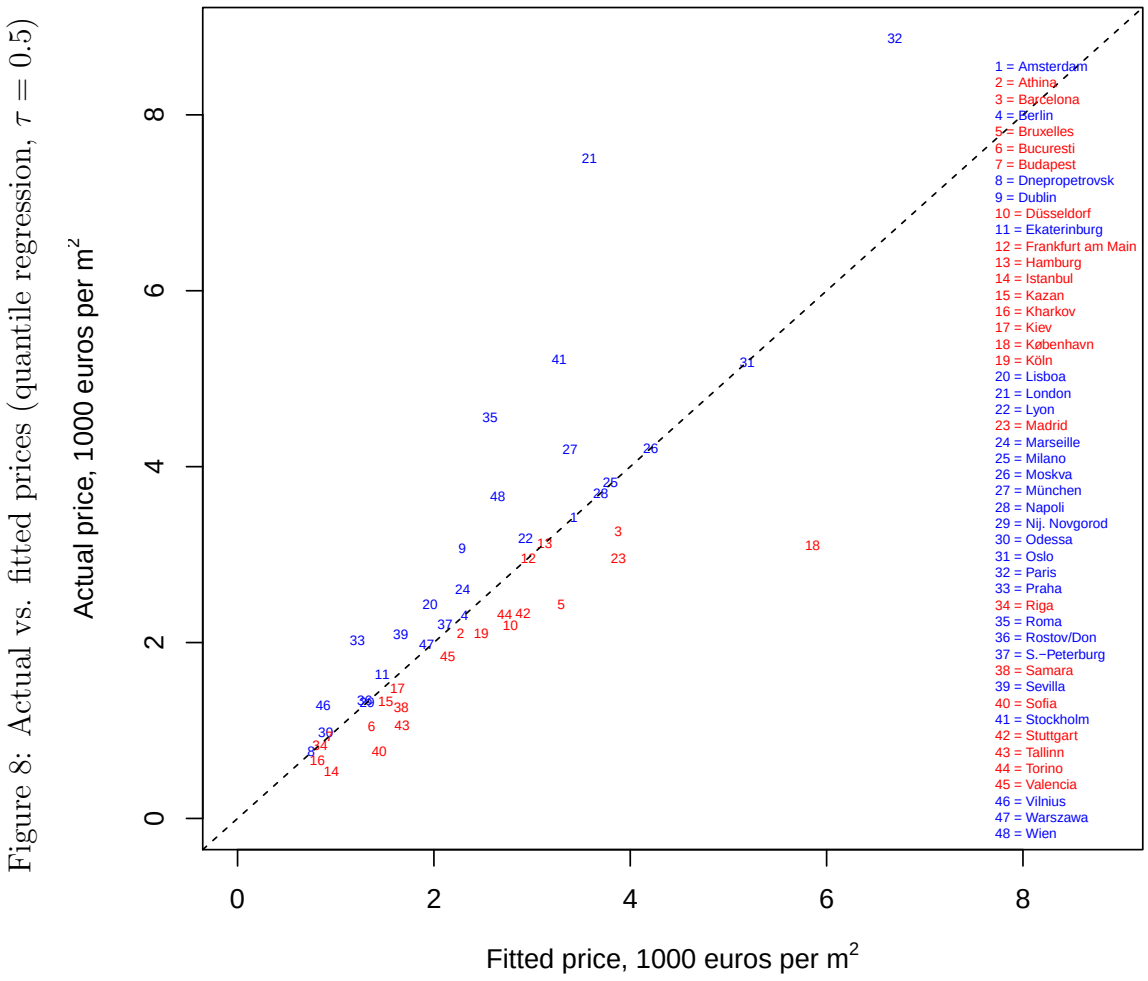


Figure 8: Actual vs. fitted prices (quantile regression, $\tau = 0.5$)

Figure 9: Distribution of relative difference between actual and fitted prices for flats, given different cities-variables combinations, January – May 2012